

Dell APEX Private Cloud for Manufacturing Edge with Litmus

September 2023

H19739

White Paper

Abstract

This white paper provides a high-level technical overview of the Dell APEX private cloud for manufacturing edge with Litmus, a validated solution that centrally manages industrial edge devices, data, and applications. The solution is built in partnership with Litmus to accelerate smart manufacturing outcomes. This document should be used as a post-deployment reference guide.

Dell Technologies Solutions

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Chapter 1 Introduction

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Introduction

Executive summary

This white paper provides a high-level technical overview for Dell APEX Private Cloud for the Manufacturing Edge with Litmus, a validated solution that centrally manages industrial edge devices, data, and applications. The solution is built in partnership with Litmus to accelerate smart manufacturing outcomes.

Dell APEX Private Cloud provides the as-a-subscription flexibility and value to limit capital expenditures. Built on the industry-leading Dell VxRail hyperconverged technology, Dell APEX Private Cloud delivers scalable compute, storage, and networking resources to the manufacturing edge with predictable monthly pricing for 1- to 5- year terms. To simplify operations and life cycle automation, use the Dell APEX console to select the workload your environment requires.

This Dell Validated Design (DVD) solution centrally manages and orchestrates industrial edge devices, data, and applications, from the factory floor to the enterprise cloud. It is built in partnership with Litmus to accelerate smart manufacturing outcomes improving Overall Equipment Effectiveness (OEE), predictive maintenance, product quality, yield optimization, and more, using available data.

Document purpose

This white paper helps potential users of the solution understand the key technical elements that consist of the solution and describes potential manufacturing use cases that the solution may be used to deliver.

Note: This document is adapted from the [Dell Technologies Validated Design for Manufacturing Edge with Litmus - TechBook](#)

Audience

The document is for customers planning to implement the DVD for Manufacturing Edge with Litmus, including the following:

- **Information technology (IT) teams** – IT operations, administrators, solution architects, application teams
- **Operational technology (OT) teams** – manufacturing operations, engineering, SME teams
- **C-suite level executives** – chief digital officers, chief technology officers
- System integrators and channel partners

Revisions

Date	Part number or revision	Description
September 2023	H19739	Initial Release

We value your feedback

Dell Technologies and the authors of this document welcome your feedback on the solution and the solution documentation. Contact the Dell Technologies Solutions team by [email](#).

Note: For a detailed technical documentation for deployment, planning, and design, see the [Dell Validated Design for Manufacturing Edge - Design Guide with Litmus](#).

Chapter 2 Dell Technologies and Litmus

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Solution positioning

The [DVD for Manufacturing Edge with Litmus](#) solution simplifies the path to smart manufacturing outcomes by:

- Streamlining deployment and integration from edge devices to cloud applications for faster time to value
- Powering live insights for OT, IT, and businesses for better, faster decision making
- Ensuring resiliency and security at the global scale while minimizing disruptions

This solution offers a scalable, unified technology architecture that is built on an award-winning hyperconverged infrastructure—Dell APEX Private Cloud—that works with edge solutions validated by Litmus and Dell Technologies.

The following figure offers an overview of the DVD for Manufacturing Edge with Litmus solution:

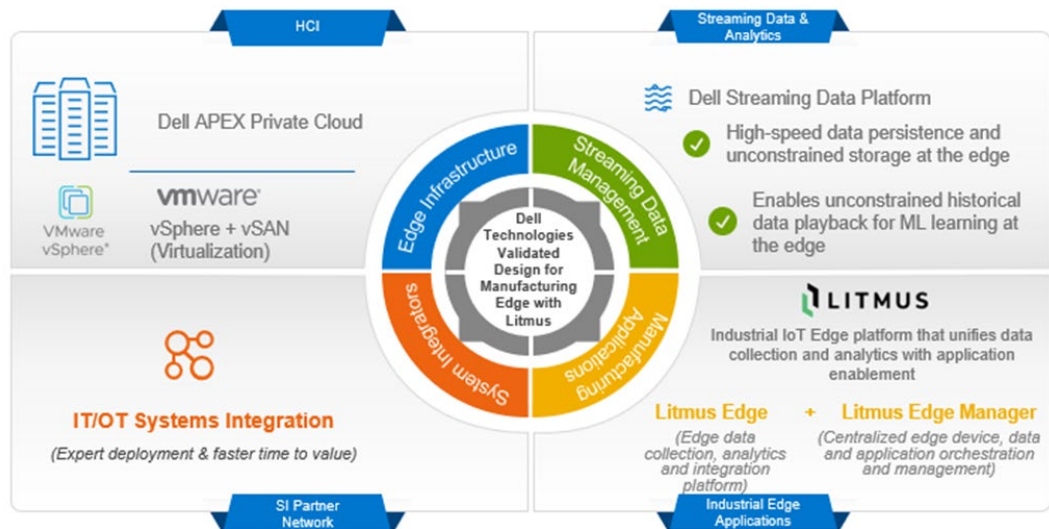


Figure 1. Dell Validated Design for Manufacturing Edge with Litmus

The DVD for Manufacturing Edge with Litmus solution simplifies edge deployments and fosters IT and OT collaboration. It also enhances systems integrator partnerships for manufacturing outcomes that are predicated around such use cases as:

- OEE
- Predictive maintenance
- Product quality
- Yield optimization

Global partnership

Dell Technologies and Litmus have a global partnership to build differentiated solutions that are focused on delivering positive manufacturing outcomes. Litmus is an application enablement platform (AEP) providing additional value to the Dell Technologies infrastructure, including:

- More than 250 industrial OT device drivers to connect manufacturing equipment, assets, and systems
- Software integration for IT systems such as enterprise applications (ERP, MES) and cloud platforms (Azure, AWS, GCP)
- Easy-to-use, integrated analytics and applications
- Management at scale with Litmus Edge Manager

The DVD for Manufacturing Edge with Litmus helps accelerate smart manufacturing outcomes by unifying OT, IT, and businesses.

Chapter 3 Manufacturing Edge with Litmus

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The challenge

Manufacturers enjoy varying levels of success with edge computing initiatives using industrial IoT (IIoT), sensors, robotics, automation, and cloud-scale data management. They face multifaceted challenges to enable smart manufacturing, including:

Complex data management

The growing number of IIoT devices, sensors, smart meters, and other edge endpoints escalate security and data management complexities around the volume, velocity, structure, and data stream formats generated by disparate sources. Moving this data to the cloud for analytics can be prohibitively expensive, limiting the real-time insights that technicians need on the factory floor for equipment efficiency, predictive maintenance, product quality, and yield optimization.

Sprawl

The proliferation of disparate edge devices crowds factory floor space and conflates the technology architecture. The sprawl of piece-meal edge initiatives limits the ability to apply a unified strategy to implement smart manufacturing.

Security and reliability

Every edge endpoint added to the infrastructure increases the vulnerability of the security perimeter and the potential for data loss to hackers. This impedes the scope and scalability of new edge applications for IT-OT convergence.

Real-time performance

While smart manufacturing creates more demand for edge compute, the limited compute, storage, and virtualization capabilities of the legacy systems limit the adoption of artificial intelligence (AI) and machine learning (ML) applications and real-time analytics at the edge. Organizations must balance the right level of compute capability from the factory to the public cloud.

Solution business benefits

Litmus adds to the key benefits delivered by the DVD for Manufacturing Edge by:

- Focusing on insights instead of managing data with prebuilt and custom data visualizations, analytics, and KPIs such as OEE
- Maintaining global visibility of business outcomes, from OT to IT, with easy integration of ready-to-use data with any cloud or enterprise application
- Powering the industrial edge with AI by easily absorbing ML-trained models and deploying them to the assets and machines on the factory floor
- Gaining multicloud flexibility to maintain compatibility with enterprise IT using integrated cloud connectors to multiple public or private clouds
- Scaling to any number of assets or sites with ease by managing all edge devices centrally through an orchestration engine
- Ensuring faster time to value with cross-factory replication to expedite manufacturing outcome

Use cases

The DVD for Manufacturing Edge with Litmus solution delivers specific operational outcomes for manufacturers. It is an IT infrastructure that achieves manufacturing-related outcomes quickly and easily, as demonstrated in the following specific, validated, and tested use cases.

By ingesting and normalizing data from industrial manufacturing assets and systems, the solution then easily builds use cases through its Analytics and Flows features within Litmus Edge. It also helps manufacturers:

- Reduce costs
- Increase and optimize operational asset performance
- Optimize the production process
- Increase and optimize yield

Note: Other use cases and specific operational outcomes can be developed. The specific use cases that are shared here are designed to help manufacturers.

Overall equipment effectiveness (OEE)

OEE is a calculation based on availability, performance, and quality, and is a common key performance indicator (KPI) in manufacturing. Operationally, high OEE value is a critical metric that manufacturers strive to improve each year.

To offer context, a 100 percent measure of OEE infers a perfect product with no delays in manufacturing operations. This means that every product is in good condition with no scrap or defects, and all production machinery and assets are always available. The following key metrics are used to measure OEE:

Availability

This refers to the uptime of manufacturing assets and process. Unplanned downtime negatively impacts the OEE metric, and 100 percent availability means that assets and process are always running during planned production.

Note: Scheduled maintenance outside of production time windows does not have a negative impact on availability or OEE.

Performance

Performance is a measure of how well the manufacturing process is running. If the process is fully optimized and the product moves at the expected rate (cycle time), the performance metric is 100 percent. However, if machinery or process factors impact the rate of progress, this impacts the performance score. This includes slow cycles, idling or small stops, or downtime and outages.

Quality

One hundred percent quality means that only a good product is being manufactured with zero defects or requirements to reassess elements of the process.

Obtaining and understanding an accurate OEE measurement can be challenging, as operators must have the following abilities:

- Access real-time data from all manufacturing assets
- Understand production processes and scheduling
- Have a clear understanding of what optimal manufacturing output is from a quality perspective
- Have a capacity to view OEE metrics on a dashboard or visualization tool in near real-time

The DVD for Manufacturing Edge with Litmus solution provides a method for manufacturers to build an OEE management approach from scratch.

The following figure and description are an example of an analytics flow built on Litmus Edge.

Note: This is a sample course. Flows and analytics are further reviewed in the [Understanding the Litmus platform](#) section.

Note: The OEE calculation for a given asset or manufacturing process can be built, edited, or optimized for any scenario. Litmus Edge provides an easy, GUI-driven approach to help manufacturers quickly visualize OEE.

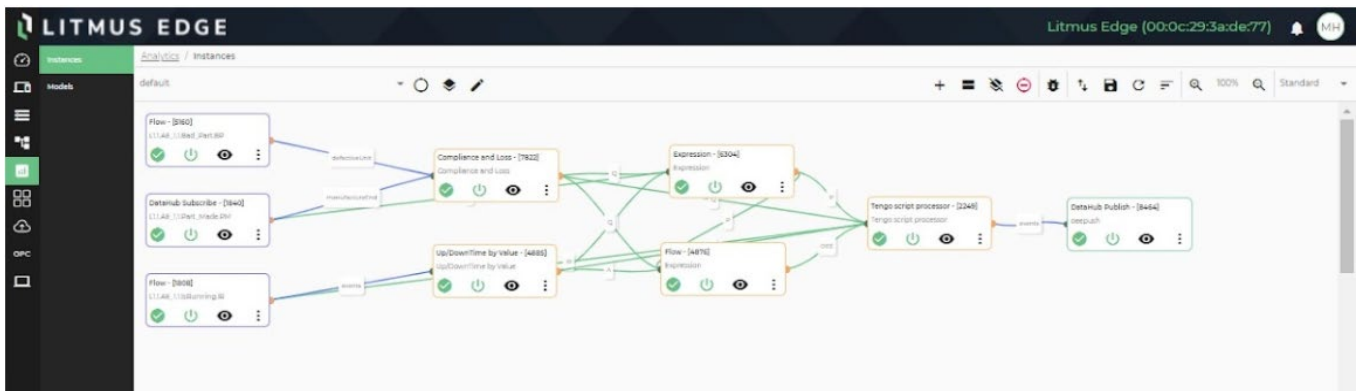


Figure 2. Flows and Analytics in Litmus Edge

As shown in the previous figure:

- The three nodes on the left side draw raw data from OT systems, machines, and assets connected to the edge device. The data points relate to production data, scrap metrics, and machine status. These three flows normalize the OT data and pass it to the data processor nodes.
- The four middle nodes are processor nodes.
 - The first (upper left) receives the data that is related to the production and scrap and calculates a quality KPI stream as data is received from the equipment.
 - The second (bottom left) receives equipment status data that is used to create an asset utilization metric based on the uptime or downtime of the asset and the expected status metrics that are configured for the machine.
 - The next node (upper right) is a custom calculation to measure productivity.

- Finally, the last (bottom right) calculates OEE-based inputs from the other three processor nodes.
- On the right side are nodes that publish the data to the persistent datastore on Streaming Data Platform, or northbound to a visualization tool such as Grafana or an application enablement platform such as PTC ThingWorx.

The following is an example of a visualization for OEE related to the example above and built in Grafana:



Figure 3. Sample OEE dashboard in Grafana

The above dashboard enables OEE review at different levels, including:

- Plant level, on the top horizontal pane
- Line level, on the second horizontal pane
- Build cell level, on the third horizontal pane
- Asset level, on the bottom pane

In summary, the DVD for Manufacturing Edge with Litmus solution helps take control of OEE metrics by simplifying OT data, creating analytical capabilities, and outputting the metric to the manufacturer's visualization display of choice.

Predictive maintenance

Predictive maintenance helps plan asset and machinery maintenance at the optimal time based on their condition during normal operations. It indicates the best time to service equipment, as opposed to relying on set preventative maintenance scheduling that impacts production or creates dependencies on vendors and maintenance teams.

Utilizing predictive maintenance in manufacturing offers significant benefits such as:

- Improved return on investment (ROI) on manufacturing assets
- Increased asset lifetime to help ensure longevity and productivity
- Reduced mean time to repair (MTTR)

Predictive maintenance depends on the condition monitoring of assets, strengthening the DVD for Manufacturing Edge with Litmus solution's ability to simplify connectivity to operational technology (OT) assets, deliver insights through analytics and streaming data capabilities, and enhance scalability and resiliency across diverse manufacturing systems and platforms.

Building on [previous examples](#), the following example of a Grafana dashboard represents a manufacturer's predictive maintenance monitoring:



Figure 4. Predictive maintenance monitoring using Grafana

Representations

- At the top of the dashboard, the **Line Runtime Status** chart plots the runtime of a specific production line over a given period. Here, the line is inactive for about 10 minutes per hour.
- On the two tiles below, the **Line Runtime Status** are the performance and predictive maintenance projections for two build cells on the line. Some of the fundamentals visualized here include:
 - **Lifetime Runtime**, or the amount of time the machine has been running since it was commissioned
 - **Maintenance Interval**, or the machine builder's maintenance interval recommendation
 - **Current Runtime**, or the runtime since the machine's last service
 - **Maintenance Due In**, or time until the next recommended service

- Most important is the **Predicted Hours to Maintenance** at the end of each tile. This is the optimal recommended maintenance time based on historical runtime and performance, and the condition monitoring obtained directly from the asset.

The DVD for Manufacturing Edge with Litmus solution delivers the statistical analytics functionality that is required to deliver this level of predictive maintenance. This helps manufacturers maximize productivity, improve asset ROI, and make production plans with confidence.

At any time, within the Flows and Analytics capability, maintenance tickets can be raised by the REST API based on specific thresholds being reached within the predictive maintenance calculations. This ensures that the appropriate maintenance and production teams are aware of any manufacturing issues, and that the correct process is followed for a timely resolution.

Product quality

Ensuring product quality entails evaluating the production process to ensure that manufactured goods meet quality standards. This solution helps speed and automate work-in-process inspection throughout the entire production cycle. It leverages basic computer vision capabilities to detect product, parts, or packaging defects to improve safety, decrease liability, and improve final product quality.

Yield optimization

Yield optimization measures the number of parts that are made in manufacturing while minimizing production time, scrap, and waste. Understanding OT system data and calculating yield optimization helps manufacturers recognize the opportunities to optimize asset and process elements and continuously seek improvement.

Note: In [discrete manufacturing](#), yield optimization is typically easier to calculate and understand, as compared to process manufacturing.

The DVD for Manufacturing Edge with Litmus solution allows manufacturers to optimize their product yield by:

- Connecting to manufacturing assets, machines, sensors, and systems to understand and maximize performance and quality, and minimize outages.
- Leveraging integrated analytical capabilities to predict and diagnose process failures and interruptions in near real time.

The following example uses an analytical flow similar to that used for [OEE within Litmus Edge](#) to illustrate yield performance. Analytics completes the necessary calculations before outputting them to the visualization platform of choice. This dashboard represents yield at a line level within the manufacturing environment over a seven-day period.



Figure 5. Using Grafana to track yield in manufacturing

Here, we normalize and calculate the manufacturing operations data, and the stream as production output or scrap is reported. Litmus Edge runs the analytics, which are then written out to the Streaming Data Platform.

Representations

- The trending line in the previous figure represents a calculation of yield based on some good parts that are manufactured out of the total parts that are made. Because this trends downward, it is clear there is a production issue.
- The different colors represent varying shift times, and the vertical lines represent annotations or notes that are made within Grafana by production operators or shift personnel, including maintenance teams.
- The vertical lines from left to right represent annotations that have been manually added by operators, production managers, and maintenance personnel for a better understanding of the trends.

The DVD for Manufacturing Edge with Litmus solution builds visualizations to create an understanding of the data coming out of manufacturing operations and ensures yield optimization based on direct data from manufacturing assets and processes.

Application consolidation

From an IT perspective, deployment of IT solutions and technology into manufacturing operations can result in multiple challenges, including:

- Disparate software solutions and vendors for different use case outcomes and processes
- Multiple hardware vendors and sprawl across varying software solutions
- Technology silos
- Dependencies on IT expertise in manufacturing operations
- Risks related to cybersecurity and lack of operational oversight on IT systems

With the DVD for Manufacturing Edge with Litmus solution, these challenges are minimized because of the solution's ability to run multiple applications for manufacturing on a single, horizontal, edge infrastructure that delivers:

- Scalability: Scale out with additional nodes, and scale up with additional compute capacity within Dell APEX Private Cloud nodes

Note: Scale out means adding Dell APEX Private Cloud nodes to provide more resources. Scale up means upgrading the existing systems to add more resources, for example, by adding more memory or disks.

- Security, which is built from inception on all Dell infrastructure solutions
- Flexibility to run applications in virtual machines and containers on Dell APEX Private Cloud
- Cost-effectiveness through a predictable and consistent subscription-based monthly consumption model

This solution ensures that manufacturers standardize their edge infrastructure over time to run multiple applications. It allows for the consolidation of multiple workloads or applications to this singular edge infrastructure, including:

- Computer and machine vision-based solutions
- IoT application enablement platforms such as PTC ThingWorx
- Data platforms and integration solutions, including Dell Streaming Data Platform, which is part of the DVD for Manufacturing Edge with Litmus solution
- AI and ML applications
- Client-based applications such as VDI or augmented reality (AR) applications that are used for connected worker use cases in manufacturing

Note: For technical details of the application consolidation on the DVD for Manufacturing Edge with Litmus, see the [Design Guide](#) document.

Chapter 4 Solution Architecture Overview

This chapter presents the following topics:

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Solution overview

A high-level architecture of the DVD for Manufacturing Edge with Litmus solution is detailed in the following diagram:

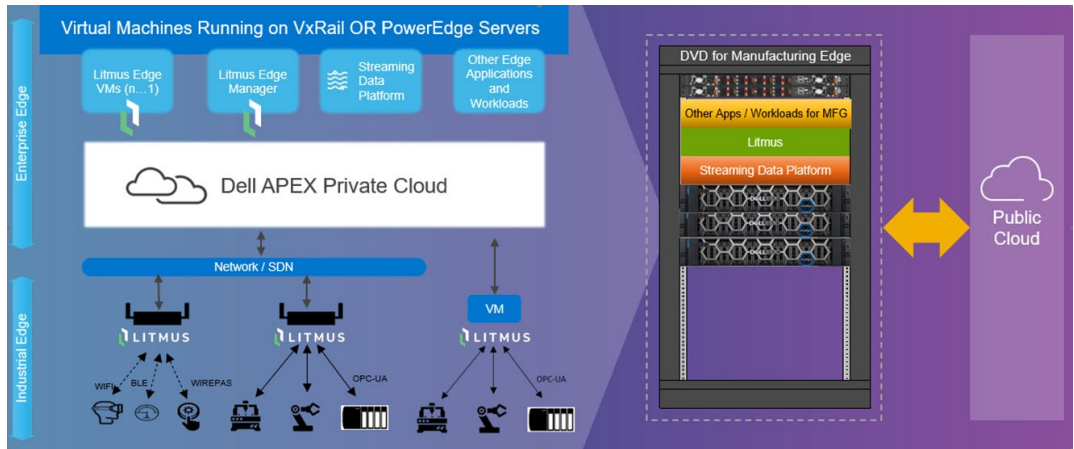


Figure 6. High-level, architectural view of the DVD for Manufacturing Edge with Litmus

Representations

- At the bottom of the diagram, the OT data sources are represented as the industrial edge. This area shows gateway devices that are connected to IoT sensors using technologies like Bluetooth, Wi-Fi, or IoT-specific protocols such as Zigbee or LoRA. Gateways interfacing directly with industrial equipment through industrial platforms by way of parallel, serial, or Ethernet cabling are also visible here; for example, OPC-UA, or CAN.
- A gateway is typically used to interface IoT sensors or industrial platforms with IT systems and networks.
- Finally, a virtual machine (VM) running Litmus Edge may connect directly to an industrial device by way of Ethernet, depending on its Ethernet and TCP-IP capabilities. In this scenario, high consolidation levels are achieved by running the required translation and applications on Litmus Edge directly in a VM on the enterprise edge.

Note: In the DVD for Manufacturing Edge with Litmus solution, the enterprise edge runs on either VxRail or PowerEdge. Details on these platforms can be reviewed in [Solution Detail](#) (Building Blocks).

Several components are represented in the diagram on the Dell Manufacturing Edge, including:

- **Litmus Edge VMs** - providing the OT data interface and running the required analytics at the edge
- **Litmus Edge Manager** - the management layer for all VMs and physical gateways running Litmus Edge

- **Streaming Data Platform** - providing data persistence and high-performance data streaming capability for AI/ML playback and data correlation from data sources at the edge
- **Other Edge Applications and Workloads** - where the application consolidation features of the DVD for Manufacturing Edge factor in
 - With Dell APEX Private Cloud availability and scale, it is possible to run multiple value-driven manufacturing applications and workloads at once. Examples include Computer Vision-based solutions for visual inspection or safety-based use cases, or Application Enablement Platforms (AEPs) that are commonly used in IoT deployments. The Dell Technologies Manufacturing Edge Reference Architecture with PTC is an AEP platform for building specific manufacturing applications, and it can run side by side with the Litmus solution on the same infrastructure.

Finally, the DVD for Manufacturing Edge with Litmus fully integrates into existing on-premises data centers and applications, as well as cloud applications and platforms. This allows for optimal placement of capabilities like analytics and AI across a manufacturer's IT infrastructure to provide maximum value.

The following figure provides a graphical overview of connecting OT and integrating IT systems to the edge infrastructure:

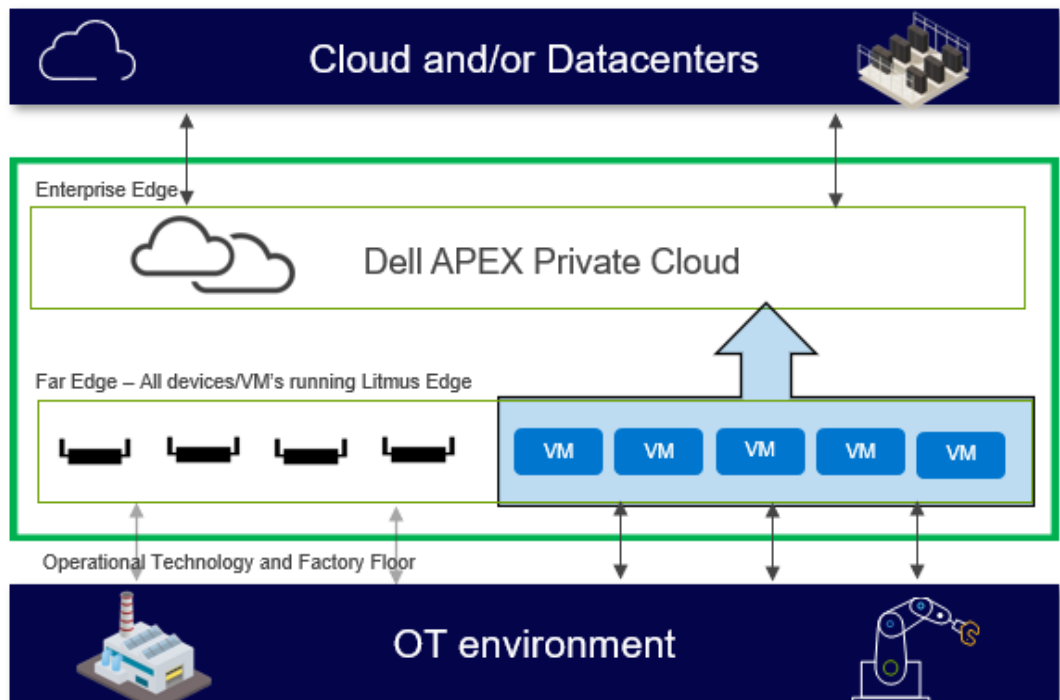


Figure 7. Connecting OT to the edge infrastructure and integrating to IT systems

Key infrastructure considerations

For an edge infrastructure to be deployed effectively, it is important to understand the following key manufacturing operations considerations, and how edge environments can potentially be deployed.

Where the DVD for manufacturing Edge with Litmus is deployed

This solution is deployed at the enterprise edge. The core building block of the platform is the Dell APEX Private Cloud hyperconverged infrastructure, which is typically deployed within an on-premises data center at the manufacturing location. For scenarios where the Dell APEX Private Cloud is not a suitable solution, various VxRail and PowerEdge platforms are validated so manufacturers can optimally deploy them within their existing data centers and operational environments.

The Dell VxRail D-Series and the Dell PowerEdge XR11/XR12 solutions have been validated and tested, carrying ruggedized specifications with enhanced environmental capabilities. This makes it possible to run the solution outside of the data center, providing flexibility and scale at the edge for the manufacturer. Examples include:

- Deploying logical aggregation points in manufacturing
 - When a data communications cabinet or control box is at the end of a production line, a PowerEdge XR11/12 can be racked within it to provide logical aggregation. This forms the line's central point for data aggregation, processing, and visualization. The data can then be moved further northbound to other assets or applications.
- Deployment outside of the data center
 - In scenarios where data center space or ownership is an issue, the VxRail D-Series can be deployed outside of the data center, if the area or room in which it is deployed meets environmental requirements.

Why manufacturing requires edge solutions

The edge helps manufacturers realize new business outcomes as they move toward today's future-focused Industry 4.0 and smart manufacturing ideals. The key technologies powering these new paradigms include:

- Artificial Intelligence (AI)
- Internet of Things (IoT)
- Private LTE and 5G connectivity solutions
- Advanced analytics
- Machine and computer vision solutions

All these technologies require large amounts of compute infrastructure. Typical data centers and cloud investments become costly when leveraged as-is for edge-based workloads; yet the ability to process at low latency nearer the point of data creation is a critical requirement for many use-case applications.

Manufacturers who want to embrace smart manufacturing trends deploy edge infrastructures to run advanced technologies and achieve ambitious outcomes. The DVD for Manufacturing Edge with Litmus solution helps manufacturers ramp up their edge deployment quickly and easily.

Who implements the solution?

Dell Technologies ensures that the DVD for Manufacturing Edge with Litmus solution is delivered in partnership with the right integrators and partners to suit your operational model. A global network of partnerships helps deploy the solution within manufacturing environments worldwide. This network includes:

- Global partnerships with the largest system integrators to ensure that deployment and integration occur at scale across entire manufacturing operations.
- Specialist partnerships with OT and Original Equipment Manufacturer (OEM) channel partners specializing in manufacturing-based implementation and the integration of industrial systems.

How the solution is supported

Support for the solution is the responsibility of Dell Technologies, Litmus, and system integrators and partners. Manufacturers receive a deployment support matrix that is customized to their specific requirements, with the integrator as their single point of contact for seamless support.

For typical deployments, the integrator will handle all Level 1 support, and then escalate any issues to Dell Technologies and Litmus (Level 2 and Level 3) as needed.

Chapter 5 Solution Detail

This chapter presents the following topics:

- Solution building blocks 25**
- Litmus 25**
- Dell infrastructure solutions 29**
- Dell APEX Private Cloud 29**
- Streaming Data Platform 30**
- Dell Edge Gateway 5200 33**

Solution building blocks

The following building blocks the architecture for Dell APEX Private Cloud for the Manufacturing Edge with Litmus.

Dell APEX Private Cloud

Dell APEX Private Cloud delivers a secure and scalable on-premises cloud experience to simplify operations at the edge with a monthly subscription and integrated life cycle management on infrastructure owned and deployed by Dell. The Dell APEX Private Cloud is built on the VxRail platform jointly engineered by Dell and VMware.

The VxRail hyperconverged infrastructure creates a turnkey deployment at the edge that offers maximum flexibility for high availability, scale, and consolidation of OT workloads and applications. As part of this solution, Litmus Edge, Litmus Edge Manager, and Streaming Data Platform (SDP) run on VMs on the VxRail HCI.

Dell Streaming Data Platform

The Streaming Data Platform provides an ingestion and storage capability for OT data streams, and also has integrated analytics capabilities. SDP is built on open-source platforms and runs on VxRail as a VM specifically for this solution.

The SDP acts as the aggregation point for the data ingested across all Litmus Edge instances in this solution. One or more SDP instances can be deployed, depending on the scenario.

Litmus

The Litmus modern-edge software platform transforms the way that industrial companies collect, analyze, and leverage machine data. By partnering with Litmus for the DVD for Manufacturing Edge, the solution delivers instant connectivity and flexibility in edge deployment.

Dell leverages two components from Litmus as part of the solution: Litmus Edge and Litmus Edge Manager.

- **Litmus Edge** - a Linux-based operating system (OS) that provides the IT/OT connectivity and capability needed to contextualize and normalize OT data. It is run within a VM or on a gateway device.
- **Litmus Edge Manager** - allows manufacturers to manage all Litmus Edge deployments within the environment.

Litmus

Litmus Edge

Litmus Edge is a complete operating system based on Linux that eases deployment and management at the edge. It can be run on a bare-metal hardware device or within a VM. With the DVD for Manufacturing Edge, the optimal physical or virtual hardware depends on the deployment scenario or the type of connectivity that is required for industrial systems.

As shown in the following diagram, Litmus Edge is typically the interface between enterprise IT applications and industrial systems and networks:

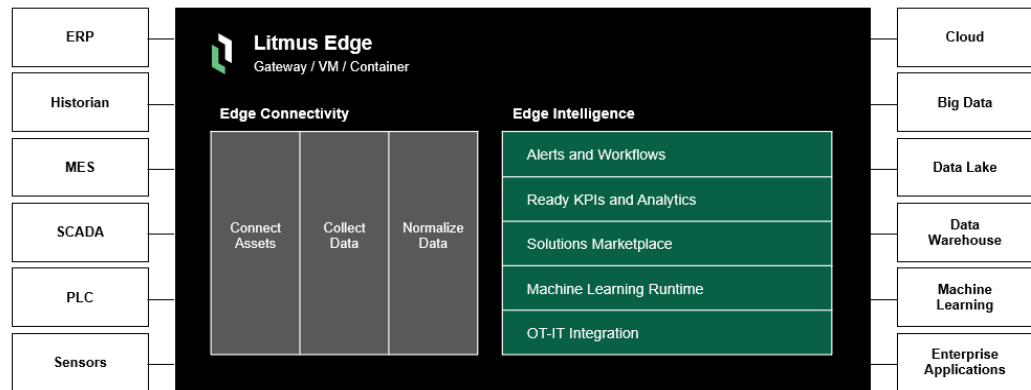


Figure 8. Litmus Edge connectivity and integration

Litmus Edge enables connectivity of manufacturing assets, with more than 250 different OT-based protocols available out of the box, along with the capability to build custom connectivity. It can collect, normalize, and contextualize data for further use on edge devices or northbound to your enterprise IT systems and platform.

The Litmus Edge platform has many integrated features and capabilities, such as:

- **Flows and Analytics** - allowing intuitive and GUI-driven approaches to building analytical engines around data ingested from OT at the edge. This capability can build specific use cases and KPI-specific data visualizations, while templates are provided for common use cases such as OEE and predictive maintenance.
- **Applications Marketplace** - where specific edge applications can be pulled from a central repository running on Litmus Edge Manager. This solution runs any application that has been containerized. By default, it has common applications in place, but custom apps can also be deployed, including ML models developed on data centers or cloud platforms.
- **Integrations** - enabling the northbound connectivity, and a key component to abstracting industrial asset data. Within the DVD for Manufacturing Edge with Litmus, a default integration is the Streaming Data Platform, sending all streamed data ingested to SDP and any analytical outputs created on Litmus Edge. The integration capability also has an integrated Store and Forward capacity, so no data is lost during a network outage.
- **OPC UA** - defining connections to Open Platform Communications (OPC) servers and allowing users to build integrations from any system needing data access in Litmus using the OPC UA interface.

For more information about Digital Twins, see the [Digital Twins](#).

Litmus Edge can also export its configuration to a template for scale and ease of deployment through Litmus Edge Manager, offering operational consistency.

As part of the DVD for Manufacturing Edge with Litmus, Litmus Edge has been tested and validated running as a VM on VxRail and on PowerEdge servers running VMware vSphere.

Litmus Edge Manager

Litmus Edge Manager is a centralized management platform for all devices running Litmus Edge. It provides a management layer for the Litmus Edge environment to create ease of deployment and scale, as outlined in the following figure:

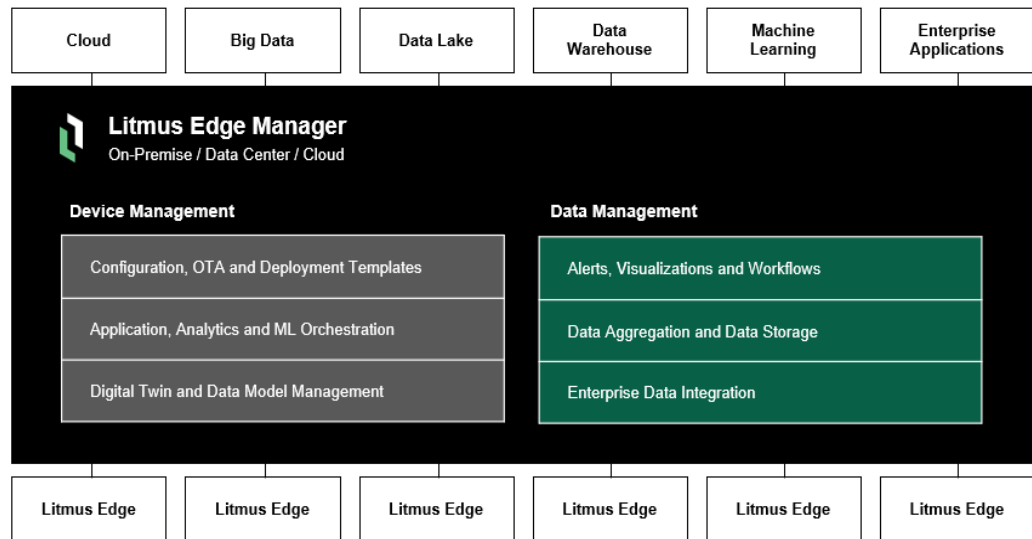


Figure 9. Litmus Edge Manager – edge management at scale

Litmus Edge Manager defines a hierarchy to manage all edge devices running Litmus Edge to reflect operations at global, regional, site, or production line levels.

Within Edge Manager, a logical group of devices is defined as a Project. This helps with the management edge devices with a specific use (connected to specific machines) or in a specific area in manufacturing (production line, build cells, warehouse, and more).

Key features within Litmus Edge Manager include:

- **Device Management**, or the configuration, Over-The-Air (OTA) updates, and deployment templates for all Litmus Edge devices
- **Application, Analytics, and Orchestration**, or the deployment and management of applications running on Litmus Edge, including configuration templates and centralized management of flows and analytics running on Litmus Edge
- **Remote Access**, or the management of user access to the Litmus environment, including role-based access control
- **Events, Alerts, and Incident Monitoring**, providing oversight on all Litmus deployment activity to support troubleshooting and manage configured alerts
- **Marketplace Catalog**, where application containers are published and made available for deployment to Litmus Edge

On the DVD for Manufacturing Edge with Litmus, Edge Manager runs as a VM on Dell APEX Private Cloud.

**Litmus
documentation**

To learn more about the Litmus solutions, browse the [Litmus Documentation Portal \(account required\)](#), which provides full technical documentation on all aspects of the solutions, including:

- Core products
- Add-on products
- Developer tools
- Recommended reading
- Customer success
- FAQ and release notes

The following figure offers a sample view of the Litmus Documental portal:

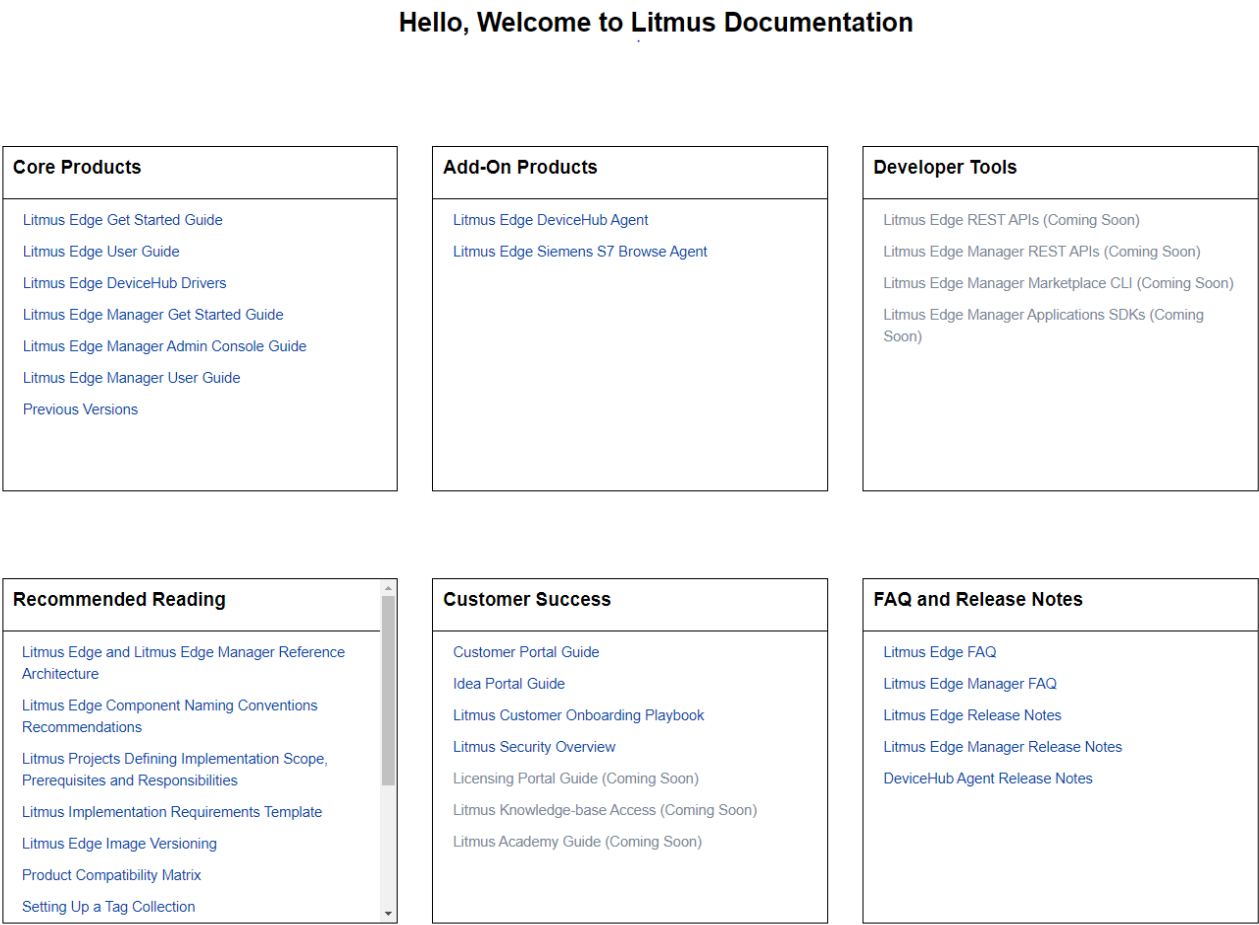


Figure 10. Litmus Documentation Portal

Note: Access is provided to the Litmus Documentation portal once Litmus licenses are fulfilled. For the standard Litmus documentation and messaging, see the [Additional Resources](#) section.

Dell infrastructure solutions

The DVD for Manufacturing Edge with Litmus solution is built upon proven solutions from Dell Technologies. The following section provides overviews of each of the specific platforms for the solution.

Dell APEX Private Cloud

Dell APEX Private Cloud leverages the Dell VxRail appliance, jointly engineered Hyperconverged Infrastructure (HCI) between Dell and VMware. Built on PowerEdge server platforms, it integrates Dell Technologies and VMware data services including compression, deduplication, replication, and backup.

VxRail delivers resiliency and centralized-management functionality for fast, easy management of consolidated workloads, virtual desktops, business applications, and edge infrastructure.

The following is an overview of the VxRail HCI:

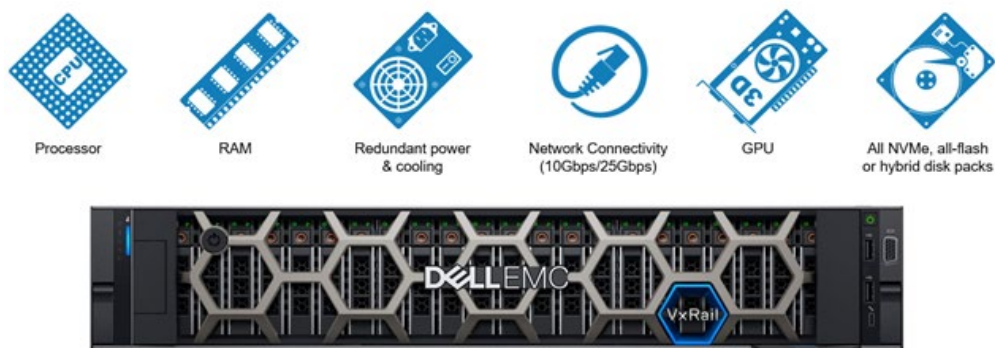


Figure 11. VxRail Hyperconverged Infrastructure

Features and benefits

VxRail provides automated end-to-end life cycle management and helps modernize data centers across edge, core, and cloud, offering the following features and benefits:

- Turnkey appliance, jointly developed by Dell Technologies and VMware
- Fully integrated, preconfigured, and tested
- Intel-based on Dell PowerEdge servers with vSphere and vSAN
- Streamlined deployment and maintenance using VxRail Manager
- Reduced operational complexity with out-of-the-box automation
- Single pane of glass
- Integrated with vCenter UI as plug-in
- One-click upgrades
- Resilient, telemetry, and secure (STIG hardening)
- Flexible configurations
- Small, medium, large workloads and edge sites

- Single point of support for hardware and software

**Validated
platforms**

The Dell APEX Private Cloud solution configured with the general purpose, 8 GB memory-to-core ratio has been validated as part of the solution.

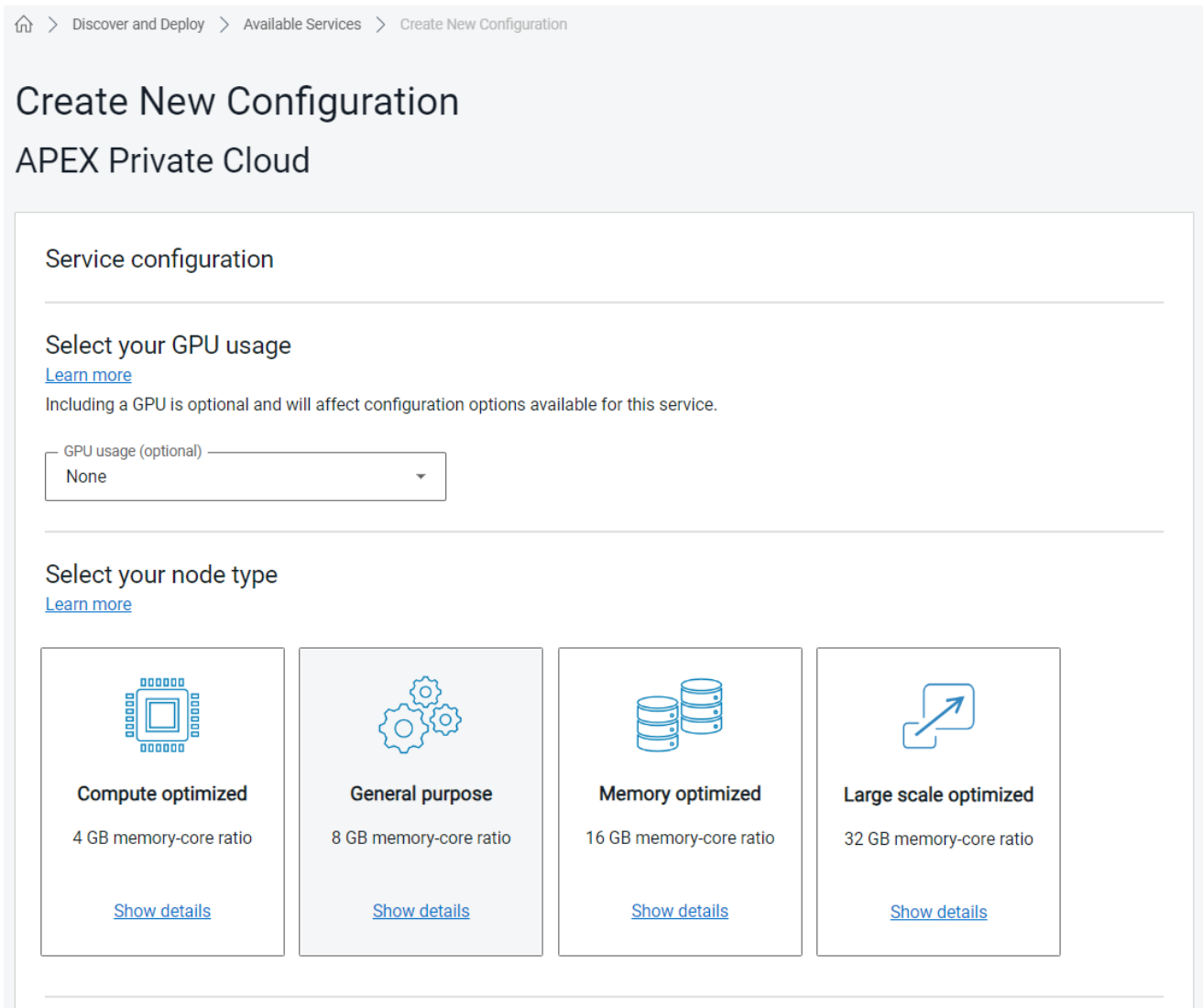


Figure 12. Dell APEX Console – Create New Configuration – APEX Private Cloud

For detailed information about Dell APEX Private Cloud specific configurations for this solution, see the links in the [Additional Resources](#) section.

Streaming Data Platform

The Dell Streaming Data Platform (SDP) is an elastically scalable, open-source platform. Created by Dell Technologies, it allows for the intake and storage of streaming data. It is designed to absorb, store, and analyze continuously streaming data in real time, using Pravega as its key engine.

Data sources

The platform concurrently processes both real-time and collected historical data in the same application, which can include millions of data streams from multiple sources, while ensuring low latencies and high availability. SDP ingests and stores streaming data from a range of sources, including:

- IoT devices
- Web logs
- Industrial automation
- Financial data
- Live video
- Social media feeds
- Applications
- Event-based streams

SDP manages stream ingestion and storage, and it hosts the analytic applications that process the streams. It dynamically distributes data processing and analytical jobs over the available infrastructure, and automatically scales resources to satisfy processing requirements in real time as the workload changes.

Integrated capabilities

SDP integrates many capabilities into a single software platform, including:

- Stream ingestion
 - The platform ingests all types of data, whether static or streaming, in real time. Even historical files of data become bounded streams of data when ingested.
- Stream storage
 - Elastic-tiered storage provides instant access to real-time data and infinite storage, and access to historical data. This loosely coupled, long-term storage enables an unbounded digital video recorder (DVR) for all streaming data sources.
- Stream analytics
 - Real-time stream analysis happens with an embedded analytics engine. Analyzing historical and real-time streaming data is unified to simplify the application-development process.
- Real-time and historical unification
 - Real-time and historical data is processed to create and store new streams, send notifications to enterprise alerting tools, and send output to third-party visualization tools.
- Platform management
 - Integrated management provides data security, configuration, access control, resource management, an intuitive upgrade process, health and alerting support, and network topology oversight.
- Run-time management

Key SDP benefits

- A web portal allows users to configure stream properties, view stream metrics, run applications, and view job status.
- Application development
 - Application Programming Interfaces (APIs) are included in the distribution. The web portal supports application deployment and artifact storage.

The benefits of using SDP at the manufacturing edge include:

- Expanded on-premises storage to include durable long-term storage on Dell APEX Private Cloud
- Pass-through high-performance/low-latency storage for higher scale
- Expanded options for developers to use open-source tools for real-time analytics using data streams
- Expanded view of the physical world to include ingestion and processing of data streams including video, X-ray, Lidar, IR, and audio together with OT feeds from Litmus and other IT data streams
- A high-performance, long-term storage option that provides persistence, scale, and centralization
- Unlimited playback of historical data for AI and ML use cases, with tiered modeling and analytics
- Combined stream analysis and OT data correlation using the ingestion of parallel data streams from other sources and contextualization

Within the DVD for Manufacturing Edge solution, SDP acts as a storage solution to persist and centralize data that is ingested at the edge, as shown in the following figure:

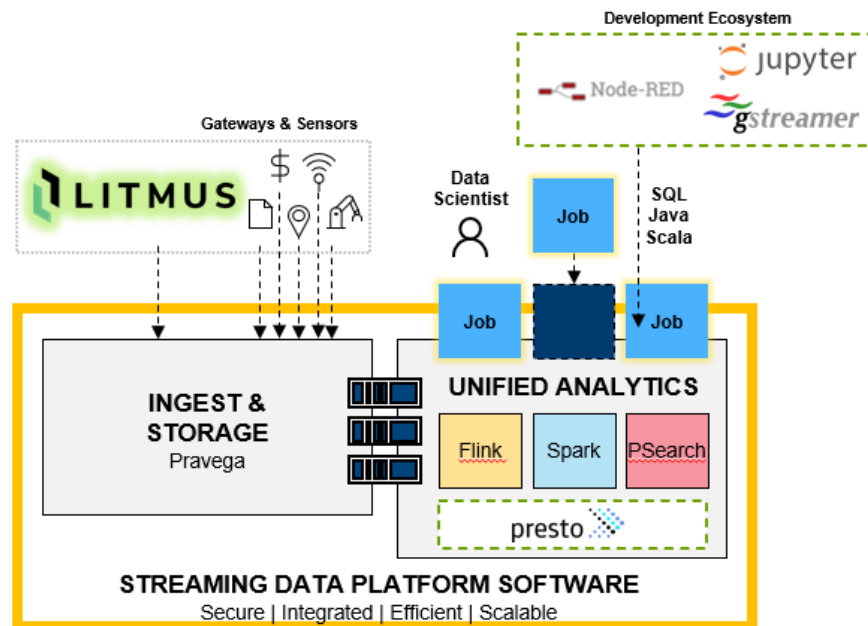


Figure 13. Streaming Data Platform overview

For more technical details and documentation, see the [Additional Resources](#) section.

Dell Edge Gateway 5200

The Dell Edge Gateway 5200 (EGW-5200) is a versatile industrial computer that is designed to meet specific requirements that enable edge computing at unmanned and remote locations. The EGW-5200 is based on the Intel ninth Generation Intel Core desktop processor on 14 nm technology, which is part of the Intel embedded processor road map. This technology means that EGW-5200 is targeted at the industrial market, where longevity and ruggedness are essential requirements.

Manufacturing and retail locations have demanding needs, which are often vastly different from traditional IT locations. Their hardware requirements include the following:

- Fan-less
- Able to meet extended temperature ranges
- Able to meet increased shock and vibration requirements
- Small

The EGW-5200 is equipped with a low power (6 Watt) embedded Intel C240 Series Chipset which has some advantages over the Intel Q370 chipset. Some key additions are:

- The ability to support Intel Active Management Technology (Intel AMT) 12.0
- The Ability to support Redundant Array of Inexpensive Disks (RAID) on Intel Rapid Storage Technology (Intel RST) with support for RAID 0/1



Figure 14. Dell Edge Gateway 5200

Note: Within the Validated Design, the Dell Edge Gateway has been tested with Litmus Edge version (3.3.1).

Note: Litmus Edge is NOT currently a factory-available OS from Dell Technologies – it requires installation.

Chapter 6 Understanding the Litmus platform

This chapter presents the following topics:

Litmus Edge35

Litmus Edge Manager40

Litmus Edge

This section provides an overview to offer a basic understanding of the Litmus platform.

Litmus Edge can be deployed on a VM (running on APEX Private Cloud) or on bare-metal hardware, such as a gateway or an embedded personal computer (PC). Running the Litmus Edge device as a VM offers maximum flexibility about scale, availability, and consolidation, yet in many scenarios, a physical device may be required. Such scenarios include:

- The need to interface using an industrial connectivity solution such as CAN or Serial
- The need for specific compute resources close to the asset for localized interface or data aggregation, or advanced use cases. (For example, it makes sense to have a logical point of aggregation on a single production line)

Litmus Edge is easily deployed and managed using Litmus Edge Manager.

Connecting industrial assets

Once a Litmus Edge device is deployed, the next step is to connect industrial assets. With more than 250 prebuilt drivers, Litmus Edge connects to almost any asset out-of-the-box, and can process and structure data into a common format for edge and enterprise applications.

The starting point in Litmus Edge to connect an industrial asset is the DeviceHub dashboard, where assets can be added and easily managed. For example, if an asset is under maintenance, a single click in DeviceHub disables its connection.

A new asset is set up using the DeviceHub wizard which helps in choosing a driver and defining the connection parameters. In an example of a PLC controller device, the following parameters are required:

- Device type (Siemens, Rockwell)
- Driver name (aligned to controller type)
- Name (a logical name for the connection)

Next, depending on the type of driver and device, additional parameters are required, such as IP address, slot number, and network port.

The following DeviceHub dashboard shows six defined connections on a Litmus Edge device: three connected and three disconnected.

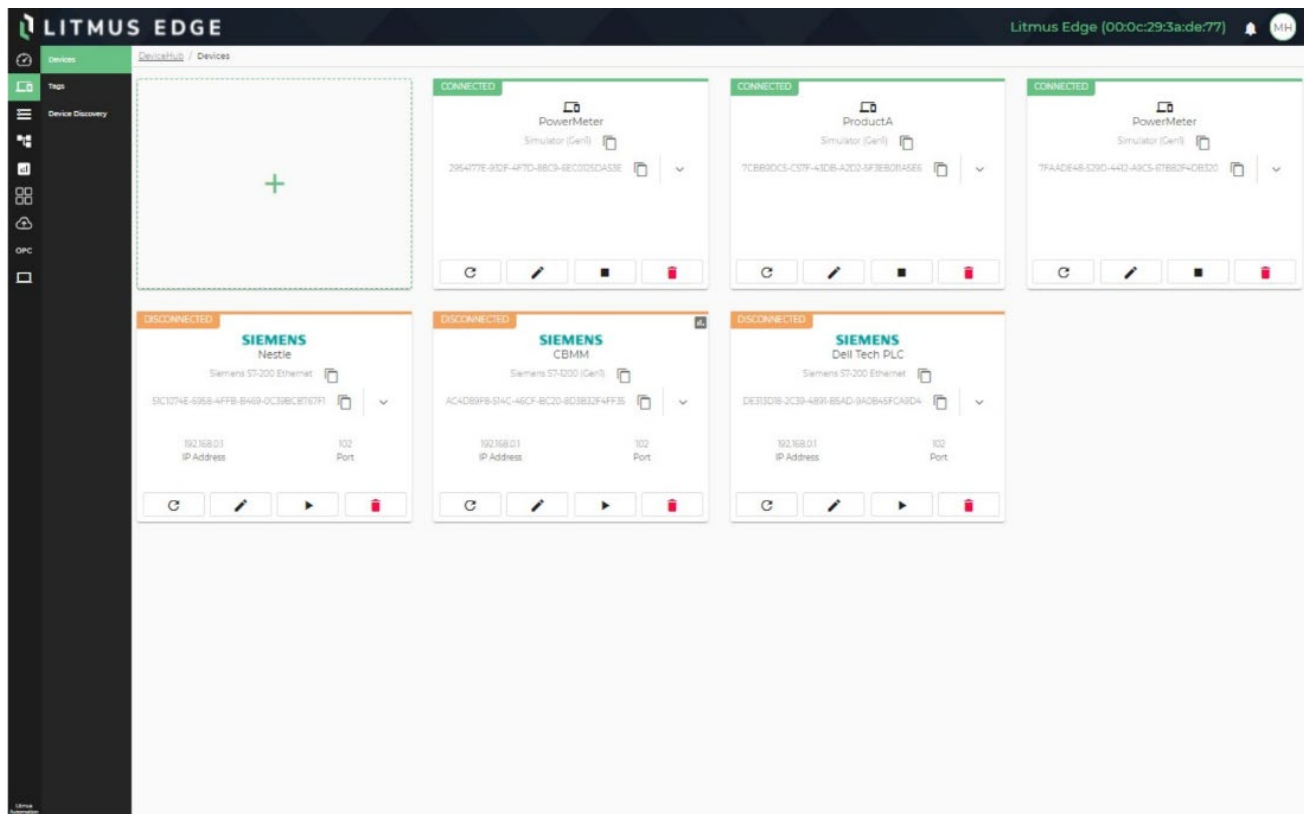


Figure 15. Litmus Edge DeviceHub dashboard overview with six defined connections

Within the DeviceHub, the tags that are ingested from a connected asset are reviewed in the left column. A tag is a data point for a specific metric on an asset, such as temperature or a specific performance threshold. Define tags by browsing the device or import them from a CSV file.

Below **Tags** in the left-hand column, **Device Discovery** allows an OT network to be scanned, which is especially useful to detect devices. For example, if there is a defined PLC network, Litmus Edge can detect and connect all the PLCs that are currently running on that network.

Lastly, if a connection appears as **Failed**, it means the connection is enabled but there is some connectivity issue with the asset.

Flows and Analytics

Within Litmus Edge, all communications from connected assets, devices, and tags are passed through the message broker. This Litmus Edge element normalizes OT data into standard JavaScript Object Notation (JSON). The message broker essentially links all OT systems and IT systems and is the key function enabling Flows and Analytics. The following is a breakdown of its individual functions.

Flows Manager

The Flows Manager is a graphical logic builder that builds logic into message broker data using a low code or no code environment. It allows values from industrial assets to be read, processed, and outputted, depending on the processing required, as the following figure illustrates.

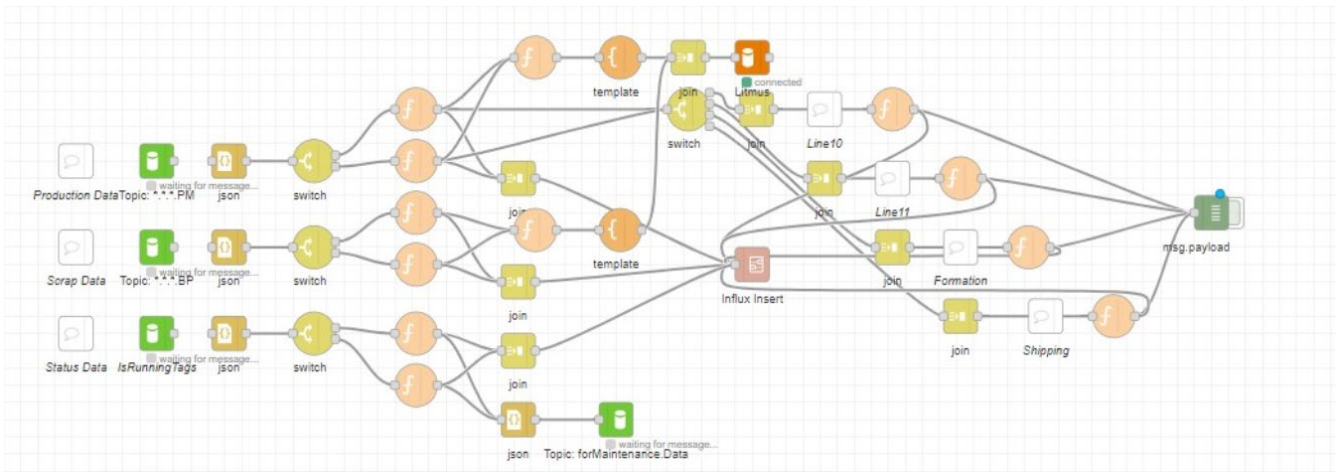


Figure 16. An example flow in Litmus Edge

Analytics capabilities

The Analytics function is a collection of advanced compute functions enabling users to derive KPIs and date and run ML models. This is key to delivering data efficiency and analytics-based use cases at the edge.

Its input nodes can ingest data from the message broker, user input, or external databases. Historical data can also be ingested from InfluxDB running on Litmus Edge. Output is sent to SDP or northbound IT systems by way of the Litmus Edge connectors.

Analytics allows organizations to build specific outcomes including anomaly detection, statistical prediction, and TensorFlow ML models, some of which are built into the DVD for Manufacturing Edge with Litmus solution.

The following is an example of Analytics designed to publish OEE metrics to a visualization platform:

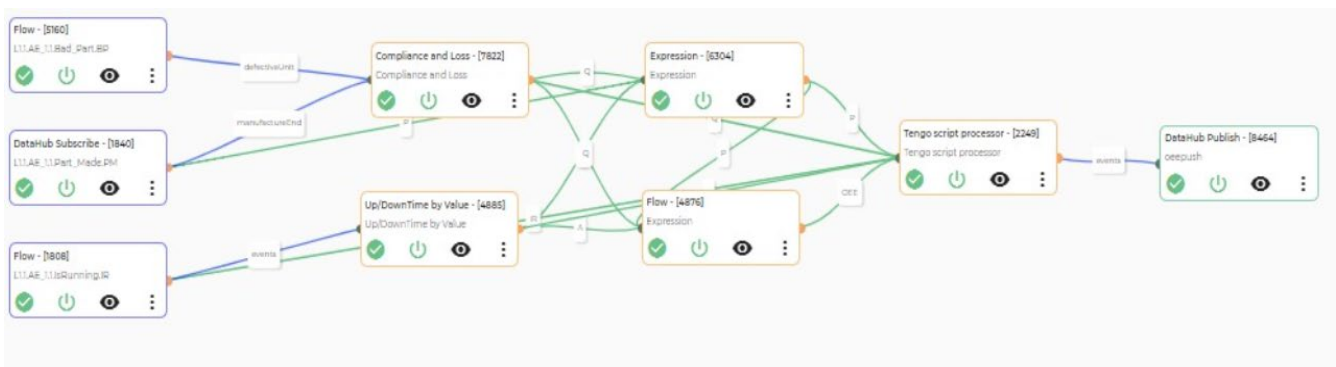


Figure 17. Analytics function on Litmus Edge

Applications capabilities

Litmus Edge runs applications locally as containers on the edge device, locally managed on Litmus Edge or from Litmus Edge Manager. A common use case includes visualization applications (such as Grafana), where operators view KPIs within the build cell where an edge device is located.

Analytical capabilities can also be containerized, deployed, and managed on Litmus Edge. Some key features include:

- **Configuration** - where the connections to Litmus Edge Manager Application Marketplace are defined
- **Marketplace** - where published applications in the Application Marketplace are pulled locally to the edge device
- **Registry** - for more information, see [Litmus Edge - Registry \(requires login\)](#).
- **Containers** - where locally running containers are managed.
- **Images** - where the local Docker containers on the edge device are managed
- **Volumes** - where local and external mount points are defined for data storage
- **System Info** - where the Docker configuration for the edge device is inspected
- **Disk Usage** - for reviewing the space used by applications and their containers

The following is an example of the **Marketplace** dashboard running locally on an edge device:

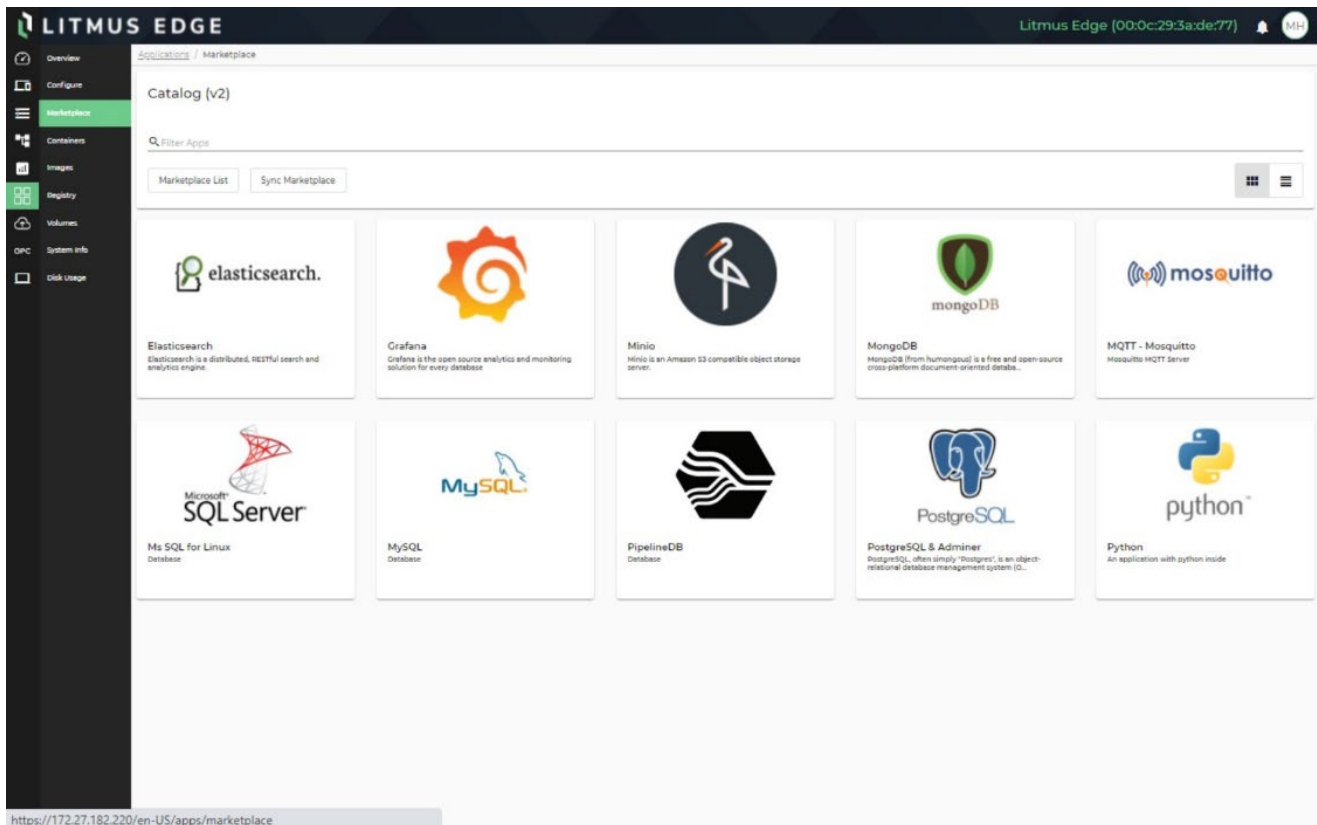


Figure 18. Application Marketplace on Litmus Edge

Integration capabilities

The Litmus Edge **Integration** capability enables enterprise IT systems and application connectivity. It connects Litmus Edge to public cloud instances or applications running in on-premises data centers through connections that are easily managed from the **Integration** dashboard. The following figure provides a comprehensive look at the dashboard.

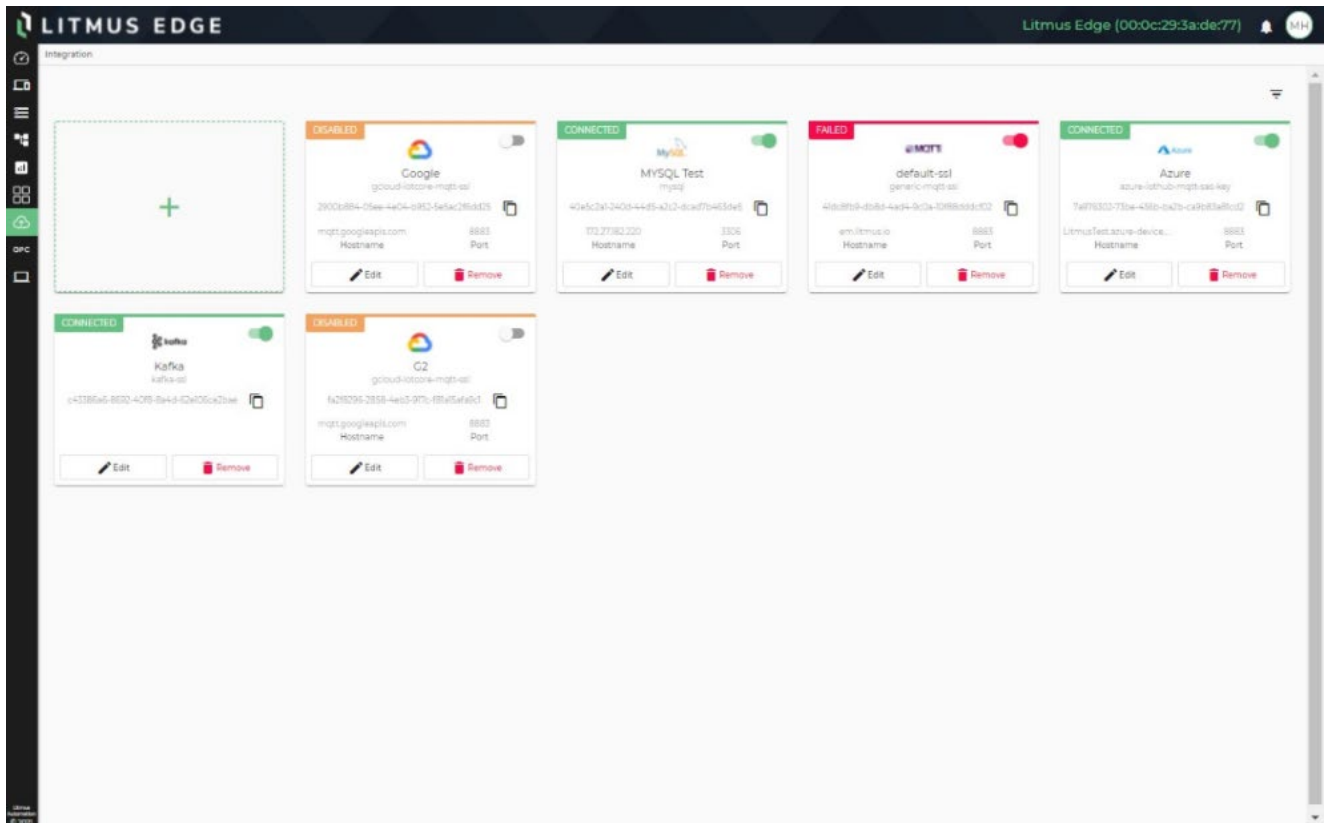


Figure 19. Integration dashboard on Litmus Edge

Data Flow on DVD for Manufacturing Edge with Litmus

A key solution feature is the Dell Streaming Data Platform. Litmus Edge leverages integration to persist data to SDP, so while local data is stored on InfluxDB on Litmus Edge, any data requiring maintenance over time is persisted to the platform. Any data outputs from the analytical functions within Litmus Edge are also persisted to SDP, as shown in the following figure:

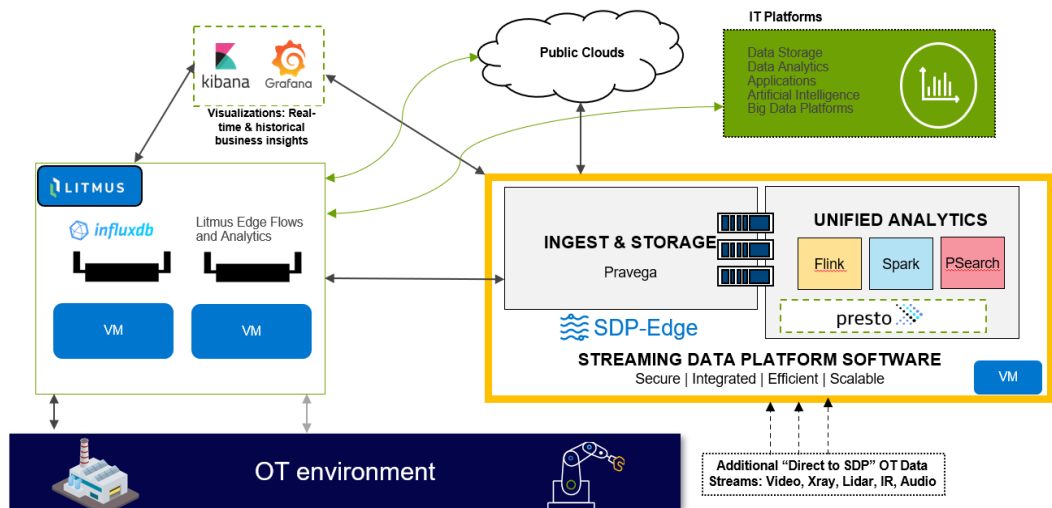


Figure 20. Unifying data with DVD for Manufacturing Edge with Litmus solution

Litmus Edge Manager

Litmus Edge Manager enables management of all Litmus Edge devices running on physical gateways, PCs, or VMs, and hierarchies are defined for logical device groupings. At the highest level, a project is defined as a logical representation of a collection of edge devices, including a factory running 50 edge devices, for example.

The following is the **Dashboard** view within Litmus Edge Manager:

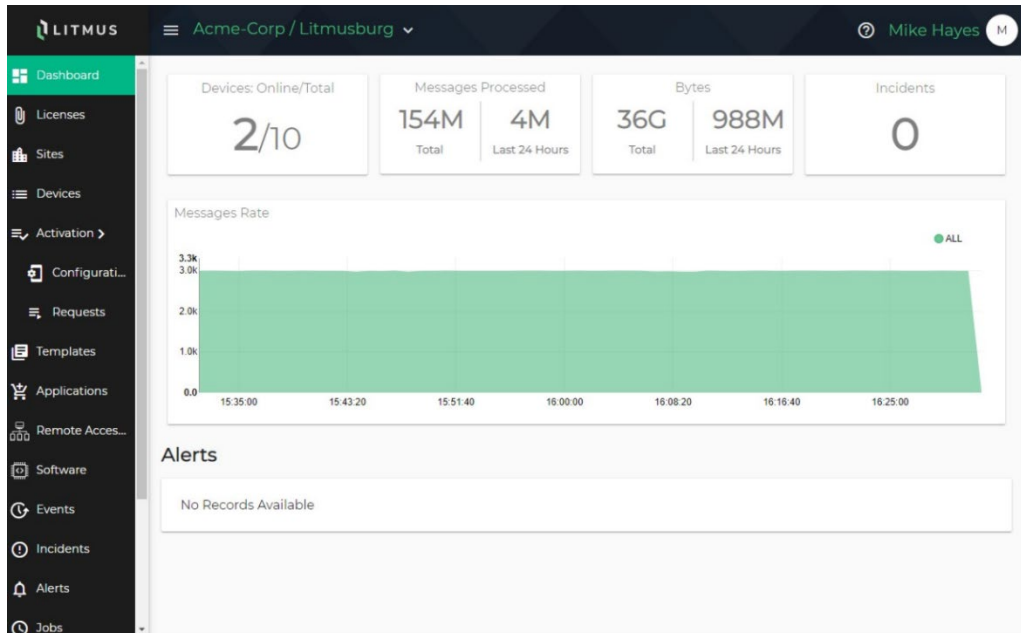


Figure 21. Litmus Edge Manager Dashboard

The **Dashboard** provides details on the current devices online and total devices, messages, incidents, and alerts. There are multiple features within Litmus Edge Manager, including:

- **Licenses** - where licenses can be applied and maintained for Litmus Edge and Edge Manager
- **Sites dashboard** - which is like projects in that it allows logical grouping of devices. For example, a project can be used to manage the Litmus Edge platform at a global scale, and a site can then be used to represent each location or factory
- **Devices dashboard** - which shows all current Edge devices, which can be fully managed from here
- **Templates dashboard** - which manages templates, a specific configuration that is captured from a Litmus Edge device to then be deployed across multiple devices. Within a template, specific settings for connectors, flows, and analytics are defined for a given use case
- **Applications dashboard** - used to centrally configure, manage, and update applications on the Litmus Edge devices
- **Remote Access dashboard** - where all remote access settings for the Litmus Edge devices are centrally managed

- **Software Update dashboard** - which allows deployed versions of Litmus Edge to be centrally managed
- **Events, Incidents, Alerts dashboards** - where all events and triggered incidents from alerts are viewed. This is a centralized place for troubleshooting issues across the entire Litmus environment
- **Marketplace Catalog** - where specific application containers are hosted and configured for deployment to Litmus Edge devices

The following is an overview of Litmus Edge Manager's capabilities for manufacturing edge:

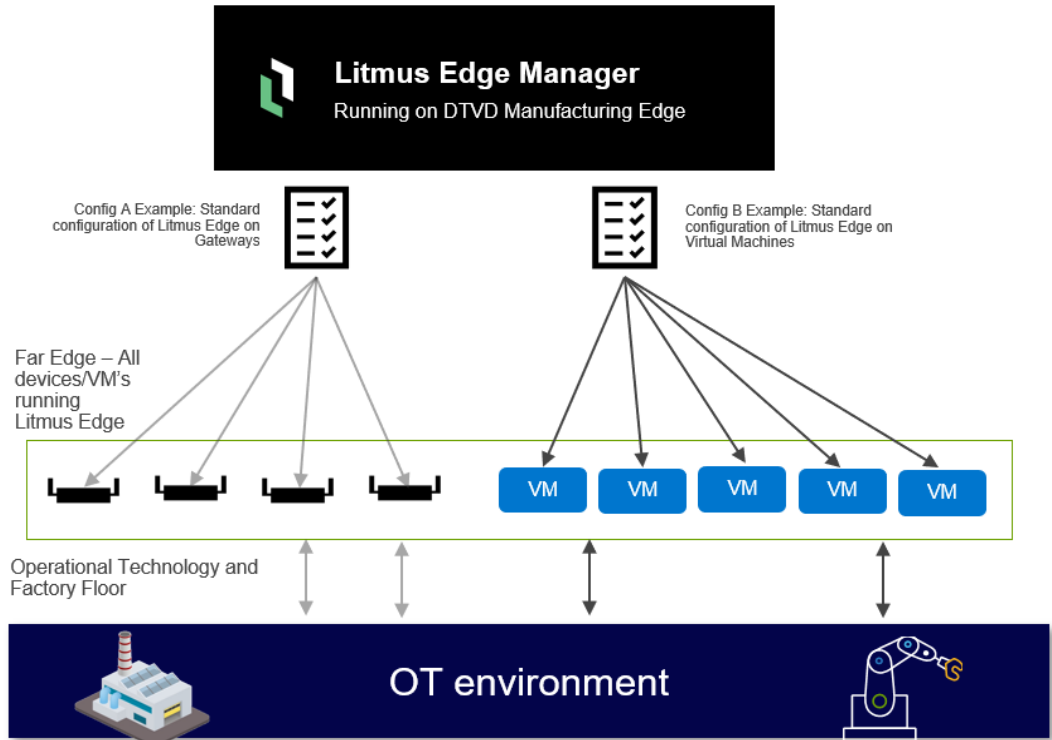


Figure 22. Managing at scale with Litmus Edge Manager

Further information about the Litmus platform can be found within the [DVD for Manufacturing Edge - Design Guide with Litmus](#).

Chapter 7 Solution Sizing and Considerations

This chapter presents the following topics:

Introduction.....43

Deployment considerations43

Introduction

Dell Technologies works directly with manufacturers to meet their specific requirements and deliver solutions.

The following are high-level questions for businesses to consider ahead of edge deployment. Once clarity is provided on the basic elements of the operational environment, Dell Technologies recommends engaging with our account teams to deliver assessment, use case identification, strategy, solutions architecture, and deployment planning:

- What are the current manufacturing challenges and pain points?
- Is there a digital strategy, business transformation effort, or project underway at the organization's highest levels?
- How does this strategy align to manufacturing operations?
- What is the scale of a potential deployment?
- Are there specific use cases or outcomes for an edge deployment to address?
- Who owns and manages manufacturing operations?
- Who owns and manages the facilities, including power?
- Who manages process engineering and quality?
- How does the IT organization support manufacturing?
- Are there are specific supply chain areas or issues to be considered?
- What are the typical areas within the specific factory (warehouse, build, process, test, ship, and more)?
- What are the top three daily issues reported in manufacturing?
- What security considerations are factored into a potential deployment?
- What are the key applications that run manufacturing?
- Is there a budget in place for proof-of-concept or full deployment?

Deployment considerations

To deploy the DVD for Manufacturing Edge with Litmus solution, understand and consider the following areas. For a detailed review of how the solution addresses these areas, review the [DVD for Manufacturing Edge - Design Guide with Litmus](#).

Solution sizing

Regarding solution sizing, the manufacturer must understand the layout and assets that make up their environments. The solution is designed to connect to these assets, so understanding the following is critical:

- Types and number of assets (robotics, CNC, motors, pumps, conveyors, and more)
- Control systems (PLC)
- Industrial connectivity used (Ethernet, CAN)

- Industrial protocols
- Datapoints per control system (tags from each device or PLC)
- Use of sensors (type, quantity, and location where data is aggregated)
- Use of vision-based solutions (use case, location, quantity of cameras, IP, or non-IP-based)
- Edge gateways (location, purpose, connectivity used)

Building a reference point or chart around the number of industrial assets and tags that are related to these assets is a recommended starting point. The DVD for Manufacturing Edge with Litmus solution is sized for easy scaling and deployment based on the number of tags that are required, as the following table shows:

Table 1. Solution sizing overview

Workload size	>5,000 tags	>15,000 tags	>30,000 tags
Dell APEX Private Cloud General Purpose 8 GB memory-core ratio	16 Cores per Node 1 CPU per Node Value Tier	32 Cores per Node 2 CPU per Node Value Tier	32 Cores per Node 2 CPU per Node Balanced Tier
Dell Streaming Data Platform			
Litmus Edge software: Foundation, Growth, or Scale			
VMware vSAN or VMware vSphere Enterprise Plus or ESXi			

High availability

In the context of high availability, the solution can be deployed out-of-the-box on the Dell APEX Private Cloud. This means that the virtualized components, such as Litmus Edge and Edge Manager, can failover to another node if there is a hardware failure within the HCI cluster. More features such as VMware DRS can be leveraged to ensure optimal performance across all the Dell APEX Private Cloud nodes.

Some key considerations related to high availability for the solution include:

- Understanding of service levels that are required and their RPO/RTO requirements
- Requirement and understanding for OT systems to have HA-based applications
- System updating, and how it impacts availability
- HA-based application recovery and how it works

Disaster recovery

Disaster recovery is a key consideration when deploying edge infrastructure. It must be fully understood whether the edge applications are required to stay running in the event of a disaster, for example, a flooded data center. Manufacturers should consider the following:

- Service levels and Recovery Point Objective (RPO)/Recovery Time Objective (RTO) as per high availability
- Strategic placements of edge compute in terms of logical aggregation and lack of dependency on a single data center or location

- Multisite redundancy (such as Dell APEX Private Cloud stretch clusters) allowing for site-level or data center failures
- Backup and recovery toolsets and how they apply for the edge (including VMware SRM)

Data management and services

Within the solution, the Dell Streaming Data Platform provides data persistence capability at the edge. When deploying the solution, consider the following:

- Volume of data from industrial assets
- Tag requirements and frequency of data from assets
- Streaming technologies used
- Other data sources under consideration (such as Computer Vision stream directly from a camera)

Within the solution, data is cached under InfluxDB on Litmus Edge before relevant analytical use cases run on that data. Data is then sent to persist on the SDP platform longer-term.

Security

Security is a critical consideration for any edge deployment, particularly as the interface point between industrial systems on the manufacturing floor and IT infrastructure and applications.

The DVD for Manufacturing Edge with Litmus is designed to leverage and extend existing IT security capabilities into manufacturing. Some key considerations from a security perspective include:

- Network security, including VLANs, firewalls, DMZ, secure protocols, encryption, RBAC, logging, and security hardening
- Physical security, including switch management, data centers, communications room access, data encryption on devices, physical system monitoring, and so on

Note: There are also several ways to harden the security posture of the solution from within the Litmus platform and SDP.

Applications

Applications can run directly on Litmus Edge if they can run within a Docker container.

Since the DVD for Manufacturing Edge with Litmus is a horizontal solution, manufacturers should consider the size of other applications and workloads running on the infrastructure (at the vSphere level on VxRail or PowerEdge). If additional applications must run on the manufacturing edge, consider sizing and architecture. The solution can scale easily once sized correctly.

Solution licensing

The DVD for Manufacturing Edge with Litmus requires licensing for the following solutions:

- Dell APEX Private Cloud (VMware vSphere and vSAN—multiple options)
 - Customers can purchase VMware licensing with the solution or leverage their existing enterprise agreements.

- Dell Streaming Data Platform
 - Licensed Per Core on the SDP-Edge virtual machine, with one or three-year license options available.
- Litmus Platform
 - Three levels of licensing—Foundation, Growth, and Scale—with different feature levels available and one, two, or three-year license options.

Cloud connectivity and integration (hyperscalers)

The DVD for Manufacturing Edge with Litmus has an integrated integration capability to connect to public cloud platforms and on-premises applications and private cloud solutions. Prior to deployment, consider the following:

- Public cloud integrations required
- Specific applications required
- Protocols to be used for the integrations (for example, MQTT)
- Integrations to be performed for on-premises applications
- HA and DR implications regarding loss of connectivity to integrations

Operational technology

Understanding how the manufacturing process works prior to deployment of the solution is critical. A full assessment of manufacturing operations is recommended, and here are some important considerations to evaluate:

- How is the manufacturing process laid out and structured, and how many build cells, lines, and regional or global sites are there?
- What are the specific opportunities and pain points?
- What assets need connecting?
- What control systems are used, and what for?
- What sensors and cameras are used, and what for?
- What automation systems are present, and who is the vendor or partner?
- What applications specifically support production?
- How are shift patterns managed in manufacturing?
- What interface points to production operators occur during production? Do they use specific devices and applications?
- What IT technology silos exist in manufacturing?
- What security issues or risks are present in manufacturing?
- Are there process challenges regarding IT/OT and how operational incidents are handled and escalated?
- What partners or vendors are present in manufacturing operations?
- Is there currently an edge infrastructure deployed (for example, edge gateways)?

Assessment is recommended to identify the best approach for edge solutions architecture and to identify the business outcomes and use cases that offer the most improvement to manufacturing outcomes.

Chapter 8 Demo Details

This chapter presents the following topics:

Demo details48

Demo details

Manufacturers can evaluate the DVD for Manufacturing Edge with Litmus for manufacturing and explore outcome-based scenarios in the following interactive demo, including:

- Introduction to Litmus Edge
- Connecting Industrial Assets
- Flows and Analytics
- Applications and Integrations
- Management of Edge at scale
- Dell Streaming Data Platform

Viewers can also review specific manufacturing use case examples such as:

- OEE
- Yield Optimization
- Predictive Maintenance

The demo can be accessed [here](#) on the Dell Technologies Demo Center, and the following provides a preview.



Figure 23. Dell Technologies Demo Center

Chapter 9 Extra Resources

This appendix presents the following topics:

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Extra resources

Hardware configurations

The following Dell APEX Private Cloud configurations underpin the DVD for Manufacturing Edge with Litmus.

	Node Type	Cores per Node	CPU per Node	Compute Performance Tier	Storage Type	Storage Capacity per Node
Small ≥ 5,000 tags	General Purpose 8 GB memory-core ratio	16	1	Value	vSan	11.5TB
Medium ≥ 15,000 tags	General Purpose 8 GB memory-core ratio	32	2	Value	vSan	23TB
Large ≥ 30,000 tags	General Purpose 8 GB memory-core ratio	32	2	Balanced	vSan	61TB

Figure 24. Dell APEX Private Cloud configurations for the DVD Manufacturing Edge with Litmus

Dell VxRail resources

- [VxRail Infohub](#)
- [VxRail TechBook](#)
- [VxRail Interactive Demo](#)

Dell Streaming Data Platform resources

- [Streaming Data Platform Home](#)
- [Streaming Data Platform Info Hub](#)
- [SDP Code Hub](#)

Dell PowerEdge resources

- [Dell PowerEdge Home](#)
- [Dell PowerEdge Info Hub](#)

Litmus resources

- [Litmus Supported Devices](#)
- [Litmus Demo Videos](#)
- [Litmus Edge Manager](#)

Dell Technologies Edge

- [Dell Validated Design for Manufacturing Edge - Design Guide with Litmus](#)
- [Dell Technologies Edge](#)

Note: For links to additional documentation for this solution, see [Dell Technologies Info Hub for Edge](#).
