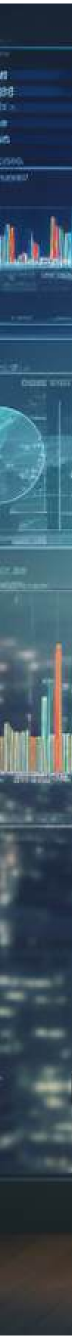
Intelligent Manufacturing with Real-Time Decisions

Stratola
Say hello to strategy

VOLT ACTIVE DATA

RTInsights Research

Contents



Introduction

Overview of Intelligent Manufacturing

Intelligent manufacturing (or Smart Manufacturing) has become a cornerstone in modern industry, combining advanced technologies and real-time data analytics to enhance and optimize production processes and outcomes. This approach integrates the Internet of Things (IoT), artificial intelligence (AI), and machine learning (ML) to create a connected ecosystem where data flows seamlessly across various manufacturing stages. The essence of intelligent manufacturing lies in its ability to make informed, real-time decisions that drive efficiency, quality, and overall productivity.

Real-time decision-making is crucial in this context. Traditional manufacturing methods often rely on delayed data, which can lead to inefficiencies and suboptimal outcomes. In contrast, intelligent manufacturing leverages immediate data access to monitor, analyze, and act on critical parameters instantaneously. This proactive approach not only reduces downtime and improves production quality but also enables manufacturers to respond swiftly to changing conditions and demands.

Industry 4.0 was announced in 2011 and we are already at the beginning of Industry 5.0. Yet, the average manufacturer suffers from at least 20 downtime incidents a month[1]. The cost of downtime can be as high as $2 million per hour in some industries such as automotive manufacturing. Intelligent manufacturing systems are purposely designed to avert such unplanned downtimes by implementing preventive maintenance effectively. However, in order for such systems to work effectively, the right data points from the IT (Information Technology) and OT (Operational Technology) systems must be made available for real-time decision-making.

Volt Active Data plays a pivotal role in this approach by providing a robust data platform for real-time decision-making. Its in-built ability to support data immediacy at scale enables manufacturers to harness the full potential of their data, ensuring they remain competitive in an ever-evolving industry. By having Volt simplify their data architectures, manufacturers can achieve significant cost savings, improved efficiency, and higher product quality, positioning themselves at the forefront of intelligent manufacturing.

1 https://blog.siemens.com/2023/04/the-true-cost-of-downtime/

Chapter 1: Understanding the Manufacturing Metrics

The Importance of Real-time Data in Manufacturing

Predictive Maintenance

By analyzing real-time sensor data from machines and equipment, manufacturers can predict when failures or breakdowns are likely to occur. This enables predictive maintenance to be performed at the optimal time, reducing unplanned downtime and maintenance costs. Predictive analytics can forecast with high accuracy the likelihood and timing of failures.

Quality Control and Early Defect Detection

Real-time data from cameras, sensors, and other sources can be analyzed using AI and machine learning to monitor 100% of products for defects. This allows manufacturers to catch defects that human inspectors might miss, improving product quality.

Supply Chain Optimization and Demand Forecasting

Manufacturers can leverage real-time data from across the supply chain - suppliers, logistics, sales, customer service, etc. - to optimize production, inventory management, and distribution. AI can analyze this data to forecast demand accurately, streamline processes, reduce costs, and improve delivery times.

Autonomous Robots and Smart Manufacturing

With real-time data insights, manufacturing processes can be automated and optimized using AI-controlled robots and smart equipment. This includes autonomous robots for material handling, AI adjusting machine settings, and automated ordering from suppliers.

Intelligent Inventory Management

By collecting and analyzing real-time inventory data, AI systems can provide accurate inventory levels, eliminate the need for manual counts, and optimize stock levels to minimize costs.

Key Performance Indicators (KPIs) in Manufacturing

The right manufacturing metrics can help you understand performance, process integrity, utilization, and machine efficiency in manufacturing.

Benefits of monitoring the right KPIs include

- New opportunities to design predictive maintenance strategies
- Gaining insights into production efficiency to enable continuous process improvement and optimization
- Reducing waste rejects, and other quality concerns
- Meeting business objectives and goals

Improve Efficiency

- Downtime - A very fundamental manufacturing KPI that measures the number of hours a machine has been down for either planned or unplanned maintenance
- Throughput - Amount of product produced over a given time period
- Capacity Utilization - Percentage of total manufacturing capacity being utilized
- Overall Equipment Effectiveness (OEE) - Multiplier of Availability, Performance, and Quality to measure equipment effectiveness
- Schedule or Production Attainment - Percentage of target production level achieved within scheduled time

Improve Customer Experience and Responsiveness

- On-Time Delivery to Commit - Percentage of products delivered on the committed schedule to customers
- Total Cycle Time - Time taken to produce one unit, from start to finish
- Time to Make Changeovers - Time required to switch production from one product to another

Improve Quality

- Yield - Percentage of products manufactured correctly the first time without rework or scrap
- Customer Rejects/Returns - Number of products rejected or returned by customers due to quality issues
- Supplier's Quality Incoming - Percentage of quality materials received from suppliers

Reduce Costs

- Cost Per Unit (CPU) - Total cost of manufacturing divided by the number of units produced
- Return on Assets - Profitability of a company's assets in generating revenue

Other important metrics include Scrap Rate, First-Pass Yield, Cost of Downtime, and Inventory Turns. Tracking these metrics helps manufacturers improve customer experience, quality, efficiency, and profitability while reducing costs and waste.

Challenges in Monitoring and Maintaining KPIs

Some of the key challenges that make it difficult to monitor and manage such manufacturing KPIs are -

- **Data collection -** Machine data has to be harvested from various types of sensors and IoT devices across the manufacturing floor. They all support a diverse range of protocols and data formats.
- **Streaming data management -** Real-time data streams from numerous sensors and machines need to be processed and analyzed instantaneously to provide actionable insights. This real-time requirement adds a layer of complexity to data management and necessitates robust and scalable solutions.
- **Integration of IT and OT data -** Another significant challenge is the integration of historical data with real-time data streams. Historical data provides context and trends that are crucial for accurate decision-making. Without this integration, the real-time data alone may not offer a complete picture, leading to suboptimal decisions. However, merging these data types requires advanced data processing capabilities and innovative data architectures like Unified Name Spaces (UNS)[2].
- **Keeping ML models afresh -** ML models need to be trained on large datasets, incorporating both historical and real-time data. Once deployed, these models must be continuously updated and refined to adapt to changing conditions and new data inputs. The real-time application of these models requires significant computational power and efficient data handling to ensure timely and accurate predictions.
- **Complexity of Operations -** Manufacturing processes often involve complex steps and stages, each needing to be measured and evaluated separately. Most manufacturers also implement a Digital Twin to measure and optimize their processes. This will require a holistic view across the data silos, adding to the set of challenges. This complexity can also make it difficult to create simple, easily understood KPIs that capture all aspects of the operation.
- **Interdependent processes -** Many manufacturing processes are interconnected and interdependent. Changes in one process can have ripple effects on others. Therefore, KPIs need to be carefully designed to reflect these interdependencies and ensure improvement in one area does not negatively impact another.
- **Balancing Efficiency and Quality -** It can be challenging to create KPIs that balance efficiency and speed with the need for high-quality output. For example, a KPI focused on reducing production time might inadvertently lead to more mistakes and lower quality.
- **Continuous Improvement -** In a manufacturing setting, processes continually change and improve. Therefore, KPIs must also be continuously evaluated and revised, adding complexity to tracking them consistently over time.

The sheer volume of data generated in manufacturing environments can overwhelm traditional data processing systems. It is not enough that you have effective data management strategies, including data storage, access, and processing to handle this volume. It is important that you are also working on the latest and most up-to-date version of the data. Business decisions based on outdated or delayed data can lead to inefficiencies and increased costs. Therefore, achieving low-latency data processing and analysis is critical to make the best decisions.

2 https://www.hivemq.com/blog/what-is-unified-namespace-uns-iiot-industry-40/

Chapter 2: The Role of Data in Manufacturing Operations

Data Diversity in Manufacturing Processes

Data is the lifeblood of modern manufacturing operations, driving insights and decisions that enhance efficiency and productivity. In manufacturing, data can be broadly categorized into real-time streaming machine data and historical enterprise data. Both types of data are essential, each providing unique value to the manufacturing process.

Real-time streaming machine data is generated by sensors and devices embedded in manufacturing equipment. This data includes information on machine performance, environmental conditions, and production metrics. Real-time data is crucial for immediate decision-making, enabling manufacturers to monitor operations continuously and respond swiftly to any anomalies or issues. Sources of real-time data include IoT devices, PLCs (Programmable Logic Controllers), and SCADA (Supervisory Control and Data Acquisition) systems.

Historical enterprise data, on the other hand, encompasses past records and datasets that provide a comprehensive view of manufacturing operations over time. This data includes production logs, maintenance records, quality reports, and inventory data. Historical data is vital for trend analysis, predictive maintenance, and long-term planning. It offers context that enriches real-time data, allowing for more accurate predictions and better-informed decisions.

The integration of IT (Information Technology) and OT (Operational Technology) data streams forms the foundation of intelligent manufacturing. IT data typically includes enterprise-level information, such as ERP (Enterprise Resource Planning) and CRM (Customer Relationship Management) data, while OT data pertains to operational metrics from the shop floor. By combining these data types, manufacturers gain a holistic view of their operations, enabling more comprehensive analysis and decision-making.

Examples of types of data across manufacturing

Operational Data

- Machine data (run times, downtimes, output, alarms, energy consumption, etc.)
- Order data (ordered quantities, order processing times, order status)
- Personnel data (time worked, quantities produced by personnel)
- Material data (inventory levels, material consumption, material stocking)
- Tool data (tool usage, tool maintenance, tool cycles)

Quality Data

- Defect rates
- Scrap rates
- Customer feedback/rejects
- Yield data (first-pass yield, rework rates)

Time-Series Data

- Sensor data from machines (temperature, pressure, speed, etc.) indexed by time

Master/Reference Data

- Product data (BOMs, routings, recipes, work instructions)
- Resource data (machines, work centers, shifts)
- Supplier/vendor data

Supply Chain Data

- Supplier lead times
- Inventory levels
- Shipping data

Customer Data

- Customer orders
- Customer preferences
- Customer feedback

Other Data Types

- Process data (cycle times, throughput, OEE)
- Maintenance data (maintenance logs, records)
- Semi-structured data (XML, JSON files from systems)
- Unstructured data (manuals, images, audio/video files)

Data Collection and Management

Efficient data collection and management are critical components of intelligent manufacturing. The ability to gather, process, and utilize data effectively determines the success of real-time decision-making and overall operational efficiency. Several techniques and technologies play a crucial role in this process.

Data collection in manufacturing involves capturing information from a wide array of sources, including sensors, machines, and enterprise systems. Advanced technologies such as IoT devices, edge computing, and automated data acquisition systems facilitate this process. These technologies ensure continuous data flow, enabling real-time monitoring and control of manufacturing processes.

Once collected, the data must be processed and stored in a manner that ensures accuracy, consistency, and reliability. Data accuracy is paramount, as erroneous data can lead to incorrect insights and decisions. Consistency across different data sources is also essential to ensure seamless integration and analysis. The reliability of data storage solutions is crucial to prevent data loss and ensure availability when needed.

Challenges in data management include handling the sheer volume of data generated in manufacturing environments while ensuring data security, and maintaining data sovereignty and integrity. Data storage solutions, such as data lakes and warehouses, provide scalable and secure repositories for vast amounts of data. These solutions support efficient data storage and access but they are far better suited for analytical needs like business intelligence and machine learning.

A key factor to be considered in data management is how the relevant data can be accessed or queried with millisecond latencies. If the data retrieval mechanisms induce latency, they can hinder real-time decision-making directly. This might warrant a different approach in the data architecture like UNS or a different data storage mechanism like leveraging main memory than the traditional hard disks. Processing the data at the data layer itself instead of waiting for an application to query and retrieve the data on a scheduled basis can largely reduce ingress and egress costs as well.

Chapter 3: Data Immediacy is Critical to Real-Time Decision-Making

Understanding Data Immediacy

Data immediacy refers to the availability and accessibility of data at the precise moment it is needed for decision-making. In the context of manufacturing, immediate access to data is crucial for making informed decisions that enhance equipment efficiency, reduce machine downtime, and improve product quality. The importance of data immediacy cannot be overstated, as delayed data can lead to missed opportunities, increased costs, and reduced competitiveness.

Immediate data access influences decision-making processes by providing real-time insights into manufacturing operations. For instance, if a machine exhibits signs of potential failure, immediate access to performance data allows for swift intervention, preventing unplanned downtime and associated costs. Similarly, real-time quality data enables prompt and possibly automated adjustments to production processes, ensuring that products meet the required standards and fewer defects are introduced.

Data immediacy does not relate to access to just streaming data alone. It also includes all the additional data points (e.g. historical data, system information, threshold data) that need to be considered along with the streaming data to make those split-second real-time decisions where even a latency of a couple of milliseconds can cost millions of dollars.

Critical manufacturing decisions often hinge on the availability of immediate data. Examples include predictive maintenance, where real-time data is used to anticipate equipment failures; quality control, where real-time monitoring ensures products meet specifications; and process optimization, where continuous data streams are analyzed to enhance efficiency. Without immediate access to relevant data, these decisions would be based on outdated information, leading to suboptimal or even incorrect outcomes.

Overcoming Challenges Related to Data Immediacy

Achieving data immediacy in manufacturing is not without challenges. Common obstacles include latency, data integration, and scalability. Addressing these challenges is essential to ensure that data is available when needed for real-time decision-making.

Latency is a significant challenge in achieving data immediacy. Delays in data processing and transmission can hinder timely decision-making and reduce the effectiveness of real-time insights. To overcome latency, manufacturers can leverage advanced data processing frameworks and technologies, such as in-memory computing, UNS, and low-latency networks. These technologies minimize delays and ensure that data is processed and delivered instantaneously.

Data integration is another challenge. Manufacturing environments generate data from diverse sources, including sensors, machines, and enterprise systems. Integrating this data in real-time is crucial for comprehensive analysis and decision-making. Advanced data integration tools and platforms facilitate seamless data flow and integration, ensuring that data from different sources is unified and available for real-time analysis.

Scalability is also a critical consideration. Manufacturing operations generate vast amounts of data, and the ability to scale data processing and storage solutions is essential to handle this influx. Scalable data architectures, such as cloud-based solutions and distributed computing frameworks, support the efficient management of large data volumes, ensuring that data immediacy is maintained even as data grows.

Real-Time Data Processing and Analysis

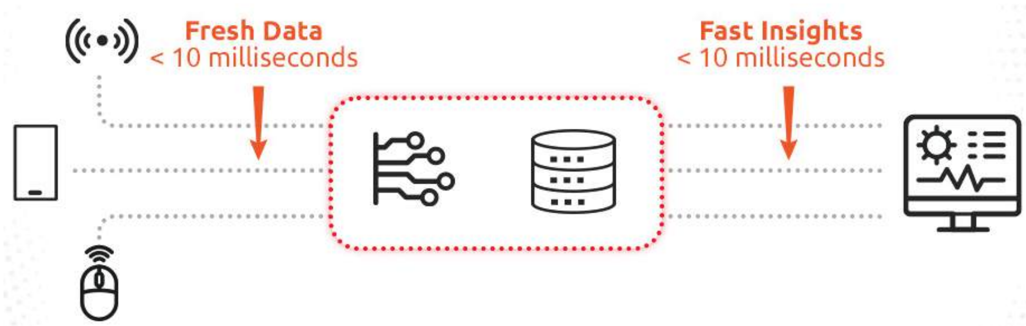
Real-time data processing and analysis are fundamental to achieving data immediacy in manufacturing. These processes involve the continuous collection, transformation, and analysis of data as it is generated, enabling immediate insights and actions. Several techniques and technologies facilitate real-time data processing, ensuring that manufacturers can respond swiftly to changing conditions and demands.

Stream processing is a key technique used in real-time data analysis. It involves the continuous processing of data streams, allowing for instant insights and decision-making. Data platforms that support stream processing can handle the ingestion, processing, and analysis of data in real-time. These platforms enable manufacturers to monitor operations continuously and detect anomalies or trends as they occur.

Given the diverse set of data sources across IT and OT systems, manufacturing companies need to design data architectures that can handle all types of data beyond just streaming data. Traditional data architectures often involve complex layers of data storage and processing, leading to latency and delays. For example, a simple lookup of master data to correlate with some incoming streaming data can cause significant query time in such dated systems. A more modern yet simplified data architecture could leverage a memory-first or an in-memory data model to store, process, and query data directly in memory, reducing latency and enhancing speed. This approach ensures that data is immediately available for analysis and decision-making, with hardly any latency at all.

In-memory data architectures have key benefits such as -

- **Faster Data Access and Processing -** In-memory databases store data in the computer's main memory (RAM) instead of disk storage. This allows for much faster data access and processing compared to traditional disk-based databases. Retrieving data from memory is orders of magnitude quicker than reading from disk.
- **Real-Time Analytics and Insights -** By keeping data in memory, in-memory databases can analyze live transactional data and provide real-time operational reporting and insights. This is valuable for applications requiring instantaneous decision-making based on the latest data.
- **Support for larger data volumes -** With the decreasing cost of RAM chips and advances in distributed computing, in-memory databases that can scale out can work with large datasets (in terabytes) entirely in memory. This removes I/O bottlenecks associated with reading such large datasets from disk.
- **Low latency performance and low cost -** With data processing happening at the data layer itself and not in the application layer, queries and access execute at highly performant levels with very low latency. And because of low data movement across layers, the ingress and egress costs can also be very low.



Chapter 4: Real-Time Decisioning with Volt Active Data

Overview of Volt Active Data Platform

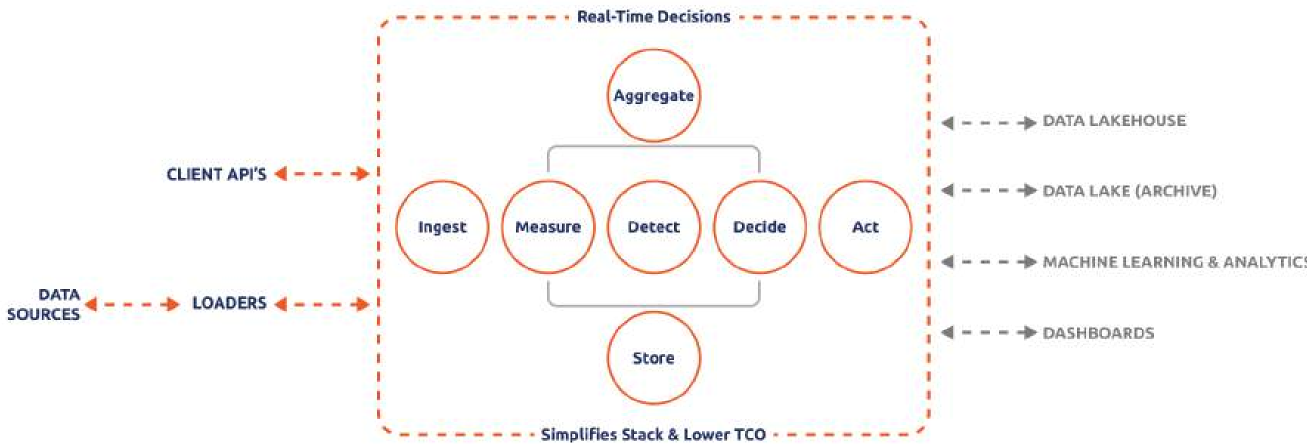
Volt Active Data is a real-time decisioning platform for all your enterprise data immediacy needs and a simplified data architecture. Store, process and capture high volumes of data in real-time with full assurance of data consistency and transactionality. Volt processes terabytes of data from multiple data stores and real-time streams with ease, speed, and low latency. Leverage Volt's limitless scalability to ensure the high availability of your data to make those critical business decisions in real-time always.

Volt Active Data offers low-cost, millisecond query performances with its main memory architecture. You can future-proof your data architecture with Volt Active Data as it reduces IT costs and increases operational efficiencies by offering an always-on deployment with its high availability and disaster recovery capabilities. Volt Active Data is also very developer-friendly as it supports SQL and stored procedures in Java, making them execute in memory with very low latency, as against moving the data over the network to a separate processing layer.

The platform supports real-time decision-making by enabling continuous data collection, processing, and analysis. It integrates data from diverse sources, including IoT devices, sensors, and enterprise systems, ensuring a unified view of manufacturing operations. Volt Active Data's in-memory data models and stream processing capabilities ensure low-latency data processing, allowing event-driven decision-making.

Some of the key differentiators that make Volt Active Data a truly unique real-time decisioning platform are -

- **Main Memory Architecture -** Volt Active Data operates entirely in-memory, allowing for extremely fast data access and processing speeds, which is crucial for real-time applications. This also simplifies the data architecture by providing a single hub from where all your enterprise data is made available.
- **High Throughput and Low Latency -** Volt Active Data is optimized for high throughput and low latency, enabling real-time decision-making and analytics on large datasets. Volt is capable of handling terabytes of information and still making timely decisions in milliseconds.
- **Limitless Scalability -** Volt Active Data can scale horizontally by adding more nodes to the cluster, allowing it to handle increasing workloads and maintain performance. This also allows for HA and supports high fault tolerance.
- **Integrated Stream Processing -** Volt Active Data integrates with streaming data sources, enabling real-time analysis and processing of data streams. With a main-memory architecture where all your relevant data resides in a central place, Volt can bring in context and correlation on streaming data as well to offer real-time business insights.



Conclusion

Future of Intelligent Manufacturing

The future of intelligent manufacturing is shaped by emerging trends and technologies that promise to revolutionize production processes and outcomes. Real-time decision-making will continue to play a pivotal role in this evolution, driving efficiency, quality, and overall productivity.

With the advent of Industry 5.0, Industrial Internet of Things (IIoT), new-age data architectures, and advanced analytics, manufacturing operations are due for an overhaul. IIoT enables seamless connectivity and data exchange between machines and systems, providing real-time insights and enhancing operational efficiency. Such advanced systems will further enhance predictive maintenance, quality control, and process optimization, enabling manufacturers to make informed decisions based on real-time data. Data architectures, that include main-memory computing, will also solve for the elimination of data silos across the manufacturing floor, bring near-edge data more closer, and enable a more unified process view of all the operational data/insights needed for business decisions.

The evolving role of real-time decision-making in future manufacturing processes is marked by increased reliance on immediate data access and advanced analytics. Manufacturers will need to adopt robust data platforms that support real-time data integration, processing, and analysis. Volt Active Data is at the forefront of this transformation, providing the tools and capabilities needed to achieve real-time decision-making and operational excellence.

Predictions for the future of intelligent manufacturing highlight the potential impact of new innovations. Autonomous production lines, driven by AI and robotics, will operate with minimal human intervention, enhancing precision and speed. Digital twins, virtual replicas of physical assets, will enable real-time simulation and optimization of manufacturing processes. These innovations will drive continuous improvement, enabling manufacturers to achieve higher levels of efficiency, quality, and productivity. But, all these innovations will also depend on a solid data architecture underneath them.

Volt Active Data's vision for the future of manufacturing is centered on supporting these innovations and driving operational excellence. The platform's advanced capabilities ensure that manufacturers can harness the full potential of their data, enabling real-time decision-making and continuous improvement. By leveraging Volt Active Data, manufacturers can stay ahead of the curve and maintain a competitive edge in an ever-evolving industry.

In conclusion, the future of intelligent manufacturing is bright, with data immediacy and real-time decision-making playing a central role in driving operational excellence. Volt Active Data provides the foundation for this transformation, enabling manufacturers to achieve significant improvements in efficiency, quality, and overall performance. By embracing these trends and leveraging advanced data platforms, manufacturers can position themselves at the forefront of intelligent manufacturing

Dinesh Chandrasekhar has been a data management veteran, thought leader, and data practitioner for 30+ years. As the chief analyst and founder of Stratola, he speaks and writes on the latest topics in data-in-motion, real-time analytics, IoT, Observability, GenAI, and more. Follow his work at www.stratola.com.

Stratola is a business strategy consulting and full-stack marketing services firm for companies that need help with their product messaging, positioning, GTM strategies, sales enablement, pricing, and business development. With deep expertise in data management, analytics, data-in-motion, observability, and AI, Stratola successfully enables its clients with market penetration, category creation, thought leadership, product launches, customer acquisition, and overall growth. We are the business growth acceleration experts. Learn more at www.stratola.com.

RTInsights Research is the definitive voice in the evolving landscape of real-time insights and its transformative business impact of better decision making. We stand as a cornerstone for CxOs, operations leaders, and forward-thinking data and IT professionals, providing them with on-the-pulse industry trend analysis of emerging technologies that are leading towards business disruption.

The **RTInsights Research** Team has deep expertise across the real-time ecosystem, and how leading companies are implementing emerging technologies to create value. Our team has published reports and delivered webinars that inform business and technology strategy in areas such as Edge computing and IoT, Real-Time and Advanced Analytics, and the deployment of AI and Generative AI in enterprises. In addition, the RTInsights Research team has deep expertise on the supporting infrastructure that enables real-time insights, including Cloud and Hybrid Cloud Data Management, Machine Learning, DataOps and AIOps.

RTInsights Research provides business and technology leaders with actionable insights, helping to drive growth through emerging technologies.