SPARK Matrix™

Data, Analytics, and AI

SPARK Matrix™: Digital Twin of an Organization, 2022

Market Insights, Competitive Evaluation, and Vendor Rankings

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Quadrant Knowledge Solutions

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Executive Overview

This research service includes a detailed analysis of the global Digital Twin of an Organization (DTO) solution market dynamics, major trends, vendor landscape, and competitive positioning analysis. The study provides competition analysis and ranking of the leading DTO vendors in the form of the SPARK Matrix. This research provides strategic information for technology vendors to better understand the market supporting their growth strategies and for users to evaluate different vendors' capabilities, competitive differentiation, and their market position.

Key Research Findings

Followings are the key research findings:

Market Drivers and Trends:

The digital twin of an organization (DTO) solution market is expected to grow significantly in the next three to five years as most industry verticals are focusing on working on a virtual representation of real processes for organizations' digital transformation. Quadrant analysts believe that technology investments will be driven by the pent-up demand and economic recovery of the key market after the impact of the COVID-19 pandemic. The primary drivers for the adoption of DTO solutions include increasing digitalization across industries, proven benefits of digital twins, increasing support for additional use cases by DTO providers, continued advancements in technologies that support DTO, and such others.

On a global scale, the DTO market is growing rapidly and the primary growth driver for this platform is compelling organizations to contemplate the creation of a 'digital twin' to optimize efficiency while maintaining consistent end-user satisfaction. Companies are now more inclined to adopt a virtual replicative model in the form of the DTO because of the currently limited workforce. The causative factors behind the drop in workforces are a leaner approach by the organizations and the non-availability of the required skill set at a precise time. This would promote the analysis of the given service or product at hand, and digitally rectify any issues that occur, providing a clear idea to the end-user as to what works and what does not, and the reasons for the same. This amalgamation of the actual and virtual space, promotion of deep analytics & newer avenues, planning for the future, and critical insights regarding system functionality. The above-mentioned market trends are expected to play a vital role in improving the penetration rate and overall market growth of DTO solution.

Technology Trends:

The technology trends that are driving the growth of the digital twin of an organization (DTO) solution market are:

- DTO solutions help understanding, implementing, and executing changes in the organization's enterprise architecture plan to support business agility and rapid innovation.
- These solutions also enable deep integration of the virtual representation with the physical products through sensors, IoT devices, and artificial intelligence, which provides an enhanced output through software analytical dashboards.
- In the current digitalized phase, IoT applications can generate data in the form of images, audio, and video. Real-time access to data and intelligence is driven by the continuous and cyclical flow of information and actions between the physical and digital worlds throughout the cycle.
- It is expected that business models of Industry 4.0 imply complete communication networks between various departments of organizations, suppliers, logistics, resources, and customers in a unified approach.
- Big data analytics, artificial intelligence, and machine learning which will fundamentally transform the way of creating and managing digital twin models.
- Increase in the simulation will play a primary role in every organizational vertical that allows experiments for the validation of products, processes, systems design, and configuration that can be defined as an operation imitation, over time, of a system or a real-world process.
- DTO solutions are increasingly supporting emerging use cases like customer experience through the increased utilization of IoT devices.
- DTO solutions help increase focus on process optimization and model calibration by utilizing contextual data through process mining technology to provide actual visualization of the product flow.

Competition Dynamics & Trends:

- Software AG, Signavio, Celonis, CANEA, and Cosmo Tech, are the top performers and market leaders in the 2022 SPARK Matrix analysis of the DTO market. These companies provide a robust technology platform with comprehensive functional capabilities and customer value proposition to support the DTO solution.

- The study includes an analysis of other major vendors, including Ardoq, Arrayworks, Bee360, BiZZdesign, BOXARR, BOC Group, BusinessOptix, Holocentric, IBM, iGrafx, Interfacing Technologies, Mavim, Ortelius, QPR Software, and QualiWare.

Market Definition and Overview

Quadrant Knowledge Solutions defines “Digital Twin of an Organization (DTO) as the virtual representation of an organizational process, system, applications, products, performance, and business model by gathering operational and circumstantial data which provides a holistic view to enterprise architecture (EA) and technology innovation leaders for prioritizing, planning, monitoring, guiding, analyzing, predicting, and making strategic decisions to deploy complex business initiatives. It thus offers real-time business updates and responses to changes and further allows optimum resource utilization, improving speed and efficiency and delivering elevated customer value.”

DTO is the virtual representation of an organization in terms of its processes, applications, business models, strategies, and such others. It enables organizations to build, operate, analyze, and tweak the digital models by offering real-time business updates and responses to changes. It further allows optimum resource utilization, which helps improve speed and efficiency and deliver elevated customer value. A DTO solution typically includes functionalities for comprehensive data integration, process modelling and visualization, process simulation, process monitoring and analysis, communication and collaboration, and process optimization and model calibration. An effective implementation of a DTO solution helps organizations accelerate digital business transformation initiatives, customer experience (CX) and transformation, achieve business and operational agility, and align the organization's vision and goals with business and operational processes, among others.

The concept of a digital twin has been around for over a decade. Digital twins have been used for driving simulations in industries like aeronautics and mining, and to diagnose the working of windmills and engines. A digital twin is a virtual replica simulating a device's physical components and how it functions throughout its lifecycle. The digital twin is a dynamic representation of what is happening in the real world and is synced for real-time adaptability. This pairing of the real and virtual world provides insights that can help prevent downtime, identify new opportunities, and help plan for the future.

A digital twin is a virtual representation of real-world elements created using sensors and 3D modeling. Sensors collect comprehensive real-time data from the physical elements. The data is then used to create a digital duplicate to help teams better understand and analyze real-world things or systems. The key elements of digital twins are as follows: model of a real-world entity, data from the entity, connection between the model and the physical entity, and the ability to monitor and receive notification pertaining to the real-world entity. Data and analytics are the major drivers of digital twins. Digital twin enables all kinds of advanced analytics for predictive maintenance, resource optimization, flow control, product development, and such others.

With the rise of digitalization, the concept of the digital twin is getting extended from the digital representation of physical objects to the digital representation of the entire organization. Therefore, rather than only focusing on the data from sensors, the data from organizational assets, processes, people, activities, and their interaction can be combined into a holistic digital model of the organization, also known as digital twin of an organization. This combination of virtual and real worlds helps organizations efficiently manage interdependencies and interrelationships between people, processes, and systems, and deal with the challenges of the modern era of digital transformation.

Process mining is one of the key enablers of DTO, as it uses data directly from operational systems and creates a visualization of processes. Process mining also offers contextual data to help see beyond process operations and identify the reasons behind their occurrence. As a process discovery, analysis, and monitoring tool, process mining automatically discovers and connects current data with the pre-existing data to provide the actual visualization of the process flow. Through its root cause analysis, process mining monitors the performance and reflects the causes of inefficiencies and bottlenecks in the process. It automates the simulation process and continuously monitors the KPIs defined by the organizations, allowing digital optimization and digital transformation of the organizations. Hence, a DTO solution offers process mining capabilities like comprehensive data aggregation, process modeling, data mining, deriving business rules, and running simulations.

Creating a Digital Twin of an Organization:

The first step in creating a DTO is developing an accurate and comprehensive virtual representation of the organization. Once the model is created and loaded with data, teams can analyze this data to learn more about systems, processes, and areas of concern. Although creating a DTO requires a robust platform and extensive enterprise architecture, it offers a strong value proposition to constantly changing and developing businesses. A DTO solution allows organizations to anticipate issues and make adjustments before implementing the changes in the real world. The solution also provides insights into the organization's functioning and identifies areas of inefficiency. A DTO offers strategic planning, optimization of resources/processes, insights, and alignment of business goals and operations by leveraging the extensive pool of data.

Some of the major DTO functionalities include data ingestion & management, process modelling & visualization, simulation, analytics & reporting, real-time monitoring, continuous feedback & improvement, support for integration & collaboration, and a 360-degree holistic view. The following is the description of each DTO functionality:

- **Data Ingestion and Management**: A DTO platform offers comprehensive data management capability, which includes ingestion of historical data from multiple storage locations and databases, data preparation, and data storage

and management to preserve time-stamped data. It also imports data from dynamic operational systems and subsystems. A DTO solution integrates relevant operational data from enterprises, including product portfolio data, customer experience data, performance data, resource cost sheets, technology lifecycle data, and others. An efficient DTO must gather real-time data from multiple sources like IoT devices, sensors, connected customers, connected employees, connected operations, supply chains, and such others. Additionally, the vendors also offer assets management to forecast asset conditions and optimize asset management strategies with a tactical and realistic plan. The risk management feature also enables organizations to optimize scenarios and plans to achieve a balance between risks, costs, and quality of service.

- **Process Modelling and Visualization**: One of the key capabilities of a DTO is offering robust modeling functionality with accurate digital visualization of all real-world entities related to the organization. A DTO should provide modeling of resources (such as machines, IT systems, and people), business operations, customer interactions (through customer journey maps), organization's offerings (products, services, and information), and such others. DTO solution vendors are increasingly offering advanced data visualization tools beyond basic dashboards and standard visualization capabilities to include interactive 3D visualization and AI-enabled visualization. It also supports the visualizations journey and ROI calculations in standard charts and tables to enable cross-functional, fact-based decision making. The DTO platform also supports model types such as BPMN process, customer journey, data model, value stream, tasks model, operating procedures, and enterprise architecture. Moreover, the platform predicts process modelling deviations using machine learning for specific use cases by leveraging the power of AI.

- **Simulation:** Simulation is one of the key drivers fueling the adoption of DTO by various organizations. Simulation allows the replication of complex business processes providing a realistic view of the organization's process, systems, and business model. It also enables the organization to experiment with various 'what-if' scenarios before actual process execution. It further allows the users to simulate and gauge the impact of their decisions on each aspect of the business model. The DTO platform enables users to create various improved and innovative models and run scenarios to understand the potential impact and choose preferred transformation paths. It provides step-by-step implementation instructions for short, mid, and long-term actions plans. Furthermore, the "what-if" simulations and "how-to" optimizations allow organizations to compare and simulate alternative scenarios, ensuring efficiency and uniformity across the value chain.

- **Analytics and Reporting**: A DTO solution aggregates and feeds data into advanced analytics algorithms to derive insights for sound decision-making. Analytics offers suggestive measures and potential improvements to drive desired results by combining the past and present data. Analytics also monitor the time taken to perform the processes and track whether processes follow the prescribed paths to meet compliance obligations. A DTO should enable all kinds of advanced analytics for predictive maintenance, resource optimization, flow control, and product development. Advanced analytics capability is powered by artificial intelligence and machine learning algorithms. The vendors also support the dynamic comparison of "as is" process models with a best practice library of processes created by identifying process drift and potential improvement opportunities. Additionally, the platform supports visualization of models and associated data collected from process metrics, change opportunities, KPI impacts, and transformation performance in an intuitive dashboard to make decisions.

- **Real-Time Monitoring**: A DTO solution should offer capabilities for continuous real-time monitoring and calibration. A DTO offers real-time monitoring of multiple assets, KPIs, and business process operations through dashboard representation. Any changes in the real-world environment should be fed into the digital representation to calibrate the model for effective real-time insights. Real-time monitoring makes the DTO solution robust and failure-proof and enables the users to take remedial actions, which can also be done remotely. The platform offers early alerts of potential bottlenecks in the production line to understand what actions need to be taken. The platform is also equipped with notification, alerting, and triggering capabilities for sending emails, text messages, or other alerts. It also exports and shares results with configurable and customizable visualization dashboards to align and meet stakeholders' expectations. Lastly, this capability allows users to view live insights on process models and journeys to improve process mining and modelling.

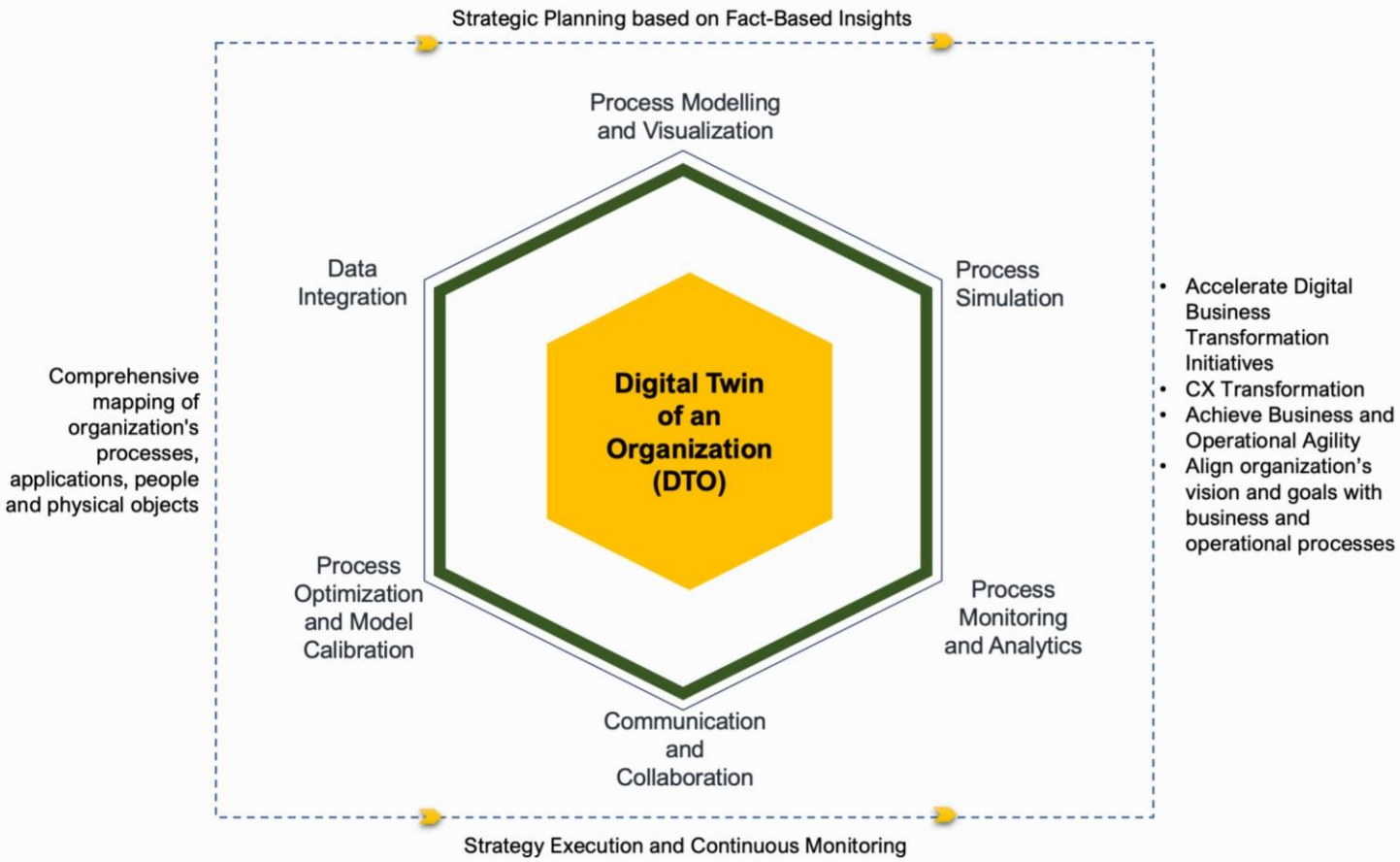
- **Continuous Feedback and Improvement**: Real-time data addition, processing, and continuous analysis are of paramount importance for the efficient functioning of a DTO system. The simulations that are undertaken are based on assumptions conforming to many parameters. Time and the demands of the real-time change in events can distort the values of these parameters. The system needs the flexibility to accommodate deviations, uncertainties, and changes in values based on human effort. Hence, the DTO offering needs a provision for continuous feedback supply, which would enhance the output provided and result in continuous improvements in the current predictive models, resulting in more accurate insights.

- **Support for Integration and Collaboration**: The DTO solution should support seamless, real-time, and bidirectional integration between the physical process and the digital platform. The integration allows multiple activities, tasks, complex processes, and various workflows to connect and interact with sensors and actuators to gather information in real-time. Integrating with system applications helps track and monitor the process status through smartphones and other devices. A DTO solution should support integration with various high-volume, real-time data sources and integrate with IoT, AI, ML, and other technologies. The platform also offers collaboration tools that allow users to comment and discuss, which enables the staff to provide feedback on processes and workspaces, along with connecting to internal and external stakeholders.

- **360-degree Holistic View:** The vendors are offering comprehensive platforms that integrate all the different organizational areas to provide a holistic view of the entire organization. They also offer seamless integration of expert systems with solutions like information technology service management (ITSM), customer relationship management (CRM), project and portfolio management (PPM), along with collaborative tools like Microsoft Teams and Slack for internal and external stakeholder communication which provides a bird eye view on all the ongoing organizational processes. Thus, the vendors are offering holistic, dynamic, and connected digital replicas to simulate entire business ecosystems.

Figure: Digital Twin of an Organization Solution

Figure: Digital Twin of an Organization (DTO) Solution



Source: Quadrant Knowledge Solutions

Factors Influencing Technology Development and Market Growth

Following are the dominant technology and market development factors influencing the overall global Digital Twin of an Organization solution and market growth:

Organizations are Increasingly Adopting Digitalization Initiatives

The technological developments over the last few decades have transformed businesses globally. Collectively, companies are increasingly becoming aware of the usage and benefits of digital transformation. However, a few organizations have been able to translate the visualized potential of digital adoption into reality. Connected technologies and the industrial internet of things (IIoT) ensure that a majority of the organizational processes are inter-connected and in sync with the central system administrator and network, creating a harmonious operational process across different departments. With the rise of digitalization initiatives amongst organizations globally and the proven benefits of continuously monitoring and optimizing the operational processes, DTO technology is witnessing adoption at a faster pace.

Emerging Technologies of AI & ML are Powering DTO solution for Smarter Business Decisions

DTO is created as a virtual extension to the business process and for optimizing the operational process under consideration. DTO offers deep analytics into the business operating cycle to provide future suggestions for decision-making and conclusive reasoning for the same. DTO can also be utilized for predicting the entire business functionality virtually. This assists in visualizing and streamlining every detailed aspect associated with business operations including people management, infrastructure management, asset management, and technology & network management. The predictive analysis requires the collation of huge data sets, which can be procured from multiple systems and processes continuously and in real-time. Thus, the use of advanced data modeling, predictive data analytics, smart data analysis, interactive data visualization, and advanced technologies like AI and ML greatly support the creation and maintenance of a robust DTO system. Additionally, the DTO solution has the ability to interpret and analyze the data captured by IoT and sensors while identifying the anomalies to identify the root cause of the errors. It also makes repeated use of learned data in the process to enhance productivity and provide valuable insights and recommendations for the users. Moreover, businesses can utilize the predictive maintenance capability of the DTO solution to eliminate breakdowns and outages by enabling the professionals to analyze maintenance workflow, including testing with all sorts of possible fault conditions and take actions to solve it.

DTO Solutions are Increasingly Supporting Emerging Use Cases like Customer Experience and IoT

DTO provides a holistic understanding of the organizational functionality along with a digital overview of the organization with complete enterprise visibility while optimizing the processes, streamlining system configuration, and accommodating human behavior and interactions. Thus, a DTO can be further utilized to design ergonomically efficient systems and business processes while keeping the customer requirements as a focal point. Elevated end-user experience ensures increased sales, business value proposition, brand value, and overall recognition. Companies realize they need to emphasize on increasing the quality of the overall customer experience.

There is a notable shift from operational excellence and performance management for DTO use cases to accommodate customer experience use cases, and the related increase in IoT use cases as well. A customer-centric approach also guarantees customer loyalty. Hence, DTOs designed for collecting, incorporating, and executing real-time customer feedback would ensure exponential business growth. Additionally, with the advent of internet penetration into every walk of human life, including hand-held devices, the boundary between systems and humans is diminishing, and people are connected to the internet 24*7. Hence, DTOs are being deployed for a variety of use cases, including software provisioning, gateway management, simulations, semantics, access control, historical data analysis, and device access & communication, amongst others.

Technology Landscape, Vendors' Capabilities, and Organizations' Infrastructure is Constantly Evolving to Support Advanced DTO Solutions

Organizations are warming up to the idea of DTO implementation and generally prefer a scaled-down version of the actual DTO model initially. This version includes all the key features like implementation scalability, performance analysis, destination mapping, and real-time decision making. The scaled-down DTO promotes the creation of KPIs, plans for implementation changes, and performance monitoring systems, amongst others. Developing a DTO necessitates a strong enterprise-scale architecture and a robust platform, ensuring multiple scales of returns and providing the company with a decisive competitive edge.

The underlying technological infrastructure should be advanced enough to support constantly evolving simulation and modeling capabilities to enable the development of constantly upgraded DTO across the organization. Additionally, better interoperability across the systems & network hierarchy would ensure a smoother flow of information and data across the organization, enabling easier prediction and replication of existing systems. Upgraded computing infrastructure, along with the

availability of modern, cutting-edge tools & software and better interoperability, is driving the adoption of DTO amongst organizations.

Balancing the Inside-out and Outside-in Perspective

In the current business operation scenario, balancing customer requirements and organizational offerings is quite important. A skew either toward the customer aspect by focusing excessively on customer expectations, or toward the organizational aspect by focusing on organizational capabilities, can lead to disastrous implications for the organizational life cycle and end business goals. Customers need to be at the center of all the designs, processes, communications, systems, and policy decisions. However, only adopting a customer-centric approach might lead to a gap between the organizational offerings in terms of the companies' strengths and the customers' wants. Likewise, if the organization decides to focus solely on its offerings depending on its capabilities and disregard the customers' desires, the company might end up offering a quality product that could witness a low demand in the market. Thus, a balance between the two strategies is essential to bring together the best of the product offering in the precise market where there is a high demand for the same. This can be achieved by making use of DTO which provides in-depth analysis with regards to the organizational process and functioning and the customers' requirements.

Increase in Adoption of Cloud-Based Storage

Nowadays, different industry verticals are increasingly utilizing IoT for business transformation and aiming for digitalization across business processes and operations. This trend plays an important role in creating a DTO solution that integrates the virtual with the physical world. Thus, the businesses are understanding the importance of connecting devices and are increasingly adopting technologies that can connect business operations efficiently and quickly. As the business runs on various processes and operations, it generates a large amount of data through IoT, sensors, and other devices that are installed in the physical world to run a simulation on the virtual world to make better business decisions and improve the process. Thus, the adoption of cloud-based storage is becoming one of the major trends that businesses will adopt to store a variety of data in one place. The DTO offers the flexibility to integrate various technologies and processes for creating a digital thread that will standardize the complete processes and provide optimum outcomes.

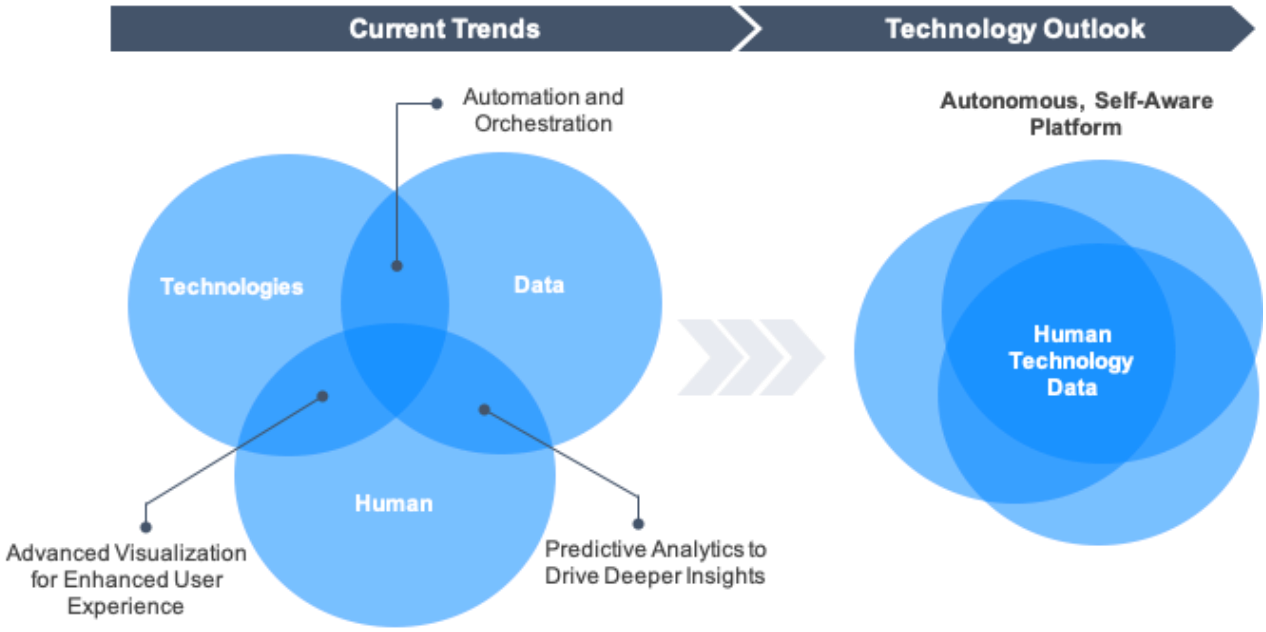
Improving Enterprise Architecture Model by Utilizing DTO

The organizations are applying the concept of DTO in IT system management, enterprise architecture, and strategy design. Integrating the conventional enterprise architecture models with real-time operational information supports improved

enterprise decisions. DTO solution is utilized to improve traditional enterprise architectural models of the organization through a detailed analysis of the processes to increase efficiency, maximize process optimization, and reduce risks of failure. The DTO provides a continuous feedback loop between traditional enterprise architecture (EA) models and the operational data of the organization that allows users to know project execution time, transformation management, opportunity costs, ROI estimation, the number of people involved in a project, and many other factors. Thus, DTO enables organizations to combine traditional architecture information with the operational information to gather this data for making business decisions quickly and effectively.

MegaTrend and Technology Convergence: The Convergence of Automation, Machine Learning, and AI

Figure: MegaTrend and Technology Convergence
The Convergence of Automation, Machine Learning, and AI



DTO vendors are leveraging automation, machine learning, and AI in automating several organizational processes to improve operational efficiency, resource utilization, and productivity. As per Quadrant's analysis of the overall market, DTO technologies are becoming collaborative, automated, and intelligent. The adoption of automation, machine learning, and AI is amongst the most significant trends and is expected to influence several technology markets during 2022-2025. Machine learning and artificial intelligence are expected to drive the next generation of data

management and analytics solutions with the emergence of self-aware platforms that integrate human, data, and technologies.

Competitive Landscape and Analysis

Quadrant Knowledge Solutions conducted an in-depth analysis of the major DTO solution vendors by evaluating their products, market presence, and customer value proposition. The evaluation is based on primary research with expert interviews, analysis of use cases, and Quadrant's internal analysis of the overall DTO market. This research study includes analysis of various key vendors including Ardoq, Arrayworks, Bee360, BiZZdesign, BOXARR, BOC Group, BusinessOptix, CANEA, Celonis, Cosmo Tech, Holocentric, IBM, iGrafx, Interfacing Technologies, Mavim, Ortelius, QPR Software, QualiWare, Signavio, and Software AG.

DTO solution market is steel in the emerging stage with the presence of a variety of vendors supporting the digital twin of an organization solution. Global DTO solution market constitutes vendors specializing in Enterprise Business Process Analysis solution, Enterprise Performance Management solution, Process Mining solution, and such others. While all the leading vendors support primary use cases of DTO, the breadth and depth of features and functionalities along with an ability to support a range of use cases may significantly differ between different vendors offerings.

Software AG offers business transformation solutions through promoting a consistent flow of data and fueling hybrid integration and the Industrial internet of things (IoT). Software AG’s ARIS Process Mining platform provides insights into operational data, promotes the analysis of actual business functionalities along with the best-case and compliant scenarios. Signavio is a leading provider of business process management solutions and offers the Business Transformation Suite – an integrated solution that supports modelling, process mining, and execution. The suite provides canvas-based modelling of business processes, creating models on notions including ArchiMate & BPMN – within a canvas and supporting drag and drop capabilities. It also promotes process analytics and investigation capabilities, which ensures detailed process investigations and reveals key metrics for continuous monitoring. Celonis is a leading provider of execution management system (EMS) solutions. Its EMS platform acts as an intelligent layer on top the business systems along with leveraging a complete set of process improvement tools, including process mining & automation. The platform assists companies in managing key aspects of business execution, including management, analytics, and automation.

CANEA is a leading provider of management consulting and IT solutions. It offers the CANEA ONE product suite, which is a multilingual out-of-the-box management system platform which links the companies' strategy with its day-to-day operations. It is an intuitive and easy-to-use low-code platform with out-of-the-box functionalities, enabling effective business management by integrating processes, strategies, and projects. It also includes a variety of modules like process, strategy, and workflow. Cosmo Tech offers solutions for the optimization of complex systems, augmented

intelligence, and optimization and simulation of industrial system processes. The company provides the Simulation Digital Twins platform which is built on a complex system modelling language (CoSML), and promotes simplified representation of hierarchical and heterogeneous systems, in a multi-scalar environment.

IBM offers digital twin of an organization (DTO), process mining, digital transformation, and operational intelligence solutions for analyzing & full management of business process improvements, along with the prediction of future trends and in-depth process analysis. The platform's advanced analytics capability continuously monitors resource bottlenecks, alignment of KPIs and process deviation, and allied activities for efficient analysis. QualiWare is a global business modelling software and consultancy provider helping organizations with their business process management, enterprise architecture, optimization initiatives, and quality management. It offers QualiWare X - an enterprise architecture and business management tool that enables organizations to transform through collaboration and smart management. The platform improves the organization's performance with its integrated smart collaboration function, which efficiently utilizes the digital twins, business ecosystem, and customer journeys. QPR Software provides solutions for enterprise architecture, performance & process management, strategy execution, & process mining, and offers the QPR business operating system (BOS), which includes integrated modules like its flagship product QPR ProcessAnalyzer for process mining & analytics. The company offers a robust DTO supporting business operating system software, promoting business process modeling, and is connected to automated business process discovery along with analysis of ERP transactional-level operative data.

The DTO market surely has several strong contenders. With continuously evolving global technology scenarios, faster adoption rates, and compelling developments happening round the clock, the vendors need to also keep up with the evolving requirements and business needs. Ultimately, any solution that eases the burden of the workforce and increases their productivity always brings the maximum value to the table. Hence, the vendors could make the best use of the current situation for innovating & establishing themselves in future.

Competitive Differentiators

Most DTO vendors provide comprehensive functionalities to support various use cases, their technology and customer value proposition. While that might differ based on their customer size, industry vertical, geographical markets, and organization-specific requirements. The digital environment is continuously transforming, requiring vendors to expand their R&D budget and continuously enhances their platform's value proposition to ensure future market needs. Users should partner with DTO vendors with robust technology strategy and roadmap for improving their platform features & functionalities, product strategy, and alignment with emerging transformational trends. The vendor's ability to accommodate emerging technology trends, including the sophistication of technology platform, integration & interoperability, ease of implementation, use cases support, AI/ML, insight driven, vendor domain knowledge & experience, product roadmap strategies are increasingly becoming key differentiators for selecting DTO solution:

- **The Sophistication of Technology Platform**: Users are advised to conduct a comprehensive evaluation of different DTO vendors before purchasing. A DTO solution depends entirely on the ability to create a sophisticated representation of the business scenarios and extract meaningful data, intelligent, logical reasoning, and advanced data analytics capabilities. For the same, the vendors are offering a robust technology platform which is capable of importing, handling, processing, and incorporating a variety of data sets from various business departments and operational fields with a precise operational understanding. A well-built technology platform is capable of replicating and simulating 'instances' under various conditions to increase the understanding of the process. An advanced technology platform also assists business leaders in precise scenario planning, exploring & choosing the optimum options, and in risk minimization for the companies' decided path of operations.

- **Integration and Interoperability**: The DTO can integrate processes through adapters/connectors like RESTful APIs, message-oriented middleware (MOM), files and databases to receive and send data. The platforms also have adapters for web services, packaged applications, or sensor data in event streams or historical databases. The vendors are also offering seamless integration with collaborative tools that help employees to accomplish their tasks more efficiently. Users should evaluate the DTO solution that provides an integral approach to operate and transform the processes and structure of the whole organization.

- **Ease of Implementation**: While the DTO solution has earned a solid reputation for delivering quick ROI, its implementation is still considered a challenge amongst the organizations. DTO solution should support large enterprises'

needs with its scalable technical architecture that allows for load-balanced deployment across multiple organizational processes. The DTO ensures that organizations are safeguarded from potential vulnerabilities in the context of business lifecycle uncertainty, product safety & security, uncertainty in the operational cycle, and repeatability of operations. The DTO also promotes a streamlined day-to-day operational sequence of the activities and real-time cross-functional collaboration. It offers lesser time to model and to visualize the organization as a whole, along with ensuring ease of analyzing and understanding the operational virtual model. The more simplified and easier to implement the DTO, the higher is the probability and rate of adoption, thus promoting an exponential increase in operational efficiency. The users should also evaluate vendors that have the ability to capture automation, innovation, process improvement, transformation opportunities in less time.

- **Supporting a Variety of Use Cases**: A DTO primarily drives the digital transformation, reduces process redundancies, and promotes a configured enterprise architecture capable of handling a variety of system complexities. The DTO is meant to mirror the entire organizational system to understand the technology trends and leverage & accommodate technologies like AI, ML and IoT into the purview of the organizational jurisdiction seamlessly. A DTO ideally supports a plethora of use cases in practically any field of operation globally, and the potential to tap into it is practically unlimited. A DTO could be used for improved enterprise-level decision-making, customer experience management, impact on change communication within the organization, monitoring business transformations in the digital context, amalgamating the project implementation and project strategy, cost optimization, and benchmarking & streamlining operational tasks. Users should evaluate the DTO vendors that support their organization-specific and industry-specific use cases to ensure an enhanced technology ownership experience.

- **Artificial Intelligence (AI) and Machine Learning (ML) Capabilities**: A DTO is highly efficient in predictive analysis and predictive modelling. This involves collating large chunks of data spread across a certain period and continuously comparing individual parameters from the available data sets to the newer data packets being added into the repository. This process is executed on a real-time basis and implemented with immediate feedback, and with corresponding corrections in the output values.ML, AI, and big data analytics are the primary drivers which differentiate organizations' operational excellence from one another. Thus, an organizational setup heavily reliant on a process-driven approach would further have the autonomy to communicate with different processes, gather and compare critical data points, and gauge the need to

tweak certain parameters as per requirement– all in a virtually simulated environment.

- **Smarter Insights - Data-Driven and Human-Based:** Modern business environment is quite complex owing to exponentially increasing data packets being generated, intricate processes and complex human behaviour and the interrelation and interdependencies between them. A DTO is capable of providing key insights and predictive suggestions based on the available data and process information. By utilizing intelligent data handling tools, business analysis, automatic task management, and the incorporation of human behaviour patterns and actions, the system can come up with better and more realistic solutions for manageable process workflows. Hence, many vendors are focusing on offering smarter insights by combining both data-driven insights with a touch of human operations management.

- **Scalability**: Previously, organizations would focus on individual monitoring devices for recording and analyzing process flows from the inventory to the delivery and understanding the run-time data to figure out the downtime, maintenance requirements, process output efficiency and improvements, as and when required. Nowadays, companies seek wide predictive maintenance, critical asset deployment analysis, and system & network monitoring. Thus, the scalability of the DTO solution is critical for integrating the increasing number of processes, systems, departments, and stakeholders. Scalability also helps redefine and visualize the organizational mission and redesign the processes and technology offerings since it provides an elaborate understanding of the organization's capacity to perform if the scale of operations was to increase multiple times and whether there would be any breakdowns in the functioning of the system operations.

- **Vendors Domain Knowledge and Industry Experience:** As the DTO market is evolving, the users should evaluate vendors based on their specific domain knowledge to provide an innovative, holistic virtual representation of the organization's process and position themselves as the provider of the wide range of use cases. Users are also advised to consider the vendor's capability of offering advanced technological tools like AI/ML into their platform in forecasting, planning, and predefining what next step should be taken to continuously improve process outcomes. Users must carefully examine vendors who are replacing tools in the areas of enterprise architecture management, IT financial management, strategy execution management, task management, and project & portfolio management.

- **Product Strategy and Roadmap**: Provision of DTO requires a systematic understanding of the application for which the system needs to be used, along

with keeping track of the current technological trends and value propositions that are expected by organizations. Further, DTO vendors focuses more on technological and simulation enhancements and fast-track situation-specific insights making use of advanced analytics, including AI & ML, for better predictive modelling. Faster and smarter insights utilizing predictive data modelling and analytics, increased support for a variety of use cases, and enhanced platform integration capabilities are some of the product strategies that vendors are looking forward for incorporation. Additionally, increasing support for big data, IoT data, and event data, along with a focus on comprehensive surveillance solutions with sophisticated data integration and analytics capabilities, would result in the incorporation of customized model development and propel the existing process and workflow technologies.

Future of Digital Twin of an Organization

The Digital twin of organization platform vendors are focusing on replacing the tools in the areas of enterprise architecture management, customer relationship management, IT financial management, task, project & portfolio management, and strategy execution management. It will also be enhancing its simulation capabilities to provide a real-time update of the processes with an integrated view through reporting and analytics dashboards. The vendors are planning to offer agile methods to be utilized by the production and process execution teams.

The vendors are continuously focusing on strengthening the integration capabilities with tools like Jira, Microsoft, ServiceNow, Gitlab and others. Additionally, the vendors also focus on improving simulation capabilities for more input variables, more complex modelling, and more comprehensive business cases. It also offers tools such as collaborative design and multi-phase/multi-state transformation. Furthermore, major focus is provided on enhancing standard operating procedure features, knowledge assessment and Kanban functionality, knowledge graphs, auto-notation of models based on data, and context workforce optimization insights.

The future of DTO will be driven by continuous focus and delivery of model-driven configuration and a low code/no-code approach. The vendors would provide data ingestion enhancements for future performance and user experience performance. Moreover, enhancement in new risk and value framework based on custom and monetized KPI (risk-based planning) and increased range of modelling use-cases ("live-simulation" using real-time data updates for asset management) will be seen in the coming future. The vendors would also be focusing on expanding mining capabilities and integration with sentiment data providers along with enterprise modelling & process governance capability. Additionally, enhancement in connectivity & data management capability through integrations will improve the data management layer. There will be a continuous focus on enhancing business accelerators for content packages, including models, metrics, and other process-relevant artifacts to accelerate time to value.

SPARK Matrix™: Strategic Performance Assessment and Ranking

Quadrant Knowledge Solutions' SPARK Matrix provides a snapshot of the market positioning of the key market participants. SPARK Matrix provides a visual representation of market participants and provides strategic insights on how each supplier ranks related to their competitors, concerning various performance parameters based on the category of technology excellence and customer impact. Quadrant's Competitive Landscape Analysis is a useful planning guide for strategic decision makings, such as finding M&A prospects, partnership, geographical expansion, portfolio expansion, and others.

Each market participant is analyzed against several parameters of Technology Excellence and Customer Impact. In each of the parameters (see charts), an index is assigned to each supplier from 1 (lowest) to 10 (highest). These ratings are designated to each market participant based on the research findings. Based on the individual participant ratings, X and Y coordinate values are calculated. These coordinates are finally used to make SPARK Matrix.

Technology Excellence	Weightage
Sophistication of Technology	20%
Competitive Differentiation Strategy	20%
Application Diversity	15%
Scalability	15%
Integration & Interoperability	15%
Vision & Roadmap	15%

Customer Impact	Weightage
Product Strategy & Performance	20%
Market Presence	20%
Proven Record	15%
Ease of Deployment & Use	15%
Customer Service Excellence	15%
Unique Value Proposition	15%

Evaluation Criteria: Technology Excellence

- **The sophistication of Technology**: The ability to provide comprehensive functional capabilities and product features, technology innovations, product/platform architecture, and such others
- **Competitive Differentiation Strategy**: The ability to differentiate from competitors through functional capabilities and/or innovations and/or GTM strategy, customer value proposition, and such others.
- **Application Diversity**: The ability to demonstrate product deployment for a range of industry verticals and/or multiple use cases.

- **Scalability**: The ability to demonstrate that the solution supports enterprise-grade scalability along with customer case examples.
- **Integration & Interoperability**: The ability to offer product and technology platforms supporting integration with multiple best-of-breed technologies, providing out-of-the-box integrations, and open API support and services.
- **Vision & Roadmap**: Evaluation of the vendor's product strategy and roadmap with the analysis of key planned enhancements to offer superior products/technology and improve the customer ownership experience.

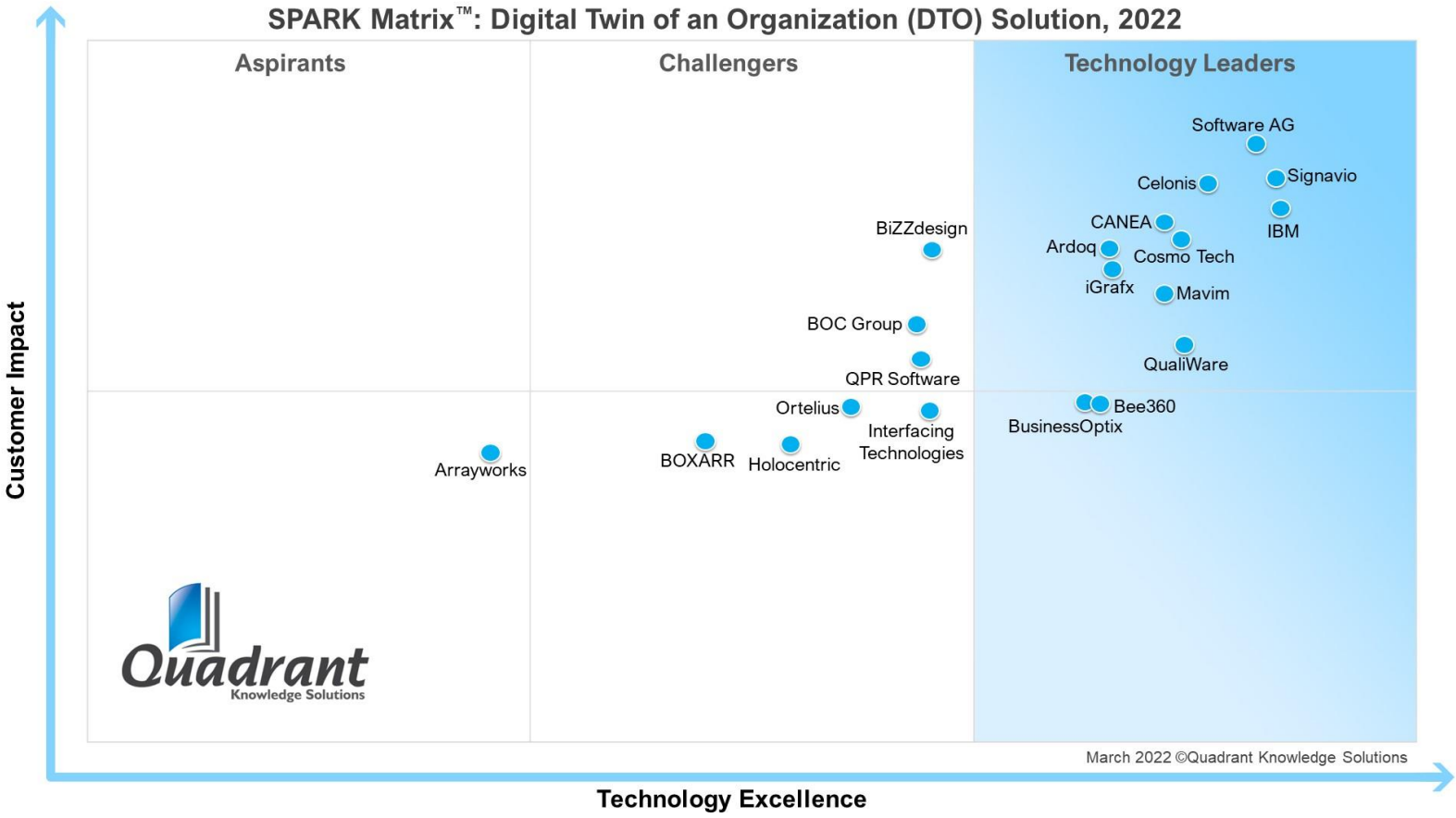
Evaluation Criteria: Customer Impact

- **Product Strategy & Performance**: Evaluation of multiple aspects of product strategy and performance in terms of product availability, price to performance ratio, excellence in GTM strategy, and other product-specific parameters.
- **Market Presence**: The ability to demonstrate revenue, client base, and market growth along with a presence in various geographical regions and industry verticals.
- **Proven Record**: Evaluation of the existing client base from SMB, mid-market and large enterprise segment, growth rate, and analysis of the customer case studies.
- **Ease of Deployment & Use**: The ability to provide superior deployment experience to clients supporting flexible deployment or demonstrate superior purchase, implementation, and usage experience. Additionally, vendors' products are analyzed to offer a user-friendly UI and ownership experience.
- **Customer Service Excellence**: The ability to demonstrate vendors capability to provide a range of professional services from consulting, training, and support. Additionally, the company's service partner strategy or system integration capability across geographical regions is also considered.
- **Unique Value Proposition**: The ability to demonstrate unique differentiators driven by ongoing industry trends, industry convergence, technology innovation, and such others.

SPARK Matrix™: Digital Twin of an Organization (DTO) Solution

Strategic Performance Assessment and Ranking

Figure: 2022 SPARK Matrix™
(Strategic Performance Assessment and Ranking)
Digital Twin of an Organization (DTO) Solution Market



Vendor Profiles

Following are the profiles of the leading DTO solution vendors with a global impact. The following vendor profiles are written based on the information provided by the vendor's executives as part of the research process. Quadrant research team has also referred to the company's website, whitepapers, blogs, and other sources for writing the profile. A detailed vendor profile and analysis of all the vendors, along with various competitive scenarios, are available as a custom research deliverable to our clients. Users are advised to directly speak to respective vendors for a more comprehensive understanding of their technology capabilities. Users are advised to consult Quadrant Knowledge Solutions before making any purchase decisions, regarding DTO technology and vendor selection based on research findings included in this research service.

QualiWare

URL: www.qualiware.com

Founded in 1991 and headquartered in Denmark, QualiWare is a global business modeling software and consultancy provider. QualiWare offers an Enterprise Architecture and Business Management tool known as QualiWare X for organizations to evolve and transform through smart management and collaboration. The company's DTO solution offers various key features and functionalities which include full enterprise architecture coverage, full BPM support, capability management, enterprise investment, strategy to execution, collaboration across the entire enterprise, advanced analytics, social analytics, AI - picture to model & text to model, 3D Visualizer, integration external performance data, and metamodel to support API development.

The company offers full enterprise architecture coverage that enables users to architect the digital twin of an organization to a very granular level for creating a true representation of reality regardless of the point of view. It also supports BPM and other related notations for processes to be structured and defined to a level that best suits the digital twin requirements of an organization. It is also coupled with the company's governance & dashboarding/monitoring platform to calculate critical paths and compare different process revisions against each other, organizations can quickly establish a graphical representation of their digital twin that is supported by operational monitoring, reporting, and metrics.

The company is also offering enterprise investment capability so that the goals are transformed into outcomes through its standard change portfolio which considers the investment process, EA, investment strategy, and management of portfolio performance. The strategy to execution feature is achieved through out-of-the-box frameworks, templates, and models that provide logical guidance depending on the requirement and maturity of an organization. The company also supports collaboration across the entire enterprise to effectively leverage the potential that digital twin offers, it is essential that stakeholders can react rapidly to either address a process (or technical) deficiency or take advantage of an opportunity.

The company's advanced analytics and reporting services offer a holistic view for visualizing dependencies within the digital twin of the organization. QualiWare X offers one unified and consistent overview of organizational data and insights through integration capabilities. Furthermore, it enables users to keep track of usage statistics through powerful visualizations, leading to proactive management through simplifying the analysis of complex data. Additionally, the social analytics capability enables management to analyze and report on usage and engagement metrics of the digital twin and operational environment. The AI - picture to model & text to model enables users to translate pictures into graphical models or text to graphical models.

The company's 3D visualizer enables a practical 3D graphical representation of a model

to be visualized, analyzed, and enhanced through a 3-dimensional representation instead of viewing individual models based on their respective templates. The company's analytics engine can seamlessly integrate with external data sources to enable a single view of performance data. It also leverages performance data of a digital twin effectively to quickly predict a potential failure or service impact based on trend analysis. The company supports open APIs based on RESTful web services to integrate with third-party systems both to read and write. Additionally, QualiWare provides a generic table interface for basic connections and import/export of CSV/Excel or table-based data. OLEDB and ODBC connectors allow QualiWare X to interrogate and integrate data from external databases.

Analyst Perspective

Following is the analysis of QualiWare's capabilities in the digital twin of an organization solution market:

- QualiWare offers global business modeling software that helps organizations with their enterprise architecture, quality management, business process management, and optimization initiatives. QualiWare X with its advanced features enables the business to integrated smart collaboration, supporting efficient use of the surrounding business ecosystem, digital twins, and successful customer journeys to improve business performance and efficiency.

- Some of the key differentiators of the company include full architecture viewpoint coverage like Business Architecture, Data Architecture, Application Architecture, Technology Architecture, and Integration Architecture at the conceptual, logical, and physical layers which can be combined with other metamodels, frameworks, and pre-defined accelerated processes to provide an end-to-end digital twin capability. It also supports strategic transformation planning and implementation support - from strategy to execution.

- Additionally, the platform is developed with collaboration as a core feature like governance workflows & social behavior analytics. It also offers extensive relational capabilities to transform a single object or model into a valuable information asset that can demonstrate its relevance, value, and contribution to the delivery of business services. The platform's digital twin is supported by the interface between physical and logical architectures to gather performance data and other relevant feedback from the operating environment to enrich the reporting and operating capabilities of processes and other models.

- The company holds a strong customer base including some of the leading brands across industry verticals such as government & public sector, energy & utilities, financial services, manufacturing, healthcare & life sciences, and many others. In terms of geographical presence, QualiWare has a major presence in Europe, followed by the American region. It also has a significant presence in the Middle East and Africa and Asia Pacific region. QualiWare supports various use cases like operating model approach, digitalization, communication & collaboration, business transformation, GRC, strategy to execution, and EA modeling.

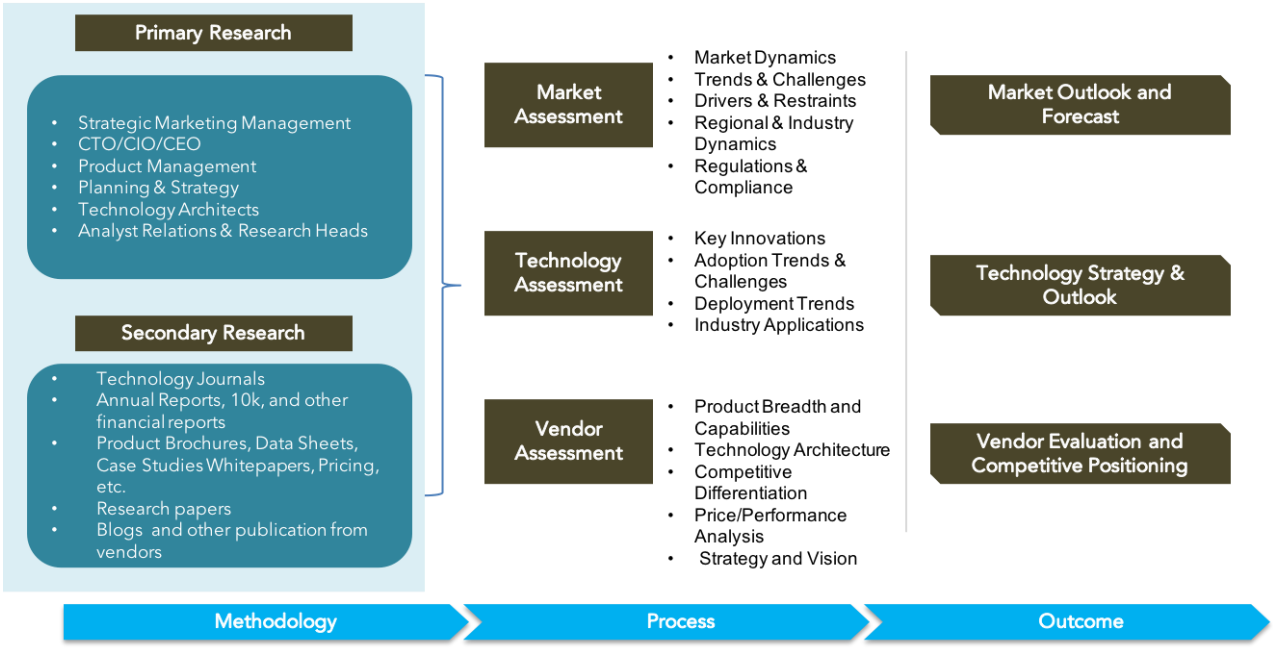
- The primary challenge for QualiWare includes creating market awareness and educating the consumers for investing in DTO solutions, and the growing competition from both emerging and established vendors in this space. However, the company, with its sophisticated technology platform, comprehensive functional capabilities, and strong customer value proposition, is well-positioned to expand its market share in the global DTO solution market.

- In terms of technological future roadmap strategies, the company is continuing to focus on offering reverse and forward engineering for automation and performance measurements of digitalized businesses to create a continuous feedback loop for improvement. They are also increasing the support and methodology for collaboration - co-creation and knowledge sharing using different types of client environments like browser, tablet, phone, watch, glasses, etc. The company is also focusing on increasing analysis and 3D visualization capabilities that will document a user's journey through content and analyses to provide a roadmap for decision making.

- Additionally, the company is planning to expand application chaining to support a federation of virtualized content across multiple systems in the ecosystem, like making SAP processes in SAP Solution Manager available through QualiWare X to enable a coherent architecture across discrete systems. It is also enhancing license sharing between servers, SCIM standard supported, new dashboards, relationship-filter and clustering analysis in 3d visualization, cloud architecture metamodel, GOWL metamodel, and further support for OpenAPI files.

Research Methodologies

Quadrant Knowledge Solutions uses a comprehensive approach to conduct global market outlook research for various technologies. Quadrant's research approach provides our analysts with the most effective framework to identify market and technology trends and helps in formulating meaningful growth strategies for our clients. All the sections of our research report are prepared with a considerable amount of time and thought process before moving on to the next step. Following is the brief description of the major sections of our research methodologies.



Secondary Research

Following are the major sources of information for conducting secondary research:

Quadrant's Internal Database

Quadrant Knowledge Solutions maintains a proprietary database in several technology marketplaces. This database provides our analyst with an adequate foundation to kick-start the research project. This database includes information from the following sources:

- Annual reports and other financial reports
- Industry participant lists
- Published secondary data on companies and their products
- Database of market sizes and forecast data for different market segments
- Major market and technology trends

Literature Research

Quadrant Knowledge Solutions leverages on several magazine subscriptions and other publications that cover the wide range of subjects related to technology research. We also use the extensive library of directories and Journals on various technology domains. Our analysts use blog posts, whitepaper, case studies, and other literature published by major technology vendors, online experts, and industry news publications.

Inputs from Industry Participants

Quadrant analysts collect relevant documents such as whitepaper, brochures, case studies, price lists, data sheet, and other reports from all major industry participants.

Primary Research

Quadrant analysts use a two-step process for conducting primary research that helps us in capturing meaningful and most accurate market information. Below is the two-step process of our primary research:

Market Estimation: Based on the top-down and bottom-up approach, our analyst analyses all industry participants to estimate their business in the technology market for various market segments. We also seek information and verification of client business performance as part of our primary research interviews or through a detailed market questionnaire. The Quadrant research team conducts a detailed analysis of the comments and inputs provided by the industry participants.

Client Interview: Quadrant analyst team conducts a detailed telephonic interview of all major industry participants to get their perspectives of the current and future market dynamics. Our analyst also gets their first-hand experience with the vendor's product demo to understand their technology capabilities, user experience, product features, and other aspects. Based on the requirements, Quadrant analysts interview with more than one person from each of the market participants to verify the accuracy of the information provided. We typically engage with client personnel in one of the following functions:

- Strategic Marketing Management
- Product Management
- Product Planning
- Planning & Strategy

Feedback from Channel Partners and End Users

Quadrant research team research with various sales channel partners, including distributors, system integrators, and consultants to understand the detailed perspective of the market. Our analysts also get feedback from end-users from multiple industries and geographical regions to understand key issues, technology trends, and supplier capabilities in the technology market.

Data Analysis: Market Forecast & Competition Analysis

Quadrant's analysts' team gathers all the necessary information from secondary research and primary research to a computer database. These databases are then analyzed, verified, and cross-tabulated in numerous ways to get the right picture of the overall market and its segments. After analyzing all the market data, industry trends, market trends, technology trends, and key issues, we prepare preliminary market forecasts. This preliminary market forecast is tested against several market scenarios, economic scenario, industry trends, and economic dynamics. Finally, the analyst team arrives at the most accurate forecast scenario for the overall market and its segments.

In addition to market forecasts, our team conducts a detailed review of industry participants to prepare competitive landscape and market positioning analysis for the overall market as well as for various market segments.

SPARK Matrix: Strategic Performance Assessment and Ranking

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Final Report Preparation

After finalization of market analysis and forecasts, our analyst prepares necessary graphs, charts, and table to get further insights and preparation of the final research report. Our final research report includes information including market forecast; competitive analysis; major market & technology trends; market drivers; vendor profiles, and such others.