Appendix: The Digital Roadmap

This appendix presents in detail the methodology I have been using for several years to define digital transformation paths. It is through this methodology that any company can determine where it currently stands and the path that will lead it through the changing landscape – a topic I have extensively discussed in this book.

The assessment matrix is based on the philosophy of control embodied in the automotive standard VDA 6.3 for assessing process excellence in companies. This method is especially useful in manufacturing and service industries, and it was designed to ensure safety and efficiency in supply chains. It allows a precise evaluation of the digital technologies currently implemented in different organizational areas, which aids in identifying areas requiring improvements or development and in making more informed decisions on investment in digital technologies. Ultimately, its use can help a company achieve greater efficiency, competitiveness and adaptation to market changes.

Each axis of the Digital Roadmap has a distinct role and describes a different objective; please keep in mind that all of them are equally important for a company. The areas of assessment and specific evaluation levels I propose are based solely on my experiences as a manager, consultant and lecturer. Companies are free to modify the assessment matrices I suggest. However, I caution against oversimplifying them. Contrary to what it might seem, a lower initial evaluation score is better, as it presents an opportunity for the company to further develop and enhance its competitiveness.

In this appendix, I will separately describe each axis of digital transformation that constitutes the roadmap. Starting with a brief introduction explaining the significance of each axis and the method used to determine the development levels within it, I will then outline the assessment rules set for each axis. Once these principles are established, I will detail the characteristics of each

evaluation level for the specific area. Please remember that in constructing such a complex assessment system, aimed at describing all types of enterprises, I had to employ certain simplifications and shortcuts. As a result, there may not be clear boundaries between individual levels. If this is the case for you, I suggest you rate your company as being on the lower level until you have met all the criteria of the higher level. This will give you greater motivation to act and make changes. As regards any lack of clarity between levels, as you return to use the tool later to assess what progress your initiatives have brought, you will assess and utilize it with greater ease and understanding.

If you find the assessment methodology and the creation of transformation initiatives outlined in this appendix unclear, I strongly advise you to return to the chapter 'Tool 3: The Digital Roadmap', where I comprehensively discuss the objectives, significance and usage of this essential tool.

Axis 1: Digital processes

We begin with assessing digital processes. For a business, a process is defined as any set of interrelated and sequential actions or operations planned and executed to achieve a specific outcome. Processes are crucial to the organization because they define how its core activities and operations are performed. The great majority of a company`s processes are encompassed within the nine areas we deal with here, namely, the seven core areas of sales, marketing, process technology and R&D, purchasing, logistics, production, and quality, and the two support domains of finance and HR.

Processes need to be well-defined, documented and optimized, as they determine the quality and efficiency of an organization. Process optimization can save time, resources and costs critical to competitiveness and success. Therefore, process management is a pivotal component of business strategy that enhances organizations` operations and adaptability.

Matrix for Evaluating Process Digitalization

7. Support Algorithms	Algorithmic offer personalization, bots, GPT	Chatbot, content generation, GPT	Algorithmic support in development work	Predictive pricing algorithms	AI optimization of inventory levels and deployment	AI algorithms for MPS, scheduling, balancing	Algorithms for quality control scope determination	Bi	AI recruitment and talent management
6. ERP	Integrated ERP	Integrated ERP	Integrated ERP	Integrated ERP	Integrated ERP	Integrated ERP	Integrated ERP	Integrated ERP	Integrated ERP
5. MES	Supply chain reporting system	Conversion tracking in the sales tunnel, lead scoring	Project management	Purchase KPIs	WMS +3D Milkrun	MES, plant-wide work control	QMS	Workflow management system	HRM software
4. Automation	Online store, marketplace, DIY online	Automated e-marketing tools	3D printer, virtual reality, augmented reality	B2B purchasing and bidding platforms	ACV, robotic operations, EDI/web	Robotization and automation	Robotic optical analysis	RPA	E-kiosk HR, web kiosk HR
3. Process Control	Automatic sales budgeting	SEO and google analytics	Failure mode and effects analysis (FMEA)	Automated process workflow	WMS, EDI web	Cmms OEE analysis , VSM	Central response system for quality defects	Decision approval system	RCP
2. Workstation Control	Sales reporting system	CRM + KPI analytics	Digital simulation tools	Material coverage plan	System locations, mobile terminals	PLC, sensors, data visualization	Built-in quality control in the machine	FK	HR and payroll system
1. Basic Data Registration	Registration of contracts and orders	CRM	Design tools	Transaction records	Barcode scanners, RFID	Data from machines and equipment	Electronic compliance cards	OCR/electronic document circulation	Electronic work cards
	Sales	**Marketing**	**Technology**	**Supplies**	**Logistics**	**Production**	**Quality**	**Finance, controlling, administration**	**HRM**

Figure 11

Organizations differ in their internal processes. Nevertheless, certain processes are fundamental to most companies, regardless of industry or size. The set of processes we will be discussing primarily derives from manufacturing companies that engage in the production of physical goods, but variations on these processes can be customized to each company`s specific activities. For non-manufacturing organizations, this list will be slightly different and tailored to their needs. However, the concept of evaluation and the use of this matrix remains the same.

The digital transformation of processes within an organization unfolds through a structured seven-level development matrix, each stage enhancing efficiency and responsiveness to both external customer needs and internal organizational requirements. As processes are more comprehensively digitalized, they not only become more cost-effective but also more precisely aligned with user demands. The seven levels of digital processes are as follows:

Basic Data Registration: At this initial stage, systems are implemented to collect and store basic data relevant to specific processes. Data entry may be manual, or it can be automated through dedicated applications, with datasets integrated and annotated for easy accessibility.

Workstation Control: Digital tools, both software and hardware, are installed at various workstations to enhance operational efficiency. This equipment enforces adherence to job descriptions and reduces process errors by streamlining tasks at each station.

Process Control: All workstations involved in a particular process are linked through a unified management and control system, allowing for detailed process planning, target setting and performance evaluation.

Automation: Automation tools are introduced based on data from individual workstations and the entire process. These tools automate tasks that are repetitive and critical for customer satisfaction or organizational stability, including physical movements and modifications of material properties.

Industrial robots, collaborative robots (cobots) and automated guided vehicles (AGVs) are examples of such automation.

Manufacturing Execution Systems (MES): MES solutions collect, analyse, and display information across large organizational areas, providing decision-making support. These systems visualize process outcomes and report real-time key performance indicators (KPIs).

Enterprise Resource Planning (ERP): At this level, most processes occur independently of operator decisions and are embedded within an integrated information system. Organizational roles are defined, with most processes relying on a unified system.

AI Support Algorithms: Algorithms that improve workflow by utilizing internal or external datasets are deployed, enhancing the precision and efficiency of processes as they evolve with new data. These algorithms provide ongoing developmental support to the processes, continually adapting and learning from operational data.

Area 1A. Sales processes

The sales process in an organization is fundamentally about converting potential leads into actual customers, thereby driving revenue growth. It involves activities such as identifying prospects, nurturing relationships through strategic communication, and closing deals by meeting the needs and expectations of clients.

Level 1. Recording of basic data. Sales employees use dedicated systems to electronically register agreements and orders. This level ensures the precise documentation and efficient storage of crucial data.

Level 2. Workstation control. There is a reporting system that allows the monitoring and analysis of sales-related data. The reporting tool automatically generates reports containing key sales indicators and statistics, facilitating decision-making.

Level 3. Process control. Budget control is implemented within the sales process through automation. An appropriate system enables the planning and control of the sales budget. The system generates the budget based on predefined parameters and sales indicators, streamlining financial management.

Level 4. Automation. We use various tools to automate sales such as online shops, marketplaces or a DIY platform that allow customers to buy online without having to interact with our employees.

Level 5. MES. Manufacturing Execution Systems are used for reporting in the sales process. These systems enable the monitoring and analysis of data related to deliveries and logistics. They generate reports on deliveries, track delivery statuses and provide information on shipments and delivery deadlines.

Level 6. ERP. Integrated ERP (Enterprise Resource Planning) solutions are used within the sales process. This comprehensive system encompasses the management of key business processes, including sales. It synchronizes sales processes with other areas of the organization, such as procurement, production and finance.

Level 7. AI support. We harness advanced algorithms within the sales process to personalize offerings and provide other advanced features. Of note here are offer-personalization algorithms to analyse customer preferences and generate personalized purchase suggestions. We also employ natural language processing technology for customer service and tools for the automated operation of sales bots.

Area 1B. Marketing processes

The marketing process is central to understanding and engaging an organization`s target audience, employing strategies that communicate the value of products or services effectively. It encompasses market research, campaign execution, and the analysis of marketing outcomes to refine future strategies and ensure alignment with the evolving preferences of consumers.

Level 1. Recording of basic data. The key feature of digitalization here is a CRM (Customer Relationship Management) system to register and manage basic customer data. It gathers contact details, precise interaction histories and marketing preferences, which are the basis for further marketing operations.

Level 2. Workstation control. The marketing domain leverages CRM tools in conjunction with key analytical indicators to assess the effectiveness of marketing operations. Integrating CRM systems with analytical tools enables precise analysis and monitoring of key marketing indicators for well-informed decision-making.

Level 3. Process control. Tools related to search engine optimization (SEO) and data analysis from Google Analytics are employed. This provides oversight of marketing processes and the ability to assess the effectiveness of online activities. SEO strategies raise the visibility of websites in search results, while data from Google Analytics enable the monitoring of website traffic and user behaviours.

Level 4. Automation. We use e-marketing tools to automate, for example, the sending of newsletters, email campaigns and offer personalization. E-marketing platforms automate campaigns based on predefined scenarios and customer segmentation, significantly enhancing the efficiency of marketing efforts.

Level 5. MES. Manufacturing Execution Systems are used to measure conversion in the sales process and evaluate the quality of marketing activities. In the marketing context, MES tools track conversions at various stages of the sales funnel and assign scores to potential customers (leads) based on their activities and behaviours.

Level 6. ERP. Marketing harnesses integrated Enterprise Resource Planning solutions to manage key processes. An ERP system integrates marketing processes with other areas of the organization, allowing for efficient campaign management, customer data management and performance analysis.

Level 7. AI support. We assess the extent to which advanced algorithms are used in marketing. Technologies such as chatbots and content generation based on natural language processing (NLP) support customer interaction and the creation of personalized content. Chatbots provide rapid responses to customer inquiries, while NLP algorithms deliver personalized information, significantly improving customer service quality and raising audience engagement.

Area 1C. Process technology and R&D processes

The process technology and research and development processes within an organization focus on innovation and the enhancement of products or services. These processes involve the systematic investigation and application of knowledge to create new technologies, improve existing products, and ultimately deliver significant competitive advantages.

Level 1. Recording of basic data. Design tools such as CAD record precise basic data on technological solutions that have been designed.

Level 2. Workstation control. In the technology field, digital simulation tools enable control over workstations and technological processes. Through process simulation software or equipment operation simulations, the efficiency of technological workstations can be analysed and controlled.

Level 3. Process control. Failure Mode and Effects Analysis (FMEA) is applied, which allows the control of technological processes and the identification of potential errors and their consequences, and thus the development of preventive action plans.

Level 4. Automation. Various automation technologies such as 3D printing, virtual reality (VR) or augmented reality (AR) are in use. These allow prototypes to be created and tested and technological processes to be improved. 3D printing enables rapid prototyping and design verification, while VR/AR technologies support process simulation and employee training.

Level 5. MES. Manufacturing Execution Systems are used to manage technological projects and monitor their implementation. MESs aid in planning, monitoring and managing technological projects, including task scheduling, resource allocation, progress control and reporting. In the development of manufacturing technologies, a Digital Twin is an MES-class tool.

Level 6. ERP. Integrated Enterprise Resource Planning solutions manage key business processes, including technological processes. An integrated ERP system enables the management of technological processes, task

scheduling, progress monitoring and integration with other areas of operation. Integrating the technological process with the ERP system also allows the exchange of data on technological cycle times, which is particularly useful during the design, price quoting and execution of new projects.

Level 7. AI support. Technologies such as AI algorithms support developmental work and the optimization of technological processes. These algorithms analyse data, optimize technological processes, generate proposals for improvements and automate actions, leading to efficiency and innovation in technological operations. AI can assist in identifying promising research areas, further expediting the innovation process and the development of new technologies. This makes AI an invaluable partner in R&D, contributing to new and unexpected results in various fields of science and technology.

Area 1D. Purchasing processes

The purchasing process in an organization entails the strategic acquisition of goods and services needed to sustain business operations. It involves selecting suppliers, negotiating contracts and managing procurement activities to ensure cost-effectiveness and compliance with quality standards.

Level 1. Recording of basic data. Basic transaction data are digitally recorded and stored, such as data about suppliers, products, quantities and prices. This level is fundamental because it ensures consistent and precise transaction information.

Level 2. Workstation control. Inventory planning tools, such as Material Requirements Planning (MRP), control material availability. These tools are used in establishing optimal ordering plans to ensure that there is always adequate availability of materials.

Level 3. Process control. An automated workflow system manages and controls the entire purchasing process, from the moment an order is placed, through its internal approval within the organization, to its execution and settlement. This makes procurement processes more efficient by automating their monitoring and management.

Level 4. Automation. We utilize B2B procurement and auction platforms that enable electronic order placement, price negotiations, supplier offer comparisons and the efficient management of procurement relationships. This level provides more efficient procurement processes that are better integrated with suppliers.

Level 5. MES. MES-class systems enable the monitoring of purchasing-related KPIs. Metrics such as procurement costs, delivery times, delivery quality and the effectiveness of price negotiations are closely monitored. This level makes procurement processes more transparent and controlled.

Level 6. ERP. Integrated Enterprise Resource Planning systems encompass the management of key business processes, including procurement processes. This allows us to schedule orders, monitor deliveries, process payments and integrate procurement processes with other areas of company operations.

Level 7. AI support. Advanced predictive algorithms are applied to support pricing and price negotiation processes. These algorithms analyse the market, forecast commodity and component prices, and support negotiations with suppliers. This level makes procurement processes more intelligent and adaptable to changes in the commercial landscape.

Area 1E. Logistics processes

Logistics processes within an organization manage the flow of goods from suppliers to customers, ensuring that products are delivered efficiently and meet service standards. This involves coordinating transportation, managing inventory, warehousing, and handling distribution channels to optimize the supply chain and reduce operational costs.

Level 1. Recording of basic data. We employ RFID or barcode scanners that allow the registration of data related to material location and identification. These scanners quickly read the labels on goods in the warehouse to precisely identify them and record their locations.

Level 2. Workstation control. We use real-time location in the system and mobile terminals to control and monitor logistics stations. Employees can thus track and update the location and condition of goods in the warehouse.

Level 3. Process control. A Warehouse Management System (WMS) and Electronic Data Interchange (EDI) are used over the Internet. This facilitates control and management of the logistics process at a higher level. The WMS system supervises the flow of materials in the warehouse, while EDI streamlines electronic data exchange with business partners to enhance logistics processes.

Level 4. Automation. We use Automated Guided Vehicles (AGVs) that can independently move goods within the warehouse. Meanwhile, robotized order-picking and other robotic operations automate or assist in many logistics operations, such as loading and unloading.

Level 5. MES. MES-class systems and an advanced Warehouse Management System (WMS) integrated with Milkrun or Kanban systems monitor and optimize logistics processes. The MES system integrates production and warehouse management, while the WMS system, combined with Milkrun and Kanban, helps optimize inventory management and internal transport services.

Level 6. ERP. Integrated ERP systems encompass the management of key business processes, including logistics processes. This allows us to manage

logistics processes such as tracking goods, warehouse management, order management and integration with other areas of company operations.

Level 7. AI support. AI algorithms support the optimization of inventory levels and the allocation of goods within the warehouse. These advanced algorithms analyse demand, forecast needs, optimize inventory levels and assist in optimizing the placement of goods in the warehouse, thereby increasing operational efficiency and accelerating responses to changing external and internal circumstances.

Area 1F. Production processes

The production process in an organization involves converting raw materials into finished products through a series of operational steps, utilizing both human labour and machinery. This process is critical for maintaining product quality and meeting production targets, while also focusing on efficiency and minimizing waste to optimize cost-effectiveness.

Level 1. Recording of basic data. A precise monitoring and recording system gathers basic data from production machines and equipment. Those data include machine runtimes, technical parameters, performance and product quality.

Level 2. Workstation control. Programmable Logic Controllers (PLCs), sensors and detectors are employed to control and monitor production stations. PLCs, sensors and detectors monitor process parameters such as temperature, pressure and speed, and they control the operation of machines and equipment.

Level 3. Process control. Advanced systems are applied, including Computerized Maintenance Management Systems (CMMS), Overall Equipment Effectiveness (OEE) analysis, and Value Stream Mapping (VSM). These help control and optimize the production process. The CMMS system aids in planning and monitoring machine maintenance; OEE analysis evaluates equipment efficiency; and VSM allows production process parameters to be visually represented.

Level 4. Automation. Automation and robotization of production operations increase productivity and precision. Automation encompasses the use of industrial robots and automation systems for repetitive tasks, eliminating human errors and enhancing efficiency.

Level 5. MES. Manufacturing Execution Systems are employed on production lines. MES systems include real-time management and control of production processes. This includes production planning, order management, material tracking, quality control and reporting on production lines.

Level 6. ERP. The key business processes that integrated ERP solutions manage include production. ERP systems integrate production management,

resource planning, purchasing, sales and other processes to optimize the production process through efficient resource management.

Level 7. AI support. AI algorithms optimize production plans, precisely schedule tasks at individual workstations, and facilitate the even distribution of loads on production lines (including based on data acquired from digital twin simulations), thereby increasing efficiency and production flexibility.

Area 1G. Quality processes

Quality processes ensure that products and services meet predefined standards and customer expectations. These processes involve rigorous testing, monitoring and evaluation at various stages of production to detect and correct defects, thereby guaranteeing the reliability and safety of the final output.

Level 1. Recording of basic data. Electronic compliance sheets are used to record basic data related to product quality. These electronic sheets contain information about quality parameters, measurement results, tests and other quality-related data.

Level 2. Workstation control. Quality control systems embedded in machines and equipment are used in the production process. These systems allow for real-time monitoring of quality parameters such as dimensions, surface features, or other critical characteristics. Cameras, sensors and analysers are used for automatic quality control.

Level 3. Process control. A central system responds to quality defects. It quickly identifies, responds to and eliminates quality defects in the production process by automatically detecting defects, generating alerts, informing relevant personnel and initiating corrective actions for improved product quality.

Level 4. Automation. Robots and advanced vision systems are employed for precise automatic examination of product quality. These systems can analyse defects, dimensions and surface characteristics and can eliminate human errors to ensure consistent quality.

Level 5. MES. A Quality Management System (QMS) controls and monitors product quality at various stages of production. This includes document management, quality planning and control, and tracking of tests and inspections, as well as reporting on product quality and process stability.

Level 6. ERP. Integrated ERP solutions are applied that encompass quality management in the production process and that integrate this information with other areas of business operations. ERP systems integrate quality

management, documentation, process control, customer complaint handling and other quality-related functions.

Level 7. AI support. AI algorithms determine the scope of quality control in the production process for efficient and precise management of the quality control process. These algorithms use data analysis and product quality histories to automatically determine which production batches require detailed quality control.

Area 1H. Financial management processes

So far, we have focused on so-called 'core processes'. In addition to these, every organization has at least two support processes. The first of these is financial management. Financial management processes are crucial for maintaining the financial health and stability of the business. These processes encompass budgeting, financial forecasting, managing cash flows, and ensuring compliance with financial regulations. They enable strategic financial decision-making to support company growth and profitability.

Level 1. Recording of basic data. Technologies such as OCR and electronic document management are used to record basic data such as invoices, contracts and other financial documents. OCR technology automatically extracts data from invoices and electronic document management to accelerate and streamline the recording of financial data.

Level 2. Workstation control. Financial control (FC) tools and systems such as financial management systems monitor and control financial indicators and financial reporting. FC systems analyse and control budgets, costs, profitability and other financial indicators.

Level 3. Process control. Decision acceptance systems coordinate and control financial decision-making processes. This improves information flow, risk assessment and the approval and monitoring of financial decisions at various levels of the organizational hierarchy.

Level 4. Automation. Robotic Process Automation (RPA) automates processes for automatic and efficient execution of repetitive tasks. RPA technology is used for tasks such as automatic invoice processing, report generation and financial analysis.

Level 5. MES. Workflow Management Systems optimize financial processes and control and track the progress of tasks. They automate and enhance financial processes such as payment approval, order management and cost reconciliation.

Level 6. ERP. Integrated ERP solutions provide financial control within the organization, process integration and real-time access to financial data.

Level 7. AI support. AI algorithms and Business Intelligence (BI) tools are utilized for financial data analysis, report generation, forecasting and making advanced financial decisions.

Area 1I. HR processes

Human Resources processes in an organization focus on managing the employee lifecycle from recruitment to retirement. This includes talent acquisition, training and development, performance management, and employee engagement. Effective HR processes are essential for building a motivated and skilled workforce that aligns with the organization`s goals and culture.

Level 1. Recording of basic data. Electronic work cards are used to register basic HR data such as work hours, employee presence and other time-management-related information.

Level 2. Workstation control. Systems engage in payroll management, overseeing salary data, payroll lists, tax declarations and other aspects of human resource management.

Level 3. Process control. Systems are used that register work time and attendance so that employees can automatically record their work hours using various technologies such as proximity cards, biometric readers or mobile applications.

Level 4. Automation. HR processes are automated using e-kiosks and web applications that allow employees to independently manage their data, request leave, access documents and perform HR-related tasks.

Level 5. MES. Comprehensive Human Resource Management (HRM) software records personal data and employee assessments, and it is used in planning training, monitoring salaries and benefits, and career management.

Level 6. ERP. An integrated ERP system with HR modules is used to centralize human resource management data.

Level 7. AI support. AI algorithms support recruitment processes, talent management, HR data analysis and employee development planning.

Axis 2: Digital products

Digital products represent a pivotal category in the digital transformation landscape, encapsulating goods and services that are stored, delivered and used in an electronic format. These products, ranging from software and apps to digital media, offer businesses a significant competitive edge due to their scalability and potential for rapid global distribution. As digital products bypass traditional physical limitations, they open avenues for companies to access wider markets more efficiently and at a lower cost. This inherent scalability and reach make digital products not just a transformative force but a critical element in redefining market boundaries and establishing new revenue streams in the hyper-competitive digital economy.

Even within digital products, we can discern various levels of maturity and sophistication. Basic products like e-books, audiobooks, or movies can be effortlessly downloaded or streamed from online platforms such as Amazon and Audible. For instance, a customer might purchase an e-book on a website and download it to their e-reader device. Moving towards more complex solutions, intermediate products that amalgamate multiple formats – such as multimedia, e-books and audio or video files – are accessible on a variety of devices or platforms, including streaming platforms like Netflix. A website might offer a multimedia package that includes e-books and audio or video files that can be utilized across different devices. Advanced electronic products enhance user experience with additional features such as personalization, user interaction, or artificial intelligence. For example, a mobile app may allow users to customize settings and interact with other users, adding a layer of engagement and functionality.

Products can offer interactivity, such as many video games, virtual reality, educational apps or design tools that enable users to actively collaborate on or modify the product. Many video games allow users to interact with a virtual environment and make decisions that affect the game`s progress. Expert products leverage innovative technologies like artificial intelligence, machine learning and blockchain to deliver more advanced products, such as intelligent data analysis systems, enterprise software or virtual reality platforms. Online services like e-learning platforms or cloud services also fit into this level. An