Critical manufacturing
an ASMPT company

# Critical manufacturing 11.0

# System Requirements

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# 1 System Requirements

The Critical Manufacturing MES System Requirements list provides a segmented view of the necessary information to prepare beforehand for a future acquisition and installation of the main software. 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.

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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, in PDF

# 2 Deployment Targets

Critical Manufacturing MES can be deployed exclusively on containerized environments. The sections below outline the different deployment options available for each layer.

## 2.1 Database Component

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 the database component, check the Database Component, in Database Component section.

## 2.2 Application Layer

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

- Kubernetes (check Application Layer - Containers 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**, which fully automates the deployment process. Installations can be done locally (by executing an installation package) or remotely, directly in a target infrastructure previously provisioned and according to the defined requirements.

In addition to the containerized components, there are currently 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.

Table 1: Optional components and 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 [[operation-guide-environmentvariables#cups_server |
| **ECAD Renderer** | Core | Required to render CAD file visualizations. |
| **Automation Managers** | Core | Required to support Windows-based automation drivers. |

On containerized installations, these components require a separate Windows Virtual Machine / server where they can be installed.

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

## 2.3 Cloud Installations

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:

Table 2: Cloud-based installation concerns

| 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. |

# 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, in Database Component
  - SQL Server Always On, in SQL Server Always On
  - Storage Area Network Configuration, in Storage Area Network Configuration
  - SQL Server Licensing, in SQL Server Licensing
  - SQL Server Permissions, in SQL Server Permissions
- Additional Components

# 4 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.

## 4.1 Software Requirements

The table below describes the software requirements for database servers:

Table 3: Software requirements for database servers

| Operating System | Database Engine | Additional Required Software |
|---|---|---|
| • Windows Server 2016 64-bit<br>• Windows Server 2019<br>• Windows Server 2022 | • SQL Server 2019 Standard Edition<br>• SQL Server 2019 Enterprise Edition<br>• SQL Server 2022 Standard Edition<br>• SQL Server 2022 Enterprise Edition | • SQL Server Reporting Services<br>• SQL Server Analysis Services (multidimensional model)<br>• Microsoft Distributed Transaction Coordinator (MSDTC) |

## 4.2 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.

Table 4: Hardware requirement use cases for database servers

| 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 |

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:

Table 5: Minimum hardware requirements for database servers

| 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<br>ODS+DWH: 1TB |
| **Production A** | 2 | 2 x Six Core, 2 GHz+ | 32 GB+ | Internal storage: 150+ GB<br>Storage hard-disk: 2.5TB |
| **Production B** | 2 | 2 x Eight Core, 2 GHz+ | 64 GB (Active/Active)<br>128 GB (Active/Passive) | Operating System: 150 GB SAS 15K rpms<br>TempDB: 200 GB+ in SSD<br>Storage: 10 TB+ |

!!! note The Minimum configuration assumes that the database server may also run other application components in addition to the database.

## 4.3 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

# 5 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

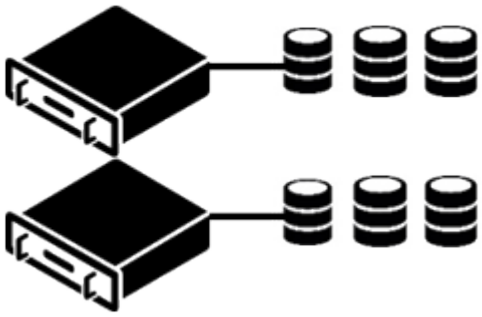


Figure 1: SQL Server Always On

## 5.1 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.

## 5.2 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.

## 5.3 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.

### 5.3.1 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.

# 6 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.

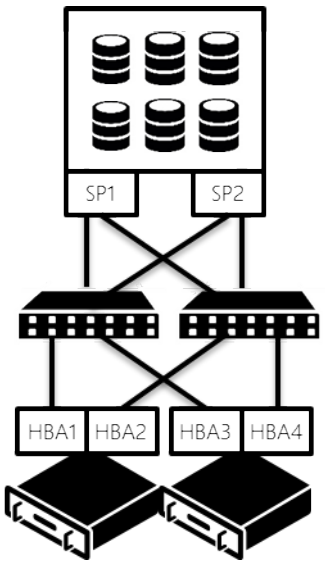
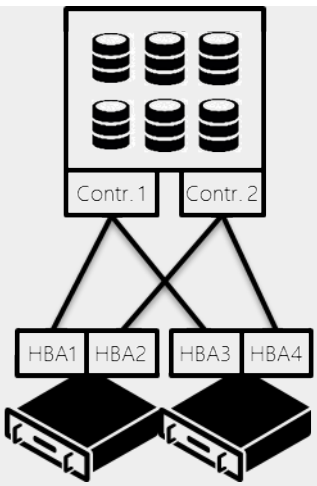
For more information about SQL Server licensing, please refer to the URLs below:

- SQL Server 2019
- SQL Server 2022

# 7 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.

Table 6: Storage Area Network configuration

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

# 8 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.

## 8.1 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.

### 8.1.1 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`

### 8.1.2 Configure Database User Permissions

Ensure that the database user is granted the following permissions: - `VIEW SERVER STATE` - `VIEW ANY DEFINITION`

### 8.1.3 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`

### 8.1.4 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`

# 9 Additional Components

This section describes the requirements for additional required components that must be running for a successful installation and operation of Critical Manufacturing MES. These requirements will vary depending on the usage of each component.

## 9.1 Kafka

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.

### 9.1.1 Minimum System Requirements

Table 7: Minimum system requirements for Kafka

| Item | Requirement |
|---|---|
| Version | 3.8.1 |
| Brokers | 3 |
| Memory | 8GB per broker |
| CPU | 2vCPUs per broker |
| Disk space | 1TB per broker |

### 9.1.2 Recommended System Requirements

Table 8: Recommended system requirements for Kafka

| Item | Requirement |
|---|---|
| Version | 3.8.1 |
| Brokers | 3 |
| Memory | 16GB per broker |
| CPU | 4vCPUs per broker |
| Disk space | 3TB per broker |

### 9.1.3 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

## 9.2 ClickHouse

### 9.2.1 Minimum System Requirements

Table 9: Minimum system requirements for ClickHouse

| Item | Requirement |
|---|---|
| Version | 24.3 or 24.8 |
| Memory | 16GB |
| CPU | 4vCPUs |
| Disk space | 1TB |

### 9.2.2 Recommended System Requirements

Table 10: Recommended system requirements for ClickHouse

| Item | Requirement |
|---|---|
| Version | 24.3 or 24.8 |
| Memory | 32GB |
| CPU | 8vCPUs |
| Disk space | 3TB |

!!! warning "Mandatory Settings for ClickHouse 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, `allow\_materialized\_view\_with\_b` setting must be configured before starting the upgrade. For more information, see ClickHouse Migration.

### 9.2.3 ACLs

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

- Privileges
  - SELECT: Read data from tables
  - INSERT: Write data into tables
  - ALTER: Modify table schema
  - DROP: Delete databases (during setup) or tables
  - SHOW: View metadata
  - CREATE: Create databases (during setup) or tables

## 9.3 RabbitMQ

### 9.3.1 Minimum System Requirements

Table 11: Minimum system requirements for RabbitMQ

| Item | Requirement |
|---|---|
| Version | 3.13.1 or above |
| Brokers | 1 |
| Memory | 1GB per broker |
| CPU | 2vCPUs per broker |

### 9.3.2 Recommended System Requirements

Table 12: Recommended system requirements for RabbitMQ

| Item | Requirement |
|---|---|
| Version | 3.13.1 or above |
| Brokers | 2 |
| Memory | 2GB per broker |
| CPU | 4vCPUs per broker |

## 9.4 AWS S3 (or compatible)

### 9.4.1 Minimum System Requirements

Table 13: Minimum system requirements for AWS S3 (or compatible)

| Item | Requirement |
|---|---|
| Version | – |
| Memory | 4GB |
| CPU | 2vCPUs |

### 9.4.2 Recommended System Requirements

Table 14: Recommended system requirements for AWS S3 (or compatible)

| Item | Requirement |
|---|---|
| Version | – |
| Memory | 16GB |
| CPU | 4vCPUs |

## 9.5 ClickHouse (Observability)

### 9.5.1 Minimum System Requirements

Table 15: Minimum system requirements for ClickHouse (Observability)

| Item | Requirement |
|---|---|
| Version | 24.9.2.42 |
| Memory | 16GB |

| Item | Requirement |
| --- | --- |
| CPU | 4vCPUs |
| Disk space | 100GB (per environment, for 7 days TTL) |

### 9.5.2 Recommended System Requirements

Table 16: Minimum system requirements for ClickHouse (Observability)

| Item | Requirement |
| --- | --- |
| Version | 24.9.2.42 |
| Memory | 32GB |
| CPU | 8vCPUs |
| Disk space | 100GB (per environment, for 7 days TTL) |

# 10 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

# 11 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.

## 11.1 Software Requirements

Containerized deployments rely on a container orchestrator. The table below describes the software requirements and the supported container orchestrators.

Table 17: Supported container orchestrators

| Operating System | Container Engine | Container Orchestrator | Additional Required Software |
|---|---|---|---|
| Any Linux distribution compatible with the selected container orchestrator.<br><br>(Recommended: Ubuntu Server 20.04 LTS or Red Hat Enterprise Linux 9)<br><br>**Only x64 architecture is supported.** Container images for x86 or ARM architectures are not available. | • CRI-O (Kubernetes only) | • Vanilla Kubernetes v1.28 or later (On-Premises)<br>• Red Hat OpenShift 4.15 or later (Cloud/On-Premises)<br>• Azure Kubernetes Services (Cloud)<br>• Amazon Elastic Kubernetes Service (Cloud)<br><br>Other Container Orchestrators based on Kubernetes are not supported or validated. | • Powershell 7.1 (On-Premises installations only) |

!!! note Only considered for on-premises installations.

## 11.2 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.

### 11.2.1 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.

Table 18: Hardware requirements for computational resources

| 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 Plaform + Machine Learning)** | 50 | 2+ GHz | 128 GB |

!!! 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 requirements may be added as seen below:

Table 19: Hardware requirements example for cluster

| 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 |

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.

!!! note This is only possible on Kubernetes clusters.

### 11.2.2 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, but Critical Manufacturing recommends that at least **25 GB** of persistent storage are provisioned.

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:

Table 20: Support for persistent volume 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). |

!!! 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.

Table 21: Volumes required for persistent storage.

| Volume | Component | Access Mode | Storage Type | Minimum Size |
|---|---|---|---|---|
| connect-iot-repo | connectiot-manager<br>envmanager<br>host | RWX | Any | 2 GB |
| grafana-share | grafana | RWX | Any | 1 GB |

| Volume | Component | Access Mode | Storage Type | Minimum Size |
|---|---|---|---|---|
| ⚠ installation-data | aggregation-engine<br>cube<br>data-manager<br>discoveryservices<br>envmanager<br>epf-alarm-mng-at<br>epf-alarm-mng-erh<br>epf-alarm-mng-mes-eh<br>epf-cdm-builder<br>epf-cdm-handler<br>grafana<br>help<br>host<br>housekeeper<br>messagebus<br>rasa-actions<br>securityportal<br>traefik-fwdauth<br>ui | RWX | Any | 5 GB |
| mes-host-documents | host | RWX | Any | 10 GB |
| 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 | 1GB |
| ml-export-folder | mlplatform-training | RWX | Any | 1 GB |
| ml-training-folder | mlplatform-training | RWX | Any | 1 GB |
| redis-data | redis | RWO | Block Storage :information_source: | 1 GB |
| cube | cube | RWO | Any | 5 GB |

!!! 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.

## Optional Volume configuration

Table 22: Volumes of optional components or optional volumes.

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

!!! 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.

### 11.2.3 Scalable Components

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

Table 23: Components can be scalable.

| Component | Image |
|---|---|
| core-host | criticalmanufacturing/core-host |
| core-ui | criticalmanufacturing/core-ui |
| data-manager | dataplatform/datamanager |
| edgesquidproxy | criticalmanufacturing/edgesquidproxy |

| Component | Image |
| --- | --- |
| 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 |
| epf-cdm-builder | dataplatform/epf-cdm-builder |
| epf-cdm-handler | dataplatform/epf-cdm-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 |
| rasa-actions | criticalmanufacturing/rasa-actions |
| reference | criticalmanufacturing/reference |
| securityportal | criticalmanufacturing/securityportal |
| traefik | traefik |
| traefik-fwdauth | criticalmanufacturing/traefik-fwdauth |
| ui | criticalmanufacturing/ui |

# 12 Application Layer - Optional Components

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

## 12.1 Software Requirements

The table below describes the software requirements for application servers:

Table 24: Software requirements for application servers

| Operating System | Required Software |
|---|---|
| • Windows Server 2016 64-bit<br>• Windows Server 2019<br>• Windows Server 2022 | • Microsoft Internet Information Services (IIS), included in the operating system<br>• .NET 6.0<br>• Microsoft .Net 4.8 - included in most Windows Server versions<br>• ASP.NET Core 3.1.8 Hosting Bundle - installed by the setup<br>• Microsoft PowerShell 5.1 - included in the Dependencies folder of the installation ISO and can also be obtained here<br>• Visual C++ Redistributable Packages for Visual Studio 2013 |

## 12.2 Hardware requirements

The exact hardware requirements will ultimately depend on the specific customer environment. The table below lists the primary factors affecting response time and scalability as well as high-availability. It also describes what mechanisms are available to improve them although it must be noticed that there is a cost associated with an increasing each factor.

Table 25: Driving factors for hardware requirements

| KPI | Primary Driving Factors | Improvement Options |
|---|---|---|
| **Response time**<br>**Scalability** | • Load (number of users and concurrent transactions)<br>• Model and Logic Complexity<br>• Data Volume<br>• Hardware | • Application optimization<br>• Model fine-tuning<br>• Database optimization<br>• Reduction of data retention time<br>• Better hardware (CPU, Memory, I/O andNetwork) |

| KPI | Primary Driving Factors | Improvement Options |
|---|---|---|
| **High-Availability** | • Software Failures and Maintenance<br>• Hardware Failures and Maintenance<br>• Human Errors<br>• Redundant hardware components (including memory, processing, storage, communications and power supply)<br>• Operations Management (including support process, monitoring procedures, backup policies, administration skills and contingency plans) | • Addition of redundant or more reliable hardware components (including memory, processing, storage, communications and power supply)<br>• Enhancement of operations management (including support process, monitoring procedures, backup policies, administration skills and contingency plans) |

In the remaining part of this section, different reference hardware configurations are presented for different environment configurations.

Table 26: Environment configuration options

| 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 |

!!! warning For any Critical Manufacturing MES deployment project, the exact hardware configuration needs to be sized according to the specific project profile.

Given the environment configurations described above, you can see the hardware requirements for each one in the table below:

Table 27: Hardware requirements for different environment configurations

| 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 |

!!! note The Minimum configuration assumes that the database server may also run other application components in addition to the database.

## 12.3 Network

Firewall systems help prevent unauthorized access to computer resources. If a firewall is turned on but not correctly configured, attempts to connect to Critical Manufacturing MES might be blocked.

The ports chosen during the Critical Manufacturing MES installation in the Network Configuration process must be configured in the firewall to allow the application server to receive requests.

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

For more information on how to configure the firewall to allow SQL Server Access, refer to the URLs below:

- Configure the Windows Firewall
- Configure a Windows Firewall for Database Engine Access

# 13 Connect IoT Requirements

The Connect IoT module has a low hardware footprint and is designed to run in a variety of platforms.

## 13.1 Software Requirements

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

Table 28: Supported operating systems for Connect IoT

| 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 |

!!! 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:

Table 29: Software components required for Connect IoT

| Requirement | Description |
|---|---|
| **NodeJS** | NodeJS must be installed and available in each computer that runs the Connect IoT Automation Manager (the Connect IoT runtime).<br>Critical Manufacturing recommends version **18.x LTS** (available from https://nodejs.org/dist/latest-v18.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<br>- The repository must be accessible by both Critical Manufacturing MES and Connect IoT runtime computers. |

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:

Table 30: Client driver specific requirements for Connect IoT

| Driver | Requirement | Can be containerized |
|---|---|---|
| **Bluetooth** (BLE) | - Must fulfill the noble pre-requisites - refer to the link https://github.com/sandeepmistry/noble<br>- Must have a compatible Bluetooth adapter - https://github.com/noble/node-bluetooth-hci-socket#Prerequisites<br>- 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** | - 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<br>- Recommended support .Net Core 6.x SDK - refer to https://github.com/dotnet/core/blob/master/release-notes/6.0/supported-os.md<br>- 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)<br>- Must have .Net Framework 4.0 installed.<br>- 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 |
| **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<br>- Recommended support .Net Core 6.x SDK - refer to https://github.com/dotnet/core/blob/master/release-notes/6.0/supported-os.md<br>- 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 |

## 13.2 Hardware requirements

Connect IoT automation controllers 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.

# 14 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.

## 14.1 Supported Browsers

Table 31: 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<br>• Microsoft Edge |
| **macOS** | • Google Chrome |

### 14.1.1 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 of the Patch Release Notes corresponding to the specific patch you have installed for Version {{ extra.current_version }} in the Critical Manufacturing Information Center. General release information is available in the 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.
```

## 14.2 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:

Table 32: Full GUI Functionality Configuration

| 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 |

## 14.3 Minimum Hardware Requirements

!!! warning "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.

### 14.3.1 General

All client devices should meet the following CPU and Memory minimum requirements:

Table 33: General CPU and RAM minimum requirements

| Processor | Memory |
|---|---|
| 1 x Quad Core, 2.4 GHz | 6 GB |

### 14.3.2 Desktop Devices

Desktop Clients must also meet the following minimum requirements:

Table 34: Minimum hardware requirements for desktop client devices

| Free Disk Space | Minimum resolution |
|---|---|
| 10 GB (desktop devices) | • 1366 x 768 (desktop devices) |

### 14.3.3 Mobile devices

Mobile devices should meet the minimum requirements displayed below and run a supported version of Chrome.

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

Table 35: Mobile device resolutions for client 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 |

# 15 Other Requirements

By default, Critical Manufacturing MES ships with integrated authentication through **Active Directory**. Authentication using **Single Sign-On** (SSO) or using **Local Users** can be manually configured.

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

To enable HTTPS, there must be a valid certificate installed on the **Personal Certification Store** of each Application Server before running the Critical Manufacturing MES setup program. The SSL certificate information must be provided through DevOps Center during installation.

!!! 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

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