Critical manufacturing
an ASMPT company

System Requirements

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1 System Requirements

Critical Manufacturing MES is a high availability Manufacturing Execution System optimized for transaction throughput with critical system requirements. For an overview of the system and its main components please refer to the System Architecture ↗ section.

The purpose of this document is to provide the user with the system requirements and different configuration options for running Critical Manufacturing MES in different environments.

Below, follows a segmented view of the necessary information to prepare beforehand for a future acquisition and installation of this software.

- Deployment
  - Available Deployment Targets
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> **Warning**
>
> The exact hardware requirements depend on the specific customer scenarios and environment.

You can access the complete PDF file of the System Requirements here: PDF

2 Deployment Targets

Critical Manufacturing MES offers flexible deployment options to suit various needs and IT strategies. The below sections present the deployment options and major considerations when establishing your strategy.

2.1 Deployment Options

2.1.1 Cloud

MES may be deployed on cloud environments using:

- **Public Cloud** - Leveraging platforms like Microsoft Azure or AWS.
- **Private Cloud** - Hosted within the on your own data center or a dedicated private cloud environment.

When deploying Critical Manufacturing on a cloud infrastructure, Critical Manufacturing recommends a containerized approach, targeting a managed Kubernetes service like Azure AKS or Amazon EKS. In the Critical Manufacturing Information Center, there are detailed guides on how to configure a Kubernetes cluster.

For cloud-based installations, the following concerns should be taken into account:

Topic	Description
Latency	In order to ensure adequate user experience and performance, it's recommended that the latency between the application clients (web browser or mobile devices) and the application servers does not exceed **200ms**.
Bandwidth	In order to ensure adequate performance of the user interface, a minimum throughput of **20 Mbps** between the application clients (web browser or mobile devices) and the application servers is recommended.
Connection availability	Cloud-based installation rely on a stable connection to the data center hosting the application backend. The system does not offer any offline capability in case there is no connectivity to the cloud.
Database and application servers co-located	In order to ensure application performance, database servers running Windows Server VMs should be co-located in the same region to ensure low latency.
On-premises components	Components related with automation are recommended to be executed on premises, due to lower latency between equipment controllers and the physical equipment to which they are connected. Connectivity is required between on-premises components and the application servers.

Table: Cloud-based installation concerns

2.1.2 On-Premise

Installing and running the MES directly on your local servers and infrastructure is also an option. On such scenario, evaluate if your deployment is a:

- **Single-plant deployment** - For a single manufacturing facility.
- **Multi-plant deployment** - Connecting and managing MES across multiple manufacturing sites.

This may impact a lot of decisions when setting up your infrastructure.

2.1.3 Hybrid

A combination of cloud and on-premise deployments, where the MES might utilize the cloud while Connect IoT Automation Managers remain on-premise, close to the shop floor.

2.2 Considerations

2.2.1 General

When choosing your deployment target evaluate:

- **IT Infrastructure Readiness** - Ensure the chosen environment (cloud, on-premise or hybrid) has the necessary hardware, software, network connectivity, and cybersecurity measures in place.
- **Scalability Requirements** - Assess the current and future production volumes and the need for the MES to handle increasing data and user loads.
- **Security and Compliance** - Evaluate data security requirements and any industry-specific regulations that might influence the choice between cloud and on-premise options.
- **Integration with Existing Systems** - Considering how the MES will need to connect and exchange data with other enterprise systems like ERP, PLM, and automation systems.
- **Company IT Strategy** - Align the MES deployment with the overall IT strategy and preferences of the manufacturing organization.
- **Disaster Recovery and Business Continuity** - Plan for data backup, system redundancy, and failover capabilities in the chosen environment.
- **Latency and Performance** - For real-time data collection and control, especially in highly automated environments, the proximity of servers (on-premise vs. cloud) can be a crucial factor.

2.2.2 MES Specifics

Below are listed the Critical Manufacturing MES specific functions that may influence your deployment target decisions.

2.2.2.1 Deployment Process

Critical Manufacturing MES environment is managed through **Critical Manufacturing DevOps Center** (a centralized deployment platform for containerized applications). This service allows you to create, configure and automate the installation, upgrade and uninstall MES environments.

The DevOps Center provides different container orchestration platforms. For each one there are one or more deployment targets to directly deal with different vendors or deployment strategies (On-Premises, Hybrid and Cloud). Also, it provides two deployment processes:

- **Remote installation** - First you configure and deploy Critical Manufacturing Infrastructure Agent into your infrastructure. The agent will then be responsible by the communication between DevOps Center and your infrastructure. This will allow you to install, upgrade and uninstall the environments just by interacting with this service GUI or CLI.
- **Local installation** - After creating and configure the environment, you will be allowed to download a package with a recipe (scripts and configuration files) required for you to manually run the setup on your environment.

For more information, see DevOps Center deployment targets documentation.

2.2.3 Database Layer Requirements

Critical Manufacturing MES requires a SQL Server installation running on Windows Server. For high-availability purposes, an Always On High Availability cluster configuration is recommended.

SQL Server for Linux or containerized versions of SQL Server are currently **not supported** for full MES workloads, including Operational Data Store (ODS) and Data Warehouse (DWH) transactions, since they offer several limitations on components required by the system. Therefore, the database component is required to be hosted on servers running Windows Server.

Managed SQL Server services like Azure SQL Database or Amazon RDS are also **not supported** due to features that are currently unavailable in those services.

There is **limited support** for Azure SQL Managed Instances. In this case, SQL Server Analysis Services (SSAS) and Reporting Services (SSRS) must be hosted separately. Please consult Critical Manufacturing for additional details on how to configure an installation using Azure SQL Managed Instances.

For additional details on the required configuration of the database component, see the Database Component section.

2.2.4 Application Layer Requirements

Critical Manufacturing MES application layer is deployed as a containerized application on one of the following platforms:

- Kubernetes (check Application Layer - Container Stack for the supported containers)
- Red Hat OpenShift

- Cloud managed container orchestration services based on Kubernetes (Azure AKS, and Amazon EKS)

The deployment process for containerized installations is managed through **Critical Manufacturing DevOps Center**.

For additional details on the required configuration for a containerized deployment, see the Application Layer - Container Stack section.

2.2.5 Optional Components Requirements

In addition to the containerized components, there are currently Application Layer optional components which, due to dependencies to Windows-specific libraries, are required to run on Windows servers. The table below describes these components and the associated modules.

Component	Module	Description
Printable Documents Renderer	Advanced Layout and Printing	On containerized environments, this component supports printing documents to Windows printers. It is also possible to configure the container infrastructure to enable printing documents using a CUPS Server ↗. On Windows environments, this is not required as the application host will be able to print directly to printers configured on the application servers.
ECAD Renderer	Core	Required to render CAD file visualizations.
IoT Automation Managers	Core	Required to support Windows-based automation drivers.

Table: Optional components and associated modules

2.3 Persistency Layer

This section describes the contents of the persistency layer that will hold the database and other additional required components for running Critical Manufacturing MES:

- Database Component
  - SQL Server Always On
  - Storage Area Network Configuration
  - SQL Server Licensing
  - SQL Server Permissions
- External Components

2.3.1 Database Component

Critical Manufacturing MES uses SQL Server databases for persistency. This section describes the requirements for the database component, including software and hardware requirements, as well as notes about SQL Server high availability, storage and licensing.

2.3.1.1 Software Requirements

The table below describes the software requirements for database servers:

Operating System	Database Engine	Additional Required Software
• Windows Server 2022	• SQL Server 2019 Standard Edition • SQL Server 2019 Enterprise Edition • SQL Server 2022 Standard Edition • SQL Server 2022 Enterprise Edition	• SQL Server Reporting Services • SQL Server Analysis Services (multidimensional model) • Microsoft Distributed Transaction Coordinator (MSDTC)

Table: Software requirements for database servers

2.3.1.2 Hardware Requirements

Depending on the expected system load, the recommended hardware configuration for the database servers may vary. This section outlines reference configurations for different use cases.

Configuration	Intended Use	Response time	Scalability	High availability
Minimum	Demonstration / Development	Medium/Slow acceptable	Not required	Not required
Training / Staging	System tests, validations and training	Medium	Not required	Not required
Production A	Low to medium volume production	Fast	Required	Very High
Production B	High volume production	Fast	Required	Very High

Table: Hardware configuration for database servers

The exact hardware requirements will depend ultimately on the specific customer environment. Consult with Critical Manufacturing in order to get a tailored recommendation

based on known requirements for your specific installation. These are the minimum requirements:

Configuration	Number of Servers	Processors	Memory	Storage
Minimum	1 *	1 x Quad Core, 2 GHz	8 GB	200+ GB
Training / Staging	1	2 x Quad Core, 2 GHz+	16 GB	Online DB: 200+ GB ODS+DWH: 1TB
Production A	2	2 x Six Core, 2 GHz+	32 GB+	Internal storage: 150+ GB Storage hard-disk: 2.5TB
Production B	2	2 x Eight Core, 2 GHz+	64 GB (Active/Active) 128 GB (Active/Passive)	Operating System: 150 GB SAS 15K rpms TempDB: 200 GB+ in SSD Storage: 10 TB+

Table: Minimum hardware requirements for database servers

> **Note**
>
> The Minimum configuration assumes that the database server may also run other application components in addition to the database.

2.3.1.3 SQL Server Configuration

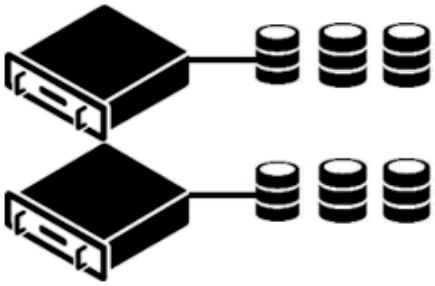
The sections below offer additional details on SQL Server configurations that are relevant to a Critical Manufacturing installation.

- SQL Server Always On
- Storage Area Network Configuration
- SQL Server Licensing
- SQL Server Permissions

2.3.2 SQL Server Always On

Always On is a feature that provides a low-cost alternative to a Storage Area Network (SAN) as each Database Server uses its own local storage as shown in the figure below. The Always On feature is supported in the SQL Server Enterprise and Standard Editions (the Standard Edition does not support Availability Groups and is limited to two nodes Failover Cluster Instances). More information about SQL Server Always On can be found in the following URLs:

- SQL Server AlwaysOn Failover Cluster Instances
- SQL Server AlwaysOn Availability Groups



2.3.2.1 SQL Server Always On Failover Cluster Instances

The Always On Failover Cluster Instances leverages Windows Server Failover Clustering (WSFC) functionality to provide local high availability through redundancy at the server-instance level - a failover cluster instance (FCI). A FCI is a single instance of SQL Server that is installed across different Windows Server Failover Clustering (WSFC) nodes and, possibly, across multiple subnets. On the network, an FCI appears to be an instance of SQL Server running on a single computer, but the FCI provides failover from one WSFC node to another if the current node becomes unavailable.

2.3.2.2 SQL Server Always On Availability Groups

The Always On Availability Groups feature is a high-availability and disaster-recovery solution that provides an enterprise-level alternative to database mirroring. Always On Availability Groups maximize the availability of a set of user databases for an enterprise. An availability group supports a failover environment for a discrete set of user databases, known as availability databases, that fail over together. An availability group supports a set of read-write primary databases and one to eight sets of corresponding secondary databases. Optionally, secondary databases can be made available for read-only access and/or some backup operations.

2.3.2.3 SQL Server Always On in Multi-Subnet Setups

Critical Manufacturing MES v{{extra.current_version}} supports SQL Server Always On across multiple subnets provided the following requirements are met:

- Use Microsoft Active Directory (AD) as the network's DNS server.
- Set `RegisterAllProvidersIP=0` on each Availability Group listener (WSFC), and adjust `HostRecordTTL` if suitable.
- The `MultiSubnetFailover` flag remains unset/false (this is the default MES configuration).

With these settings, the listener registers only the active IP, enabling reliable client connections and cross-subnet failover without `MultiSubnetFailover`.

> **Info**
>
> Support for `MultiSubnetFailover` is planned for a future MES release.

2.3.2.3.1 MICROSOFT ACTIVE DIRECTORY ALTERNATIVES

Using other DNS servers or different architectures may also work, assuming they follow the previous requirements.

> **Warning**
>
> Keep in mind that any alternative configurations are your responsibility and need to be managed and maintained independently.

Among the alternatives are:

- Using other DNS services may work as long as they implement the RFC 2136, allowing dynamic DNS updates. However, these may require custom configuration to ensure that the WSFC updates their DNS entries when performing failovers.
- Other cloud-native services - such as AWS Route 53 or Azure Private DNS - may work but are more complex to set up and typically require custom automation via provider APIs because they do not implement RFC 2136.
- Alternatively, you can leverage a Load Balancer that will only route traffic to the active replicas, assuming that it has healthchecking capabilities. The Availability Group Listener hostname must be resolved through any DNS Server to the Load Balancer's IP address. For more information, see the how to reduce failover times on AWS.

2.3.3 SQL Server Licensing

This section contains licensing information regarding SQL Server.

SQL Server Standard editions are licensed in Core-Based and Server + CAL modes, whereas Enterprise editions are licensed only in Core-Based mode.

When running Critical Manufacturing MES on SQL Server Standard edition, the following limitations apply:

- Database instance maximum hardware consists of 128 GB and 24 cores of CPU.
- Power BI Report Server is not available.
- Index rebuilding is only available in offline mode.
- Analysis Services Multidimensional has limited partitioning capabilities, severely impacting DWH cubes performance in large volume sites.

For more information about SQL Server licensing, please refer to the URLs below:

- SQL Server 2019
- SQL Server 2022

2.3.4 Storage Area Network Configuration

Critical Manufacturing recommends the usage of SQL Server Always On for productive installations of Critical Manufacturing MES. The usage of Storage Area Network (SAN) is also supported. This section describes the productive configuration of a Storage Area Network.

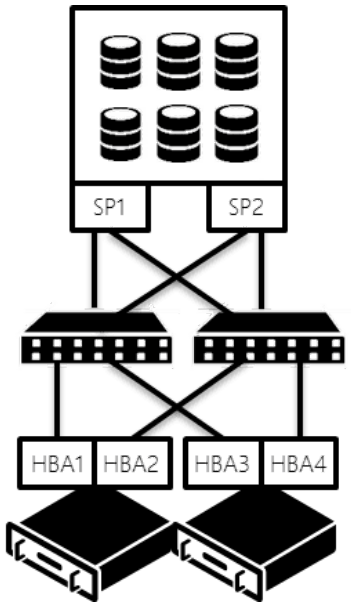
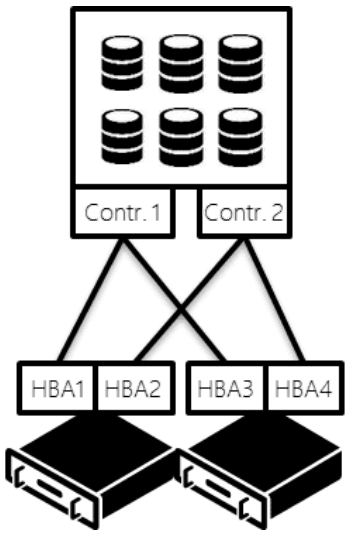
Type	Configuration
Storage does not support direct attach	
Storage supports direct attach	

Table: Storage Area Network configuration

2.3.5 SQL Server Login Permissions for MES Installation and Operation

This section provides essential information regarding the database user required to install and run the MES system.

To successfully install or upgrade MES to a newer version, the designated database user must be assigned the `sysadmin` role in SQL Server. This elevated permission is necessary to ensure that the installation or upgrade process completes without issues.

Once the MES system is fully operational, the `sysadmin` role can be removed from the database user, as it will no longer be required for regular system operations.

2.3.5.1 Removing sysadmin Role from Database User

This section outlines the necessary steps and permissions required to remove the `sysadmin` role from the database user, once the MES system is up and running.

> **Warning**
>
> This process involves removing the `sysadmin` role from the existing database user, **not replacing** the user itself.

By removing the `sysadmin` role, the database user will retain ownership of the MES databases and associated jobs. This ownership grants most of the necessary permissions to ensure that the system continues to operate correctly.

Therefore, before removing the `sysadmin` role from the database user, please ensure that the following conditions are met.

> **Warning**
>
> If the environment is configured with SQL Server Always On, the following configurations must be performed on all database servers.

2.3.5.1.1 CONFIGURE USER MAPPING FOR MES LINKED SERVERS

To ensure proper functionality before removing the `sysadmin` role, you need to configure user mapping for the MES Linked Servers as follows:

- **Local Login**: The database user specified during MES installation
- **Impersonate**: No
- **Remote User**: The same database user specified during MES installation
- **Remote Password**: The password for the database user specified during MES installation

This user mapping must be applied to the following Linked Servers:

- `cm{system_name}ODSLink`
- `cm{system_name}DWHLink`
- `cm{system_name}OnlineLoopback`

- `cm{system_name}OnlineLink`

If the environment is configured with **SQL Server Always On**, the user mapping must also be applied to the following Linked Servers:

- `Online High Availability LinkedServer`
- `ODS High Availability LinkedServer`
- `DWH High Availability LinkedServer`

2.3.5.1.2 CONFIGURE DATABASE USER PERMISSIONS

Ensure that the database user is granted the following permissions:

- `VIEW SERVER STATE`
- `VIEW ANY DEFINITION`

2.3.5.1.3 CONFIGURE USER MAPPING FOR THE MSDB DATABASE

To ensure proper operation of the MES system, the database user must have a user mapping to the `msdb` database. Additionally, the following permissions must be granted within the `msdb` database:

GRANT SELECT on the following tables:

- `dbo.sysjobhistory`
- `dbo.sysjobsteps`
- `dbo.sysjobs`
- `dbo.sysjobservers`

2.3.5.1.4 TRUSTED ASSEMBLIES

The MES databases include and utilize certain custom assemblies (using CLR) that provide various utility functions and procedures. To ensure these assemblies can be used without the `sysadmin` role, they must be added to the list of trusted assemblies for the server.

The following assemblies need to be added to the trusted assemblies list for each respective database:

- Online:
  - `OnlineDatabaseUtilsCLR`
- Operational Data Store (ODS):
  - `cmFoundationSQLServerCLRUtils`
  - `ICSharpCode.SharpZipLib`
- Data Warehouse (DWH):
  - `cmFoundationSQLServerCLRUtils`
  - `ICSharpCode.SharpZipLib`
  - `System.IO.Compression`

2.3.6 External Components

Critical Manufacturing MES has depends on external system, besides SQL Server database, that must be running prior to setup a new environment.The following subsections present these dependencies in two groups:

- **Mandatory**: systems required by the setup of a new MES environment;
- **Optional**: systems only required when a specific functionality of the MES is activated.

2.3.6.1 Mandatory

This section describes the requirements for additional required components that must be running for a successful installation and operation of Critical Manufacturing MES:

- AWS S3 (or compatible)
- ClickHouse for Data Platform
- Kafka
- RabbitMQ

The requirements will vary depending on the usage of each component.

2.3.7 ClickHouse Requirements

2.3.7.1 System Requirements

Item	Minimum	Recommended
Version	25.3	25.3
Memory	16GB	32GB
CPU	4vCPUs	8vCPUs
Disk space	1TB	3TB

Table: Minimum and recommended system requirements for ClickHouse

Mandatory ClickHouse Settings

- **Cloud Upgrades**: When upgrading from MES versions earlier than 11.0.0 to 11.0.0 or later, and migrating from an in-stack ClickHouse deployment to an external ClickHouse Cloud setup, the `allow_materialized_view_with_bad_select` setting must be configured before starting the upgrade. For more information, see ClickHouse Migration.
- **Correct ODS Behavior**: In ClickHouse, when the `do_not_merge_across_partitions_select_final` setting is set to `1`, merging across partitions may cause data duplication when querying ODS state tables (for example, `CoreDataModel_T_Material`). ClickHouse 25.3 sets this value to `0` by default; however, some operators may have manually overridden it to `1`. To ensure correct behavior, this setting must always remain set to `0`. Starting from MES version 11.2.3, the system automatically enforces this configuration.

2.3.7.2 ACLs

When creating an MES Customer Environment ↗, ClickHouse users can be automatically provisioned with predefined roles and permissions.

Depending on how the environment is configured, the following options are available:

- If automatic provisioning is enabled, the system creates the required users with the necessary permissions.
- If automatic provisioning is disabled, the system assigns all required permissions to the default user.
- For advanced scenarios (for example, when following custom security or compliance policies), administrators may disable automatic provisioning and manually configure both user creation and permission assignments.

> **Info**
>
> Permissions in ClickHouse are assigned using the GRANT statement. All users should authenticate with strong credentials and be restricted to the relevant databases only.

2.3.7.2.1 DEFAULT USER

The default ClickHouse user is the account that must already exist in the customer ClickHouse installation. This user is either created manually by the customer or corresponds to the default user provided by their ClickHouse setup.

The Environment Manager uses this account to connect to ClickHouse during environment creation and configuration. Therefore, the default user must have all of the permissions listed in the table below.

This requirement exists because ClickHouse only allows users to grant permissions that they already possess. Without these privileges, the system will not be able to create or configure additional users correctly.

2.3.7.2.2 OTHER USERS

The table below summarizes the standard ClickHouse users created by MES, their database scope, and the permissions required for installation, upgrades, and daily operations.

User Role	Primary Function	Databases	Permissions
Analytics (Read/Write) Admin	Administrative user with extended privileges for managing all analytics databases and deployments.	All required databases	`CREATE DATABASE`, `DROP DATABASE`, `SHOW`, `SELECT`, `INSERT`, `ALTER`, `CREATE TABLE`, `CREATE TEMPORARY TABLE`, `CREATE VIEW`, `CREATE DICTIONARY`, `DROP TABLE`, `DROP VIEW`, `DROP DICTIONARY`, `UNDROP TABLE`, `TRUNCATE`, `OPTIMIZE`, `CREATE ROW POLICY`, `ALTER ROW POLICY`, `DROP ROW POLICY`, `SHOW ROW POLICIES`, `dictGet`
MES (Read/Write)	Responsible for reading and writing core operational MES data.	`MES`	`SELECT`, `INSERT`, `ALTER`, `CREATE TABLE`, `CREATE VIEW`, `CREATE DICTIONARY`

User Role	Primary Function	Databases	Permissions
Analytics (Read)	Provides read-only access for general reporting and data consumption across all Analytics databases.	`ODS`, `CDM`, `DWH`, `system`	`SELECT` (on analytics databases), `SELECT(volume_name, policy_name)` on `system.storage_policies`, `SELECT(value, name)` on `system.build_options`
Analytics (Read) / DWH (Read/Write)	Used for processes that populate the DWH, but only require read-only access to source databases (`CDM`).	`CDM`, `DWH`	- `CDM`: `SELECT` - `DWH`: `SHOW`, `SELECT`, `INSERT`, `ALTER`, `CREATE TABLE`, `CREATE VIEW`, `CREATE DICTIONARY`, `DROP TABLE`, `DROP VIEW`, `DROP DICTIONARY`, `UNDROP TABLE`, `TRUNCATE`, `OPTIMIZE`, `CREATE ROW POLICY`, `ALTER ROW POLICY`, `DROP ROW POLICY`, `SHOW ROW POLICIES`, `dictGet`
DWH (Read)	Provides read-only access exclusively to the Data Warehouse.	`DWH`	`SELECT`
DWH Playground (Read)	Provides read-only access to Cube Explorer users.	`DWH`	`SELECT` (with quotas: `MAX execution_time = 900s`, `MAX result_rows = 1,000,000`)

Table: Standard ClickHouse user roles, associated databases, and required permissions for MES

2.3.7.2.3 PERMISSION DESCRIPTIONS

- **CREATE DATABASE / DROP DATABASE** – Create or remove entire databases.
- **SELECT** – Read data from tables.
- **INSERT** – Write data into tables.
- **ALTER** – Modify table schema.
- **CREATE TABLE / VIEW / DICTIONARY** – Create new database objects.
- **DROP / UNDROP** – Remove or restore database objects.
- **TRUNCATE / OPTIMIZE** – Manage and maintain table data.
- **SHOW** – Display metadata or policies.

- **dictGet** – Access data from external dictionaries.
- **ROW POLICY permissions** – Manage row-level access control policies.

2.3.8 Kafka Requirements

In regards to Kafka, the system requirements might change depending on several key factors such as:

- message volume (count and size)
- throughput
- number of partitions
- replication factor
- data retention policies

Proper benchmarking and monitoring of Kafka is essential for fine-tuning resource allocation.

2.3.8.1 Minimum system requirement

Item	Requirement
Version	>=3.8.1 to <4.0.0
Brokers	3
Memory	8GB per broker
CPU	2vCPUs per broker
Disk space	1TB per broker

Table: Minimum system requirements for Kafka

2.3.8.2 Recommended system requirements

Item	Requirement
Version	>=3.8.1 to <4.0.0
Brokers	3
Memory	16GB per broker
CPU	4vCPUs per broker
Disk space	3TB per broker

Table: Recommended system requirements for Kafka

2.3.8.3 ACLs

To simplify the setup of ACLs by system administrators, Kafka topics created by MES adhere to a standardized naming convention. For example, if the system name is "MESIntegrationEnvironment", all Kafka topics will be created with the prefix of the system name in lower case. So, in this case, all Kafka topics will have the prefix of "mesintegrationenvironment" or "_mesintegrationenvironment".

The user used by the system must have at least the following permissions:

- Topic Permissions
  - Alter
  - AlterConfigs
  - Create
  - Delete
  - Describe
  - DescribeConfigs
  - Read
  - Write
- Consumer Group Permissions
  - Read
  - Delete
  - Describe
- Cluster Permissions
  - Create
  - Describe
  - DescribeConfigs

2.3.9 RabbitMQ Requirements

2.3.9.1 Minimum system requirements

Item	Requirement
Version	>=3.13.1 to <4.0.0
Brokers	1
Memory	1GB per broker
CPU	2vCPUs per broker

Table: Minimum system requirements for RabbitMQ

2.3.9.2 Recommended system requirements

Item	Requirement
Version	>=3.13.1 to <4.0.0
Brokers	2
Memory	2GB per broker
CPU	4vCPUs per broker

Table: Recommended system requirements for RabbitMQ

2.3.10 AWS S3 (or compatible) Requirements

2.3.10.1 Minimum system requirements

Item	Requirement
Version	--
Memory	4GB
CPU	2vCPUs

Table: Minimum system requirements for AWS S3 (or compatible)

2.3.10.2 Recommended system requirements

Item	Requirement
Version	--
Memory	16GB
CPU	4vCPUs

Table: Recommended system requirements for AWS S3 (or compatible)

2.3.10.3 Used S3 APIs

The following S3 APIs are used by Critical Manufacturing MES components for storage operations:

API Operation	Purpose	Required Permission
DoesS3BucketExist	Validates bucket availability before performing operations	`s3:HeadBucket`
Upload	Stores data and files in S3 storage	`s3:PutObject`
GetObject	Downloads and accesses stored data from S3	`s3:GetObject`
PutBucket	Creates new S3 buckets for storage initialization	`s3:CreateBucket`

Table: S3 APIs used by CM MES

API Compatibility

These APIs are compatible with AWS S3 and S3-compatible storage solutions. Ensure your S3-compatible storage provider supports all listed operations for full CM MES functionality.

2.4 Application Layer

This section describes the contents of the application layer that will hold the business logic as well as other additional optional components for running Critical Manufacturing MES:

- Container Stack
- Optional Components

2.5 Application Layer - Container Stack

The Critical Manufacturing MES application tier is deployed in a containerized environment, providing solid gains in terms of configuration and usability by taking advantage of a mature containerization architecture such as the one supplied by the Kubernetes or Docker engines.

The application tier takes advantage of a container orchestrator in order to ensure almost boundless horizontal scalability. Additional worker nodes can be added to the cluster and additional instances of specific components can be launched to accommodate extra load on a particular installation.

2.5.1 Software Requirements

Containerized deployments rely on a container orchestrators. Critical Manufacturing MES supports the following container Orchestrators:

Orchestrator	Version	On-Premises	Cloud
Vanilla Kubernetes	v1.33 or later	✓	
Canonical Kubernetes	v1.33 or later	✓	
Red Hat OpenShift	v4.15 or later	✓	✓
Azure Kubernetes Services			✓
Amazon Elastic Kubernetes Service			✓

When using these container orchestrators, keep in mind the following restrictions:

- **Operating System**
  - Any Linux distribution compatible with the selected container orchestrator.
  - Recommended: Ubuntu Server 20.04 LTS or Red Hat Enterprise Linux 9.
  - **Only x64 architecture is supported.** (Container images for x86 or ARM architectures are not available).
- **Container Engine**
  - CRI-O (Kubernetes only)
- **Additional Required Software**
  - Powershell 7.1 (On-Premises installations only)

2.5.2 Workload characterization

Due to the flexibility offered by container orchestrators, Critical Manufacturing does not recommend specific hardware configurations, but provides an adequate description of the expected workload generated by the MES system. With this information, system administrators

can provision and adequately size a cluster to run the MES application tier, considering high-availability and scalability requirements.

This section offers a description of the MES workload in different example configurations.

Similarly to what happens in the more traditional approach, the exact hardware requirements depend ultimately on the specific customer environment. Please consult with Critical Manufacturing for more specific recommendations adapted to specific deployments.

2.5.2.1 Hardware requirements for computational resources

The following table describes the approximate requirements for some sample configurations, depending on their purpose. All examples assume no workloads related with equipment integration.

- **Development**: Development sandbox with no significant system load.
- **Training / Staging**: System with a similar configuration to a productive deployment, with higher resource demands.
- **Production (MES only)**: Productive MES deployment with low to medium volume, without significant usage of Data Platform or Machine Learning capabilities. This configuration includes adequate overhead to support a new MES deployment during an upgrade process.
- **Production (MES with Data Platform and Machine Learning)**: Productive MES deployment with medium to high volume, considering usage of Data Platform and Machine Learning features. This configuration includes adequate overhead to support a new MES deployment during an upgrade process.

Workload	vCPU	Clock speed	Memory
Development	10	2+ GHz	18 GB
Training / Staging	20	2+ GHz	32 GB
Production (MES Only)	30	2+ GHz	64 GB
Production (MES + Data Platform + Machine Learning)	50	2+ GHz	128 GB

Table: Hardware requirements for computational resources

> **Note**
>
> The workloads defined above may be combined in the same cluster by simply adding the characteristics of the intended environments to host on the same cluster.

For example, if you want to host two Development Systems (one Staging and one MES-only production system) in the same cluster, the resource requirements will add up, as shown

below:

Workload	vCPU	Memory
Development 1	10	18 GB
Development 2	10	18 GB
Staging	20	32 GB
Production (MES only)	30	64 GB
Total	70	132 GB

Table: Hardware requirements example for cluster

If several environments are deployed to the same cluster, Critical Manufacturing recommends resource quotas to be defined for each environment in order to prevent resource starvation on other environments or applications hosted on the same cluster. Usually, this is only possible on Kubernetes clusters.

2.5.2.2 Persistent Storage

The application layer requires access to persistent storage volumes to hold object attachments, documents, installation packages, and other application files. The storage requirements depend heavily on the expected usage of the system.

Persistent volumes can be provisioned in different ways, depending on the deployment target platform. At the time of release of this version, Critical Manufacturing MES supports the following volumes types:

Volume type	Usage
Local	Refers to local path on the node file system.
SMB/CIFS	Refers to a shared folder accessible through the SMB protocol.
NFS	Refers to a shared folder accessible through the NFS protocol.
Azure File	Refers to an Azure File Share available in an Azure Storage Account (for AKS and OpenShift deployments only).
Storage Class	Refers to a Kubernetes API for dynamic PV provisioning based on defined storage profiles (provisioners).

Volume type	Usage
Persistent Volume	Refers to a cluster-level, provisioned storage resource with an independent lifecycle, accessed via PVCs; can be static or dynamically provisioned.

Table: Support for persistent volume types

Note

Support for additional volume types may be added in the future.

The table below lists all the required volumes along with the component that requires it. Please note that, especially for **Kubernetes** deployments, there are different requirements for access modes. Some volumes require Read-Write-Many (RWX) access mode.

Info

Note that due to the specific requirements of some technologies, high-performance block storage is required (identified in the table above). The volumes can be statically provisioned using existing Persistent Volumes (previously created by the customer) or dynamically provisioned using Storage Classes in Kubernetes deployments. For high-performance block storage, we recommend a storage solution with at least 10000 IOPS (Input/Output Operations Per Second)

Volume	Component	Access Mode	Storage Type	Minimum Size
connect-iot-repo	connectiot-manager, envmanager, host	RWX	Any	2 GB
grafana-share	grafana	RWX	Any	1 GB
⚠️ installation-data	aggregation-engine, cube, data-manager, discoveryservices, envmanager, epf-alarm-mng-at, epf-alarm-mng-erh, epf-alarm-mng-mes-eh, grafana, help, host, housekeeper, messagebus, rasa-actions, securityportal, traefik-fwdauth, ui	RWX	Any	5 GB
mes-host-documents	host	RWX	Any	10 GB

Volume	Component	Access Mode	Storage Type	Minimum Size
ml-agent-folder	mlplatform-agent	RWX	Any	1 GB
ml-agent-folder	mlplatform-training	RWX	Any	1 GB
ml-export-folder	data-manager	RWX	Any	1 GB
ml-export-folder	mlplatform-training	RWX	Any	1 GB
ml-training-folder	mlplatform-training	RWX	Any	1 GB
redis-data	redis	RWO	Block Storage	1 GB
cube	cube	RWO	Any	5 GB

Table: Volumes required for persistent storage.

Warning

The `grafana-share` volume needs to POSIX compliant. It is recommended to avoid using Azure Files as they can cause issues related with this requirement.

Warning

The `installation-data` volume is used by the system to store installation artifacts consumed by other components. In this volume, a directory named `<environmentname>/backups` will be created in order to extract the database backups for initial database deployment. This directory must be accessible by the SQL Server engine and the path must be provided during system installation, in order to ensure the initial database backup can be restored. For this reason, dynamic provisioning of this volume is not recommended since it may not generate a deterministic folder path that can be provided to an external SQL Server.

2.5.2.2.1 OPTIONAL VOLUME CONFIGURATION

Volume	Component	Access Mode	Storage Type	Minimum Size

Volume	Component	Access Mode	Storage Type	Minimum Size
dagster	dagster	RWO	Any	1 GB
kafka-data	kafka	RWO	Block Storage	100 GB (per broker)
clickhouse-data	clickHouse	RWO	Block Storage	100 GB
clickhouse-log	clickHouse	RWO	Block Storage	20 GB
rabbit-data	rabbit	RWO	Block Storage	1 GB
rabbit-log	rabbit	RWO	Block Storage	1 GB
storage-data	storage	RWO	Block Storage	25 GB
⚠ mes_logs_share	host, discoveryservices, envmanager, help, messagebus, UI	RWX	Any	20 GB

Table: Volumes of optional components or optional volumes.

Info

The amount of storage required by the Critical Manufacturing components greatly depend on how the system is modelled and used. The size indications present in this document are a recommendation for low/medium volume sites, based on our experience. During the configuration of the system these values should be adjusted according to the defined parameterization.

> **Warning**
>
> While the `mes_logs_share` volume does not require Block Storage, it is crucial to consider that the overall system performance will be significantly impacted by the write speed to this volume. For example, a high-latency network share must be avoided in production environments to maintain optimal performance. When installing MES in containerized environments on a Linux-based environment in Ext4 (or a Unix file system family), a `lost+found` folder will be created (typically through fsck) for the volumes. Kafka containers are deployed together with the application and will not start due to inconsistent naming format. This folder must be either removed before starting the relevant Kafka containers or a different file system must be used that doesn't create this folder.

2.5.2.3 Scalable Components

The table below lists all the components along with the images that can be scalable.

Component	Image
core-host	criticalmanufacturing/core-host
core-ui	criticalmanufacturing/core-ui
data-manager	dataplatform/datamanager
edgesquidproxy	criticalmanufacturing/edgesquidproxy
epf-alarm-mng-at	dataplatform/epf-alarm-management-action-trigger
epf-alarm-mng-erh	dataplatform/epf-alarm-management-event-rule-handler
epf-alarm-mng-mes-eh	dataplatform/epf-alarm-management-mes-event-handler
grafana	criticalmanufacturing/grafana
help	criticalmanufacturing/help
host	criticalmanufacturing/host
housekeeper	dataplatform/housekeeper
messagebus	criticalmanufacturing/messagebus
mlplatform-agent	dataplatform/mlplatformagent
mlplatform-training	dataplatform/mlplatformagent
rasa	criticalmanufacturing/rasa

Component	Image
rasa-actions	criticalmanufacturing/rasa-actions
reference	criticalmanufacturing/reference
securityportal	criticalmanufacturing/securityportal
traefik	traefik
traefik-fwdauth	criticalmanufacturing/traefik-fwdauth
ui	criticalmanufacturing/ui

Table: Components can be scalable.

2.6 Application Layer - Optional Components

This section outlines the software and hardware requirements for application layer components of Critical Manufacturing MES that require traditional installation methods, distinct from the container-based main stack.

2.6.1 Software Requirements

The target application server must meet the following software specifications:

- **Operating System (OS):**
  - Windows Server 2016 64-bit
  - Windows Server 2019
  - Windows Server 2022
- **Microsoft .NET Runtimes:**
  - Version 8.0
- **Microsoft PowerShell:**
  - Version 5.1 or later (available in the `Dependencies` folder of the MES installation ISO or downloadable here)
- **Visual C++ Redistributable Package:**
  - Visual Studio 2013 (required solely by the ECAD Service)

2.6.2 Hardware Requirements

The precise hardware demands will vary based on the specific customer environment. The table below highlights key factors influencing response time, scalability, and high availability. It also suggests possible improvements, while noting that enhancing each factor may incur additional costs.

KPI	Primary Driving Factors	Improvement Options
Response Time & Scalability	• Load (number of users and concurrent transactions) • Model and Logic Complexity • Data Volume • Hardware	• Application Optimization • Model Fine-tuning • Database Optimization • Reduction of Data Retention Time • Enhanced Hardware (CPU, Memory, I/O and Network)

KPI	Primary Driving Factors	Improvement Options
High-Availability	• Software and Hardware Failures & Maintenance • Human Errors • Redundant Hardware Components (memory, processing, storage, communications and power supply) • Operations Management (support processes, monitoring procedures, backup policies, administration skills and contingency plans)	Implementation of Redundant or More Reliable Hardware (memory, processing, storage, communications, and power supply)\ • Strengthening Operations Management (support processes, monitoring procedures, backup policies, administration skills, and contingency plans)

Table: Driving factors for hardware requirements

The subsequent parts of this section reference hardware configurations tailored for different environment setups.

Configuration	Intended Use	Response time	Scalability	High availability
Minimum	Demonstration / Development	Medium/Slow acceptable	Not required	Not required
Training / Staging	System tests, validations and training	Medium	Not required	Not required
Production A	Low to medium volume production	Fast	Required	Very High
Production B	High volume production	Fast	Required	Very High

Table: Environment configuration options

Warning

The exact hardware configuration for any Critical Manufacturing MES deployment project must be carefully sized according to the specific project requirements.

The following table specifies the hardware requirements for each environment configuration outlined above:

Configuration	Number of Servers	Processors	Memory	Storage
Minimum	1 *	1 x Quad Core, 2 GHz	8 GB	200+ GB
Training / Staging	1	2 x Quad Core, 2 GHz+	16 GB	100+ GB
Production A	2	2 x Quad Core, 2 GHz+	16 GB+	150+ GB
Production B	3	2 x Quad Core, 2 GHz+	32 GB+	150+ GB

Table: Hardware requirements for different environment configurations

Note

The Minimum configuration assumes that the database server may host other application components in addition to the database.

2.6.3 Network Considerations

Firewall systems are crucial for preventing unauthorized access to computer resources. If a firewall is active but not properly configured, connection attempts to Critical Manufacturing MES may be blocked.

Ensure that the ports specified during the Network Configuration step of the Critical Manufacturing MES installation are opened in the firewall, allowing the application server to receive incoming requests.

To enable database communication between application and database servers, the necessary SQL Server ports must also be configured in the firewall.

For more information, see:

- Configure the Windows Firewall to Allow SQL Server Access
- Configure a Windows Firewall for Database Engine Access

3 Connect IoT Requirements

The Connect IoT **Automation Manager** component has a low hardware footprint and is designed to run in a variety of platforms.

3.1 Software Requirements

The supported operating systems (must be supported by Node.js), are listed in the table below:

System	Architecture	Version
GNU/Linux	x64	kernel >= 3.10, glibc >= 2.17
GNU/Linux	arm64	kernel >= 4.5, glibc >= 2.17
Windows	x64, x86 (WoW64)	>= Windows 7/2008 R2/2012 R2
macOS	x64	>= 10.11

Table: Supported operating systems for Connect IoT

Note

Requirements based but not limited to the *Tier 1* values of the Node.js platform list compilation/execution support, available in https://github.com/nodejs/node/blob/v16.x/BUILDING.md#platform-list.

Independent from the Operating System, the following software components must also be available:

Requirement	Description
NodeJS	NodeJS must be installed and available in each computer that runs the Connect IoT Automation Manager (the Connect IoT runtime). Critical Manufacturing recommends version **20.x LTS** (available from https://nodejs.org/dist/latest-v20.x/) for improved functionality.
Local Package Repository	- There must be one local package repository available per site. We support **NPM** based repositories or our custom **directory** based directory for installation/server free solution - The repository must be accessible by both Critical Manufacturing MES and Connect IoT runtime computers.

Table: Software components required for Connect IoT

Furthermore, there some driver specific requirements as listed in the following table that are applicable to the computer that will host the Connect IoT runtime engine that uses that driver:

Driver	Requirement	Can be containerized
Bluetooth (BLE)	- Must fulfill the noble pre-requisites - refer to the link https://github.com/sandeepmistry/noble - Must have a compatible Bluetooth adapter - https://github.com/noble/node-bluetooth-hci-socket#Prerequisites - In Microsoft Windows, it is necessary to change the Bluetooth driver to use WinUSB instead of the Microsoft Bluetooth Stack. To accomplish this, use the *zadig* tool supplied in the Setup ISO.	Yes (requires hardware devices to be forwarded to container)
File (CSV + Raw)	- The directory(ies) to be used by the driver must be fully accessible, mapped and authenticated within the OS.	Yes
IPC-CFX	- .Net Core 8.x SDK - refer to https://github.com/dotnet/core/blob/main/release-notes/8.0/supported-os.md - Install Visual C ++ Redistributable 2015-2022 in every machine - refer to https://learn.microsoft.com/en-us/cpp/windows/latest-supported-vc-redist?view=msvc-170	Yes
Keyboard Wedge	- Can only work in Linux OS (it is restricted by Windows because it acts as a keyboard logger).	Yes (requires hardware devices to be forwarded to container)
OIB	- Must have Microsoft .Net Framework 4.6 installed.	No
OPC DA	- Can only run on a Windows OS (OPC DA protocol requirement) - Must have .Net Framework 4.8 installed. - Must have *AdvosolOpcCoreComponents* (supplied in the Setup ISO) installed.	No
OPC UA	- Must have OpenSSL installed (for on-demand certificate generation). For more information, see https://www.openssl.org/docs/.	Yes

Driver	Requirement	Can be containerized
SECS/GEM	- Minimal support .Net Core 2.x SDK - refer to https://github.com/dotnet/core/blob/master/release-notes/2.0/2.0-supported-os.md - Recommended support .Net Core 8.x SDK - refer to https://github.com/dotnet/core/blob/master/release-notes/8.0/supported-os.md - Install Visual C ++ Redistributable 2015-2022 in every machine - refer to https://learn.microsoft.com/en-us/cpp/windows/latest-supported-vc-redist?view=msvc-170	Yes

Table: Driver requirements for Connect IoT

3.2 Hardware requirements

Connect IoT **Automation Managers** are designed to be executed on edge devices, with limited hardware capabilities. However, they can also be deployed in containerized environments together with the MES Application Layer. The actual requirements in terms of processing power and memory will depend on the number of integrations and the workflow implemented for each integration.

Contact Critical Manufacturing for additional information to help you estimate the workload associated to your integrations.

4 Client Devices

The Critical Manufacturing MES UI is an HTML5 Single Page Application accessible with a compatible web browser. It does not require any installation on client devices.

This section outlines the supported browsers and specific requirements for client devices.

4.1 Supported Browsers

Operating System	Supported browsers
Android 10 or later	• Google Chrome
Linux ARM	• Chromium
Microsoft Windows 10 / 11 (32 or 64-bit editions)	• Google Chrome • Microsoft Edge
macOS	• Google Chrome

Table: Supported browsers

4.1.1 Supported Chrome Drivers

To ensure browser compatibility and UI stability, each MES version undergoes automated testing using a specific Web Driver (ChromeDriver).

For more information, see the Supported Browsers section in the Release Notes for Version {{ extra.current_version }} in the Critical Manufacturing Information Center. Customers must always verify that the information applies to the specific patch installed in their environment by consulting the Patch Release Notes for Version {{ extra.current_version }}.

Warning

Important information to prevent possible compatibility issues:

- It's highly recommended that Critical Manufacturing customers use the enterprise version of Google Chrome, which can be obtained from: https://cloud.google.com/chrome-enterprise/browser/. The Chrome Browser Deployment Guide, offering information on organizational deployment, is available at: https://support.google.com/chrome/a/answer/3115278.
- Auto-updates for the browser **must be disabled** to ensure optimal compatibility with the tested MES version. This is often managed through group policies or browser settings (https://support.google.com/chrome/a/answer/187202). If newer browser versions are used, support will be provided on a best-effort basis.
- Refer to https://chromium.googlesource.com/chromium/src/+/master/docs/chromium_browser_vs_google_chrome.md for the differences between Google Chrome and Chromium on Linux.

4.2 Full GUI Functionality Configuration

In order to enable all the functionalities of the GUI, it is necessary to configure the browser used to access the HTML GUI site as described in the table below:

Setting	Description
Allow Pop-ups	Pop-ups must be allowed for the GUI site.
Whitelist ad-blockers	The GUI site must be whitelisted in any ad-blocker software

Table: Full GUI Functionality Configuration

4.3 Minimum Hardware Requirements

Try before buying new devices

UI performance should be validated before moving forward with the purchase of additional devices. Different manufacturers have different flavors of the operating system and additional system applications running that may significantly affect a device's performance. Depending on your specific requirements or workload, more powerful devices may be required (for example, if FabLive 3D is used with complex scenes).

The following sections present the minimum hardware requirements for clients accessing the Critical Manufacturing MES GUI.

4.3.1 Desktop Devices

Desktop Clients must meet the following minimum requirements:

- **Processor**: 1 x Quad Core, 2.4 GHz
- **Memory**: 6 GB
- **Free Disk Space**: 10 GB
- **Minimum resolution**: 1366 x 768

4.3.2 Mobile devices

Mobile devices must meet the following minimum requirements:

- **Processor**: 1xOcta Core, 2.4 GHz
- **Memory**: 6 GB

We recommend the following resolution formats for optimal viewing and operation of the Critical Manufacturing MES on mobile devices:

Horizontal Resolution	Vertical Resolution	DPI	Scaling	Android Density Qualifier
360	640	160	1	mdpi
540	960	240	1.5	hdpi
720	1280	320	2	xhdpi
1080	1920	480	3	xxhdpi
1440	2560	640	4	xxxhdpi

Table: Mobile device resolutions for client devices

5 Other Requirements

5.1 Authentication

You need to decide how your users shall authenticate in the system. Critical Manufacturing MES supports:

- **Active Directory**
- **Single Sign-On** (Open ID Connect)
- **Local Users** (account credentials stored on MES database).

Each enabled strategy will require distinct requirements. Check Critical DevOps Center and Operations ↗ guides for additional details about their requirements and setup.

5.2 SAP Integration

If you intend to generate SAP interface code or proxies based on the Critical Manufacturing MES ERP module, then you must acquire an ERPConnect license from Theobald Software.

5.3 HTTPS

To enable HTTPS, you will need to provide SSL certificate information during DevOps Center new environment configuration.

> **Note**
>
> Although is not mandatory, it is highly recommended to use HTTPS. Some features that require access to device peripherals (Augmented Reality, Clipboard) may not work when running on an insecure connection.

5.4 GenAI Providers

The Generative AI Provider defines which external service is used to deliver Generative AI capabilities. You can choose from Anthropic, AWS Bedrock, Google, or OpenAI. Before enabling Generative AI features, ensure that the selected provider is correctly configured in your environment.

For more information, see the Package Configuration ↗ section.

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