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In response to turbulent business environments, organizations are embarking on digital transformation journeys, often turning to "high speed" methods such as agile practices. These methods are key enablers for addressing time complexities in digital transformations, including time-to-delivery, cycle time, lead time, latency, real-time and velocity. We describe how Fujitsu used agile practices to manage time complexities in a successful attempt to set a world record, and the benefits gained by four Fortune 500 companies that also applied agile practices to manage time complexities.[1,2]

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Adopting Agile Practices Helps to Address Time-Related Complexities

Digital transformation is ubiquitous and companies of all sizes from virtually all industries are under pressure to innovate their business models as new competitors create new products or services with the help of digital technologies. While startups or "born digital" companies like Amazon, Facebook and Google are agile by nature, established enterprises struggle with how best to react quickly and flexibly to rapidly changing market environments. As a consequence, many established companies face challenges caused by the pace of change in the digital age.[3] In particular, they need to balance the need for increasing speed and flexibility against maintaining their existing operations ("keeping the lights on") while simultaneously allocating sufficient resources (i.e., time and capacities) to innovate with digital technologies. In response,

1 Yolande Chan is the accepting senior editor for this article..

2 The authors thank Yolande Chan and the reviewers for their suggestions and guidance throughout the review and publication process.

3 Recommended references for challenges imposed by digital transformation are: 1) Matt, C., Hess, T., Benlian, A. and Wiesböck, F. "Options for Formulating a Digital Transformation Strategy," *MIS Quarterly Executive* (15:2), June 2016, pp. 123-139; and 2) Dixon, J. A., Brohman, K. and Chan, Y. E. Dynamic Ambidexterity: Exploiting Exploration for Business Success in the Digital Age," in *Proceedings of the 38th International Conference of Information Systems: Transforming Society with Digital Innovation, ICIS 2017*, Seoul, South Korea, December 10-13, 2017.

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many companies are redesigning their digital strategies[4] and introducing agile practices and structures to increase speed and flexibility.[5]

To increase flexibility and reduce time-to-market, companies need to manage inherent complexities related to time. These complexities arise from different timing types, temporal interdependencies and temporal management styles, and managing these dimensions of temporal complexities requires organizations (and individuals) to understand the dimensions as well as their own relationships and interactions with time. How an individual perceives time, and his or her experience of time and relationship with it, depends both on a person's social context and on the particular circumstances of the organizational setting, resulting in a phenomenon we refer to as "time complexities."

We build on temporal research to examine how established companies manage the challenges resulting from time complexities. By adopting this temporal lens, we aim to enrich the understanding of strategic change inherent in digital transformations and thus provide deeper insights into the potential conflicts arising from different perspectives of time.[6]

In this article, we show how agile practices have helped established companies manage time complexities. After providing an understanding of what we mean by time complexities, we describe how Fujitsu overcame the challenges of time complexities to set a Guinness World Record for the world's largest animated tablet PC mosaic. We complement the Fujitsu case with four cases of Fortune 500 companies that have adopted agile practices to manage the challenges resulting from time complexities. (Appendix A describes our research method.) The article concludes by providing managerial recommendations for reducing time complexities by applying agile practices in today's turbulent business environment.

Understanding Time Complexities

From a practitioner's perspective, today's volatile and rapidly changing business environment can be considered a combination of complex business changes, situations and decisions. The complexities include changes in the business environment brought about by technological innovations or changing customer requirements, team and project dynamics and regulatory changes. In response to these complexities, many organizations are embarking on digital transformation journeys, which are characterized by multiple complexity dimensions including structural, uncertainty, ambiguity, dynamics and pace.[7]

Though uncertainty is inherent to innovation and novelty, it can also result from a gap between the amount of available information and the information that would be ideally required for decision making. Project dynamics relate to changes in requirements (or changes in objectives caused by volatile market conditions or competitive pressure) and are highly interrelated with time uncertainty. Pace is an important complexity driver because the level of urgency and criticality of time goals determines the most appropriate structures and level of managerial attention.[8] As time is a common denominator of

4 Good case studies on how to formulate a digital strategy and transformation include: 1) Sia, S. K., Soh, C. and Weill, P. "How DBS Bank Pursued a Digital Business Strategy," *MIS Quarterly Executive* (15:2), June 2016, pp. 105-121; 2) Hansen, R. and Sia, S. K. "Hummel's Digital Transformation Toward Omnichannel Retailing: Key Lessons Learned," *MIS Quarterly Executive* (14:2), June 2015, pp. 51-66; and 3) Dremel, C., Herterich, M., Wulf, J., Waizmann, J.-C. and Brenner, W. "How AUDI AG Established Big Data Analytics in Its Digital Transformation," *MIS Quarterly Executive*, (16:2), June 2017, pp. 81-100.

5 For an overview of agile forms of organizational design at established companies, including adoption paths, see Gerster, D., Dremel, C., Brenner, W. and Kelker, P. "How Enterprises Adopt Agile Forms of Organizational Design: A Multiple-Case Study," *ACM SIGMIS Database: the DATABASE for Advances in Information Systems*, (51:1), January 2020, pp. 84-103.

6 For a comprehensive literature review on time in strategic change, see Kunisch, S., Bartunek, J. M., Mueller, J. and Huy, Q. N. "Time in Strategic Change Research," *Academy of Management Annals* (11:2), March 2017, pp. 1005-1064.

7 For reviews of complexity in projects, see: 1) Geraldi, J., Maylor, H. and Williams, T. "Now, Let's Make it Really Complex (Complicated): A Systematic Review of the Complexities of Projects," *International Journal of Operations & Production Management* (31:9), August 2011, pp. 966-990; and 2) Williams, T. "Assessing and Building on Project Management Theory in the Light of Badly Over-Run Projects," *IEEE Transactions on Engineering Management* (52:4), November 2005, pp. 497-508.

8 For information on the complexity of the pace dimension, see: 1) Clift, T. B. and Vandenbosch, M. B. "Project Complexity and Efforts to Reduce Product Development Cycle Time," *Journal of Business Research* (45:2), June 1999, pp. 187-98; 2) Remington, K. and Pollack, J. *Tools for Complex Projects*, Routledge, 2007; and 3) Shenhar, A. J., and Dvir, D. *Reinventing Project Management: The Diamond Approach to Successful Growth and Innovation*, Harvard Business Review Press, 2007.

these complexity dimensions, we focus in this article on the handling of time complexities as a key challenge in digital transformations.

Time complexities may result from temporal structuring such as forming a group (e.g., related to a group's lifecycle, with a group's development stages often referred to as "forming, storming, norming and performing."[9]) Complexities may also result from changes in the timing of a group's actions caused by temporal ambiguity, conflicting temporal interests and requirement changes, as well as the potential scarcity of resources.

As a result, organizations (and teams within an organization) must be able to deal with and respond to the temporal problems inherent in collective action.[10] For instance, the question of how to respond effectively to uncertain market environments changing at a quick pace is heavily related to knowledgeably managing time complexities. But research and practice related to this issue often emphasize a traditional clock view of time, where technology implementation and value are often judged in terms of *speed*.

Time, however, is an inherently complex, multifaceted, context-dependent and subtle concept, and is by nature socially embedded—a phenomenon we refer to as "time complexities." Time complexities arise in situations where different temporal dimensions converge and need to be continuously identified and managed. While IS practitioners and researchers often emphasize the impact of information technology on the speed of organizational and social life, IS research has not addressed the polymorphous, complex and nuanced nature of time.[11] For instance, studies of project or organizational complexity tend to omit temporal elements completely or tend to focus on pace or speed as a single one-dimensional aspect of time complexity.[12]

The Three Dimensions of Time Complexities

We argue that there is a need to look at the vast range of temporal complexities inherent to digital transformation. We have therefore developed a set of temporal complexities (see Table 1) to provide practitioners with a model to think about and engage with the temporal complexities related to digital transformation. This classification of temporal complexities builds on the foundational work of Ancona et al.,[13] a framework that has been used as the basis for other temporal studies in our field.[14]

The set of temporal complexities shown in Table 1 provides a comprehensive and holistic analysis of temporal concepts and synthesizes the various concepts across different areas. As such, it provides a common framework for temporal constructs and variables and emphasizes the social issues of time complexities. We believe that a framework that emphasizes these issues is particularly suited to exploring the complexities inherent in digital transformations.

Table 1 identifies three dimensions of time complexities: *timing types*, *temporal interdependencies* and *temporal management styles*. The three dimensions are not mutually exclusive but are interrelated and form a framework for considering and dealing with time complexities. Each dimension is described below.

Timing Types Dimension. The timing types dimension refers to the different ways in which activities can be timed. For example, a team could organize an activity primarily by clock time[15]—e.g., breaking down a plan into months or specifying that a certain activity (such as a software release) has to be done on a Friday. Similarly, a sprint of a defined length

9 For a classic description of the lifecycle of groups, see Tuckman, B. W. and Jensen, M. A. C. "Stages of Small-Group Development Revisited," *Group & Organization Studies* (2:4), December 1977, pp. 419-427.

10 For information on the generic temporal problems inherent in collective action, see McGrath, J. E. "Time Matters in Groups," *Intellectual Teamwork: Social and Technological Foundations of Cooperative Work*, January 1990, pp. 23-61.

11 We recommend the following standard references on temporal theory and time complexity: 1) Nandhakumar, J. "Managing Time in a Software Factory: Temporal and Spatial Organization of IS Development Activities," *The Information Society* (18:4), July 2002, pp. 251-262; 2) Saunders, C. and Kim, J. "Editor's Comments: Perspectives on Time," *MIS Quarterly* (31:4), December 2007, pp. iii-xi; and 3) Shen, Z., Lyytinen, K. and Yoo, Y. "Time and Information Technology in Teams: A Review of Empirical Research and Future Research Directions," *European Journal of Information Systems* (24:5), September 2015, pp. 492-518.

12 Geraldi, J., Maylor, H. and Williams, T., op. cit., August 2011.

13 Ancona, D. G., Okhuysen, G. A. and Perlow, L. A. "Taking Time to Integrate Temporal Research," *Academy of Management Review* (26:4), October 2001, pp. 512-529. For more information on the framework of Ancona et al. and how it relates to other temporal theories, see Shen, Z., Lyytinen, K., and Yoo, Y., op. cit., September 2015.

14 See, for instance, Conboy, K., Dennehy, D., O'Connor, M. "'Big Time': An Examination of Temporal Complexity and Business Value in Analytics," *Information & Management* (57:1), January 2020.

15 Mosakowski, E. and Earley, P. C. "A Selective Review of Time Assumptions in Strategy Research," *Academy of Management Review* (25:4), October 2000, pp. 796-812.

Table 1: Classification of Temporal Complexities

Dimension	Subdimension	Examples
1. Timing types	Timing of activities	Activities are structured around event or clock time
	Socially constructed time	Work organization (e.g., nine-to-five workdays), celebrations (e.g., public holidays)
2. Temporal interdependencies	Single work activities	Estimation, scheduling, rate of completion and duration
	Repeating work activities	Cycle, rhythm, frequency and interval
	Connecting work activities	Ordering or synchronization
	Changing or transforming work activities	Life cycles, jolts, interruptions, aligning and patterning
3. Temporal management styles	Temporal perception of work activities	Experience of time during work, time passing, time dragging, experience of duration or novelty
	Temporal personality of individuals	Temporal orientation or temporal style of individuals (e.g., preference for being early or late)

is related to clock time. Event time, on the other hand, organizes work around events and things that need to be achieved (e.g., the release happens when all tests are passed regardless of what day, week or month it happens to be). Complexity can be caused by inconsistencies or misunderstandings regarding the exact clock or event times being used, or when some teams or people are using clock time while others are structuring their work around event times.

Complexities can also arise from socially constructed time and its impact on work organization (e.g., nine-to-five workdays or five workdays per week, and public holidays such as Easter and Passover[16]). For instance, some employees may have very different expectations of what overtime is expected and which public holiday times are sacrosanct. In today's world of global work, complexity arising from socially constructed time is ever-present because there are often multiple teams from different countries and time zones, religions and cultures working on the same project. Each team operates according to its own unique set of norms and expectations of themselves and of each other's obligations.

Temporal Interdependencies Dimension. The temporal interdependencies dimension refers to how activities are mapped to time. We suggest that practitioners first analyze the temporal complexities inherent in individual activities. Estimating the time required for a single activity and scheduling the activity may be complex, particularly in terms of how long it should take vs. how long it actually takes.[17] Next, practitioners should consider repeating

16 Shen, Z., Lyytinen, K. and Yoo, Y., op. cit., September 2015.

17 For more information on the time dimensions of work and their relationships with organizational culture, see Schriber, J. B. and Gutek, B. A. "Some Time Dimensions of Work: Measurement of an Underlying Aspect of Organization Culture," *Journal of Applied Psychology* (72:4), November 1987, p. 642-650.

activities (e.g., sprints). They need to think about how frequently a repeating activity should take place and how long the intervals between each repetition should be. Creating a sustainable rhythm of activities can be inherently complex, and managing multiple, often conflicting, rhythms even more so. The next step is to consider how different activities should be temporally connected. What order should they take place in? What happens when they cannot or do not happen in the pre-ordained order, and what complexities arise? Can and should the activities run simultaneously? Should they be synchronized and how can the complexities of maintaining synchronization be resolved?

Finally, and probably most importantly, it is unlikely that all activities will adhere to the original plan. Inevitably, there will be unexpected jolts and interruptions. Practitioners should therefore be prepared to handle the temporal complexities arising from changes in the timing of activities. Organizations should have processes for preempting such changes, or at least addressing them when they do occur. Teams often behave differently under time pressure or when striving to meet short deadlines, and thus need to address the complexities that occur during these extreme periods.

Addressing the temporal interdependencies of activities like scheduling, synchronization and task allocation is, in effect, a team's response to the challenges resulting from time complexities. It is easy to assess a process in a calm, quiet stage of a project. But it is often during times of crisis that a team can truly see how well activities are synchronized and how well it can manage time complexities.

Temporal Management Styles Dimension. The temporal management styles dimension refers to the way in which individuals perceive and respond to time. First, they may perceive time in a many different ways. Individuals have temporal personalities—some may like to be put under time pressure and create outstanding results as the deadline approaches, while others are incapable of coping with such pressure. Some may like to see their temporal performance illustrated in dashboards or team story boards or sprint boards, others may not. Some thrive in a sustainable work rhythm while others might be bored by it. Moreover, individuals' relationships to time vary significantly, depending on their culture, subculture and personality.[18] Generally, methods for managing time complexities do not take account of these factors: they tend to ignore the diverse and multifaceted complexities arising from temporal perceptions and personalities.

Agility Is the Key to Managing Time Complexities

In today's ever-changing business environment, a core organizational capability is having the agility to continually sense changing market conditions and respond rapidly, which is also the purpose of many digital transformations.[19] Thus, agility is also a core capability for addressing the challenges of digital transformation. We argue that an important component of complexity for organizations is time-related complexities, and that the agility needed to tackle new challenges resulting from changes in the business environment is also the key to reducing the level of time complexities. Though agility is often superficially associated with increased speed, the organizational capability to sense change and respond rapidly is much more complex than just increasing speed. The main premise of our argument is that organizational agility helps to address the challenges resulting from an increasingly multifaceted, time-complex digital world.

Below, we describe how Fujitsu addressed the three dimensions of time complexities during its endeavor to set a Guinness World Record for the largest animated tablet PC mosaic. We then provide four case studies of Fortune 500 companies that applied agile practices at scale (referred to below as "scaled agile practices"[20]) to overcome the time complexity challenges arising from digital transformations.

18 Mosakowski, E. and Earley, P. C., op. cit., October 2000.

19 A standard reference work on enterprise agility and organizational capabilities to sense environmental change and respond appropriately is Overby, E., Bharadwaj, A. and Sambamurthy, V. "Enterprise Agility and the Enabling Role of Information Technology," *European Journal of Information Systems* (15:2), April 2006, pp. 120-131.

20 "Scaled agile practices" is taken to mean "applying agility practices at scale throughout an organization or department of an organization."

Fujitsu's Endeavor to Set a Guinness World Record

In July 2017, Fujitsu initiated a project to set a Guinness world record for the largest animated tablet PC mosaic. This endeavor can be classified as having medium to high time complexities because it had a highly challenging time frame, with inherent technical complexity and a highly focused scope (setting a world record).

Founded in 1935, Fujitsu is a leading Japanese information and communication technology (ICT) supplier, and supports its customers in more than 100 countries with approximately 130,000 employees.[21] As a long-established business, Fujitsu has highly optimized internal processes and is accustomed to dealing with the challenges inherent in an innovative endeavor like setting a Guinness World Record, which combined both technical complexity and novelty with an ambitious timeline of less than three months. Initially, it was far from obvious that Fujitsu would succeed. As Fujitsu's Head of Product IT in EMEIA (Europe, Middle East, India and Africa) noted: "We have done something new, something disruptive, something completely different. And this is currently a real challenge especially for large, established companies' IT departments and business units" (Fujitsu Head of Product IT in EMEIA).

The world record attempt was planned as part of "Fujitsu Forum 2017," a long-running annual fair for clients, partners and prospects in the EMEIA region. With over 10,000 visitors from more than 80 countries, Fujitsu Forum is one of the largest customer events in the ICT industry.[22] Representatives of Fujitsu's top 100 EMEIA clients were invited to an exclusive dinner reception on the evening before Fujitsu Forum 2017—the "showtime" for the Guinness World Record attempt on November 7, 2017.

At the dinner, the invited guests were provided with tablet PCs, which they were asked to place in a specific order on a display wall to build a huge screen consisting of a minimum of 220 animated tablet PCs to create the largest-ever animated tablet PC mosaic. At first sight, this might not sound overly complex, but it turned out to be quite challenging. For instance, since tablet PCs are computers rather than monitors, they needed to be modified to display a specific part of the animated mosaic, and to prevent unwanted antivirus or firewall notifications, Windows updates or Wi-Fi setting pop-ups. A key success factor for the endeavor was the successful management of time complexities—i.e., considering the different timing types, time interdependencies during the attempt, and the temporal management styles of the project leader and Fujitsu's management.

21 For more information about Fujitsu, see the company's website (http://www.fujitsu.com/global/about/corporate/info/index.html).

22 The Fujitsu Forum 2017 website (https://www.fujitsu.com/de/microsite/forum-2017/) includes full details of the event, its agenda, speakers, presentations and videos.

Phases of Fujitsu's World Record Attempt

In its endeavor to set a Guinness World Record, Fujitsu managed the three dimensions of time complexities through an evolving step-by-step approach that allowed for failure and incorporated instantaneous feedback and continuous optimization. It purposefully addressed the dimensions by appointing a project leader who knew how to: 1) address a definite event time (in this case, the "showtime" when the world record attempt would be made), 2) slice the available time, 3) free up resources to make best use of available time, and 4) avoid potential productivity limitations resulting from socially constructed strict and inflexible working schedules.

Figure 1 shows the six phases of the project. The challenges arising at each phase from the three dimensions of time complexities are described below.

Phase 1: Idea Generation

The idea-generation phase lasted from July 26, 2017 to August 31, 2017. Invitations to Fujitsu's dinner reception guests were sent out on July 26, 2017. Fujitsu hired an event agency to host the dinner reception, and this agency came up with the idea of setting a Guinness World Record for the world's largest animated tablet PC mosaic as part of the event. The initial idea was that the event agency would take care of the world record attempt. Initially, Fujitsu was not actively involved in the preparation of the attempt and only reacted to the event agency's requests.

Phase 2: Preparation and Ramp-up

The second phase (preparation and ramp-up) lasted from September 1, 2017 to October 11, 2017. Initial time complexity challenges began to emerge during this phase. For example, because Fujitsu only builds to order, one issue was how 250 tablet PCs (including spares, development and test devices) could be manufactured without the usual production lead time. Furthermore, the technical difficulties of handling the time lag of signals transferred via Wi-Fi to the tablet PCs and synchronizing each device to create a seamless mosaic display across all devices turned out to be especially challenging.

During this phase, it became clear that, under the event agency's leadership, project progress was not in line with Fujitsu's expectations. Fujitsu therefore took on sole responsibility for the endeavor in early September, less than two months before the world record attempt was due to take place. Because of the time criticality, Fujitsu appointed a small team led by a fully dedicated project leader who was given extensive power. The project leader specified two conditions as prerequisites for taking on the role. First, he asked to be relieved from all other duties so he could dedicate 100% of his time to the project. Second, he wanted the budget flexibility necessary to circumvent existing (nonagile) processes because there would be no time to follow regular processes such purchasing and approval. In addition to the project leader, the team consisted of two full-time members and three part-time student helpers, along with various colleagues involved in specific ad hoc tasks and a total of 13 external partners.

From the beginning, the project team focused on getting everything accomplished before Fujitsu's key event time—the showtime where the Guinness World Record attempt would be made. The remainder of the preparation and ramp-up phase was spent on planning, preparing and commissioning the components needed for the world record attempt, which involved addressing challenges concerned with the timing of various activities caused by the novelty of the project and a lack of experience with comparable endeavors. For instance, an Indian software company was engaged to sort out the synchronization of Wi-Fi lags so that a seamless display of the mosaic across all tablet PCs could be achieved. During this phase, the project team also identified a location (a nearby science park) for installing a test wall to ensure readiness for showtime.

Phase 3: Technical Realization and Challenges

The technical realization and challenges phase lasted from October 12, 2017 to October 26, 2017. By mid-October, Wi-Fi was up running and an initial version of the software for the video app was available for testing. However, there were several unexpected jolts and interruptions related to, for instance, the poor synchronization of pictures and significant time lags of Wi-Fi signals. The project team discovered that one of the three brand-new Wi-Fi routers was not working properly; it was generating noise that was disturbing the signals of the other two routers. This malfunctioning router was replaced with an old, but properly functioning, back-up router. After this issue was successfully resolved on October 25, the animated mosaic was tested for the first time. Poor synchronization issues with tablet PCs that were causing defects in the correct display of the mosaic had to be fixed successively by the software provider.

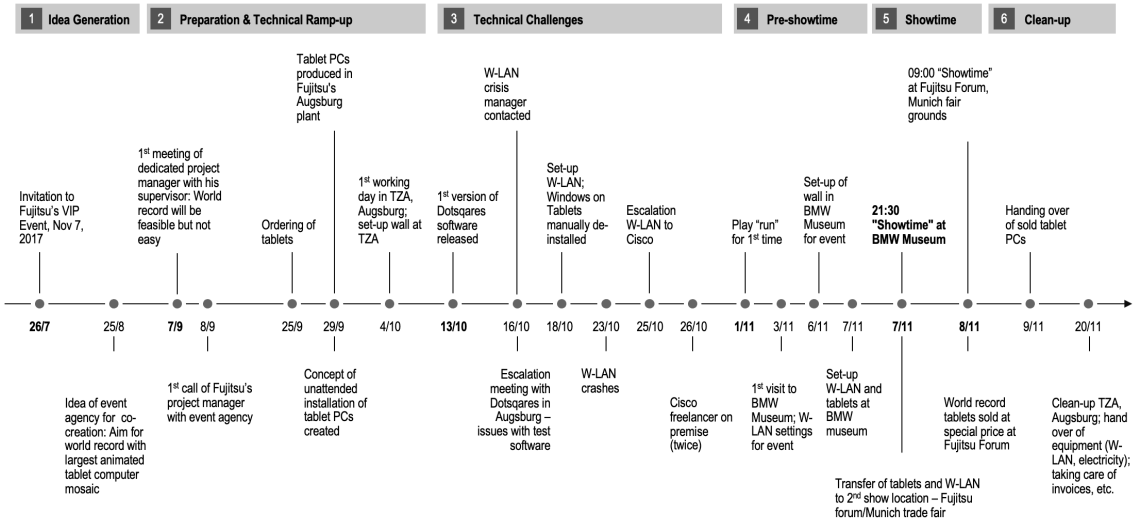
Phase 4: Pre-Showtime

The pre-showtime phase lasted from October 27, 2017 to November 6, 2017. With less than two weeks to showtime, a software update correcting incorrect content being displayed allowed the animated tablet PC mosaic to be displayed seamlessly for the first time on November 1, 2017, eight days before showtime. This provided some spare time for carrying out small software refinements, logistics planning, packing the tablet PCs and visiting the event location—the BMW Museum in Munich. The event wall, which had no power supply and featured minimum gaps between the tablet PCs, was set-up in the BMW Museum on the day of the event.

Phase 5: Showtime

The showtime lasted from November 7, 2017 to November 8, 2017. As part of the VIP dinner on November 7 at the BMW Museum, the tablet PCs were handed out to the guests shortly before showtime and they were asked to put the tablet PCs in designated grid positions on the show

Figure 1: Overview of Key Project Phases and Timeline



wall. A maximum of three attempts to create the animated tablet PC mosaic was granted by representatives of the Guinness World Record committee, who supervised the attempt. After all of the tablet PCs had been placed by the event's guests at their specified positions, an initial test revealed that, except for three devices, all tablet PCs had connectivity and responded correctly. Because project team members had already acquired impressive troubleshooting expertise, they quickly identified the root cause of the problem: two tablet PCs had erroneously been connected to the BMW Museum's Wi-Fi hotspot and the third device had been manually placed into airplane mode.

After manually correcting the settings of these three devices, all 220 tablet PCs correctly displayed the animated mosaic, setting the Guinness World Record on November 7, 2017, for the largest animated tablet PC mosaic.[23] Figure 2 shows photographs taken during the successful world record attempt.

Phase 6: Clean-up

The final clean-up phase lasted from November 9, 2017 to November 21, 2017. On November 21, 2017, the project team dismantled the training wall, cleaned up the location and returned rented electricity equipment and Wi-Fi routers.

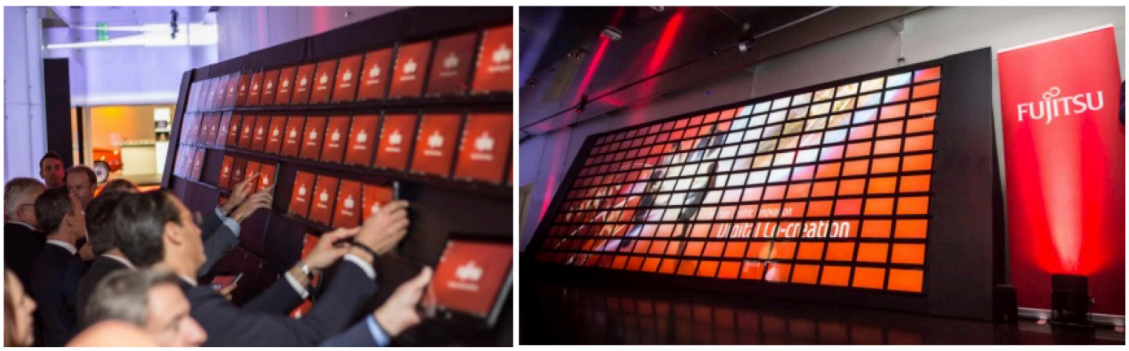
Time-Complexity Challenges Faced by Fujitsu in its World Record Endeavor

Timing Types Challenges Faced by Fujitsu

Fujitsu faced challenges related to all three timing types—clock time, event time and socially constructed time. Once the decision was made that Fujitsu would take responsibility for setting the Guinness World Record, the remaining available time was divided into small chunks, and high-level milestones were identified. By segmenting time into small pieces, the available (clock) time could be allocated most effectively. The showtime date for the VIP event was a fixed, unmovable deadline and everything required for the world record attempt needed to be in place before then. Despite the ambitious timeline and the need to ensure basic functionalities (i.e., defined minimum requirements to set a Guinness World Record), Fujitsu had to remain

23 A video documenting the successful Guinness World Record attempt at the event is available on YouTube: https://www.youtube.com/watch?v=mzrfKUqQgws.

Figure 2: Fujitsu's Guinness Word for the Largest Animated Tablet PC Mosaic



The left picture displays the installation of the tablet PC mosaic by Fujitsu's VIP clients and the right picture shows the animated tablet PC mosaic

flexible in terms of solution design and to allow for compromises. Thus, Fujitsu faced event-time challenges because the entire project planning, status tracking and progress reporting were focused on the day of the VIP event.

Fujitsu also faced challenges related to the time aspects of a socially constructed work organization. These challenges arose because the project team was given complete freedom to organize work. Despite employees having regular 40-hour per week contracts, the team decided not to operate on the usual Monday-to-Friday basis, but to work on an as-needed basis as required by project progress and critical activities like troubleshooting. The project team had the flexibility to set its own working schedule so that it could meet the fixed deadline. This resulted in sometimes working nights and weekends and taking time off during weekdays to compensate. The small core team of fully dedicated, self-confident and empowered individuals enabled a flexible work organization, which was essential to Fujitsu's success. Moreover, the flexible work schedule aided the internal alignment of team members and kept formal communication between them to the absolute minimum.

Temporal Interdependency Challenges Faced by Fujitsu

To set the Guinness World Record, Fujitsu had to deal with complexities resulting from multiple temporal interdependencies. There were challenges in mapping single and repeating work activities to time, connecting and synchronizing different work activities, managing interdependencies, and changing or transforming work activities in response to jolts or interruptions.

Mapping Single and Repeating Work Activities to Time. Fujitsu applied three approaches to mapping single work activities to time: 1) a high-level estimation of time to completion; 2) scheduling activities according to available time; and 3) applying a "fail fast, fail often" approach to make the most efficient use of time.

The first approach (estimation to completion), gave the team a rough idea of general feasibility, and confidence that it was possible to set the Guinness World Record despite the ambitious timeline and other issues: "I knew that it could work—otherwise I wouldn't have accepted this assignment. I had to know the involved components and to know how they could be provided" (Project Manager, Fujitsu).

With this first approach to mapping single work activities to time, Fujitsu sequentially planned activities to limit the number of potential sources for errors and reduce complexity arising from interrelated work packages. Fujitsu chose this approach because a traditional approach to project planning involving the detailed up-front planning of all activities was simply not feasible because of the lack of comparable experience and applicable knowledge for such an endeavor: "I initially tried to draw a Gantt chart but realized

soon that this chart requires more time to draw than it provided benefits. I only could do one step after the other, as circumstances and priorities changed rapidly" (Project Manager, Fujitsu).

The second approach (scheduling activities according to the available time) meant that the project team had to successively develop specifications and plan and proceed step-by-step in small iterations once a single activity had been successfully completed. The detailed specifications were developed subsequently in sprints, along with the implementation, a vital component of Fujitsu's approach to mapping single activities to work time.

The third "fail fast, fail often" approach to mapping single work activities to time enabled the project team to test possible solution components and to explore issues and limits at an early stage. One of the key challenges was to synchronize all the tablet PCs, which used custom-made software, to create a seamless display of the mosaic. Though the initial results were poor because of incorrect ratios of the mosaic pieces, synchronization was successively improved by trial and error in iterations between the team and the Indian software provider.

To map repeating work activities to time and provide a structured approach to developing, testing and continuously improving features, the project team proceeded in sprints of a defined length of two weeks. This repeating rhythm provided a clear structure of available (clock) time. Related work packages had to be adjusted so they could be completed within the length of a sprint, thus limiting the available time for a specific feature or for specific activities like solution development, programming, testing and so forth. To make the most efficient use of the available time, the project team partly adapted a strict time-slicing approach when planned activities were completed or when technical challenges or hurdles required immediate attention. The team even halted sprints if hurdles required special attention. For example, the project team immediately stopped a sprint as soon as the problem with interfering Wi-Fi signals occurred and focused on isolating potential sources of errors to identify the root cause of the problem.

Connecting and Synchronizing Different Work Activities and Managing Interdependencies. In connecting different work activities, Fujitsu's project team needed to allocate the available time in the most effective way so that it could order, synchronize, relocate and (if necessary) reschedule interdependent activities. To achieve this, the team focused on the minimum requirements for setting the Guinness World Record. One important decision related to the ordering of work activities was to separate the vision for setting a Guinness World Record from its realization: Fujitsu took over responsibility for technical realization of the attempt from the event agency that had created the idea because, after almost two months, not much progress had been made. While Fujitsu's project team focused on overall feasibility and coordination of activities, details of solution design and realization were left to specialists.

Changing or Relocating Work Activities in Response to Jolts. Involving specialists also provided the flexibility to modify solutions and reschedule work activities in response to jolts. Relocating activities was particularly challenging because of the wide range of external partners. The 13 partners were involved in specific aspects of the solution design—ranging from hardware providers, software providers, providers of connectivity or power supply, to specialists in designing fair booths like video animation on tablet PCs, an area in which Fujitsu did not have expertise. When an activity was relocated to one of these partners, the project team avoided resource conflicts by effectively leveraging Fujitsu's comprehensive partner ecosystem to provide an overall direction and manage interdependencies between activities. Fujitsu realized that its established and readily workable relationships with a diverse set of expert external partners could save valuable time.[24]

Another challenge relating to changing activities arose from a jolt that occurred soon after Fujitsu decided to take over responsibility for the technical realization of the Guinness World Record attempt. The project team realized that it had to work out how to get 250 tablet PCs manufactured at short notice without interfering with its regular production of PCs. The usual production lead time was several weeks because Fujitsu builds to order. To respond

24 Appendix B describes the architectural components of the solution and the involved external partners.

to this jolt and speed up tablet PC production, Fujitsu drew on its experience of successfully resolving similar problems by circumventing the traditional ordering process. For example, the project team experienced a jolt with the latest, but untested, Wi-Fi routers that were initially chosen. After causing significant problems, the brand-new devices were replaced by old routers that were usually used as back-up devices for events. The project team immediately stopped troubleshooting once it realized that the signal noise generated by one of the routers was interfering with the others, and instead decided to employ a technically suboptimal but workable solution using spare routers, which thus saved valuable time.

Temporal Management Styles Challenges Faced by Fujitsu

Fujitsu needed to deal with challenges arising from differing temporal management styles because the event date of November 7, 2017 could not be moved. Individuals' temporal perceptions are determined by their experience of time, e.g., time passing during work, whether they feel like time is dragging, and their perceptions of the duration of time and novelty. The novelty aspect of the world-record attempt was that nothing similar had ever been attempted in such a short time frame. This temporal perception of novelty was vital because it helped to create the common team identity needed to succeed with the ambitious and disruptive endeavor to set a Guinness World Record. The unmovable deadline of the VIP dinner event focused the project team's efforts on synchronizing all the activities required for on-time completion. As a hobby lighting designer for concerts, Fujitsu's project manager was fully aware of the concept of showtime: "There is a fixed date and time called "showtime" with a precisely defined starting time [by which] everything needs to be completed and up running" (Project Manager, Fujitsu).

The unmovable deadline helped the project manager set priorities right from the start and ensured he had the required freedom to make decisions and acquire the necessary resources. Also, the perception of time passing without significant progress being made caused Fujitsu to take over responsibility for the world record attempt. Team members' temporal perceptions of duration and novelty were present right from the beginning and persisted throughout the endeavor: "It was the spirit that was new to us: We had this showtime and we had not discussed what could go wrong" (Project Team Member, Fujitsu). The perception of novelty engendered a team identity and team spirit that motivated the team to handle challenging situations.

Temporal orientation and management styles were also evident in the responses to challenges arising from time complexities as the project team strived to meet the ambitious goal under challenging conditions. At the management level, Fujitsu executives clearly committed to the initiative by granting the project leader powers to bypass existing rules and procedures and thus speed up processes. Furthermore, management made it clear that there would be no negative consequences of failure, and this commitment provided the team with the freedom to experiment and devise innovative solutions.

At the team level, the project leader adopted a temporal management style in response to specific challenges concerning direct and proactive communication between team members, external partners and Fujitsu management: "Agility is [the] result of immediate action. I preferred personal talks to emails, to immediately address challenges and needs of key stakeholders" (Project Manager, Fujitsu).

How Managing Time Complexities Helped Fujitsu Set a Guinness World Record

To set the Guinness World Record, Fujitsu had to manage and synchronize the three dimensions of temporal complexities—timing types, temporal interdependencies and temporal management styles. Table 2 summarizes the measures used by Fujitsu to address the challenges arising in each of the three dimensions. By overcoming the challenges, Fujitsu succeeded in setting a Guinness World Record for the largest animated tablet PC mosaic.

Though each single task required to set the world record was manageable, the complexity of the very different time dimensions that the project team had to contend with made the overall goal ambitious, as noted by Fujitsu's

Head of Product IT in EMEIA: "This is not going to be easy—there are so many bits and bytes that need to work seamlessly in sync together—this hasn't been done [before]." The endeavor to set the world record had medium to high time complexities for three reasons:

1. The timing of the endeavor was ambitious because it was determined by the unmovable date of the VIP dinner event on November 7, 2017. Moreover, the initial plan to use the event agency turned out to be not feasible and more than half of the preparation time had passed when Fujitsu took over responsibility for the endeavor.

2. The three different locations caused specific temporal interdependencies. During the preparation and ramp-up phase, a test wall was installed at a nearby science park. The event itself was held at the BMW Museum, which is open to the general public six days per week. Installation and testing of the show wall therefore had to be accomplished in just a few hours prior to the event to avoid interference with the museum's regular opening hours. After the VIP dinner, the show wall had to be dismantled and immediately transported to the location of the Fujitsu Forum 2017 (Munich fair grounds), reinstalled and tested before Fujitsu Forum 2017 opened at 09:00 am the following day. The different locations, together with the very tight timing, left almost no spare time between scheduled events.

3. Because of time pressure, technological novelty and the complexity of tasks that had to be completed, Fujitsu needed to leverage 13 external partners. Though the partners contributed necessary skills and expertise, steering and managing them caused additional complexities in the timing of the work activities, interdependencies between activities and mastering technical challenges. The most critical timing issue, however, was the unmovable date of the world record attempt. But managing the different and multiple facets of time complexities involved many more challenges than just meeting the ambitious showtime deadline. The different aspects of time that Fujitsu had to simultaneously manage and synchronize reflect the complexity of the successful endeavor to set a Guinness World Record for the largest animated tablet PC mosaic.

Overview of Four Case Companies that Have Applied Agile Practices to Manage Time Complexities

Having explained how managing time complexities helped Fujitsu set a Guinness world record, we now present four other case studies of Fortune 500 companies applying agile practices to address time complexity challenges. Time-related challenges for some companies are obvious—for instance, a fixed planned date for a product market launch. Other companies, however, face multiple and less obvious time complexity challenges imposed by digital transformation. Examples include the need to: 1) reduce the number of unsuccessful projects to optimize the rate of completion, 2) respond to frequently changing market conditions, and 3) increase competitive advantage in response to competitive market entries.

The first two case study companies, anonymously called AviationCo and CommunicationCo, were formerly state-owned European companies. AviationCo has been in business for more than 90 years and has over 30,000 employees; CommunicationCo has been trading for more than 20 years and has over 210,000 employees. Table 3 provides an overview of both companies.

AviationCo is a leading European airline and aviation pioneer, and its key challenge is to increase organizational flexibility and speed. However, it has struggled with fostering innovation. For example, AviationCo's cockpit procedures tend to reflect the company's hierarchical structures and consist of routines, checklists, clearly defined procedures and a prespecified chain of command. This type of mindset makes the establishment of an error culture especially demanding:

> *We don't want the pilot to test whether it makes sense to land without the landing gear extended. Consequently, an error culture at an airline is not a question per se, but rather a question of how to establish a learning culture, allowing for mistakes where there are no negative consequences.* (Director Digital Innovations, AviationCo)

Table 2: Measures Used by Fujitsu to Address Time Complexities

Benefits	(Potential) Risks	Potential
1. Timing types	Timing of activities	– Allocate high-level milestones within available clock time. – Allocate time to chunks of a defined length (i.e., sprints). – Focus on the deadline with a defined minimum functionality and adapt available time accordingly.
	Socially constructed time	– Allow for a flexible working schedule to reflect project needs rather than following the usual working schedule.
2. Temporal interdependencies	Single work activities	– Replace detailed advance planning by a high-level initial feasibility assessment. – Specify requirements successively during implementation. – Use a "fail fast, fail often" approach that does not penalize failure.
3. Temporal management styles	Repeating work activities	– Apply iterative sprints for gradual solution improvement.
	Connecting work activities	– Leverage specialists for relocating work activities in response to unexpected challenges.
	Changing/transforming work activities	– Rely on tried-and-tested approaches to address jolts or interruptions.
3. Temporal management styles	Temporal perception of work activities	– Perceive "showtime" as an unmovable deadline.
	Temporal personality of individuals	– Apply a direct and personal communication style. – Credibly commit that failure has no consequences.

CommunicationCo is a provider of telecom and IT services, and its key challenge is also to increase speed and flexibility, with a particular focus on reducing the number of unfinished projects, which causes delays in customer delivery and customer dissatisfaction: "It is like the [rowing] boat was still in the harbor because someone was missing, but everybody else was in perfect position; if we would have gone out, we would have rowed perfectly" (Product Owner, CommunicationCo).

The other two case study companies, anonymously called AutomotiveCo and BankCo, are both stock market-listed companies. AutomotiveCo is a leading car manufacturer in Germany that has been in business for more than 100 years and has over 130,000 employees. BankCo is a European direct bank (with a country subsidiary) that has been in business for more than 50 years and has more than 5,000 employees. Table 4 provides an overview of AutomotiveCo and BankCo.

Table 3: Overview of AviationCo and CommunicationCo (Data correct as of the end of 2019)

	AviationCo	CommunicationCo
Industry	Airline	Telecoms and IT services
Age (years)	90+	20+
Employees	30,000+	210,000+
Key challenges	Eliminate bottlenecks to reduce cost of delay; shorten time-to-market	Reduce the number of unfinished projects; increase delivery speed
Scaled agile framework	SAFe	SAFe
Type of agile unit investigated	Business	Business
Employees in agile unit	Approximately 800	Approximately 12,500

In terms of exposure to multiple dimensions of high time complexity, AutomotiveCo and BankCo differ from AviationCo and CommunicationCo. AutomotiveCo and BankCo aimed at increasing customer centricity and organizational innovation to defend their market positions as innovation leaders against tech companies like Apple and Google. Both Apple and Google are increasingly active in innovation areas such as autonomous driving and electromobility (in the case of AutomotiveCo) and FinTech initiatives aimed at disrupting the financial services industry (in the case of BankCo). Thus, the primary time complexity challenge for both AutomotiveCo and BankCo was to innovate so they could maintain and defend their competitive positions. AutomotiveCo's car development unit responsible for establishing autonomous driving capabilities was exposed to multiple challenges related to time complexities, including:

- Technological novelty (e.g., autonomous driving or machine learning) and hurdles (e.g., analyzing data volumes of up to 200 petabytes)
- Frequent changes or unclear regulatory requirements in combination with an ambitious timeline (the start of serial production of cars with high driving automation features[25] was planned for 2021)
- A complex organizational setting involving teams provided by cooperating partners (suppliers) or even competitors (other car manufacturers).

Like AutomotiveCo, BankCo also aimed to adopt scaled agile practices to address the high level of time complexities within its market environment. Operating as a direct bank, BankCo had been being successful right from the beginning and had a reputation for disrupting established banks. However, it felt the need to respond to the increasing competition from FinTechs and to defend its competitive position as these new competitors gained traction.

As described below, all four of these case study companies faced time complexity challenges in all the three dimensions listed in Table 1.

Challenges Related to Time Complexity at the Four Case Companies

Timing Type Challenges

Types of Time. Like at Fujitsu, clock time and event time were important at the four case companies. Event time was important for AutomotiveCo because the planned start of serial production of high automation cars in 2021 placed high time pressure on development efforts. As a result, all activities had to be scheduled and synchronized to match the planned date for product launch. All four companies also applied clock time by allocating short time cycles (sprints) of a defined length to the available time.

25 High driving automation is one of the five levels of vehicle autonomy. At this level of automation, the vehicle performs all driving tasks under specific conditions but human override is still an option.

Table 4: Overview of AutomotiveCo and BankCo (Data correct as of the end of 2019)

	AviationCo	CommunicationCo
Industry	Automotive	Financial services
Age (years)	100+	50+
Employees	130,000+	5,000+
Key challenges	Manage technical innovation in the context of unclear requirements under high time pressure	Increase customer centricity; reduce organizational complexity
Scaled agile framework	LeSS	Own framework (best of breed)
Type of agile unit investigated	Business (car development)	Business (entire company)
Employees in agile unit	Approximately 1,100	Approximately 4,800

Socially Constructed Time. We also observed how socially constructed time was used to organize work at AviationCo, AutomotiveCo and BankCo. Whereas AviationCo aimed to reduce the importance of hierarchies, AutomotiveCo colocated all resources from its various development units working on autonomous driving to a newly formed "Autonomous Driving Campus." The aim was to foster interaction between teams physically working together and to prevent potential frictions resulting from collaborating employees scattered across different work locations. To complement the physical colocation of resources, AutomotiveCo introduced more flexible working time arrangements, in particular to address the needs of a primarily young workforce of IT professionals. These arrangements included regular home-based work for activities requiring no interaction with colleagues to compensate for the remote location of the new Autonomous Driving Campus.

BankCo completely reorganized the entire business to create an agile structure. The CEO wanted to prevent frictions resulting from different (socially constructed) working styles when agile teams collaborated with nonagile teams: "We realized that the entire organization has to work agile and not just parts of it, as frictions resulting from two different working styles were too big" (Product Owner, BankCo).

Temporal Interdependency Challenges

All four case companies faced challenges resulting from temporal interdependencies. As at Fujitsu, the presence of multiple perceptions of time resulted in high time complexity as multiple time dimensions had to be managed simultaneously. The challenges in each of the four subdimensions of the temporal interdependencies dimension are described below.

Single Work Activities. AutomotiveCo had to ensure that the launch of autonomous driving cars scheduled for 2021 could be achieved. CommunicationCo used the SAFe[26] framework to schedule and facilitate product development so that projects could be finished, and customer requirements could be met. Like Fujitsu, AutomotiveCo and BankCo replaced detailed advance planning with high-level planning and subsequently filling in the details during implementation. AutomotiveCo excelled in specifying requirements from a functional perspective and provided IT providers with the maximum degree of implementation freedom.

Repeating Work Activities. All four case companies used sprints so that the available time for repeating work activities was sliced into slots of a defined length: "We realized that a classic project setting was not helpful for what we were doing and that it is much better to proceed in short, interactive cycles" (Agile Coach, AviationCo).

Using sprints to allocate the available time provided a fixed structure and rhythm for development and improvement cycles of defined

26 For information on the SAFe framework, see *Essential SAFe 5 for Lean Enterprise*, ScaledAgile, March 2021, available at http://www.scaledagileframework.com.

length. This approach ensured that the value generated in a given time slot could be increased, and gradual improvements from sprint to sprint facilitated continuous improvement and allowed the early incorporation of customer feedback. Continuous improvement cycles were especially important to CommunicationCo because they reduced the number of errors and unfinished products. Similarly, AutomotiveCo used biannual release bundles to apply feature enhancements, with software updates being deployed continuously over the air.

When mapping, allocating ordering or relocating repeating activities, product owners played an important role in allocating activities from the backlog to sprints, and also in allocating resources when activities were relocated to ensure there were no conflicting priorities, challenges or hurdles. BankCo, for instance, relocated previously conflicting activities by reorganizing the entire company according to agile structures. This reorganization ensured that previously conflicting objectives and working styles resulting from the collaboration of agile and nonagile units were removed.

Connecting Work Activities. All four case companies made use of feature backlogs, with feature prioritization being done by the responsible product owner. The strict ordering of activities was critical for AutomotiveCo and CommunicationCo, as was the rapid development of new features resulting from interdependencies between single activities.

Changing or Transforming Work Activities. All four case companies needed to change or transform work activities in response to life cycle issues, midpoint transitions, jolts, and interruptions. Life cycles were an important issue for AutomotiveCo because the development of autonomous driving capabilities required rapid improvement and optimization of the radar and lidar (light detection and ranging) sensors, and cameras necessary for providing the required capabilities. AutomotiveCo also had to handle midpoint transitions related to the bundling of all required resources in one unit and the physical colocation of all staff involved in the development of autonomous driving cars at the newly created Autonomous Driving Campus. Another trigger for a midpoint transition was the decision to follow a standardized chain of tools for development that fosters cross-team collaboration. As AutomotiveCo's area product owner pointed out, the company perceived the need to entirely transform the work organization of the autonomous driving unit to foster collaboration and innovation: "We wouldn't have achieved such an ambitious objective with the traditional approach."

AutomotiveCo also experienced frequent jolts and interruptions when deploying new sensors, which repeatedly caused significant delays. Similarly, CommunicationCo struggled with jolts caused by the challenges of connecting to large legacy systems that contained customer master and invoicing data required for the provision of new features: "We have developed too many years on existing systems and have missed the point where tearing down and rebuilding would have been better" (Product Owner CommunicationCo).

Temporal Management Style Challenges

The challenges faced by the four case companies in the two subdimensions of temporal management styles are described below.

Temporal Perception of Work Activities. This subdimension was a critical issue for BankCo because it perceived the lack of speed when reacting to emerging competition from FinTechs as a barrier to quickly realizing and responding to customer demands:

> *We as a bank are the elephant that has to keep up with the greyhounds of the FinTechs. FinTechs are fast, modern, innovative and customer-oriented, and can realize customer requirements quickly. We have been very successful for the last years [in] making it difficult for the ordinary employee to understand why we need to change something.* (Product Owner, BankCo)

CommunicationCo was also concerned about the lack of speed, and perceived organizational decisions as taking too long: "The challenge was that we had become too rigid, too inflexible, too slow and too expensive" (Product Owner, CommunicationCo). The four case companies also experienced novelty in their temporal perception of work activities because they all reorganized according to fully agile structures and adopted

scaled agile practices. These reorganizations resulted in significant changes in working style, collaboration, allocation of resources and, especially, the time available for work activities.

Temporal Personality of Individuals. This subdimension, which relates to how someone perceives, interprets, uses, allocates or otherwise interacts with time, was important at all four case companies. BankCo's CEO sponsored and personally supervised the transformation to an agile organization so the bank could react quickly to new competitors (fintechs) and optimize the use of time. AutomotiveCo's division head initiated and supervised the colocation of all autonomous driving resources at the centralized Autonomous Driving Campus because he was convinced that traditional approaches of organizing work were no longer feasible and the centralized campus would allow for more effective use of time and resources.

Similarly, temporal management style played an important role at AviationCo during the organizational transformation because the company had to foster a culture of learning from errors in non-safety critical areas: "The only mistake a company can make is not learning. There are actually no mistakes, only the possibility to learn" (Agile Coach, AviationCo).

Benefits Gained by the Four Case Companies from Using Agile Practices to Manage Time Complexities

To address the challenges resulting from high time complexities (i.e., situations where time pressure is high and where different, partly conflicting time dimensions occur simultaneously), all four case study companies selectively used scaled agile practices.[27] AutomotiveCo used LeSS[28] whereas BankCo adopted its own internally developed framework, which integrated best practices from various frameworks. AutomotiveCo adopted scaled agile practices department-wide and BankCo organization-wide, with AutomotiveCo's department head and BankCo's CEO as the sponsors. Implementation took place at both companies with a time-boxed approach in waves, with a total duration of 18 months (BankCo) and 9 months (AutomotiveCo), respectively.

Both AutomotiveCo and BankCo aimed at making the contribution of single tasks and the dependencies between different agile teams transparent. Both also aimed at continuously improving at the product, process and organizational levels. In terms of structure, both companies focused on establishing a matrix structure, with product-orientation on the vertical axis and professional or technical expertise on the horizontal axis. Both companies also defined agile roles at the multiteam level, and used agile routines for repeating activities such as quarterly business reviews for product planning.

All four case study companies used scaled agile practices with iterative delivery cycles of a defined length (sprints), which provided benefits in terms of scope and value, and reduced time-to-market for critical features. This approach meant that the requirements defined by the product owner could be implemented with minimum time and resources. Note that an agile approach does not require an initial specification of requirements; features are defined successively based on the product manager's prioritization during the sprints. Moreover, an agile approach enables an incremental approach to innovation.

27 According to Dikert et al., scaled agile structures consist of at least six feature teams each with over 50 members, with a feature team responsible for a product that is managed by a corresponding product owner. See Dikert, K., Paasivaara, M. and Lassenius, C. "Challenges and Success Factors for Large-Scale Agile Transformations: A Systematic Literature Review," *Journal of Systems and Software* (119), September 2016. pp. 87-108. Good summaries and comparisons of the different scaled agile frameworks include: 1) Conboy, K. and Carroll, N. "Implementing Large-Scale Agile Frameworks: Challenges and Recommendations," *IEEE Software* (36:2), March 2019, pp. 44-50; and 2) Kalenda, M., Hyna, P. and Rossi, B. "Scaling Agile in Large Organizations: Practices, Challenges, and Success Factors," *Journal of Software: Evolution and Process* (30:10), May 2018. p. 1954.

28 For information about the LeSS framework, see *LeSS Framework*, available at https://less.works/less/framework/index.html.

AviationCo and CommunicationCo chose a unit-wide scope for adopting scaled agile practices (the SAFe framework in both cases), and each established a dedicated team to take the lead on transformation. The team sizes and composition varied according to implementation scope. Each feature team included at least of one transformation lead, one agile coach and one scrum master. Both companies chose a stepwise and iterative implementation approach to mitigate the risks inherent in a "big bang adoption" of the scaled agile SAFe framework.

By implementing the SAFe framework, both AviationCo and CommunicationCo benefited from the essential agile principles—transparency, continuous improvement, result ownership and customer-centricity. Transparency was achieved by clearly allocating products to dedicated units and by examining time interdependencies between feature teams and the current challenges preventing prompt delivery. Continuous improvement of internal processes or structures was achieved through repeating and structured customer-facing and non-customer-facing meetings that reflected on success stories and areas for improvement.

Both AviationCo and CommunicationCo adopted a cyclical pattern of repeating activities in the form of agile sprints to map activities to a fixed period of time. Both companies followed a demand-driven approach, and teams were not given a strict implementation timeline. Instead, teams sliced the available time via sprints. CommunicationCo's objective was to eliminate bottlenecks and to reduce the cost of delays. To achieve this objective, it was essential to have transparency on current issues causing delays. The adoption of scaled agile practices, including feature teams with clearly defined product responsibilities and a product backlog that was worked on via repeated sprints, helped to increase transparency on the delivery status and potential bottlenecks.

Adopting an agile structure, including a transparent team structure consisting of feature teams with experienced and broadly skilled employees, helped AviationCo to increase transparency at the organizational level. Agile coaches enabled AviationCo's feature team members to adopt agile routines. The agile coaches also fostered team alignment and identification, which helped to increase the team's output within each sprint. AviationCo found that short sprint cycles were superior to the traditional (nonagile) approach because a defined workload (i.e., a backlog item) was carried out within a given period and with a clear focus.

Agile practices helped CommunicationCo properly manage time complexities while considering customer feedback early. Putting the focus on customer priorities and business results by getting things "almost ready" is not feasible when adopting agile practices. Interestingly, AviationCo realized that an agile approach is not necessarily faster; the traditional approach can sometimes be faster because it requires less time for alignment and communication:

> *[With an agile approach] you ... get faster feedback allowing [you] to focus on features with value to the customer, but the implementation itself [may] not [be] faster [because of the] increased communication and alignment effort.* (Agile Coach, AviationCo)

In summary, all four case companies purposefully used scaled agile practices and structures to manage the time complexities in their business and activities. They successfully addressed the challenges arising from different timing types and temporal interdependencies while acknowledging and building on temporal management styles.

Recommendations for Managing Time Complexities

The Fujitsu case and the four case studies of Fortune 500 companies illustrate the rich and diverse facets of time complexities. Based on our analysis of these cases, we provide recommendations for managing situations with high time complexity and synchronizing the four dimensions of temporal complexities.

Our findings suggest that there are two different evolutionary approaches that established companies can follow to manage time complexities. The first is a bottom-up approach that involves adopting scaled agile practices either retroactively in situations that initially had low time complexity or selectively in situations with high time complexity. Fujitsu adopted such

a bottom-up approach. The second approach is a top-down approach involving organization-wide adoption of scaled agile practices in situations where there is high time complexity. Each of the four Fortune 500 case companies followed a top-down approach. Figure 3 shows both approaches and their evolutionary paths through four quadrants defined by high or low time complexity and the extent of the agility approach (fully scaled or "agile islands").

Adopting agile practices helped Fujitsu and the four Fortune 500 companies managing time complexities. The choice of a bottom-up or top-down approach to adopting agile practices depends on a company's specific circumstances. Those facing imminent time complexity challenges should adopt a bottom-up evolutionary approach. Those facing foreseeable but business-critical time complexity challenges in the near future (e.g., new market entrants in the case of AutomotiveCo or new digitally based competitors in the case of BankCo) should adopt a proactive top-down approach.

Thus, depending on the trigger, companies may adopt agile practices either selectively (bottom-up approach) or in a scaled and structured manner right from the start (top-down approach). The two possible evolutionary paths are from quadrant III to II of Figure 2 (this is the path followed by Fujitsu) and subsequently slowly traversing to quadrant I (as happened in the AviationCo and CommunicationCo cases), or from quadrant III to IV and subsequently traversing to quadrant I (as per the AutomotiveCo and BankCo cases). We now provide specific recommendations relating to the bottom-up and top-down approaches.

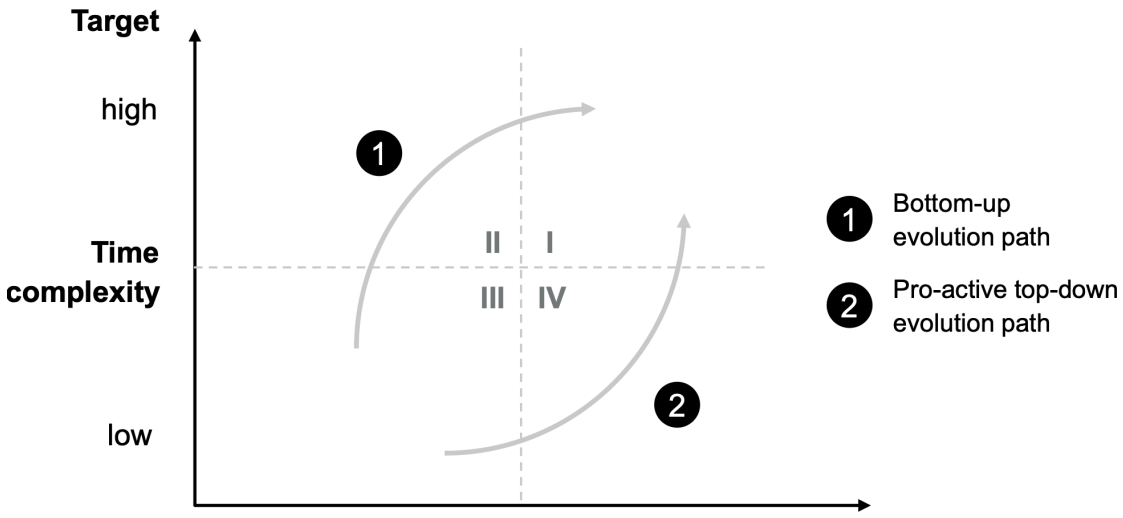
Apply a Bottom-up Approach Where Time Complexity Is Initially Low

The bottom-up approach is appropriate for situations where companies will experience limited time complexity in the foreseeable future, or where high time complexity affects just parts of the organization. The latter situation was illustrated by the Fujitsu case. The unit accepting the challenge to set a Guinness World Record had to work with an extremely ambitious timeline and experienced high time complexity resulting from multiple timing types. In situations like this, the interdependence across products within a unit or across different units is limited, which thus allows for a more flexible approach to managing the challenges arising from time complexities. Thus, the bottom-up evolutionary path is not restricted to or affected by a finite timeline. The rate of progress is determined by single units and reflects team-specific requirements for adopting agile practices. We recommend that organizations follow this approach when an increasing number of units grow organically with each unit adopting scaled agile practices once it sees the positive experiences of other units.

At Fujitsu, a selective (and even a partly intuitive) application of agile practices helped manage time complexities in their attempt to set a Guinness World Record. Likewise, AviationCo and CommunicationCo were in a similar situation. In both companies, time complexities resulting from different timing types were initially low. AviationCo's primary objective was to foster innovation, whereas CommunicationCo wanted to decrease the incidence of unfinished projects. In both cases, the companies chose a selective approach, focusing on a gradual implementation of scaled agile practices based on initial learnings and the voluntary participation of units. The bottom-up approach helped AviationCo and CommunicationCo identify and eliminate bottlenecks and thus reduced costs caused by delays. Introducing cyclical patterns of repeating activities (i.e., agile sprints) helped CommunicationCo to almost but not entirely identify finished projects and to focus on getting things accomplished.

Similarly, Fujitsu adopted key principles of agile practices (e.g., focusing on functionalities rather than processes) to manage the high time complexities inherent in their endeavor to set a Guinness World Record. However, Fujitsu did not adopt scaled agile practices throughout the company; instead, it created an "agile island" to further its aim of setting a world record. The keys to success in that endeavor were top management commitment, allocating time chunks to a small core team consisting of fully dedicated, self-confident and empowered individuals, and a strong and reliable ecosystem of partners. Thus, Fujitsu applied a cyclical pattern for tasks leading up to the successful world record attempt but also purposefully transformed activities (e.g.,

Figure 3: Two Evolutionary Paths for Managing Time Complexity



increasing speed) to ensure it met the unmovable deadline.

While an "agile islands" bottom-up approach has the advantage of allowing gradual improvements, trial-and-error, and a more flexible adoption of agile practices, its disadvantage is a slower and less homogeneous rollout of scaled agile practices throughout the organization. As time complexities increase, organizations should therefore adopt a more structured, top-down approach that will allow them to implement agile practices in a more homogeneous and scaled manner. Both AviationCo and CommunicationCo adopted a top-down approach to deploying scaled agile practices through the SAFe framework.

Apply a Proactive Top-down Approach Where There Is High Time Complexity

A proactive top-down approach is appropriate for situations where high time pressure affects large parts of the organization and where all three dimensions of temporal complexities need to be addressed. At AutomotiveCo and BankCo, innovations (autonomous driving) and high market pressure from new market entrants (fintechs) meant they had to find ways to increase speed and flexibility to keep their leading market positions. Despite its innovative nature and technological excellence, AutomotiveCo still had to contend with bureaucratic and inefficient processes, as did BankCo. In both of these cases, the different dimensions of temporal complexities had to be managed simultaneously, which required a more coordinated and centralized approach.

Both companies had already demonstrated that they could successfully handle situations of low time complexity; both had reduced time-to-market, the cost of delays and the number of unfinished projects. In particular, BankCo had deployed scaled agile practices selectively more than five years ago, which meant that the bank had already gained substantial expertise in using agile practices and addressing the challenges related to low time complexity. AutomotiveCo had implemented scaled agile practices on a departmental basis, sponsored by the department head. The implementation at BankCo was organization-wide, with the CEO as sponsor. Both companies used a top-down approach to implementing scaled agile practices in a relatively short period (months rather than years).

The advantage of the top-down approach is that it results in a more synchronized and homogeneous implementation of scaled agile practices, although individual units have less freedom. The top-down approach is appropriate for organizations where time complexity is high and a structured and aligned approach is required right from the beginning. It is also appropriate for more mature organizations that

already have a common understanding of what needs to be done for an agile transformation, where there is potentially less resistance from individual units to a more standardized approach. The top-down adoption of scaled agile practices helped AutomotiveCo and BankCo address the significant and imminent challenges posed by digital transformation and the resulting high time complexities.

Thus, we recommend that organizations with high time complexities adopt a proactive top-down approach to adopting scaled agile practices organization-wide, with ownership of the implementation lying with the relevant department head or even the CEO. Further, we recommend they use a time-boxed approach with a predefined time horizon for adopting the chosen scaled agile framework. Setting a clearly defined deadline will ensure a smoother implementation with stricter governance and faster (i.e., top-down) decision-making.

Concluding Comments

To retain their competitive positions, companies operating in rapidly changing business environments need to increase their speed and flexibility and this requires them to manage time complexities. For startups or born digital companies, innovation, speed and flexibility are their main modus operandi, but established enterprises struggle with how to respond to uncertainty and rapidly changing market environments in an adequate and timely way.

Our research for this article was motivated by the lack of empirical evidence on how established enterprises manage different aspects of time complexities. We adopted a temporal lens to examine the challenges of time complexities related to digital transformations because this lens provides a different, more comprehensive view of agility beyond the superficial misperception that agility just equals speed.

The insights reported in this article are based on five case studies. The first is a description of how Fujitsu set a Guinness World Record for the largest animated tablet PC mosaic. The other four are of Fortune 500 companies that used scaled agile practices selectively to manage time complexities. We found that shifting from a strict application of sprints following a clock time perspective to modifying a sprint's length in response to already completed work or to reflect specific situations is a pragmatic approach to handling multiple time complexity challenges simultaneously. By applying agile practices selectively to manage the different dimensions of temporal complexities, Fujitsu succeeded in reducing time complexities despite an ambitious and unmovable deadline.

Our findings from the Fujitsu case and the four Fortune 500 cases show that organizations with low time complexities should use a bottom-up approach for adopting scaled agile practices, and those with high time complexities should adopt a proactive top-down approach. Agile practices are a key enabler of synchronizing and managing the different facets of time complexities.

Appendix A: Research Method

The objective of this study was to gain an in-depth understanding of how time complexities can be successfully managed by adopting agile practices. We examined how Fujitsu set a Guinness World Record for the largest animated Tablet PC mosaic by adopting selective agile practices to succeed in the project, which involved a challenging objective, technical novelty and an ambitious timeline. We supplemented our findings from the Fujitsu case with those from four cases of Fortune 500 companies that applied scaled agile frameworks to manage time complexities. Because of the exploratory nature of this study, we used a qualitative case study research approach.[29]

Researching the Fujitsu Case

Fujitsu's Robert Mayer, a research team member and co-author of this article, provided access to interview candidates at Fujitsu and to relevant internal information such as internal reports, photos, videos made during the world record attempt, presentations, minutes, etc. We conducted and tape-recorded in-depth interviews with Fujitsu's project manager and Fujitsu team members.

We reviewed various documentation in the form of pictures, emails, notes and memos on specific incidents to create an extensive dataset

29 For case studies of using exploratory research, see: Yin, R. K. *Case Study Research: Design and Methods*, Sage, 2009.

(our fieldwork journal.)[30] Using an open interview format,[31] two members of the research team conducted extensive face-to-face interviews with Robert Mayer and other Fujitsu team members. The interviews (totaling 192 minutes) were recorded, transcribed and coded, and then evaluated in detail along with 108 pictures and nine videos. The data analysis followed a three-stage process of open, axial and selective coding[32] to get a comprehensive view of Fujitsu's endeavor to set a world record. This approach created a rich set of reflections on the endeavor.

Researching the Fortune 500 Cases

In total, we conducted 13 interviews using a semistructured interview guideline, which enabled us to gather information in a discovery-oriented way. The interviews, which lasted from 32 to 60 minutes, were recorded and transcribed, resulting in 130 pages of verbatim transcript, which we then coded using an open, axial and selective coding procedure. We checked the transcripts for completeness and analyzed them separately. Where available, memos or notes were used to capture ideas and identify further questions or thematic differences. The qualitative data analysis software MaxQDA was used to support the coding procedure, which facilitated the comparison of coding results and memos and enabled us to check for sufficient intercoder reliability. Where interpretations between coders diverged, we discussed the different perspectives iteratively to reach a consensus and ensure consistency of coding and interpretation.

Appendix B: Overview of Fujitsu's World Record Attempt Architecture and External Partners

The figure below shows the overall architecture (hardware, software and infrastructure) of Fujitsu's world record endeavor and the ecosystem partners involved in the project.

Hardware

- 250 Fujitsu Stylistic R726 tablet PCs, including 20 devices used for development and testing, and 10 spares.
- Two Fujitsu CELSIUS H770 mobile workstations used for content creation, scripting and internet access, and for running the Baramundi tools for software distribution to the tablet PCs.
- Cisco wireless access points and WLAN controller, network switches and VPN routers.

Software

- A central server application, developed by Dotsqares, for remotely controlling 220 tablet PCs. This app provided "load video," "start play," "stop play" and "pause play" features. It calculated an offset for each tablet PC according to network latency and started all 220 players simultaneously. It also ran a visual overview of the available tablet PCs (like an inventory scan). The player application on each tablet PC was set to a specific grid location and displayed a specific part of the video content. The player app software with graphic mosaic content was stored locally on each tablet PC.
- Baramundi management suite software, which was used for centralized distribution of software, drivers and scripts to the tablet PCs. It provided basic controls such as reboot, shutdown, applications start and stopping.
- "Pingeling," a tool developed by Fujitsu for validating the connectivity of tablet PCs and allowing the unattended installation of specific configurations of Microsoft Windows 10.

Infrastructure

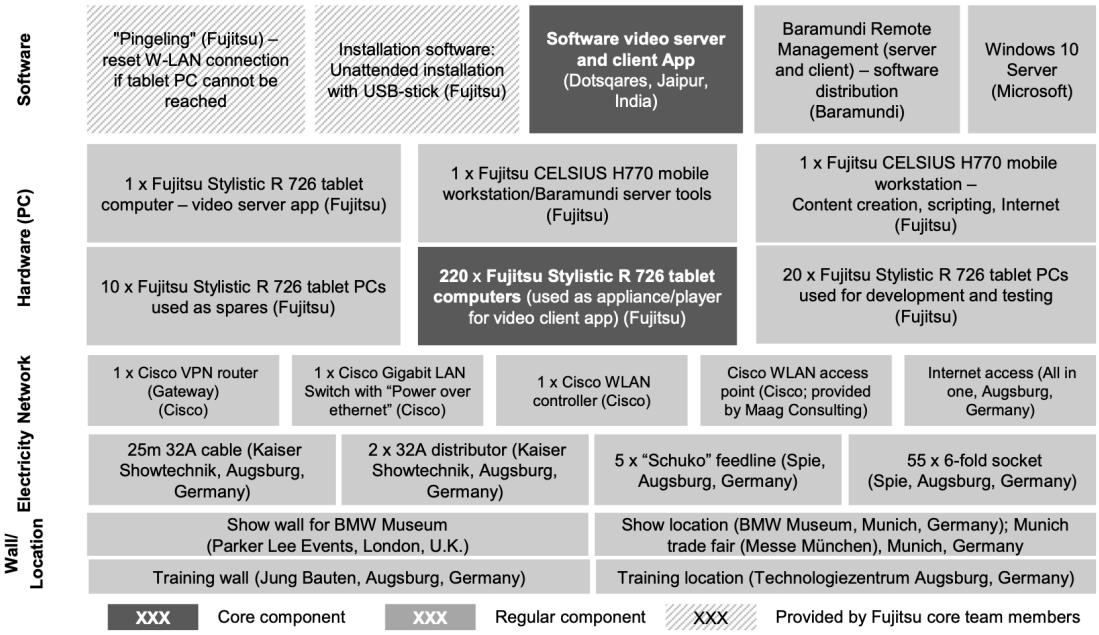
- The display wall (providing 11 vertical grid positions and 20 horizontal positions) used for positioning the tablet PCs:
- The training wall included electricity supply for each tablet PC grid position

30 Further helpful recommendations for qualitative research can be found in Yin, R. K. *Qualitative Research from Start to Finish*, 2015, Guilford Publications.

31 For further details on interviewing techniques in qualitative research, see Myers, M. D. and Newman, M. "The Qualitative Interview in IS Research: Examining the Craft," *Information and Organization* (17:1), December 2007, pp. 2-26.

32 For information on interview coding, see McCracken, G. *The Long Interview*, SAGE Publications, 1988.

Key Components of the Architecture and Involved Partners



- The showtime wall for the VIP dinner event had no electricity, so the tablet PCs had to operate on battery power
- Wireless network and routers to connect 223 devices (220 tablet PCs, one server and two workstations).
- Electricity supply and distribution of 15 kW (for charging the tablet PCs during development and to run on battery power during showtime).

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