How Deutsche Telekom Uses Emerging Technologies to Enhance the Internal Control System

Abstract

Adequately designing, effectively operating, and subsequently monitoring an internal control system (ICS) along with digitally transforming business and assurance processes has become a major challenge in today's business environment. Deutsche Telekom has established a state-of-the-art ICS by using emerging technologies such as artificial intelligence, robotic process automation, data analytics including process mining, and blockchain. The purpose of our study is to explore how these technologies can be utilized to enhance the ICS. We describe and analyze use cases implemented by Deutsche Telekom to provide practical insights into how organizations can conduct a digital transformation of the ICS. We further present avenues for future research. Our findings are informative to ICS managers, other assurance functions, management, CFOs, audit committee members, and corporate governance researchers.

Keywords: artificial intelligence; robotic process automation; data analytics; process mining; blockchain; digitalization strategy

I. INTRODUCTION

In times of increasing uncertainty and regulatory pressure, risk management and controls are steadily shifting into the spotlight. As a result, a strong and effective internal control environment has emerged as an imperative for organizations to embrace (e.g., KPMG 2022). With mounting regulatory requirements, heightened liability concerns, the accelerating pace of digitalization, and the ever-increasing complexity of business operations, the importance of establishing a robust and effective internal control environment cannot be overstated. Furthermore, the number of internal controls needed has significantly grown because of these developments. Following numerous corporate and economic scandals in the past, the question has arisen as to whether current ICSs of companies represent a reasonable mechanism for reducing risks and thus meeting the requirements of various stakeholders (e.g., IFAC 2012; EY 2019) - or whether significant technological improvements are needed to enhance the efficiency and effectiveness of ICSs.

Simultaneously, companies strive to digitally transform[1] existing business and corporate governance processes that consequently need to be re-designed to be adequate in a completely digitized business environment. Digital transformation is essential for enhancing the efficiency and effectiveness of monitoring activities (e.g., Eulerich, Huang, Pawlowski, and Vasarhelyi 2024). Therefore, the adoption of digital technology is crucial for corporate governance functions, including internal control managers. However, the transformation of corporate governance functions, structures, and processes is difficult to achieve without the required expertise and without knowing feasible use cases. Thus, providing use cases of how technologies can be leveraged in practice should be beneficial to corporate governance leaders, management, and audit committee members.

Prior research on internal controls has mainly concentrated on financial reporting, lacking a broader view of the ICS. While recent studies in the corporate governance context have identified new technologies enhancing efficiency and effectiveness (Eulerich et al. 2024), to our knowledge, there is no research on innovations and technologies to derive such improvements for the ICS.

The purpose of this paper is to explore how emerging technologies are utilized to enhance the ICS. Therefore, we present a case study of Deutsche Telekom (DT), since DT has digitally transformed its ICS with several use cases that are state-of-the-art even beyond the telecommunications industry. This company represents a prime example of how digitalization can revolutionize ICS across industries, setting a benchmark for others to follow. We describe and analyze these use cases to infer implications, insights, and lessons learned.

[1] The term digital transformation can subsume both processes and technologies that can improve the effectiveness and/or efficiency of companies either fundamentally or in individual areas. Every process can be subject to change because of companies striving for digital transformation.

To provide a comprehensive overview of the integration of emerging technologies into ICS, we explore several transformative tools, including artificial intelligence, Robotic Process Automation (RPA), data analytics, process mining, and blockchain. Each of these technologies contributes distinctively to enhancing the robustness and efficiency of ICS. Artificial intelligence has matured from theoretical concepts to practical applications, utilizing advanced algorithms for predictive analytics and risk management, thereby enhancing monitoring and control activities, particularly in the realms of compliance and operational efficiency (Almufadda and Almezeini 2022). Concurrently, RPA streamlines and automates routine tasks such as data entry and transaction processing, directly impacting the control activities related to transaction processing efficiency and error reduction (Zhang, Issa, Rozario, and Sveistrup Soegaard 2023). Furthermore, data analytics and process mining provide powerful tools for analyzing vast datasets and visualizing actual process flows within organizations. These techniques optimize both controls over information processing and monitoring, essential for operational performance and compliance by identifying inefficiencies and potential improvements (American Institute of Certified Public Accountants 2017; Hawkins, Pickerd, Summers, and Wood 2023). Blockchain technology enhances transactional integrity and transparency through its decentralized ledger, influencing control environments by strengthening the trust and verification mechanisms without intermediaries, and potentially increasing firm value while managing new risks (Huang, Wang, and Ju-Chun Yen 2024; Dai and Vasarhelyi 2017).

This study is particularly relevant to a range of professionals including ICS managers, auditors, CFOs, and researchers focused on corporate governance, all of whom are pursuing innovative methods to enhance control environments through technology. We offer relevant perspectives on integrating cutting-edge technologies into ICS, highlighting how these advancements can improve internal controls and support the broader goals of organizations. Finally, we provide guidance for future research in this largely unexplored field.

Given that both internal controls and emerging technologies are important and timely topics to study, this paper has several contributions as it (a) provides practical insights into how organizations can digitally transform their ICS and how an ICS can be built with sophisticated technologies; (b) shows that emerging technologies used in conjunction can advance and enhance an ICS; and (c) offers recommendations for organizations that aim to improve their ICS.

The remaining paper is structured as follows. We present background information about the ICS and digitalization initiatives to infer how these can build a symbiosis. We then present the case company and describe DT's general approach to digitalizing its ICS, before we describe and analyze how the company adopts different use cases in its ICS and what benefits are derived. We conclude with a discussion pointing to concrete implications for practical use and questions for further research avenues.

II. BACKGROUND

This section discusses background information on the ICS and the most prominent technologies for enhancing corporate governance efficiency and effectiveness. Generally, internal controls are critical for the achievement of objectives and especially for the financial reporting process, since internal control deficiencies can lead to an increasement in strategic, operational, reporting, and/or compliance risks.[2] The design of ICS is not universal but varies depending on each company's characteristics, risk appetite, and cost-benefit considerations. The SEC and other regulators encourage firms to adopt the 2013 internal control framework developed by The

[2] The objectives of internal controls are to ensure the effectiveness and efficiency of business activities, including the protection of assets, the prevention and detection of asset misappropriation, the propriety and reliability of internal and external accounting, and compliance with the legal regulations applicable to the company (Ashbaugh-Skaife, Collins, Kinney, and LaFond 2008; Skaife, Veenman, and Wangerin 2013; Feng, Li, McVay, and Skaife 2015; Chan, Chen, Liu 2021). The internal control system (ICS) should cover all business processes including corporate purchasing or production along with administrative processes in human resources and finance. It is further supposed to ensure the effectiveness and efficiency of a company's processes and to minimize any kind of risk from both economic and non-economic perspectives.

Committee of Sponsoring Organizations of the Treadway Commission (COSO),[3] which can be regarded as a guide for organizations striving to design and evaluate ICSs in line with strategic, operational, reporting, and compliance objectives.

Especially after the rules of the Sarbanes-Oxley Act (SOX) were enacted, internal controls have been used as an indicator for solid internal governance mechanisms in academic research (Ashbaugh-Skaife, Collins, Kinney, and LaFond 2008; Skaife, Veenman, and Wangerin 2013; Feng, Li, McVay, and Skaife 2015; Fan, Li, and Raghunandan 2017; Chan, Chen, and Liu 2021). However, there has been less emphasis on the overall structure of the ICS, with most studies concentrating on internal controls over financial reporting. A holistically effective and efficient ICS is of major importance, which for example includes internal controls over operations and compliance (Chang, Chen, Cheng, and Chi 2019). As a consequence, companies face different challenges pertaining to the ICS and the incorporation of technologies (Masli, Peters, Richardson, and Sanchez 2010; COSO 2013).[4]

In recent years, research on corporate governance functions, assurance activities, and accounting has shifted to increasingly analyze digitalization matters such as the adoption and effects of technology (Eulerich, Masli, Pickerd, and Wood 2023; Christ, Emett, Summers, and Wood 2021).[5] In this regard, academic research and practitioner reports have primarily focused

[3] As an established model, COSO has a key role in designing and operating ICSs as it is helpful in remediating internal control weaknesses and reducing the likelihood of reporting internal control weaknesses (Tadesse, Rosa, and Parker 2022). With regard to our study, COSO is of secondary importance because we refer to digitization initiatives and use cases for improving the ICS. Nonetheless, knowing the basics of the COSO model is necessary for a solid understanding of the overall topic.

[4] First, they need to identify risks and uncertainties that are prevalent in their organization and need to be addressed. Second, they need to adequately design and effectively operate an ICS that includes internal controls mitigating the previously identified risks. Third, they need to regularly monitor whether the ICS is adequately designed and effective. Fourth, they are required to continuously work on efficiency and effectiveness improvements regarding their internal controls and monitoring activities. Finally, the fast-paced digitization of processes entails a series of challenges such as data collection, preparation, and reporting, data privacy, adoption and utilization of technologies, acquisition and maintenance of IT-related knowledge (e.g., Richardson, Smith, Weidenmier Watson 2019; Eller, Alford, Kallmünzer, and Peters 2020; Li and Juma'h 2022).

[5] Liew, O'Leary, Perdana, and Wang (2022) summarize a panel discussion demonstrating that businesses need to embrace digital strategies and are required to undertake a digital transformation to remain competitive in today's business environment.

on the areas of artificial intelligence, RPA, data analytics tools such as process mining, and blockchain. Most of these technologies have been studied in the context of internal and external auditing (Moffitt, Rozario, and Vasarhelyi 2018; Dai, He, and Yu 2019; Smith and Castonguay 2020; Liu, Robin, Wu, and Xu 2022). Table 1 briefly describes these emerging technologies and provides an overview of which benefits are derived from using them, respectively.

Research on the overlap of ICS and technology is limited, with only a few studies examining either the development of internal controls to secure specific technologies (Li, Chang, Wang, and Chang 2020) or the use of technology in internal control monitoring. Masli, Peters, Richardson, and Sanchez (2010) document an association between the implementation of internal control monitoring technology and a lower likelihood of material weaknesses. However, the authors investigate associations of overall technology use rather than analyzing specific emerging technologies and practical use cases. Other papers study the combination of different emerging technologies (e.g., Zhang 2019; Bakarich and O'Brien 2021). However, to our knowledge, there is no research on leveraging emerging technologies in companies to enhance the ICS.

In describing the use cases implemented by DT, we provide practical guidance and a starting point for a scientific discussion regarding the most promising emerging technologies to improve both the performance and monitoring of the ICS.

III. METHOD AND CASE COMPANY

Given the identified research gap about how technology can enhance an ICS, we used DT as a case company with different use cases implemented that address this matter. During our research project with DT, we analyzed about 100 pages of internal documents, observed how the company utilizes the technologies, conducted informal interviews, and had discussions with representatives of the company.[6] In several feedback rounds, we identified different use cases that are of interest to other companies, academics, and regulators. We descriptively document these use cases in this paper to offer recommendations for leveraging emerging technologies in other companies. Finally, we provide concrete research questions to guide further studies in this field.

DT operates in the telecommunications sector in more than 180 countries with around 200,000 employees. With sales of over 100 billion euros and an increasing market share, DT is one of the world's leading providers of information and communications technology. It is the largest telecommunications provider in Europe by revenue and is headquartered in Bonn, Germany. As an internationally-oriented company with numerous holdings, Deutsche Telekom recognizes the importance of effective corporate governance for fostering sustainable value creation. Its listing as a Fortune 500 company, with a 2020 ranking of 86th, is an indicator of its worldwide success and prominence in the global market. DT's ICS is based on European and German capital market law and is additionally obliged to follow SOX requirements for T-Mobile US. T-Mobile US is a US publicly listed company and DT's by far biggest fully consolidated subsidiary. DT has documented more than 7,000 control elements across 57 entities including about 3,000 transaction-level controls with a focus on financial reporting. DT applies the widely acknowledged Three Lines of Defense Model of the Institute of Internal Auditors (2020) as their risk governance framework (see p. 164 of DT's most recent annual report, DT 2022). The Three Lines Model assists in identifying the structures and processes within an organization to best facilitate the achievement of objectives and ensure strong governance and risk management (The Institute of Internal Auditors 2020). Operational units handle risk identification and assessment (first line of defense), internal control and compliance management support and oversee these

[6] A diverse range of information sources was needed to understand the specific methods and approaches at DT. Prior research emphasizes the importance of informal communication in fostering relationships and enhancing understanding of organizational culture and dynamics (e.g., Bhandari, Jaggi, and Yan 2024).

functions (second line of defense), and internal audit serves as an independent assurance and advisory function (third line of defense).

Increasing regulatory requirements, including those introduced by the German Financial Market Integrity Strengthening Act, its governance systems, the growing complexity of business processes, and a large number of transactions are challenges for the company and necessitate robust governance systems. DT discovered different ICS improvement opportunities and initiated an optimization program for its internal control and compliance processes. We detail DT's multi-stage approach consisting of four subsequent steps in the following.

First, during the "inventory and determination of the status quo" stage, the existing landscape of internal control and compliance processes—documented in risk-control matrices—was compiled by the company and subsequently reviewed by the external auditor. The related optimization approach in turn consists of two phases: (a) standardization and harmonization (re-design) and (b) automation of controls. Consequently, based on the control documentation, DT (a) analyzed which controls offer potential for simplification or merging through re-design of controls and (b) which controls can bring efficiency gains through digitalization or automation. A distinction was made between simple automation through the use of the enterprise resource planning (ERP) system, data analytics, workflow systems, or RPA - characterized as an order of magnitude simpler and business-skills-based (EY 2018) - and more complex automation using artificial intelligence or its subset machine learning (IBM 2023).[7] A combination entailing re-design and digitization or automation of controls was also under consideration. The potential

[7] The differentiation between "simple" and "complex" automation hinges on the nature of these technologies. Simple automation technologies, like ERP systems and RPA, are typically rule-based and excel at automating routine, time consuming, and repetitive tasks (e.g., Deloitte 2020). They follow predefined instructions and do not possess the ability to adapt or learn from data. On the other hand, complex automation, driven by AI and ML, introduces a level of sophistication that goes beyond rule-based automation. AI and ML algorithms have the capability to learn from data, recognize patterns, and make decisions based on evolving information (Holmes and Douglass 2022). This dynamic and adaptive nature of AI/ML enables them to handle more nuanced and cognitive tasks, making them suitable for applications that require problem-solving, predictive analytics, and decision-making in unstructured environments (McCarthy and Edmund 1989; Richens, Staleton, Stratopoulos, and Wong 2017).

savings associated with optimization were calculated using business cases, in which the cost drivers “number of inspections” and “duration of inspections” were considered.

Second, during internal discussions, DT determined possible optimization approaches and finalized the targeted optimization concept through a continuous exchange. The company “validated the assumptions of the proposed use cases and verified the results” of the optimization proposals.

Third, DT “developed and rolled out pilot use cases” of the technologies to be deployed. The optimization measures were technically implemented in such a way that the use cases could be used as proof of concept and to validate the business case. After technical implementation, DT examined whether the use cases can achieve content-related requirements and control actions. This involved analyzing whether the control execution achieves the same results as the control executor would if the control were performed manually. For this purpose, the use cases can, for example, be taken over into the production system, while the manual control execution continues to be carried out in parallel. Any technical and content-related issues that arose were resolved during this phase. In addition, the company validated whether the efficiency gain planned and presented in the business case can be realized by automating the control.

Fourth, after successful testing of the use cases, they were transferred to the production system and “scaled to additional controls”. To realize the originally calculated efficiency gains, DT rolled out and thus scaled the automated controls to its subsidiaries. After successful implementation and scaling, optimization options for further controls were analyzed and implemented. Taking a holistic perspective, DT has effectively utilized technological innovations by following the approach of utilizing, learning, governing, and leveraging these, which allowed operational optimization and ongoing improvement.

IV. IMPLEMENTED USE CASES: FINDINGS

Implementing a plethora of internal controls and regularly monitoring their effectiveness is practically infeasible to do manually.[8] Compared to automated controls, manual control processes are labor-intensive, lead to lower quality, and comprise a restricted sample. To improve its ICS, DT uses emerging technologies such as artificial intelligence, RPA, data analytics including process mining, and blockchain which we present in the following.

Artificial Intelligence

The implementation of artificial intelligence for ICS principle documentation and testing represents one component of DT's digitalization roadmap. ICS principles are generally perceived as a key element for risk mitigation. The overall structure makes control testing somewhat complex, given the tremendous amount of control owners and the degree of manual checks along with the generic pattern that these ICS principle descriptions follow. Yearly control effectiveness testing is usually conducted through self-assessments, which already bear a considerable risk for bias and limited comparability amongst assessments. While internal audit offers a valuable resource for mitigating this difficulty, limited resources and increasingly complex audit universes result in independent control testing taking place merely every five years at DT. During this time, however, additional risks might emerge. Quality assessments on part of ICS management, on the other hand, are performed manually for a selected sample. Quality constraints result from the variety and complexity of control descriptions with a large number of control owners. As a result, there are certain shortcomings, which are anticipated to be mitigated through the use of a digital approach. DT therefore aimed to enhance the quality of documentation by leveraging technology, which also leads to increased standardization.

[8] Resource constraints affect various corporate governance functions (e.g., Houston 1999; Asare, Trompeter, and Wright 2000; Kim and Kogan 2014; Johnson, Sutton, and Theis 2020), thus requiring companies to prioritize and allocate resources correspondingly.

For this purpose, DT developed a natural language processing approach that extracts the respective information from individual control descriptions. This extraction process follows a systematic pattern aimed at providing selected indicators based on the control description. These include, amongst others, the responsibility of who is performing the control, a description of how the control is performed along with the frequency of the control performance. Machine learning is then employed to generate a quality score and identify related quality gaps. The control description should be checked and updated regularly, as this constitutes a part of the quality score and is reflected in a separate score describing the recency of control documentation. The description of the control has to be sufficiently business unit-specific and requires a detailed description of the control effectiveness test. For the compilation of the quality score, both the number of characters of the text description and a similarity check with existing control descriptions are integrated. Here, certain threshold values are used to restrict similarity to other control descriptions. The extracted indicators are subsequently included with respective weights in the creation of the overall quality score. Therefore, the impact of a control description being rather short may differ from the impact of missing control evidence. Finally, the resulting overall score is reflected on a scale ranging from 1-5, where 5 represents the highest possible control quality result and 1 represents the lowest possible result. To visualize all this information comprehensively, scoring reports and corresponding dashboards are created to show the quality of the ICS principles in the individual business units.

As an example, the approach analyzes a control description of the monthly reporting process of financial data. For this purpose, Natural Language Processing and Machine Learning are employed to parse and assess the textual content in the documentation. The description details the responsibilities of the controlling team in preparing a monthly report, which includes key financial data such as revenues, EBIT, EBITDA, and OFCF. This data is compared year-over-year and reviewed by board members after month-end closing.

Natural Language Processing identifies expressions that denote the frequency and verification processes within the report, pinpointing the monthly occurrence of the reports and the application of the four-eyes principle for internal verification. Meanwhile, Machine Learning algorithms evaluate metrics of the control description. These include checking for mentions of necessary control evidence to ensure the completeness of financial data comparison and verification statements. They also verify if the description meets a minimum character count of over 500 characters to ensure the report provides sufficient details. Additionally, originality is assessed through a similarity score, where a low similarity score of 23% indicates a high level of original content. Finally, the age of the document is evaluated to ensure that the information is no more than 2 years old, confirming that the procedures and data are current and relevant. The outcome of this analysis is a quality score of 3.8 out of 5. This score highlights the areas where improvements are needed to achieve improved compliance and control effectiveness.

This automated approach allows us to send real-time feedback to the control owner and to directly identify areas of improvement. Ever since this approach has been implemented at DT, considerable quality improvements have been observed and measured through ongoing quality testing. This approach has led to a substantial increase in various quality metrics. The total score of all assessed control descriptions (more than 2800 control descriptions) has improved from 3.416 to 4.501 in just one year. Specific metrics have also seen clear enhancements, as illustrated in Table 2.

The observed improvements with an average improvement across all metrics of approximately 34.93 percent suggest that the facilitated real-time feedback with hints at how to improve the control description offers a clear way to improve ICS principles documentation. The ongoing assessment of ICS principle documentation covers the full population to validate their effectiveness. With this approach, both the risk of bias and auditor's sampling risk are eliminated making risk assessments more precise (Appelbaum, Kogan, and Vasarhelyi 2017). The overall suitability of applying artificial intelligence to ICS principles testing is facilitated by the structured format of the data to be analyzed (AICPA 2013).

Based on the largely automated review of existing controls, a higher-level analysis is expected to be facilitated in the future. The overview of all ICS quality key performance indicators allows for a breakdown by business unit or business function based on the results to be extracted. The results can, for example, be mapped in an Excel file and thereby provide the ICS manager with important insights in a holistic manner. This feature enables a comparison between different levels, providing top management with important insights regarding the functionality of the controls. As a result, the hurdles described previously, for example regarding legal requirements or human bias, are largely addressed. So far, the described artificial intelligence approach has successfully been used for ICS principles documentation. However, given the proven effectiveness of this application, the developed artificial intelligence approach has been extended to cover test procedures and test executions of ICS principles such as the four-eyes principle[9]. In the near future, it is expected to be expanded to include transaction-level controls. The initial version of the Artificial Intelligence application has now been enhanced through continuous feedback and algorithm development and has been replaced by a follow-up version. However, the success of this approach has not yet been evaluated considering the relatively recent implementation of this technology. Continuous improvement of the algorithms based on extensive feedback and regular re-training of the artificial intelligence engine is a reasonable

[9] The four-eyes principle, also known as the two-person control principle, is a concept rooted in the segregation of duties. It operates on the premise that no single individual should have the authority to both initiate and authorize a transaction or process. This principle aims to prevent suboptimal decisions and fraudulent activities by ensuring that at least two individuals are involved in critical tasks, thus minimizing the risk of errors or intentional misconduct. For example, one person may initiate a transaction while another verifies and approves it. This collaborative approach enhances decision rationality and provides mutual control, thereby representing a fundamental element of internal control systems (ICS).

The concept of the four-eyes principle has been recognized as crucial in enhancing organizational governance since the implementation of the Sarbanes-Oxley Act (SOX) in 2002 (Kobelsky 2014). Its effectiveness in preventing fraud and ensuring accountability has been extensively discussed in the literature (Hiebl 2015).

expectation.[10] Each version of the artificial intelligence approach at DT builds upon the last to continuously evolve and meet the needs of internal control systems.

Robotic Process Automation

Before enhancing its ICS, DT identified several insufficiencies in its internal control process. For example, a lack of control execution usually remained undetected until ICS effectiveness was tested, deadlines of control milestones were often exhausted or forgotten, ICS managers had to manually ensure via phone or email that open tasks are completed, potential roadblocks were discovered late in an internal control process, response collection from some stakeholders was challenging, and segregation of duties (SoD) conflicts were not always reported on time. Consequently, solutions for the named issues had to be found under maximum time pressure, indicating that the previous internal control process was inefficient and ineffective.

Thus, DT started developing RPA solutions that focus on (1) automatically tracking control performance and collecting evidence, (2) monitoring processes, (3) reviewing user governance, and (4) reporting on SoD and access management (called ‘Management of Access Governance by ICS’ or MAGICS) conflicts in 16 business units in 2017. In 2018 and 2019, DT elevated its RPA approach by rolling out the initially created bots to the group ICS and industrialized automation efforts by establishing ten golden rules for RPA development,[11] and encouraging design thinking to foster RPA rollouts in other business units and entities. To provide practical insights into how RPA can be applied, we list four concrete examples of how DT uses RPA to enhance the efficiency and effectiveness of its ICS.

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[10] After receiving feedback on the control element description, users are informed that the scoring is artificial intelligence-based and asks them to provide feedback to improve the overall accuracy of the AI.

[11] These ten 'golden rules' act as guidelines to harmonize RPA development and generate a common understanding. They include (1) definition of RPA, (2) responsibilities of bot business owners, (3) bot identities, (4) DT regulations, (5) user right restrictions, (6) development in non-productive systems, (7) tests and approvals, (8) non-functional changes, (9) bot inventory, and (10) ICS guidance. We listed these golden rules with respective descriptions in the appendix.

First, the RPA bot called "Control Operation Tracking Bot" automatically tracks control execution and escalates the process in case of no reaction. The bot automatically identifies which controls need to be addressed and reminds those responsible via automated email notification. Evidence is automatically stored locally in the company's international share drive, allowing quick and sorted access to the stored information. In developing these bots, all controls can be easily integrated into the automated monitoring process while responsible employees and the frequency of execution are freely configurable. As a result of leveraging these scalability potentials, several hundred controls are managed by the Control Operation Tracking Bot as of 2022. Overall, the bot helps DT ensure continuous control execution, significantly reducing monitoring effort, and detecting deficiencies in the control execution at an early stage, enabling the company to create timely solutions that avoid unnecessary control weaknesses.

Second, DT introduced the "Milestone Notification Bot" that sends automated email notifications to control owners for open milestones. The bot analyzes which milestones are relevant and extracts open tasks for each person. To configure the bot, the ICS manager selects milestones to be addressed, recipients, frequency of notification, and relevant information that should be shown in an open task list. Accordingly, the bot automatically creates an open tasks list and distributes it to affected employees. DT finds that the bot significantly reduces monitoring efforts for the ICS manager and timely identifies potential roadblocks for the ICS process. As the bot can easily be implemented—only an MS Excel template and local share drive are needed—the bot is ready within a few days and can quickly be scaled to other entities.

Third, as DT operates globally, all sales regions are obliged to inform the headquarter about deferred revenues every month. To ensure complete reporting of sales deferrals, management accounting queries the sales heads via email each month. As an answer is required from each department, even if no action is required, management controlling needs to remind those locally responsible frequently and has to document that all answers are collected. Given this process is labor-intensive, DT developed a bot that calculates ultimo dates for the month, addresses local contacts, and creates a report as evidence. The bot (a) requests a response on ultimo minus eleven working days, (b) forwards all relevant information to management accounting and checks plausibility for missing documents, (c) sends reminders for open requests on ultimo minus five working days, and (d) provides an overview of all responses collected and sends this document out one day later as evidence. Overall, implementing the bot has led to effort reduction and increases in quality.

Fourth, DT needs to report all SoD conflicts monthly to all the locally dedicated process owners that are responsible for implementing a resolution. However, data must be extracted from various sources, combined in databases, and then analyzed before reporting can be executed. As this process was lengthy and dragging, in 2017, DT implemented a so-called ‘MAGICS’ bot that automatically completed the entire reporting process on the third working day of each month. The bot extracted, analyzed, and communicated SoD conflicts to the selected process owners. The reporting included all technical details related to each SoD conflict (e.g., conflicting functions and transaction codes). While the MAGICS bot helped DT become more efficient and transparent in the reporting process, the complexity of this bot increased gradually.

Overall, DT designs bots as catalysts for rapid efficiency improvements and re-transfers them into the backend system once a system integration is feasible. We this approach, DT wants to use RPA especially for “low-hanging fruits” before developing a more complex, e.g. SAP-embedded automation. For example, developing and implementing the MAGICS bot was an important interim solution in DT’s journey to a next-level SoD approach since it provided DT with the time needed to update systems, streamline the process, and pursue a system integration.

Data Analytics and Process Mining

In recent decades, organizations shifted from paper-based, slow, and manual to entirely digitized business processes that generate large amounts of data (e.g., Bierstaker, Burnaby, and

Thibodeau 2001; Krahel and Titera 2015; Vial 2019). Data can be used to create meaningful insights, better anticipate customer needs, or mitigate risk and fraud. Aiming to achieve these associated benefits, DT aims to leverage data analytics, which includes process mining software, to enhance its ICS.

DT uses a combination of data analytics and process mining software for ICS process analytics to continuously analyze internal controls and elaborate on future automation initiatives groupwide.[12] To date, DT has identified about 40 use cases and partially implemented them as lighthouse projects. To foster and facilitate this initiative, the company uses a center of excellence for digitalization with data and business analysts which possesses broad experience in the implementation and operations of data analytics.

Using algorithms and defining alarm parameters, DT identifies errors in real-time and performs root-cause analyses. This solution helps the company detect control failures in real time or in preventing them upfront. Real-time alert handling is focused on process intervention. For example, the workflow management in Salesforce allows for active handling of alert processing and audit-proof storage. Using dashboards on the process mining software Celonis, DT visualizes actual processes, identifies systematic sources of errors, and reports various key performance indicators. To further improve its processes, the company identifies dependencies and predicts critical activities.

One specific example of using data analytics and process mining pertains to the SoD management process. DT uses systematic process analytics at the voucher level to identify SoD violations that have actually occurred. While a previous initiative (called‘'MAGIC’') has reduced the number of SoD risks from 230 to 29, the current initiative entails a data model and analytics for the remaining 29 SoD risks. Breaches of rules on vouchers and user levels are monitored in

[12] DT uses the term 'Process Bionics' to refer to the combination of data analytics and real time analysis (DART) and process mining.

real time. Workflow management in Salesforce allows for active handling of alert processing, even across entity boundaries. The ICS SoD controls are harmonized and stored as audit-proof evidence. Furthermore, centralized monitoring for entities and a general overview as self-service for localized ICS managers are realized via dashboards.

Benefits of this sophisticated SoD management process include stopping inefficient activities such as reviewing sensitive transaction codes, labor-intensive monthly reporting (and follow-up activities), extensive preparation of quarterly management reporting, and time-consuming cause and effect analyses. During the project, 157 manual mitigation controls were eliminated and about 20 fully digitized monitoring controls were implemented. Thirty-seven process checkers in 16 entities were activated for the initiative. There is now continuous transparency on SoD status with end-to-end monitoring via dashboards. Furthermore, it allows for greater flexibility in operations as the role and authorization scheme have been simplified, and granting access rights has been sped up.

The process is completely integrated into the ICS (process risk and monitoring control). To ensure that process checkers handle assigned alerts in a timely, complete, and correct manner, DT uses monthly monitoring checks in the entities for all SoD risks which include (a) plausibility and deviation analysis regarding overall status, tickets per calendar week, ticket classification, age structure, and (b) a sample of documented SoD violations regarding their correct ticket classification by the process owner as well as a verification that the process checker did not work on tickets that were triggered by himself.

The quality of the applied solution for data analytics and process mining at DT is further validated by the ISAE 3402 certification by a Big Four as an external verification. This internationally recognized standard provides an independent assessment of processes and their effectiveness, ensuring that the methodologies meet the highest standards of reliability and quality.

Additional examples of how data analytics and process mining had a beneficial effect on the performance of the ICS include the following: First, in performing a three-way match[13] using process mining, DT has increased control quality due to full testing and transparency of process weaknesses. Second, process mining allows for reducing assets under construction because of effort and time reduction via optimized steering. Third, early alerting on cost overruns and timely renegotiation of customer orders improves cost observance. Fourth, DT introduced a dashboard on ICS scope and results, allowing top management to monitor ICS activities and ICS managers to view the process status at a glance.

Blockchain

Another "innovative and arguably organizationally disruptive distributed database technology" (Kostić and Sedej 2022, 1) is referred to as blockchain. Initially, blockchain technology has mostly been used to support cryptocurrency transactions. Use of this technology, however, is continuously growing and constantly offers new solutions for companies (Vincent and Barkhi 2021). To evaluate the benefits of this technology on a case-specific level, DT is pursuing a proof-of-concept approach. This is aimed at first exploring how blockchain works and subsequently developing corresponding learnings for its ICS. A prototype is to be developed to determine the related scalability and integration costs. The idea is to develop a simple initial approach to obtain direct customer feedback for further improvement.

For this purpose, DT has decided on a private blockchain network to be applied in the ICS functional sign-off process. This type of blockchain is used and accessed only by authorized

[13] The three-way match intends to ensure accurate invoice payments. This process verifies the following: First, it matches the quantities and prices listed on the vendor's invoice to those specified on the approved purchase order (PO). Second, it checks these quantities and prices against the physical receipt of goods, as documented by a packing slip or delivery receipt. Finally, it ensures all invoice details - including additional charges and terms - align with the information on both the PO and the physical receipt documentation (Deloitte 2023). If discrepancies are found that exceed predefined tolerances, the payment systems place a hold on the invoice, preventing payment until the hold is resolved or manually overridden. This matching sequence is critical for detecting and resolving reconciliation issues in accounts payable, particularly where incorrect receiving transactions might complicate the tracking of goods received versus invoices received (Schaeffer 2004; Doxey 2021).

stakeholders of organizations. The ownership lies in the hand of a single entity and it is centrally organized (Liu, Robin, Wu, and Xu 2022). Their implementation in the test environment is based on the open-source blockchain framework Hyperledger Fabric by the Linux Foundation. DT uses three nodes, in terms of users, to assess the operability of its blockchain network. A key decision to be resolved in this context is whether to make or buy. To keep the knowledge within the company, however, it was initially decided to create it in-house. This is admittedly related to higher costs, yet it results in greater flexibility and a greater range of functions. The creation of the concept took roughly 4 months, at the end of which a first test run had already been conducted. Particular hurdles in this phase resulted from the lack of blockchain developers and the required knowledge transfer. Finally, the entire development process was subject to an agile approach.[14] DT embraced the agile approach by fostering cross-functional teams comprising developers, testers, business analysts, and stakeholders from diverse departments and geographical locations. These teams collaborated closely throughout the development lifecycle, leveraging practices such as Kanban for visualizing the work process and Scrum for dividing projects into sprints to ensure alignment and adaptability. DT uses Kanban for efficient tool-based multi-project and resource steering. It serves as a resource management tool, aiding in the prioritization of departmental targets and as an instrument for visualizing sprint backlogs and distributing tasks in agile teams. Scrum is commended for delivering faster and better results through a clear focus and iterative approach within teams. It has been adopted across various teams within the ICS Management at DT, improving work organization and methodology. Furthermore, DT has launched the ICS Digitalization Roadshow to promote best practices in

[14] The agile approach (Rajaram 2023; Hooda, Sood, Singh, Dalal, and Sood 2023; Azanha, Adrialdo, Argoud, de Camargo Junio, and Antoniolli 2017), essential for organizational agility, is characterized by its focus on adaptability, iterative development, and responsiveness to changing technology and market demands. This methodology is particularly relevant for technological innovations, as it enables organizations to rapidly adjust and evolve in response to new challenges and opportunities, ensuring they remain competitive and effective in a rapidly evolving digital landscape (e.g., Forbes 2022; McKinsey 2015).

digital transformation and the strategic use of tools like Celonis and DART within internal control systems. The roadshow facilitates knowledge sharing and aligns teams across the organization. It serves as a platform to disseminate advanced methodologies, address specific challenges, and foster a culture of continuous improvement and digital agility within DT. By emphasizing cross-functional collaboration and international engagement, DT aimed to connect the collective expertise and perspectives of diverse teams, enabling faster decision-making, enhanced innovation, and greater market responsiveness.

The precise description of the anticipated process consists of six separate steps as illustrated in Figure 1.

1. All functionally related controls are documented in the IT environment. Once the function is ready for sign-off, a trigger is sent via middleware to the blockchain.
2. Blockchain stores all relevant information about controls, issues, etc. along with effectiveness assessments and hashes as blocks for each function.
3. An e-mail is created and sent to the function owner with a respective link to the blockchain user frontend.
4. All relevant data for signoff are available in the user frontend so that the sign-off can be performed.
5. The resulting sign-off is stored with a timestamp as a new block in the blockchain.
6. Information is provided in the IT environment to finalize the process.

The described application has revealed that the setup of the infrastructure can pose challenges and make approval processes using blockchain technology infeasible, despite its inherently highly reliable nature. It allows a straightforward set-up of different functionalities and rules outside complex backend systems. However, it is subject to high uncertainty and tremendous efforts as there is no confirmed blockchain system in place yet. Therefore, DT to date has stopped at the proof-of-concept approach and the elaborated blockchain has not gone live.

Trust issues, as described by Lineros (2021), regarding data and approvals are even more important for external processes than for internal processes.

V. DISCUSSION AND CONCLUSION

As the adoption of technology in business evolves rapidly, current ICS structures will likely not remain adequate in the upcoming years but rather require a major revision and re-design that includes the use of emerging technologies. We analyze and describe the use cases applied by DT, one of the largest telecommunications providers worldwide with a state-of-the-art ICS. These use cases encompass an application of artificial intelligence, RPA, data analytics including process mining, and blockchain in the context of the ICS. All technological solutions are based on the existing internal control system. Each technology use case tries to address one or more specific objectives to improve the efficiency and effectiveness of the internal control system and to help responsible internal control managers, other assurance functions, or the C-Level and audit committee. Figure 2 visualizes this combination of existing technology, specific technological use cases and stakeholders.

We observe that these solutions help DT in enhancing its ICS in general along with improvements in the efficiency and effectiveness of ICS processes and monitoring activities. The presented pilot use cases offer practical insights for ICS managers, management, internal and external auditors, and audit committee members of other companies that aim to advance their ICSs. In our discussions, representatives of DT noted that applying agile working methods and having an open mindset were significant success factors in leveraging their digitalization initiative and implementing the use cases described. Building on this foundation, DT's progressive adoption of agile practices, initially evident in blockchain projects and now permeating across the organization, has effectively facilitated a shift towards DevOps. This strategic evolution underscores a commitment to rapid iteration, robust collaboration, and comprehensive automation, which promises to drive continuous operational improvements and enduring efficiency across the organization. They also documented that providing dedicated resources is crucial because otherwise, the day-to-day work inhibits employees from fostering digitalization endeavors. DT dedicated a team of three to four full-time equivalents solely to work on digitalization projects and reinvested automation gains to continue with their digitalization journey. Our paper is valuable to academics and regulators given the scarcity of insights into technology use cases in the context of the ICS.

Although DT sophisticatedly utilizes emerging technologies, it is not yet exploiting its full potential—for example, regarding machine learning and natural language processing. We recommend readers consider these use cases as insights rather than seeing them as concrete instructions for implementation in their company. Each of the implemented pilot use cases should be critically examined before implementation as they are highly context-specific and not necessarily generalizable. For example, the suitability for automation endeavors varies among different use cases and company-specific surroundings. A cost-benefit assessment is required to evaluate procedures that may be valuable to be automated in the long term (Moffitt, Rozario, and Vasarhelyi 2018). The digital transformation of the ICS does not guarantee an efficient and effective ICS. On the contrary, it is a long and iterative process that requires feedback from various stakeholders. Existing technological and organizational structures, the availability and quality of underlying data, and the overall design of an existing ICS are general requirements for the successful implementation of emerging technologies aiming to improve the ICS. We suggest incorporating insights and recommendations derived from existing studies and frameworks (e.g., Eulerich, Pawlowski, Waddoups, and Wood 2022) to assess and plan the implementation of emerging technologies. Moreover, we emphasize that human capital is of crucial relevance within this context. It requires the right people with the right mindset to understand what is required by stakeholders and which areas offer actual potential for improvement through digital transformation.

VI. LIMITATIONS

As with all research projects, our study is subject to certain limitations. First, because it is a timely topic with fast-evolving technologies, there is a chance that our findings will be valuable for a few years but will be outdated fairly soon. Second, we descriptively examine pilot use cases from DT only. The reader needs to decide which insights can be taken away from our study. Third, we present different pilot use cases and infer enhancements from the feedback of DT, without validating the results with another company. This is an avenue for future research. Furthermore, it would be interesting to better understand the effects of this improvement in the field of the internal control system on the external auditor and audit fees.

Nevertheless, we view this paper as an initial study of how emerging technologies can improve the ICS in a global company. Finally, we point to three key research areas with respective research questions resulting from our collaboration with DT and by consulting the existing literature in the corporate governance context (see Appendix B).

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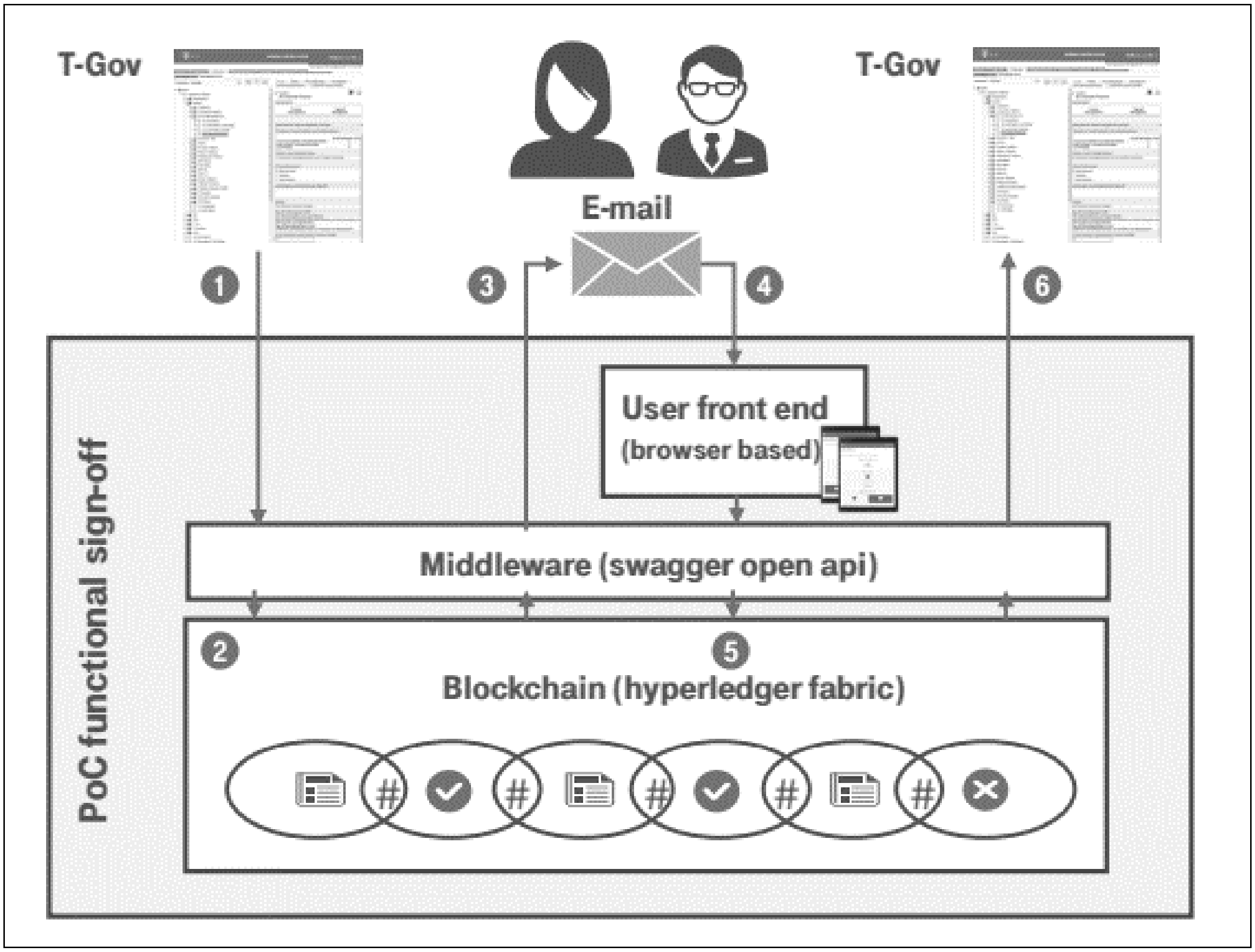
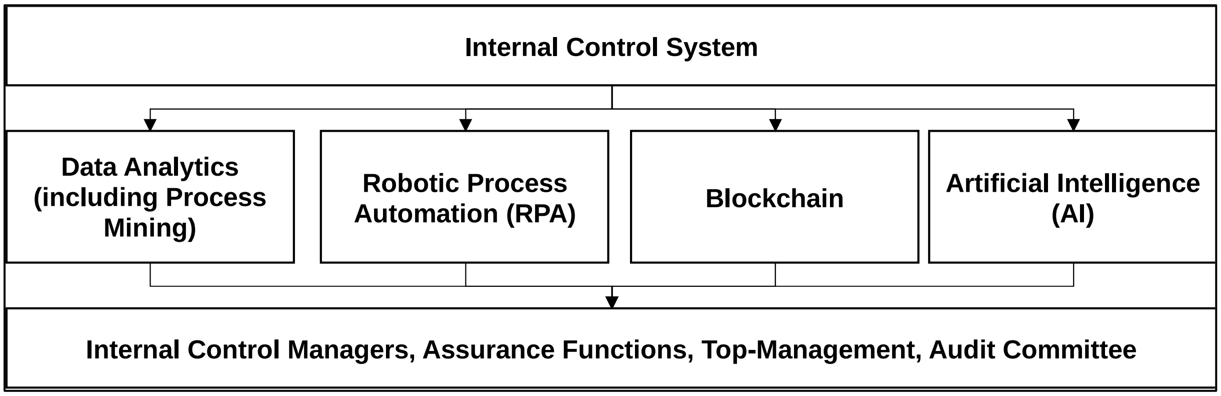
FIGURES

Figure 1. Anticipated Blockchain Process with Six Separate Steps



As shown in the figure, the precise description of the anticipated process consists of six separate steps.

Figure 2. Visualization of Technology use cases linked to the Internal Control System



TABLES

Table 1. Emerging Technologies with Expected Benefits and Challenges

Technology	Definition	Benefits indicated by prior research
Artificial Intelligence	Artificial intelligence (AI) describes the use of computer programs that mimic cognitive functions or qualities of a human mind, including the ability to understand language, recognize pictures, learn from experience, and solve problems. Its subsets include knowledge reasoning, machine learning, natural language processing, automated planning, and computer vision (Coombs, Hislop, Taneva, and Barnard 2020).	Related to assurance matters, Marshall and Lambert (2018) suggest that by storing information on internal controls, audit standards, and frameworks, an audit algorithm can verify the companies' compliance with internal and external regulations. Other studies find that the use of artificial intelligence (or its subsets) can support assurance providers in extracting insights from a large amount of previously unexplored qualitative data (Sun 2019), improve accounting estimates (Ding, Lev, Peng, Sun, and Vasarhelyi 2020), enhance audits of inventory (Christ, Emett, Summers, and Wood 2021), or get auditees to disclose more information using virtual agents (Pickard, Schuetzler, Valacich, and Wood 2020).
Robotic Process Automation	Robotic process automation (RPA) describes the use of low-code software programs that are used to automate repetitive, routine business processes (Cooper, Holderness, Sorensen, and Wood 2019, 2021; Eulerich, Pawlowski, Waddoups, and Wood 2022).	Benefits derived from RPA technology include improvements in operational efficiency, accuracy, and traceability, and relieving human individuals from routine and non-value-adding tasks. These advantages have been widely discussed in practice reports and academic studies (e.g., Lacity and Willcocks 2016; Lacity, Willcocks, and Craig 2016; Hallikainen, Bekkhus, and Pan 2018; Kokina and Blanchette 2019; Radke, Dang, and Tan 2020; Christ, Eulerich, Krane, and Wood 2021; Harrast and Wood 2022; Plattfaut and Borghoff 2022). Recent studies suggest that the use of RPA can have a beneficial impact on accounting and assurance functions (e.g., Moffitt, Rozario, and Vasarhelyi 2018; Cooper, Holderness, Sorensen, and Wood 2019, 2021; Eulerich, Pawlowski, Waddoups, and Wood 2022).
Data Analytics and Process Mining	Using data analytics tools, users aim to discover hidden patterns and trends, identify indicators, draw conclusions, and derive recommendations for action by collecting, managing, and examining data sets (Chan and Kogan 2016). Process mining is a sub-category of data analytics and allows users to extract knowledge from event logs that are available in a company's information system (van der Aalst 2016).	Research finds positives to the use of data analytics and process mining. For example, it can improve the (perceived) performance of assurance processes (Li, Dai, Gershberg, and Vasarhelyi 2018; Eulerich, Huang, Pawlowski, and Vasarhelyi 2023), enhance fraud prediction performance (Perols, Bowen, Zimmermann, and Samba 2017), and facilitate the discovery of patterns and outliers (Dilla, Janvrin, and Raschke 2010; Anderson, Hobson, and Peecher 2021).
Blockchain	Blockchain is a growing list of records that are linked together using cryptography. As a decentralized public ledger, blockchain provides a secure infrastructure for transactions that cannot be altered once approved (Kokina, Mancha, and Pachamanova 2017).	Blockchain is one of the most innovative technologies developed in recent years (Dai and Vasarhelyi 2017). Advantages of blockchain include the increase of transaction settlement speed, reduction of trading costs and fraud risk, improvement of the auditability of transactions, and enhancement in the effectiveness of auditing (Fanning and Centers 2016; Yermack 2017; Lacity 2018).

This table presents definitions of and benefits indicated by prior research about emerging technologies.

Table 2 Changes in Internal Control Documentation Quality Metrics

Metric	Description	Before Artificial Intelligence	After Artificial Intelligence	Percentage Change	Example
Age	Measures the recency of control documentation	3.416	4.561	+ 33.52%	Updated from "last reviewed 3 years ago" to "reviewed annually"
Length	Assesses the level of detail in the control descriptions	3.526	4.501	+ 27.56%	Expanded descriptions from brief summaries to detailed step-by-step processes
What	Evaluates the clarity and completeness of descriptions regarding the objectives and execution of controls	3.553	4.525	+ 27.36 %	Updated from "controls financial transactions" to specifying "controls and audits all financial transactions involving asset acquisitions"
When	Determines how clearly the documentation specifies the frequency of control execution	2.934	4.352	48.33 %	Clarity improved from "periodically" to "monthly reconciliation and quarterly audits"
Who	Assesses specificity and clarity regarding which personnel are responsible for executing the controls	2.995	4.336	44.77 %	Detailing changed from "managed by department" to specific roles such as "executed by Senior Accountant, reviewed by CFO"
Evidence	Measures the presence and quality of evidence supporting the effectiveness of controls	3.416	4.478	31.09 %	Documentation shifted from generic evidence references to explicit inclusion of audit trails and third-party verification reports

This table presents quantitative changes in the scoring of internal control documentation across selected metrics before and after DT's implementation of artificial intelligence along with practical examples.

APPENDIX

Appendix A. Golden Rules for the Use of Robotic Process Automation

No.	Rule	Description
1	Definition	Bots are automated solutions that access IT systems via user interfaces, using their own identities. Bots are acting like employees by using the same functionalities of the IT systems.
2	Bot Business Owner	Responsible for the action of any bot is the same executive, that would be responsible for an employee doing the same work. This executive, called Bot Business Owner, must ensure that the bots are acting in line with all relevant regulations.
3	Bot Identities	The Bot Business Owner is accountable for the identities the bots are using. These identities must be traceable during the entire life cycle.
4	Internal Regulations	The development and use of bots must be in line with all relevant regulations and guidelines that exist for the processes and employees of DT.
5	User Rights	User access rights for bots must be granted based on existing roles and authorization concepts of the backend systems.
6	Non-productive Systems	Bots must be developed against the non-productive backend systems (e.g. test or acceptance systems).
7	Test and Approval	Before bots are allowed to run in productive backend systems, risk-based functional tests must be conducted and documented so that third parties can retrace them.
8	Non-functional Changes	Non-functional changes on bots running in production must be executed and documented in cooperation with the department using the bots.
9	Bot Inventory	Each business unit using bots must keep a list, including the name of the bot, the Bot Business Owner, the name of the process the bot is running in, the user ID’s of the bots, and the operations contacts (department/IT).
10	ICS Guidance	Bots with relevance for financial reporting have to be addressed and considered within the ICS process.

This table presents ten rules for the use of RPA at DT. These rules are to be adhered to by all RPA and citizen developers.

Appendix B: Research Questions for Future Research

Internal Control Environment[15]

1. How does the implementation of emerging technologies[16] change the nature of ICS?
2. How do company characteristics influence the implementation of emerging technologies in the ICS?
3. How does the implementation of emerging technologies support the efficiency of conducting business?
4. How does the implementation of emerging technologies support safeguarding assets?
5. How does the implementation of emerging technologies support prevention and detection of fraud?
6. How does the implementation of emerging technologies support completeness and accuracy of financial records?
7. How does the implementation of emerging technologies support timely preparation of financial statements?

Auditing and Regulatory Environment

8. How does a client's use of emerging technologies in the ICS impact audit engagements and the required expertise of the external auditor?
9. Is a client's use of emerging technologies in the ICS associated with changes in audit fees?
10. Is a client's use of emerging technologies in the ICS associated with reduced internal control weakness reporting?
11. What changes are necessary for the regulatory environment to enable companies to use emerging technologies?

Digital Transformation of Corporate Governance

12. How can a company use emerging technologies to enhance its digital strategy?
13. How do data protection laws impact the digital transformation of corporate governance functions?
14. What factors impede companies from using more emerging technologies?
15. Which cost-benefit considerations need to be taken into account for emerging technologies?
16. Are policies in place that guide the company's decision-making on using emerging technologies in the ICS by balancing opportunities and risks?
17. Are users relying on emerging technologies more susceptible to biases resulting from the use of these technologies? Are internal control managers more likely to make unfavorable decisions when relying solely on results obtained from emerging

[15] Questions #3 to #7 are derived from the internal control objectives defined by the Association of Chartered Certified Accountants (ACCA 2023).

[16] With "emerging technologies" we refer to artificial intelligence, RPA, data analytics including process mining, and blockchain, respectively, hereinafter.

technologies (e.g., if they lack expertise in using the tool and understanding how it works)?

18. How does the use of emerging technologies in the ICS affect other corporate governance functions (e.g., compliance, law, internal audit)?