



Manufacturing Operations Reference Design



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1 Document History

Date	Doc Version	Updated By	Change Description
2021/05/01	0.1	André de Beer	First draft – submitted for peer review.
2021/05/12	0.2	André de Beer	1. Section 9.2 updated: Level-3 Historian added to landscape and Labware Web Server updated. 2. Various Peer Review changes as per the comments. 3. Sections 9.2.1 to 9.2.4 added.
2021/05/13	0.3	André de Beer	1. Added section 10.2.1 to 10.2.2 to show the different network deployment patterns.
2021/05/31	1.0	André de Beer	ARB Published version.
2021/05/31	1.1	André de Beer	Section 9.3.1 updated – Item 6 added for VM hosting hardware failure.
			To add: 1. Batching options 2. Application authorisation options 3. Auto log out
2021/07/09	1.2	André de Beer	1. Section 10.3 – Server configuration added.
2021/08/12	1.3	André de Beer	1. Section 9.4 – MOM Reporting Model 2. Section 14.1.4 – Reporting Principals
2021/08/23	2.1	André de Beer	1. Section 9.5 Added – Label printing
2021/09/17	2.2	André de Beer	1. Section 9.1 Updated – Beamex CMX Calibration Management solution added. 2. Section 9.2 Added – Listing of level-3 applications.

2 Document Purpose

This document provides the foundation for the manufacturing operations systems in Johnson Matthey (JM). This is a living document and will be updated as new business requirements are added.

3 Overview

JM IT Owner:	Business Sponsor:	Key Stakeholders:
Problem Statement: The building blocks within the JM manufacturing operations landscape have a similar pattern for the low-level design with exceptions usually relating to the phased replacement of legacy systems. The phased approach to the legacy system replacement usually involves the development of tactical interfaces between the strategic MES component and legacy system. To streamline effort in developing future sector or plant LLD's a standardised manufacturing operations reference architecture is required which can be deployed across sectors. All future solutions will be based upon this standardised reference architecture where any sector or plant specific deviations will be recorded in the project specific documentation. This reference design will list the standard application implementation patterns with the strategic interfaces into the ERP and LIMS systems. Tactical interfaces and legacy systems will be listed in the specific sector/plant LLD's.		

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In Scope: Strategic application and interface components.	Out of Scope: Legacy applications and tactical interfaces.
Data Requirements: A generic data model will be depicted. The physical data components for off-the-shelf applications will not be discussed as this is internal to specific application.	Non-functional Requirements: Please refer to the standard MES Non-functional requirements listing .

4 Principles/Guardrail/Pattern/Standard Compliance	
Reference	Comments
STD000039	Access Control Mechanisms – Passwords Standard
STD000041	Access Management Standard
STD000042	Encryption Standard
STD000043	Identity and Access Management Standard
STD000044	Information Security Architecture
STD000052	Security Event Logging
STD000058	User Authorization Standard
STD000060	Cloud Computing Security Risks and Controls Standard
Pattern	JM - EP - INF - Infrastructure Architecture Specification for Manufacturing Sites



5 Acronyms

Acronym	Description
MO	Manufacturing Operations
MES	Manufacturing Execution System
MSB	Manufacturing Service Bus
DSB	Data Service Bus
ESB	Enterprise Service Bus
PLC	Programmable Logic Controller
MDM	Master Data Management
mMDM	Manufacturing Master Data Management
OLAP	Online Analytical Processing
DW	Data Warehouse
ODS	Operational Data Store
ETL	Extract Transform and Load
GI	Goods Issues
GR	Goods Receipts
FOL	Front of Line
EOL	End of Line
TS	TrakSYS – Strategic MES
SOA	Service Orientated Architecture
PRR	Production Readiness Review
SAP IM	SAP Inventory Management module.
HU	Handling Line Segment, a stock containing entity with a unique identification.
PO	Process Order
CS	Control System
SOA	Service Orientated Architecture
IIOT	Industrial Internet of Things
PLC	Programmable Logic Controller
DCS	Distributed Control System
OPC	Open Platform Communication (used to be called OLE for Process Control)
CMMS	Computerised Maintenance Management System
EAM	Enterprise Asset Management

6 Definitions

Term	Description
Job	A job is generic term used to describe an order to produce something.
Process order	A process order is the description of a Job in SAP.
Product	A material produced by a job/process order.
By-product	A material that can be produced by job/process order, however this is not the main output product of the process order.
Finished product	Material produced by a process order that is in its end state.
Intermediate product	Material produced by a process order that is not yet a finished product (for Batch Production will include Slurries and Remnants).
Lot	A lot is a reference to material being produced with a distinct start and ending.

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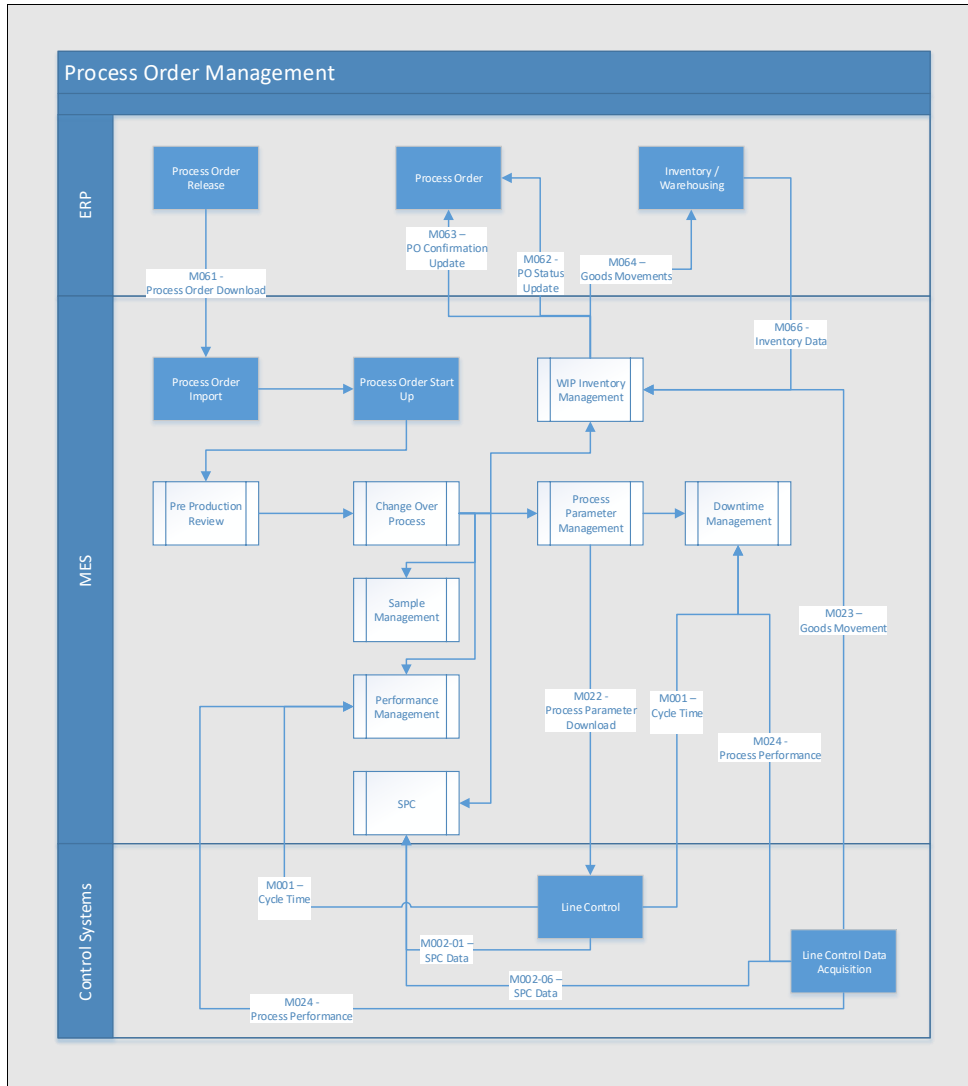
Batch Number	A batch number is the description of a Lot in SAP.
Processing Cell	This is a reference to a processing component within a Site/Area. A processing cell usually produced a product for a job.
Line Segment	This is a refence to sub-component within in a Processing Cell, referring to the ISA-88 physical equipment model standard.
Control System	Control systems refer to ISA95 level-2 systems. Control systems includes DCS's, PLC's, Historians, IoT devices, Recipe Execution systems or any other piece of equipment that either controls the equipment and related process or that gathers process data.

7 Business Architecture

7.1 Level 4 Business Processes

7.1.1 Process Order Management

The Process Order Management process depicts the overall flow of process within the manufacturing. Execution within the MES will always occur against a specific job (referred to a process order in the ERP). This applies to discrete, batch and continues operations.



7.1.2 Process Parameter Management

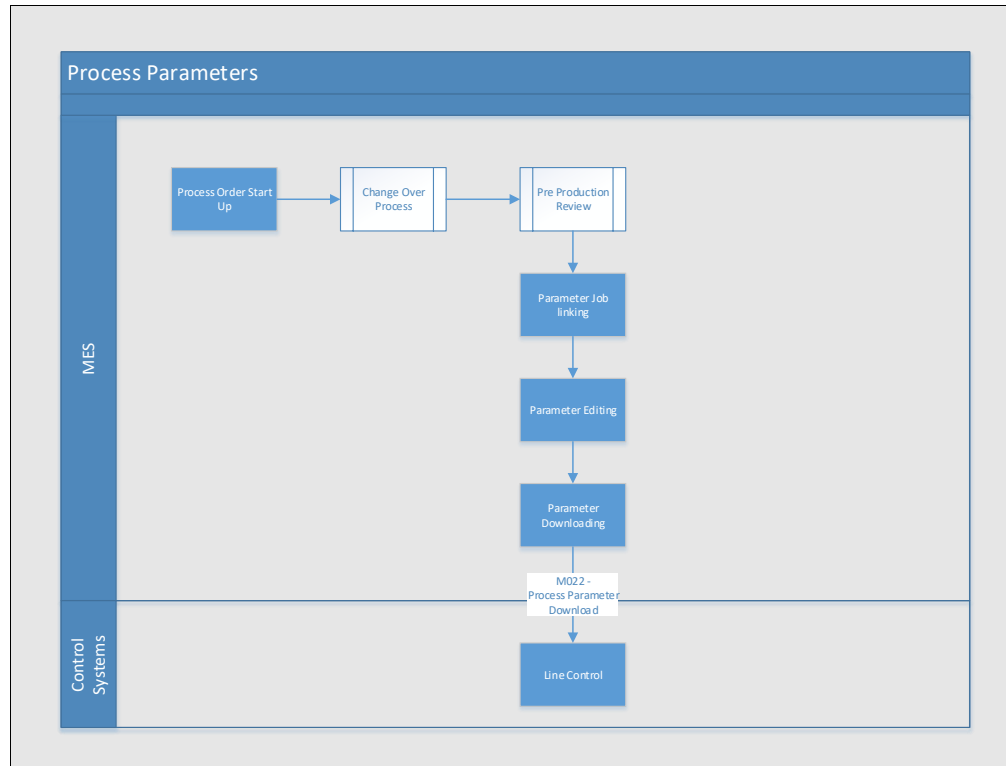
Process Parameters critical to ensuring process capability are captured throughout the manufacturing process. These parameters include specific in-line material and equipment values which can be read to a control system. This

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provides the ability for a control system to execute a standard recipe within specific process parameters which are downloaded from the MES system when a job is started.

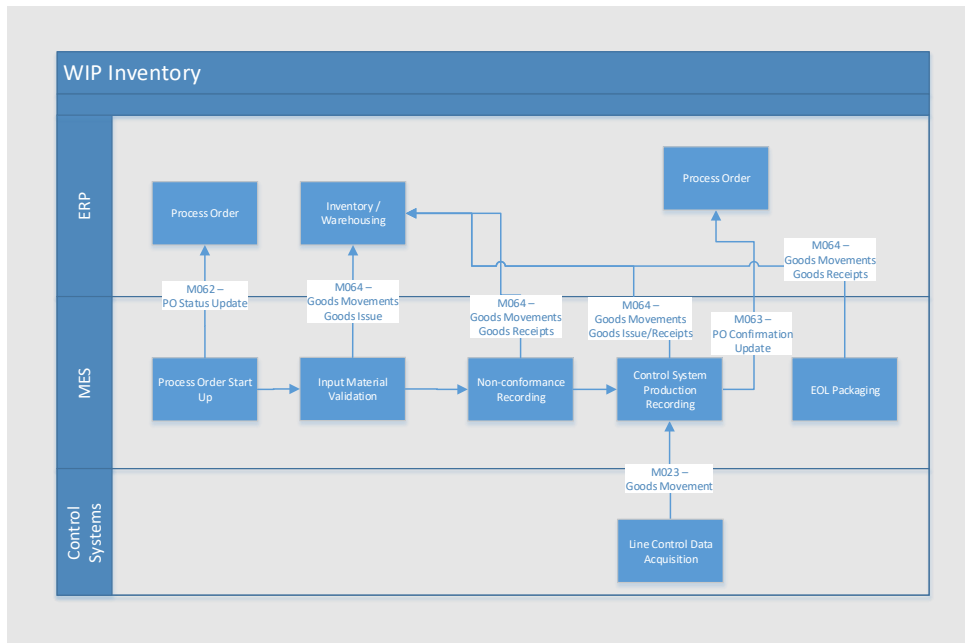


Commented [AH1]: Do we want to say something about the MES being able to adjust the recipe (within prescribed limits) according to what the analysis of process parameters is telling us?

Andre to pick up.

7.1.3 WIP Inventory Management

The WIP Inventory Management process includes tracks all material movement against a Job (Process Order). This includes the tracking of input materials, by-product material output and the main output material of a job. Lot numbers are recorded for discrete and batch processes and for continuous processes where possible.



7.1.4 Sample Management

Sample management is the process in the MES of executing a sample or sample instruction. A sample will be maintained in LIMS and can be imported into the MES for execution. Sample instructions can be maintained in the MES as a defined task or as a control system recipe step. Execution of a sample instruction involves informing an operator to take a sample, tracking of the process and optionally logging of an at-line samples in LIMS through an interface.

Three sample types are defined:

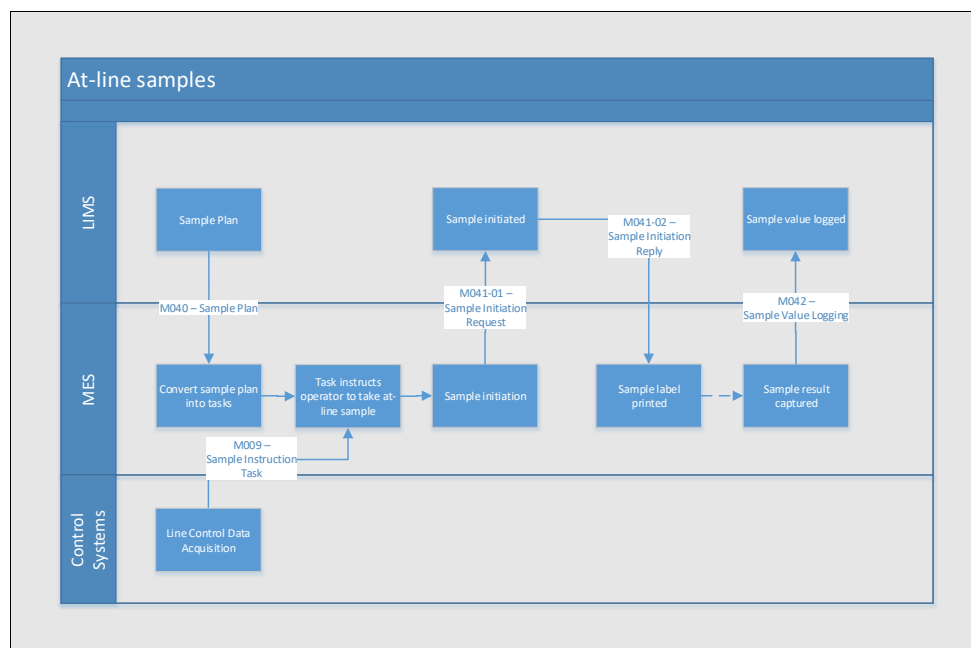
- In-process samples – these samples are usually analysed during the process by the control system and the results are recorded either in the control recipe execution system or in a control process historian. These samples measurements are usually taken at a high frequency.
- At-line samples – these samples are usually manually taken by production operators and as the name suggests are tested close to the production process. Results can be logged in either the MES system or the LIMS system. Results logged in the MES system can also be sent to the LIMS system through an interface. At-line samples can be triggered by a time-based task in the MES, from an imported LIMS sample plan or from a specific step in the recipe execution system.
- Laboratory samples – these samples usually get analysed on a laboratory-based equipment and this equipment are also usually connected to a LIMS system that will record equipment results through an

interface. Like at-line samples, laboratory samples can be triggered by a time-based task in the MES, from an imported LIMS sample plan or from a specific step in the recipe execution system.

The below processes will outline the at-line and laboratory sample execution processes.

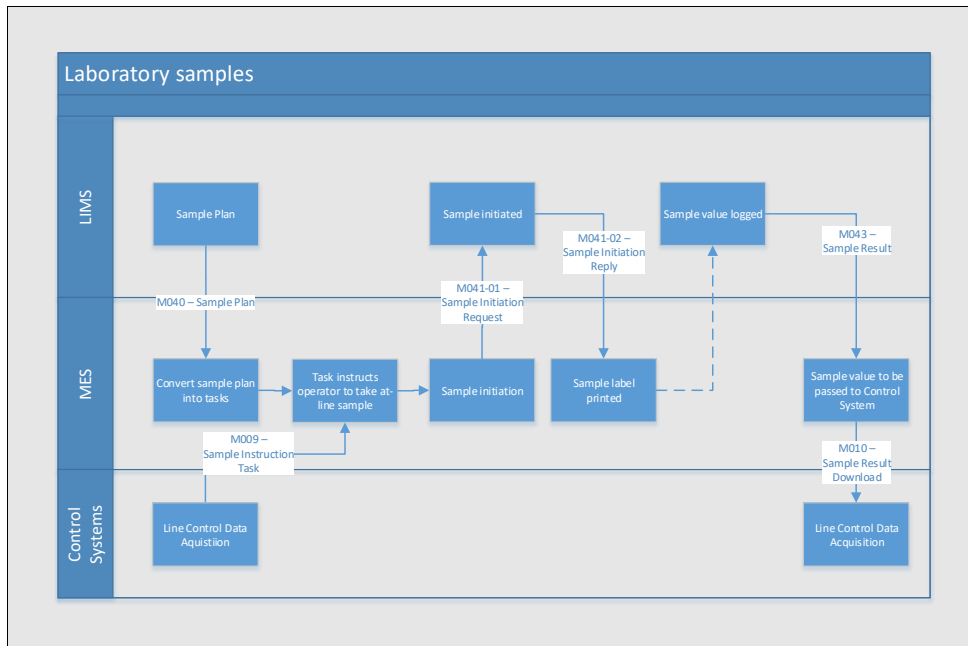
7.1.4.1 At-line Samples

The below flow depicts the at-line sample process. The logging of an at-line sample result in TrakSYS and passing the value to LIMS is optional.



7.1.4.2 Laboratory Samples

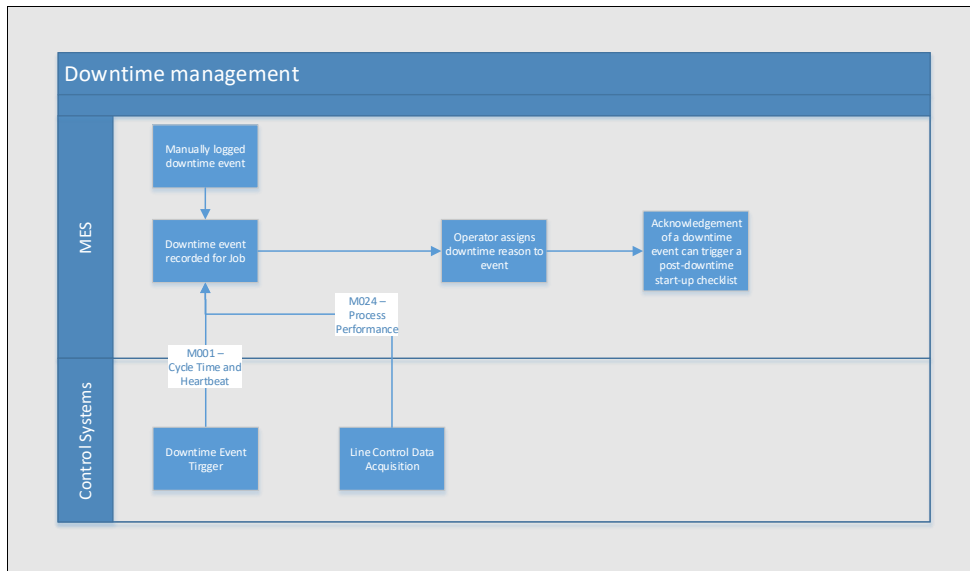
The below flow depicts samples that will be tested in the Laboratory and results will be logged in LIMS directly. The sample initiation and label printing function in the MES is an optional process. Sample test results and values can also optionally be sent to the control system.



7.1.5 Downtime Management (OEE Availability)

Downtime Management is the process of recording downtime events in the MES and accounting for the downtime by assigning downtime reasons to a downtime event. Downtime events can be triggered by the control system or can be read by the MES from the Line Control Data Acquisition system, which in most cases will be a historian-type data store. Downtime events can also manually be recorded. Downtime events are always recorded against a Job (Process Order). Downtime recording is the main attribute in determining the Overall Equipment Effectiveness (OEE) Availability measure.

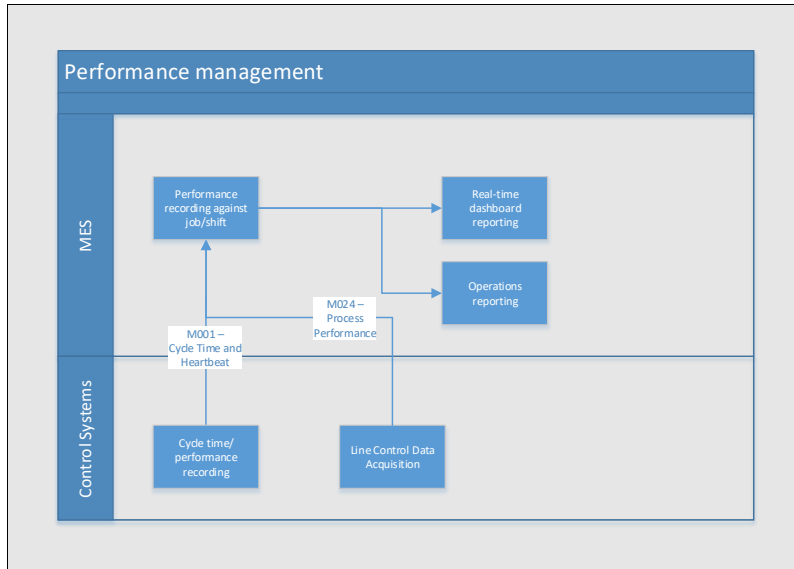
There is an optional function to launch a post start-up checklist after the downtime event acknowledgement.



7.1.6 Performance Management (OEE Performance)

Performance management is the process of recording the OEE performance measure. Performance measurements will be supplied by the control system.

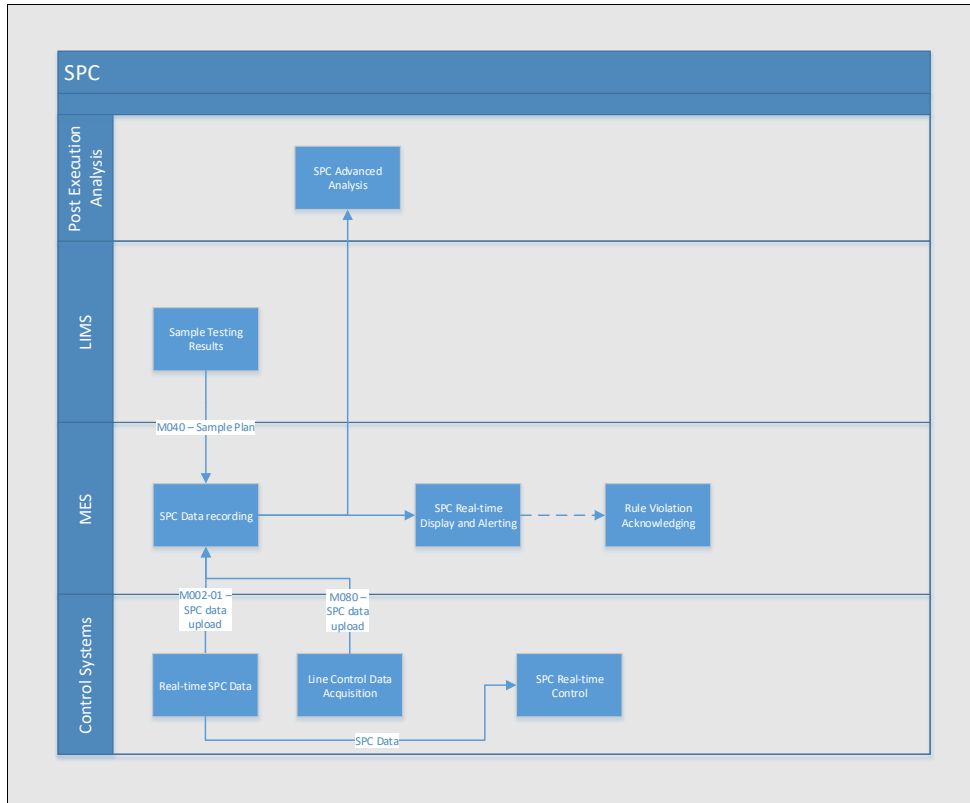
Commented [AH2]: Consider adding a standardised OEE definition? Otherwise reference out to it if there is one.



7.1.7 Statistical Process Control (SPC)

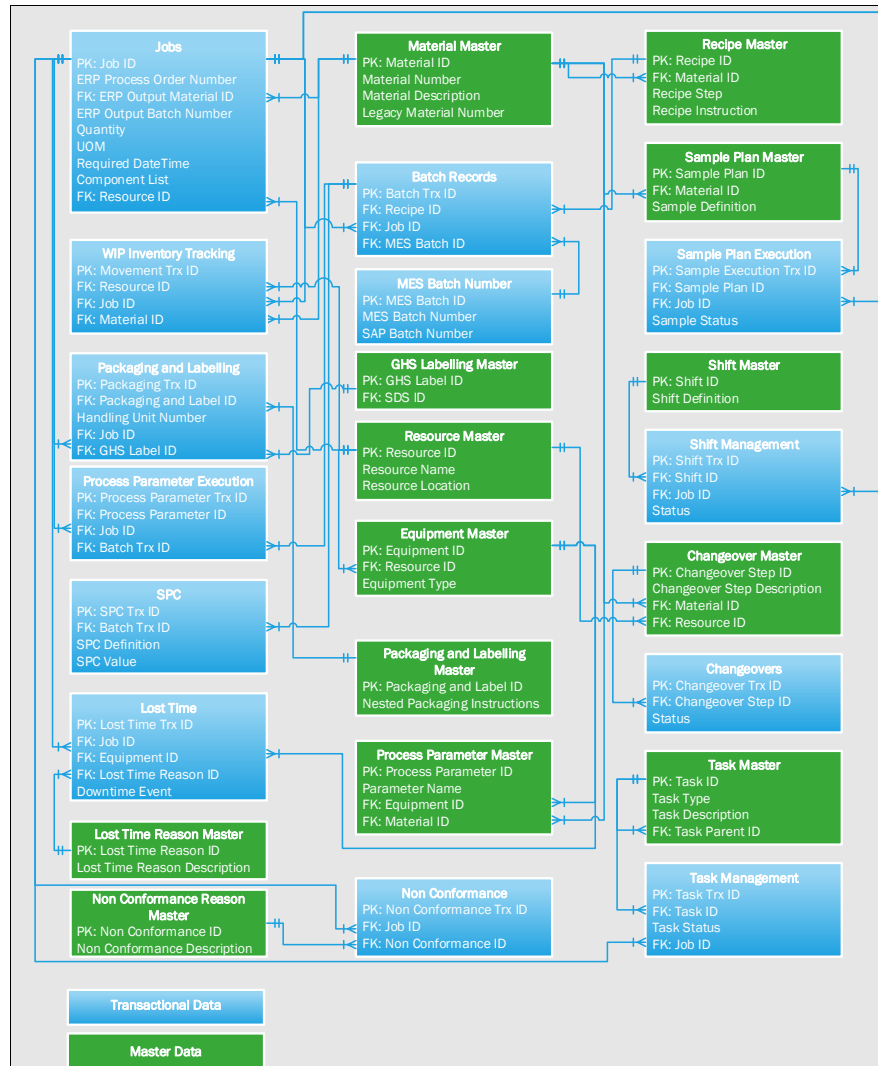
SPC is defined in three categories:

- Real-time control – this category refers to real-time process control and correction.
- SPC display and rule violation alerting – this category is for SPC display and alerting on SPC rule violations for manual process corrections.
- SPC post execution analysis – this category refers to the analysis of SPC data post the execution of a production lot and usually provides for more advanced SPC analysis tools.



8 Data Architecture

8.1 Data Definition Catalogue





Entity	Type	Description	Data Source
Changeover Master	Master Data	List of changeover steps for a resource and change over type.	TrakSYS
Equipment Master	Master Data	List of equipment per process cell resource.	TrakSYS
GHS	Master Data	List of global hazardous safety labelling requirements. Includes label/identification classification and safety data sheets (SDS') showing chemical composition for safe storage, handling and use.	Sphera
Material Master	Master Data	List of unique material codes. This includes raw materials, intermediate and finished goods materials. This entity to be populated with data from SAP material master.	SAP
Lost Time Reason Codes	Master Data	Reasons for step overages or downtime.	TrakSYS
Packaging and Labelling Master	Master Data	List of packaging instructions and associated labels. This entity to be populated with data from SAP Packaging master.	SAP
Process Parameter Master	Master Data	List of process parameters against a material code.	TrakSYS
Recipe Master	Master Data	List of unique recipe steps linked to a material and the product routings.	TrakSYS / Level-2
Resource Master	Master Data	List of distinct manufacturing resources	SAP
SDS	Master Data	List of safety data sheets for material handling. Linked to IMDB.	Sphera
Sample Plan Master	Master Data	List of sample plan per material.	Labware
Sample Execution Master	Master Data	List of sample execution plan to be executed against a process order. This entity to be populated with the master sample plan data from LIMS for the specified material.	TrakSYS
Shift Master	Master Data	List of defined shift patterns.	TrakSYS
Task Master	Master Data	List of tasks for defined task types.	TrakSYS
Batch Records	Transactional Data	Transactional data reflecting all batch operations against a defined recipe step and MES batch.	TrakSYS / Level-2
Changeovers	Transactional Data	Transactional data for all changeover activity performed against a process order.	TrakSYS
MES Batch Number	Transactional Data	List of unique MES batch numbers as an extension to the SAP batch number.	TrakSYS
Non-Conformance	Transactional Data	Transactional data for non-conformance inventory activity against a process order.	TrakSYS
Packaging and Labelling	Transactional Data	Transactional data for all packaging and labelling transactions against a process order and handling unit.	TrakSYS

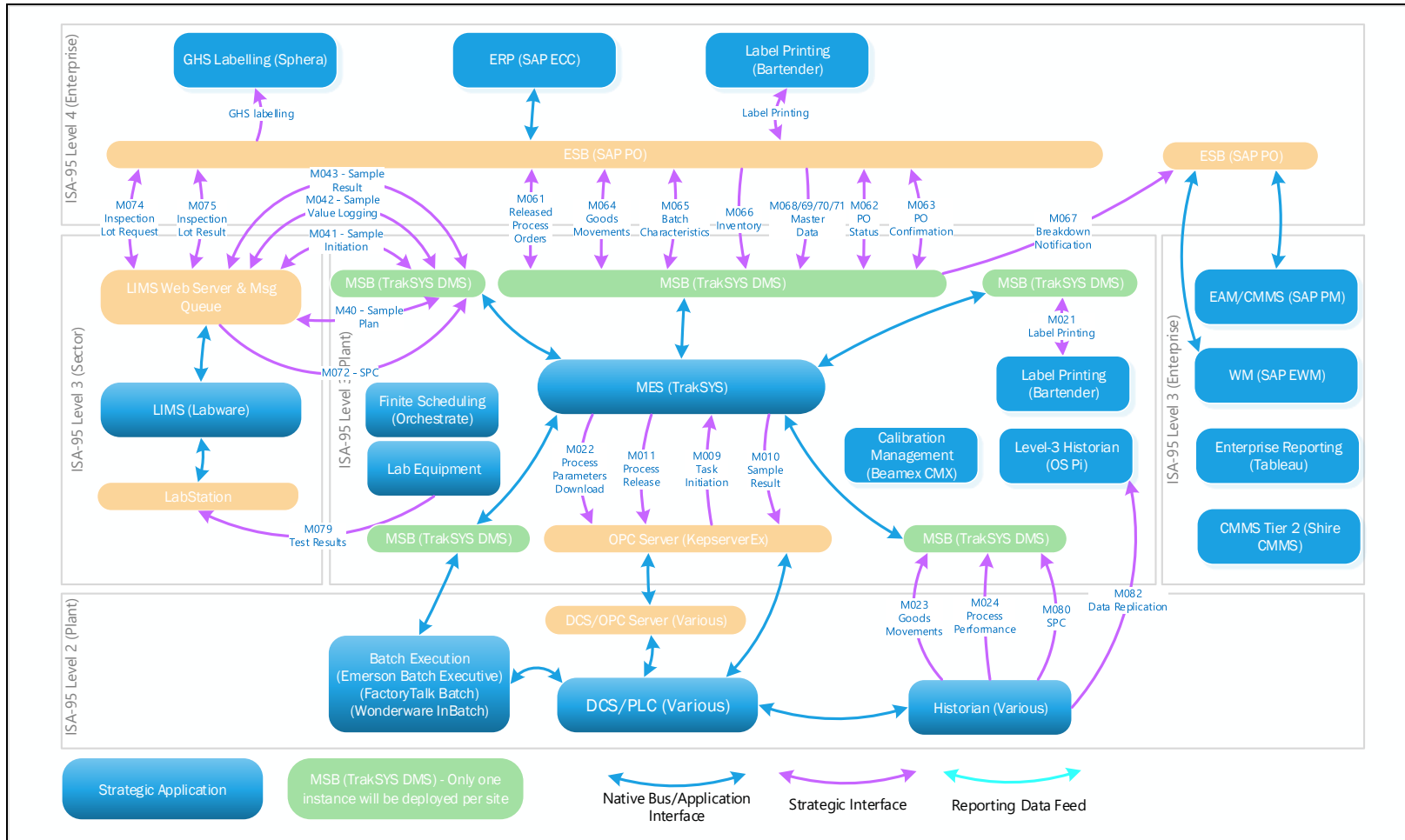


Jobs	Transactional Data	List of unique process orders from SAP. This entity to be populated by the strategic SAP Released Process order interface.	TrakSYS
Process Parameter Execution	Transactional Data	Transactional data for all process parameter changes against a batch and process order.	TrakSYS
Sample Execution	Transactional Data	Transactional data for all sample execution activity against a process order.	TrakSYS
Shift Management	Transactional Data	Transactional data for all shift activity.	TrakSYS
SPC	Transactional Data	Transactional data for all SPC related data recorded against an MES batch.	TrakSYS
Task Management	Transactional Data	Transactional data for tasks performed against a process order.	TrakSYS
WIP Inventory Tracking	Transactional Data	Transactional data of all WIP inventory movements against a process order and material number.	TrakSYS

8.2 Data Retention and Archiving

All manufacturing data to be retained indefinitely, unless a specific sector/site have different requirements. No data to be archived and therefore the MOM data and reporting design does not currently include archive data reporting functionality.

An analysis of whether the volume of past and current data accumulation in existing JM manufacturing sites justifies the cost of an overarching and archive reporting solution has not been performed, compared to the cost of acquiring additional storage and the indexing / partitioning of that storage. Developing volume trends that exceed the cost of additional storage will be monitored.





9.2 Solution Applications – Level 3

Application Category	Application	Deployment	Overview
MES	TrakSYS MES (2021/09/17-MES lite being investigated)	Site	
Label Printing	Bartender	Site	
Level-3 Historian	OsiSoft Pi	Site	Historian used for reporting and analysis purposes. Populated with data from level-2 Historian.
Finite Scheduling	Orchestrate	TBC	
Calibration Management	Beamex CMX	TBC	Used for calibration of Production equipment. Note that calibration of laboratory instrumentation will be managed in Labware.
LIMS	Labware	Sector	
CMMS – Option 1	SAP PM	Enterprise	Integrated CMMS for connected factory implementations.
CMMS – Option 2	Shire CMMS	Site	Standalone CMMS for lite CMMS implementations.
MSB	TrakSYS DMS	Site	
OPC	KepserverEx	Site	
Warehouse Management (WM)	SAP EWM	Enterprise	
Reporting	Tableau	Enterprise	End-user non-dashboard type reporting.

9.3 Solution Integration Middleware

9.3.1 Level 4/3 Interface Bus

There are two busses to facilitate the level 4/3 interfaces, an enterprise service bus (ESB), provide by SAP PO and a site level Manufacturing Service Bus (MSB) provided by TrakSYS DMS.

9.3.2 Manufacturing Service Bus (MSB)

The diagram indicates more than one MSB component. However, there will only be a single instance of the TrakSYS DMS MSB service deployed on-premises per site.

9.3.3 Labware Bus Service

The Labware Bus service is provided for by the Labware Web Server component. The strategic approach is for Labware to be deployed in Azure with a database instance per sector. The MSB will not be used for the Labware Azure deployment.

9.3.4 Level 3/2 OPC Bus

There are various level-2 OPC deployments at different sites in JM. These deployments are support by local or sector-based automation teams. To standardise OPC security and support of level-3 systems the KepserverEx OPC application will be implemented along side TrakSYS for implementations that requires a connection to the control systems, either a DCS or individual PLC's.

9.3.4.1 Level 3/2 DCS Communication

Where a DCS is utilised in the level-2 control space, the level-3 OPC server must always interact with the level-2 OPC application and not directly with DCS system, unless there is a control system device that resides outside of the DCS, in which can the level-3 OPC server may interact directly with the device.

9.3.4.2 Level 3/2 PLC Communication

Where PLC's are utilised in the level-2 control space, the level-3 OPC server can either communicate directly to a PLC or with a level-2 OPC server.

9.4 Application Functions

Please refer to the [MOM Functional Modules](#) document for a more detailed listing of functions.

MOM Functional Module L1	MOM Functional Module L2	MOM Functional Module L3	ISA-95 PQIM	Platform (Strategic)	Software (Strategic)	Detail
Process Order Management	Non-ERP Process order creation		P	MES	TrakSYS	Ability to create a works order outside of the ERP system. This function can be used for sites that do not have an ERP system or an interface to an ERP system that will download works orders.
Process Order Management	Process order importing	Strategic ERP	P	MSB	TrakSYS DMS	Ability to import process orders from the strategic or a legacy ERP system
Process Order Management	ERP Process order splitting	Manual	P	MES	TrakSYS, Orchestrate	Ability to split an ERP process order automatically or manually into sub production orders.
Process Order Management	Process Order Starting	Start Logic	P	MES	TrakSYS	Ability to start a process order and to apply the required start-up logic. Ability to send a process order start release to a level-2 system.
Process Order Management	ERP Process order status update		P	MSB	TrakSYS DMS	Ability to update the ERP system with the MES status of a process order. For example, when a process has started or has been completed. This will prevent process order updates in the ERP while the process order is being executed in MES. In addition, for long running processes, the ERP will receive a process status.
Process Order Management	Process order balancing		P	MES	TrakSYS	Ability to account for all input and output materials against a process order.
Process Order Management	Process order completion		P	MES	TrakSYS	Ability to complete a process order.
Process Order Management	Batch Splitting and Numbering		P	MES	TrakSYS	Ability to create batches against a process order in MES, based on a period or other criterion. The MES to keep a link to the master ERP batch.
Process Order Management	Process Execution	Equipment validation & interlocks	P	MES	TrakSYS	The ability to validate equipment at defined frequencies or events and to perform a process interlock in the control systems where required.



Process Parameters	Parameter Definition	Parameter Definition	P	MES	TrakSYS	Ability to setup and categorise parameters. These parameters can then be linked to materials and equipment within a process. Categories: Static parameter Calculated parameter Manual parameter Analytical parameter
Process Parameters	Parameter Setup per Line Segment	Parameter Setup per Line Segment	P	MES	TrakSYS	Setting up a parameter and linking it to a line segment and equipment. Preferred for MES to have equipment hierarchy that has segments at its highest level and to link parameters to equipment. Parameters to be downloaded per segment or process. A parameter is linked to equipment with attributes: default value (used if no material specific value provided), Upper/Lower limits, Set-point Changes Auth Group, In-batch Changes allowed, In-batch Changes Auth Group.
Process Parameters	Parameter Setup per Material	Parameter Setup per Material	P	MES	TrakSYS	Ability to change a set-point value of parameters per output material. Material values will always override equipment values.
Process Parameters	Role Authorisation	Role Authorisation	P	MES	TrakSYS	Ability to maintain roles with permissions assigned to set-point and in-batch parameter changes.
Process Parameters	Parameter Downloading	Parameter Downloading	P	MES	TrakSYS	Ability to download parameters as a defined recipe step in L3 or per process.
Process Parameters	In-batch Parameter Changes	In-batch Parameter Changes	P	MES	TrakSYS	Ability to change and download parameters enabled for in-batch changes anytime during batch execution. The in-batch changes will only be applicable for the duration of the batch.
Recipe Management	Recipe Setup and Approval		P	MES	TrakSYS	Ability to make changes to recipe steps and for the changes to be approved before the recipe is released.
Recipe Management	Recipe Execution	Recipe Performance	P	MES	TrakSYS	Ability to measure a recipe step's performance, and to classify the loss as either an OEE Performance loss for a slow running step or an OEE Availability loss for downtime on a step. OEE to be implemented as L3 recipe steps to provide more flexibility for changes and defined touch-points into L2 system as well as other L3 system.
Recipe Management	Recipe Execution	Manual Step Execution	P	MES	TrakSYS	Ability to manually start and complete a recipe step.



Recipe Management	Recipe Execution	Automatic Step Completion	P	MES	TrakSYS	Ability to receive an input from a level-2 control (PLC or DCS) or standalone system (IIOT), which will automatically complete a step.
Recipe Management	Recipe Execution	Process Parameter Downloading	P	MES	TrakSYS	Ability to download process parameters during defined steps to level-2 and level-3 systems, with required interlocks.
Recipe Management	Recipe Execution	Process value importing	P	MES	TrakSYS	Ability to import process values such as data from a scale for an in-process quality check or any other system as a defined recipe step, either level-2 or level-3.
Recipe Management	Recipe Execution	Dynamic formula adjustments	P	MES	TrakSYS	Ability to make dynamic formula changes based on sample analysis results per defined recipe steps.
Recipe Management	Recipe Execution	Add-hoc Steps	P	MES	TrakSYS	Ability to manually add a recipe step.
Recipe Management	Recipe Execution	Electronic Batching Records (EBR)	P	MES	TrakSYS	Ability to record all activity and information during recipe execution and to produce all the required electronic batching records.
Recipe Management	Recipe Execution	Equipment Orchestration	P	Level-2	Level-2 batching	Ability to orchestrate the interaction and flow between different Units within a Process Cell.
Recipe Management	Recipe Execution	Master (Equipment) recipe control	P	Level-2	Level-2 batching	Ability to execute steps that controls Units, Equipment Modules and Control Modules.
Downtime Management	Downtime event recording	Recipe step overage - Manual	P	MES	TrakSYS	Ability to manually capture a step overage event for a batching process.
Downtime Management	Downtime event recording	Discrete - Manual	P	MES	TrakSYS	Ability to manually capture a downtime event for a discrete process. This refers to the defined time between the production of two discrete parts.
Downtime Management	Downtime event recording	Continues - Manual	P	MES	TrakSYS	Ability to manually capture a downtime event for a continues process.
Downtime Management	Downtime event recording	Discrete - Automatic	P	MES	TrakSYS	Ability for MES to determine a downtime event for a discrete process or to receive the value from a control system.
Downtime Management	Downtime event recording	Recipe Step overage - Automatic	P	MES	TrakSYS	Ability for MES to determine a step overage on a recipe execution step or to receive the value from a control system.



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Downtime Management	Downtime event recording	Continues - Automatic	P	MES	TrakSYS	Ability to receive an input signal from a level-2 system, usually coming from a flow-meter to indicate that a continues process has stopped or started.
Downtime Management	Downtime categorisation	Manual	P	MES	TrakSYS	Ability to manually assign a downtime category to a downtime event.
Downtime Management	Downtime categorisation	Automatic	P	MES	TrakSYS	Ability to record a downtime category provided by the control system to a downtime event.
Downtime Management	Downtime event recording	ERP Breakdown Notification	P	MSB	TrakSYS DMS	Ability to log a breakdown notification in SAP from MES
Downtime Management	Start-up checklist		P	MES	TrakSYS	Ability to complete a checklist when a process is about to start up from a downtime event.
Production Reporting	General Reporting	Dashboards	P	MES	TrakSYS	Real-time reports from the MES transactional database. - Seconds
Production Reporting	General Reporting	Operational - Site	P	ODS	SSRS	Near to real-time reports from the site ODS replicated database. - Minutes
Production Reporting	General Reporting	Operational - Region	P	ODS	Tableau/SSRS	Reports from various site MES replicated databases. - Hours
Production Reporting	General Reporting	Analysis	P	MAP	Tableau/NWA	Reports used for advanced analysis, from individual or combined sites. - Hours
Production Reporting	KPI Reporting	Dashboards	P	MES	TrakSYS	Real-time reports from the MES transactional database. - Seconds
Production Reporting	KPI Reporting	Operational - Site	P	ODS	SSRS	Near to real-time reports from the site MES replicated database. - Minutes
Production Reporting	KPI Reporting	Operational - Region	P	ODS	Tableau/SSRS	Reports from various site MES replicated databases. - Hours
Production Reporting	KPI Reporting	Analysis	P	MAP	Tableau/NWA	Reports used for advanced analysis, from individual or combined sites. - Hours
WIP Inventory Management	Inventory traceability	Material consumption recording	I	MES	TrakSYS	Recording of all consumed input material against a process order.
WIP Inventory Management	Inventory traceability	Material production recording	I	MES	TrakSYS	Recording of all product and by-product produced material. This includes samples, and non-conforming product.
WIP Inventory Management	Inventory traceability	Material Consumption Reversals	I	MES	TrakSYS	Ability to reverse material consumption transactions.

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WIP Inventory Management	Inventory traceability	Material Production Reversals	I	MES	TrakSYS	Ability to reverse material production transactions.
WIP Inventory Management	Inventory traceability	Equipment Weight Recording	I	MES	TrakSYS	Ability to read and record a weight from a weighing device for a consume or produce transaction.
WIP Inventory Management	Inventory traceability	Manual Weight Recording	I	MES	TrakSYS	Ability to manually record a weight for a consume or produce transaction.
WIP Inventory Management	Inventory traceability	Genealogy	I	MES	TrakSYS	Ability to record and display a full (or partial for continues) lot genealogy view of a final product.
WIP Inventory Management	Inventory traceability	Inventory levels	I	MES	TrakSYS	Ability to track and display inventory levels for WIP inventory locations. Calculations to determine material levels/qty's.
WIP Inventory Management	Inventory traceability	WIP Container Tracking	I	MES	TrakSYS	Ability to track movements of WIP containers
WIP Inventory Management	Discrete product tracking	Serialisation	I	MES	TrakSYS	Individual piece tracking and routing is function to track products with a serial number through the process and to make process routing decisions.
WIP Inventory Management	Discrete product tracking	Genealogy	I	MES	TrakSYS	Ability to trace serialised input materials.
WIP Inventory Management	Discrete product tracking	Route determination logic	I	MES	TrakSYS	Ability to determine advanced route of product based on current parameters and previous statuses.
WIP Inventory Management	Packaging & Labelling	Container packing	I	MES	TrakSYS	Ability to count or measure the quantity of material being packed.
WIP Inventory Management	Packaging & Labelling	Nested container packing	I	MES	TrakSYS	Ability to nest containers.
WIP Inventory Management	Packaging & Labelling	Upfront label printing	I	MES	TrakSYS	Ability to print labels before a process starts.
WIP Inventory Management	Packaging & Labelling	Production process printing	I	MES	TrakSYS	Ability to print labels as product is produced and packed.
WIP Inventory Management	Packaging & Labelling	Packed label verification	I	MES	TrakSYS	Ability to verify a printed label, usually by means of scanner or RFID input.
WIP Inventory Management	Production Label printing	Direct label printing	I	MSB	TrakSYS MSB	Ability to communicate and send a print instruction directly to a label printer.
WIP Inventory Management	Production Label printing	Indirect label printing	I	MSB	TrakSYS MSB	Ability to send a print instruction to a labelling solution.
WIP Inventory Management	Input material control	Validation	I	MES	TrakSYS	Ability to verify whether a material and/or batch is contained in the process order component list / process / location.

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WIP Inventory Management	Input material control	Level-2 Material Usage Release	I	OPC	KeptserverEx	Ability to pause the usage of material in level-2 systems for input material validation.
WIP Inventory Management	ERP goods movement interfaces	Consumed goods movement	I	MSB	TrakSYS DMS	Ability to upload consumed material lot and quantities to the ERP.
WIP Inventory Management	ERP goods movement interfaces	Produced goods batch characteristics	I	MSB	TrakSYS DMS	Ability to upload the batch characteristics of a produced batch to the ERP. This interface should also accommodate for reversals.
WIP Inventory Management	ERP goods movement interfaces	Produced goods movement	I	MSB	TrakSYS DMS	Ability to upload the lot numbers and quantities of product or by-product produced. This can occur on a discrete step or on a frequency. This interface should also accommodate for reversals.
Warehouse Management	Container Splitting/Repacking and labelling		NA	WMS	SAP EWM / TrakSYS (Refining)	Ability to split containers and repack the containers as a warehouse function.
Warehouse Management	Stock receiving and warehouse put away		NA	WMS	SAP EWM / TrakSYS (Refining)	Ability receive stock from a supplier or another warehouse, perform the required validations and to perform the put away.
Warehouse Management	Warehouse movements and container tracking		NA	WMS	SAP EWM / TrakSYS (Refining)	Ability to move and track stock within defined warehouse/production/storage locations.
Warehouse Management	Dispatch		NA	WMS	SAP EWM / TrakSYS (Refining)	Ability to perform all dispatching activities from a warehouse to another warehouse of customer.
Warehouse Management	Stock Take & Cycle Counting		NA	WMS	SAP EWM / TrakSYS (Refining)	Ability to perform stock taking and cycle counting within the defined warehouse locations.
Quality Control	Sample plan	Maintenance	Q	LIMS	Labware	Maintenance of the sample plan.
Quality Control	Sample Plan Execution	Executed through Recipe Execution module	Q	MES	TrakSYS	Function to import sample plan from LIMS and to inform the process of when to pull a sample integrated with the Recipe Execution Module.
Quality Control	Sample Plan Execution	Executed through Task Management module	Q	MES	TrakSYS	Function to import the next required sample from LIMS and to send the instruction to the Task Management System. (Only importing one sample request at a time will accommodate for process downtime).

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Quality Control	Laboratory Samples	Laboratory sample logging and results analysis	Q	LIMS	Labware	Logging of samples and their results.
Quality Control	Laboratory Samples	Results from LIMS to Level-2	Q	MSB	TrakSYS MSB	Ability to request a sample result from LIMS and to pass the value to the level-2 system.
Quality Control	In-process Samples	Automatic sample logging	Q	MES	TrakSYS	Automatic logging of in-process samples and their results.
Quality Control	In-process Samples	Result from LIMS	Q		TrakSYS	MES to make a decision based on the received sample value. The sample analysis result can also be send back to the level-2 system.
Quality Control	At-line Samples	Manual sample logging	Q	MES	TrakSYS	Manual logging of off-process at-line samples and their results.
Quality Control	At-line Samples	From Equipment		MES	TrakSYS	
Quality Control	At-line Samples	Pass/fail calculations		LIMS	Labware	
Quality Control	At-line Samples	Process calculations		MES/L2	Level-2/TrakSYS	
Quality Control	At-line Samples	LIMS sample logging	Q	MSB	TrakSYS MSB	Ability to post a logged sample to LIMS.
Quality Control	At-line Samples	Results to Level-2	Q	MSB	TrakSYS MSB	Ability to pass back an at-line sample result to the level-2 system.
Quality Control	Reference Samples	Reference sample logging	Q	MES	Labware	Logging of retention or lot reference samples. This function is separate from the inventory logging function.
Quality Control	Non conformance	Scrap Logging	Q	MES	TrakSYS	Ability to log non-conforming product as MES scrap (Scrap ERP movement code) and to specify the non conformance reasons code.
Quality Control	Non conformance	Waste				
Quality Control	Non conformance	Quarantine Logging	Q	MES	TrakSYS	Ability to log non-conforming product as MES quarantines (Quarantine ERP movement code) and to specify the non conformance reasons code.
Quality Control	Non conformance	Rework decision	Q	QMS	CAQ	Logging of rework decision making for a quarantine lot, whether to rework in current batch or new batch.
Quality Control	Non conformance	Label printing	Q	MES	TrakSYS	Ability to print non conformance labels.
Quality Control	Non conformance	Reason maintenance	Q	MES	TrakSYS	Ability to maintain non conformance reasons per resources and material.

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Quality Control	Non conformance	Reason assignment	Q	MES	TrakSYS	Ability to assign a non conformance reason to a discrete product or batch bulk material.
Quality Control	Non conformance	Notifications	Q	MES	TrakSYS	Ability to raise notifications for specified conditions.
Quality Control	Layered Process Audit (LPA)	Maintenance	Q	QMS	CAQ	Ability to maintain audit templates.
Quality Control	Layered Process Audit (LPA)	Execution	Q	MES	TrakSYS	Execution of an audit as part of the production process.
Quality Control	SPC	Post Production Analysis	Q	QMS	TBC - MiniTab, NWA	Post execution analysis.
Quality Control	Quality DMS (Document Management System)	Production displaying	Q	MES	CAQ	Ability to display quality documentation to production in the execution system.
Quality Control	Sample Logging	Inspection Lot Request	Q	LIMS	Labware	Ability to receive an inspection lot request from SAP.
Quality Control	Sample Logging	Inspection Lot Result	Q	LIMS	Labware	Ability to send a result for an inspection lot request to SAP.
Quality Assurance	Standards/certifications governance		Q	QMS	TBC	Certification standards repository and control.
Quality Assurance	Concerns and Corrective and Preventative Actions (CAPA)		Q	QMS	TBC	Ability to log CAPA events.
Quality Assurance	Customer Complaints		Q	QMS	TBC	Ability to log customer complaint against a specific batch.
Quality DMS (Document Management System)	Document Control		Q	QMS	TBC	Ability to edit, control send release all quality related documents.
Quality Assurance	FMEA		Q	QMS	TBC	Ability to manage FMEA for define processes.
Production Planning	Capacity Planning		NA	ERP	SAP	Ability to generate a capacity plan for the plant.
Production Planning	Material and Resource Planning		NA	ERP	SAP	Ability to perform material and resource planning against customer demand.
Process Order Finite Scheduling	Constraints maintenance		P	MES	TrakSYS	Ability to maintain constraints for production resources.

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Process Order Finite Scheduling	Automatic scheduling	Basic	P	MES	TrakSYS	Limited scheduling constraints.
Process Order Finite Scheduling	Automatic scheduling	Advanced	P	MES	Orchestrate	More advanced scheduling constraints and algorithms.
Process Order Finite Scheduling	Basic manual scheduling		P	MES	TrakSYS	Ability to manually adjust the schedule.
Process Order Finite Scheduling	Simulation		P	MES	Orchestrate	Ability to run a simulation before a schedule is approved.
Process Order Finite Scheduling	Advanced scheduling system interface		P	MSB	TrakSYS DMS	Ability to send and receive information from the MES to the Advanced Scheduling System.
Process Order Finite Scheduling	ERP plan update interface		P	MSB	TrakSYS DMS	Ability to update the SAP plan.
Equipment Performance	OEE Recording	Performance - Recipe step overage	P	MES	TrakSYS	Ability to record the step overage of a batch process.
Equipment Performance	OEE Recording	Performance Loss Classification	P	MES	TrakSYS	Ability to provide a reason for the performance loss from a pre-defined reasons list hierarchy.
Equipment Performance	OEE Recording	Performance - Cycle Time Losses	P	MES	TrakSYS	Ability to record the cycle time losses.
Equipment Performance	OEE Recording	Availability	P	MES	TrakSYS	Ability to record availability losses.
Equipment Performance	OEE Recording	Quality	P	MES	TrakSYS	Ability to record quality losses real-time or back calculated.
Equipment Performance	OEE Recording	Performance - Continues process	P	MES	TrakSYS	Ability to record performance losses - expected output vs target.
Equipment Performance	OEE Maintenance	Discrete process planned cycle time	P	MES	TrakSYS	Ability to maintain the planned cycle time for discrete processes.
Equipment Performance	OEE Maintenance	Batch process step planned time	P	MES	TrakSYS	Ability to specify the standard step time in batch process.
Equipment Performance	OEE dashboard reporting		P	MES	TrakSYS	All operational reporting done by TS, as MAP will not be a production Critical application
Equipment Performance	OEE operational reporting		P	MES	SSRS	Operational reporting from replicated MES database. May be critical.
Equipment Performance	OEE analysis reporting		P	MAP	Tableau	Analysis reporting via Tableau web reporting.



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Equipment Performance	TEEP (Total Effective Equipment Performance)	Utilisation recording		MES	TrakSYS	Ability to record schedule losses.
Equipment Performance	Control systems micro cycle-time recording		P	MES	TrakSYS	Note this may be a Historian function
Equipment Performance	Control systems micro cycle-time analysis		P	MES	SSRS	Site operational reporting from replicated database.
Equipment Performance	OEE Maintenance	Continues process throughput rate	P	MES	TrakSYS	Ability to specify the throughput rate.
Production Readiness Review (PRR)	PRR step configuration		P	MES	TrakSYS	Ability to maintain PRR steps.
Production Readiness Review (PRR)	PRR execution, tracking and escalation		P	MES	TrakSYS	Ability to start and complete PRR steps.
Production Readiness Review (PRR)	PRR dashboard reporting		P	MES	TrakSYS	Dashboard reporting from the live MES database.
Production Readiness Review (PRR)	PRR operational reporting		P	MES	SSRS	Operational reporting from replicated MES database. May be critical.
Production Readiness Review (PRR)	PRR analysis reporting		P	MAP	Tableau	Analysis reporting via Tableau web reporting.
Production Readiness Review (PRR)	PRR automatic step completion		P	MES	TrakSYS	Integration into equipment or systems to auto complete steps.
Production Readiness Review (PRR)	Escalations and notifications		P	MES	TrakSYS	Ability to raise notifications for defined step overages.
Changeover	Changeover algorithm		P	MES	TrakSYS	Ability to setup and use a changeover algorithm to specify the different changeover types that will align to steps to execute.
Changeover	Step configuration		P	MES	TrakSYS	Ability to configure the steps for each changeover type.
Changeover	Execution, step tracking and escalation		P	MES	TrakSYS	Ability to execute the changeover process by completing steps and to escalate steps that are running longer than the target.
Changeover	Automatic step completion		P	MES	TrakSYS	Integration into equipment or systems to auto complete steps.

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Shift Management	Shift log book		P	MES	TrakSYS	Ability to record events during a shift.
Shift Management	Shift handover		P	MES	TrakSYS	Checklist of actions and information for shift handover.
Shift Management	Shift sign-off		P	MES	TrakSYS	Ability to sign off a shift, completing a checklist and accounting for stock during the shift.
Shift Management	Shift dashboard reporting		P	MES	TrakSYS	Dashboard reporting from the live MES database.
Shift Management	Shift operational reporting		P	MES	SSRS	Operational reporting from replicated MES database. May be critical.
Shift Management	Shift analysis reporting		P	MAP	Tableau	Analysis reporting via Tableau web reporting.
Shift Management	Labour recording		P	MES	TrakSYS	Ability to record line personnel per shift.
Start-up and shutdown management	Step setup			MES	TrakSYS	
Start-up and shutdown management	Step execution			MES	TrakSYS	
Start-up and shutdown management	Reporting				TrakSYS Manufacturing Analytics Platform (MAP) SSRS Tableau	
SPC	SPC Real-Time Display	SPC Graphs	P	MES	TrakSYS	Ability to display real-time SPC graphs from an OPC (PLC/DCS) or database source.
SPC	SPC Real-Time Display	Overview Dashboard with Drill Down				
SPC	SPC Real-Time Display	PPK, CPK, Mean, SD				
SPC	SPC Real-Time Automatic Control		P	Level-2	DCS/PLC	Ability to do real-time process control by automatic process adjustment.
SPC	SPC Alarms	Spec and control limit alarms	P	MES	TrakSYS	Ability to raise an alarm when a process is out of control and/or out of specification.
SPC	SPC Alarms	Ruled-defined successive out of Control or Spec Limits alarms				Ability to raise alarms for rule-defined successive out of control and spec limits.

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SPC	SPC Alarms	Alarm acknowledgement	P	MES	TrakSYS	Ability to acknowledge an alarm.
SPC	SPC Alarms	Alarm Actions Decision Recording	P	MES	TrakSYS	Ability to specify the action taken against an alarm.
Process Historization	Recording of process values			Level-2	DCS/PLC	Ability to record defined process values.
Task Management	Task Setup	Task type setup	P	MES	TrakSYS	Ability to maintain task types. Task types to be assigned a priority. Examples: Internal, External-LIMS, External-Level2 etc
Task Management	Task Logging	Manual task logging	P	MES	TrakSYS	Ability to manually log and assign a task to an operator or role.
Task Management	Task Logging	Internal task logging	P	MES	TrakSYS	Ability to receive a task logged by an internal MES workflow function.
Task Management	Task Logging	External task logging	P	MSB	TrakSYS DMS	Ability to receive a task through an interface from an external system.
Task Management	Task Logging	Time-based task	P	MES	TrakSYS	Ability for tasks to be logged to user/process based on a frequency of discrete time.
Task Management	Task Logging	Sub-task logging	P	MES	TrakSYS	Ability to log a sub task.
Task Management	Task Display	Hierarchical task list	P	MES	TrakSYS	Ability to display a task list hierarchy to an operator or process/area. List to auto update or update on demand.
Task Management	Task Display	List Filtering	P	MES	TrakSYS	Ability to filter a task on Area or Task Type.
Task Management	Task Display	Status indication	P	MES	TrakSYS	Ability to colour code task statuses as well as displaying the actual status (colour-blind).
Task Management	Task Display	SOP linking	P	MSB	TrakSYS DMS	Ability to link and display SOP's from another system.
Task Management	Task Completion	External task feedback	P	MSB	TrakSYS DMS	Ability to provide asynchronous feedback to a task, through a web service call.
Task Management	Task Completion	Manual completion	P	MES	TrakSYS	Ability to manually complete a task and provide the required responses.
Task Management	Task Completion	Automatic completion	P	MES	TrakSYS	Ability for a task to be completed by an interface from level-3 or level-2.
Task Management	Task Escalation	Internal system escalation	P	MES	TrakSYS	Ability to escalate a task that has overrun its allotted time within the MES system.
Task Management	Task Escalation	External system escalation	P	MES	TrakSYS DMS	Ability to escalate a task that has overrun its allotted time to an external system, like MS Teams or an SMS (Text) message.



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Maintenance Management	Asset management and register			ERP	SAP EAM	
Maintenance Management	Maintenance spares store management			ERP	SAP PM	
Maintenance Management	Scheduling			ERP	SAP PM	
Maintenance Management	Breakdown maintenance management			ERP	SAP PM	
Maintenance Management	Preventative maintenance management			ERP	SAP PM	Planned + predictive; AMW - To do predictive maintenance will need lots of sensor data, do we want that in SAP? or should this be in level 3 applications?
Maintenance Management	Reporting			ERP	SAP PM	
Maintenance Management	Raw process data collection and aggregation		M	MES	TrakSYS, Historian	
Maintenance Management	Compliance/EHS			ERP	SAP PM	
Maintenance Management	Job management			ERP	SAP PM	
Maintenance Management	Maintenance strategy management			ERP	SAP PM	
Maintenance Management	Maintenance certification management			ERP	SAP PM	
Maintenance Management	Condition Based Maintenance	Recording	M	MES	TrakSYS	Ability to receive a signal from level2 system indicating a condition based event.
Energy Management	Resource setup		P	MES Level-2	TrakSYS Level-2	Ability to maintain resource to monitor energy consumption.
Energy Management	Data Collection	Manual data capturing	P	MES	TrakSYS	Ability to manually capture energy consumption.
Energy Management	Data Collection	Real-time data collection and decision making	P	Level-2	Level-2	Ability to collect data from energy meters.

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Energy Management	Equipment control		P	Level-2	Level-2	Ability to control equipment to avoid maximum demand scenarios or to accommodate for shutdown and start-up ramp downs and ups.
Energy Management	Reporting	Dashboards	P	Level-2	Level-2	Ability to display real-time energy data on dashboards.
Energy Management	Reporting	Process Order	P	ODS	TrakSYS SSRS	Ability to calculate and report energy usage against a process order.
Energy Management	Notification		P	MES Level-2	TrakSYS Level-2	Ability to raise notifications for energy usage alarms.
Tool Management	Tooling inventory management				TrakSYS	
Tool Management	Tooling status				TrakSYS	
Tool Management	Tooling maintenance				TrakSYS	AMW - Why not SAP PM?
Tool Management	Tooling requests				TrakSYS	

9.5 High Availability and Resilience

9.5.1 TrakSYS

ID	Description
1	The TrakSYS production instance will be deployed on clustered windows servers.
2	Physical storage will be held on a Storage Area Network.
3	The database will be continuously replicated using Always-On Availability Groups for Microsoft SQL Server.
4	Regular backups will be taken of the application and database.
5	Recovery in the event of a VM failure - In the event of a VM failure a backup VM instance will be restored using VEEAM. TrakSYS will recover its status and configuration from the database. All TrakSYS configuration is stored in the database.
6	Recovery in the event hosting hardware – In the event of hosting hardware failure, the VM must start up automatically on the backup node. Note: The backup hardware may be in a different server room.

9.5.2 Bartender

ID	Description
1	The Bartender production instance will be deployed on clustered windows servers.
2	Physical storage will be held on a Storage Area Network.
3	The database will be continuously replicated using Always-On Availability Groups for Microsoft SQL Server.
4	Regular backups will be taken of the application and database.

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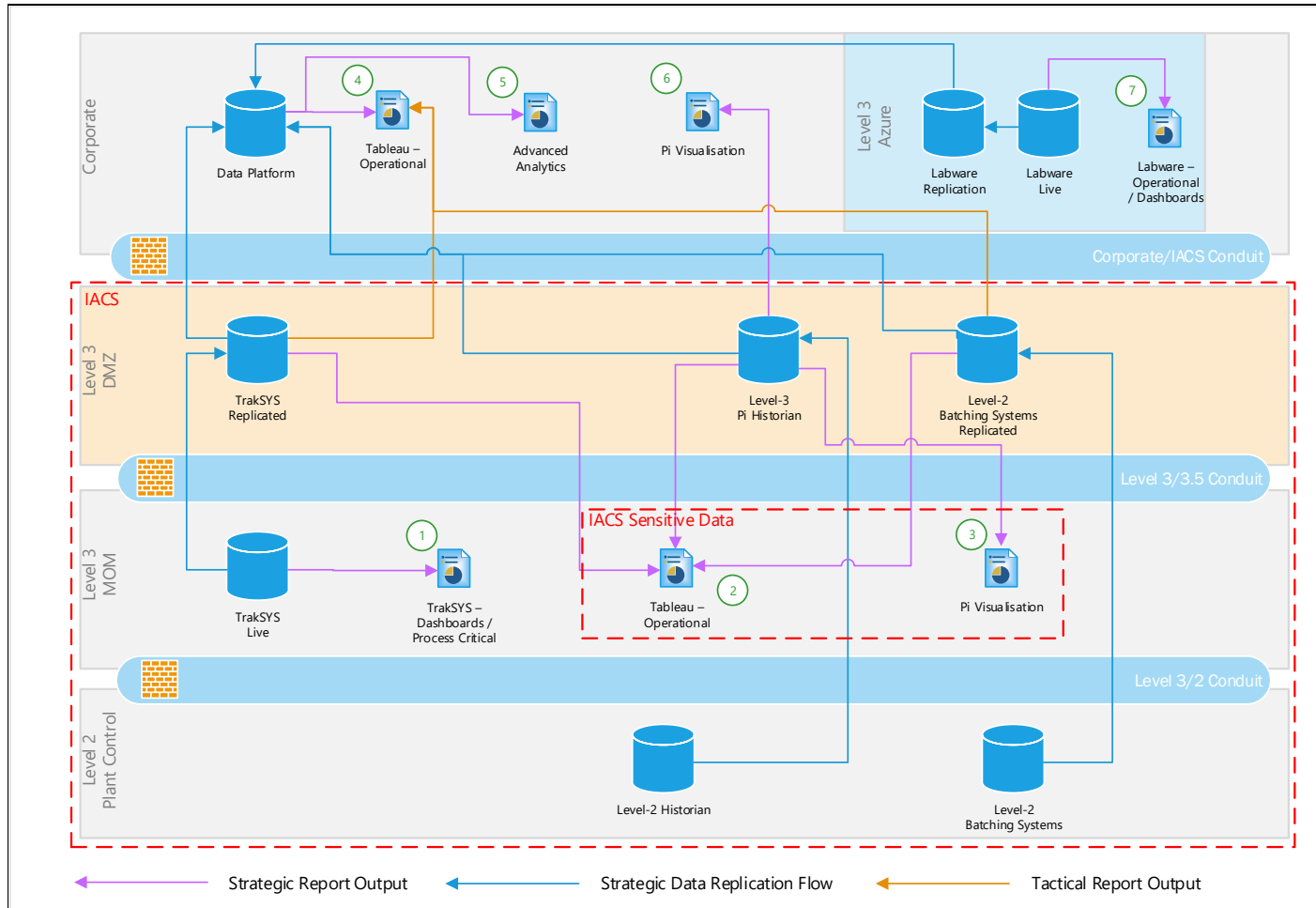


5	Recovery in the event of a VM failure - In the event of a VM failure a backup VM instance will be restored using VEEAM. TrakSYS will recover its status and configuration from the database. All TrakSYS configuration is stored in the database.
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9.6 Reporting Model

9.6.1 Reporting Structure Diagram



9.6.2 Reporting Use Cases

Reporting is an essential function used to provide the business with timely, accurate information which is critical to analysing the performance of an operation. The aim is to ensure that reports are as close to real time as possible so that only current information is used to make decisions.

Item	Use Case	Description	IACS Sensitive Data	Data Availability	RTO (Generic estimation)	Single/Multi Site Reporting
1	TrakSYS – Dashboard and Process Critical Reporting	This option allows for the display of critical real-time dashboards and process critical reports that are required for decision making. The data for both reporting types will come from the live TrakSYS database.	NA	Seconds	< 1 minute	Single
2	On-premises Tableau – Operational Reporting	This option allows for less critical operational reporting. On-premises reporting will be required for IACS sensitive data. This option will also be used where data must be stored within a specific country or region.	Yes	Minutes	< 30 minutes	Single
3	On-premises Pi Visualisation	Provides functionality to connect directly to a replicated copy of the process historian data. This option will provide visualisation and reporting for: <ul style="list-style-type: none"> IACS sensitive data. Data that must be stored within a specific country or region. Ability to provide a visual representation of an operation's equipment and associated trend data. This function is not intended as a replacement for SCADA functionality.	Yes	Seconds	< 30 minutes	Single
4	Corporate Tableau – Operational Reporting (Data lake)	This option will provide functionality to report on data from the data lake repository. The data lake can contain data from various sources. Operational reporting at the corporate layer refers to reporting activities that are less critical and usually contain data from many sources and potentially multiple sites.	No	< 1 Hours	< 2 Hours	Usually, multi-site
5	Advanced Analytics	This option provides for the provision of advanced analytical reporting in the corporate layer. This function can be provisioned for by multiple applications (JMP, MiniTab, NWA, TrendMiner).	No	< 2 Hours	< 4 Hours	Usually, multi-site
6	Corporate Pi Visualisation	Ability to use the Pi Visualisation toolset in a corporate environment without the need to log into the IACS domain. This capability is for process data that is not required for real-time monitoring.	No	Minutes	< 30 minutes	Usually, single site
7	Labware Reporting	Ability to display labware reports.	No	Minutes	< 1 Hour	Single or multi-site



9.7 Label Printing

There are currently 2 types of labels being printed from Labware and TrakSYS:

1. Handling unit labels.
2. Sample labels

Label prints initiated from TrakSYS will be printed by Bartender with the data being supplied by TrakSYS through the M021-01/2 strategic interface.

Label prints initiated from Labware will be printed directly from Labware.

Where the same label needs to be printed from both TrakSYS and Labware the following are potential approaches:

1. The label can be manually maintained in both Labware and Bartender and will be printed by each individual system. This approach is usually applicable where there are a limited number of labels that is the same in both systems.
2. The label is either maintained only in Bartender or Labware and the printing of the label will then also be performed by the system in which the label is maintained. This approach will however require additional interfaces that is not currently on the landscape.

9.7.1 Handling Unit Labels

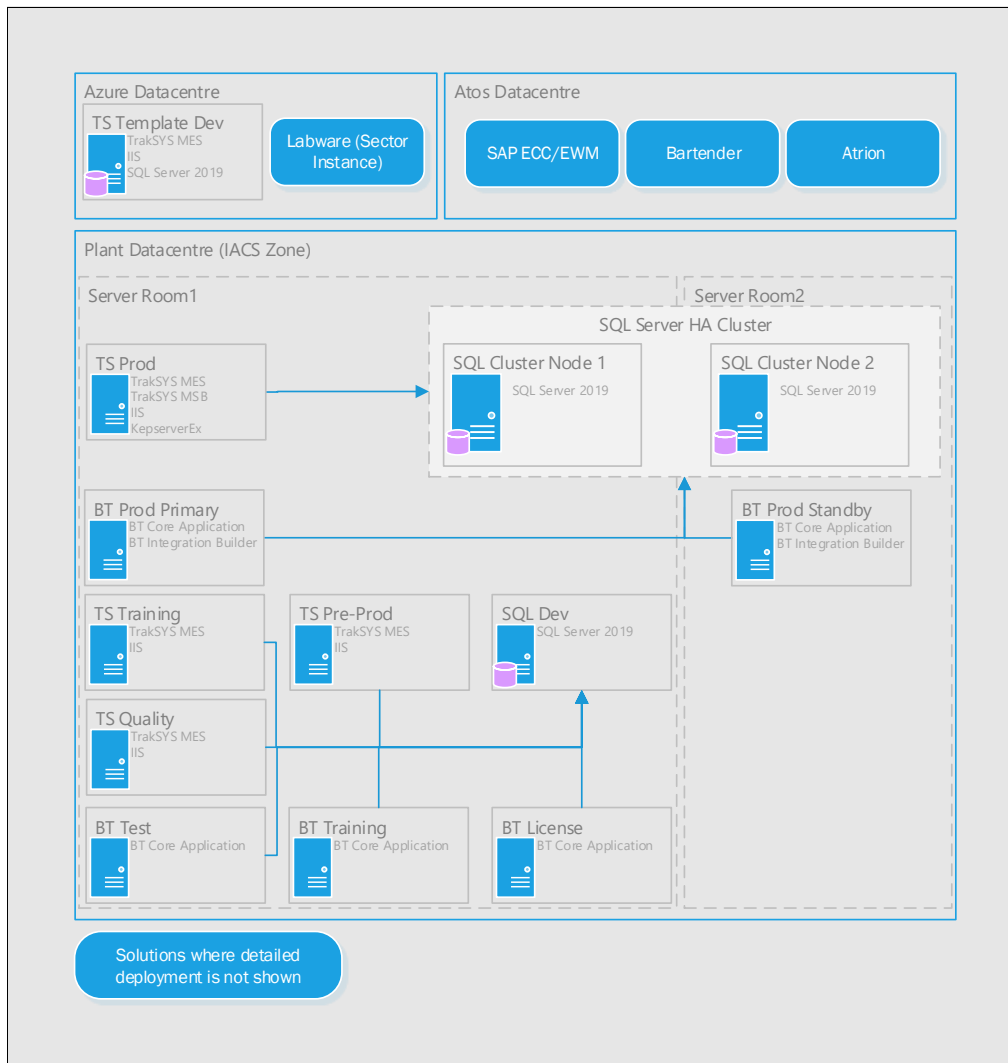
Handling unit labels are printed by TrakSYS to identify packaging containers, typically at packaging stations in the process for intermediate and final products. There are tactical implementations where TrakSYS also prints handling unit labels for stock being received into the warehouse.

9.7.2 Sample Labels

Sample labels are printed to identify samples taken in the process. There are two types of sample labels:

1. Labels that are generated with the purpose of being logged into Labware. These labels are generated directly in Labware or indirectly in TrakSYS. TrakSYS will initiate the sample in Labware using the strategic M041-01 interface from where Labware will supply the sample number through the M041-02 interface.
2. Labels that are printed together with a handling unit label. These sample labels are usually only printed to facilitate the tracking of samples in the process. Where these samples need to be tested in the laboratory and the results logged in Labware, a Labware generated sample label will be printed.

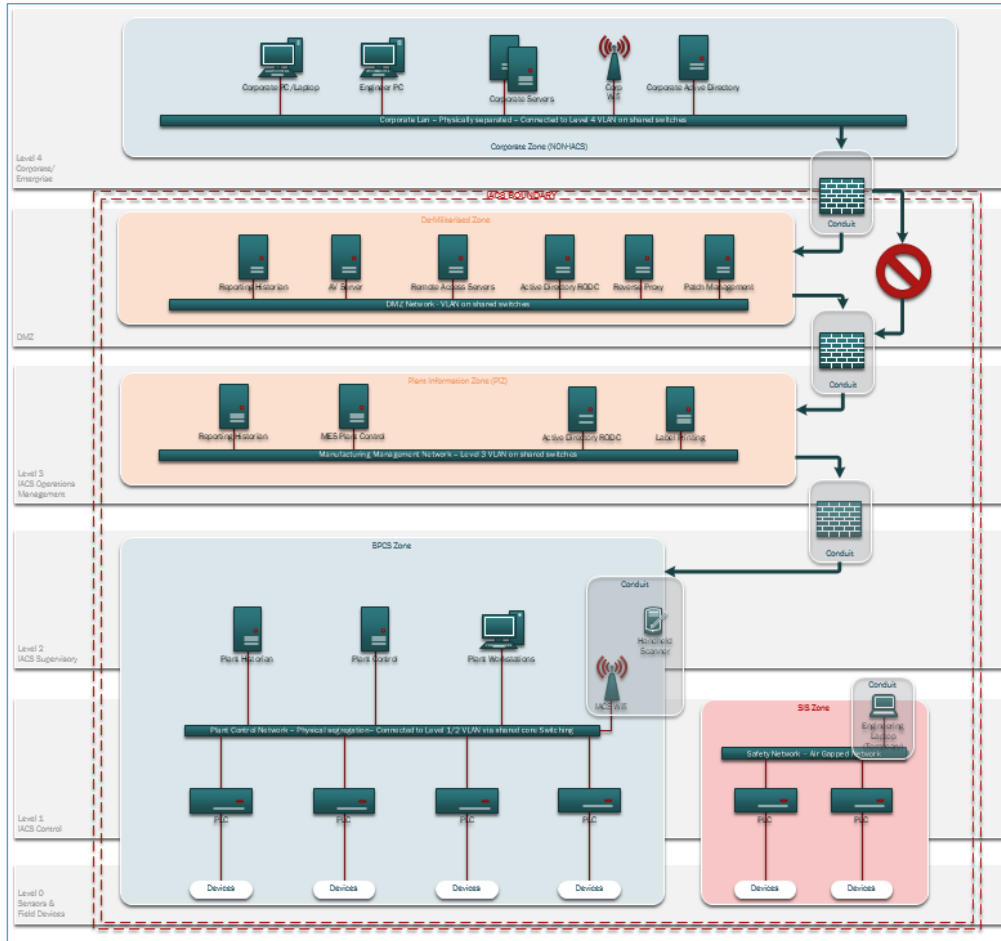
10 Technology Architecture
10.1 Technology Deployment Diagram



10.2 Network Deployment

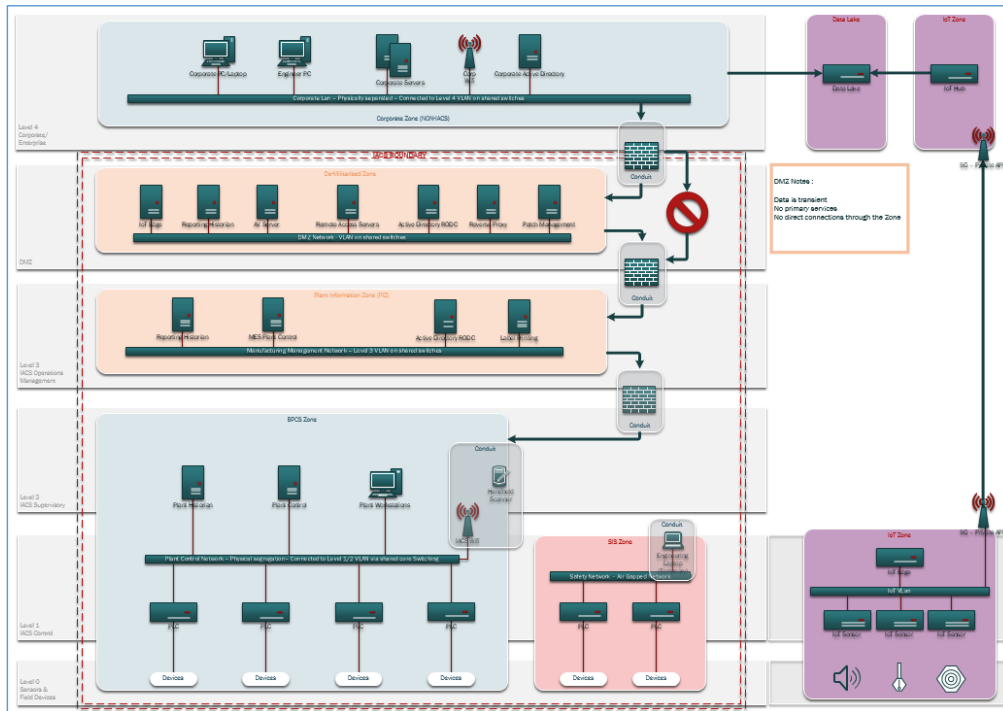
10.2.1 Deployment with 3.5 DMZ

Please refer to the [Manufacturing Site Reference Models](#) for the latest version.



10.2.2 Deployment with IoT

Please refer to the [Manufacturing Site Reference Models](#) for the latest version.



10.3 Server Configuration

10.3.1 SQL Server

Environment	RAM	CPU	Storage	OS	Database
MOM SQL Development	16GB	2 Cores	C (OS): 100 GB D (Data): 200 GB	Windows Server 2019	SQL 2019 Developer
MOM SQL Production Cluster					

10.3.2 TrakSYS

Environment	RAM	CPU	Storage	OS	Database
TrakSYS Development /	16GB	2 Cores	C (OS): 100 GB D (Data): 200 GB	Windows Server 2019	SQL 2019 Developer

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Pre-Production / Training					
TrakSYS Production					

10.3.3 Bartender

Environment	RAM	CPU	Storage	OS	Database
Bartender Development	16GB	2 Cores	C (OS): 100 GB D (Data): 200 GB	Windows Server 2019	SQL 2019 Developer
Bartender Production					
Bartender License					



11 Security Architecture

11.1 Security Technologies and Protection

The following table describes the security protections and technologies that must be employed:

Technology	Description
Data Encryption at Rest	Data should be encrypted at rest i.e. data should be encrypted before it is held in a data store. The solution databases will reside on SQL Server Cluster and databases will be encrypted using SQL Transparent Data Encryption .
Data Encryption in Flight	Data should be encrypted in flight i.e. data should be encrypted before it is transmitted across a network using HTTPS end-points and JM managed certificates.
Managed Encryption Keys	Johnson Matthey should control the private encryption keys.
Security Zones	Networks should be zoned according to the ISA95 layering model to enforce vertical and horizontal security zoning. IEC62443 (OG86) should be implemented for applicable sites and regions. May 2021 – A separate HLD/LLD is being developed to define the zoning and associated security tools.
Firewalls	Zones should be created and enforced using physical Firewalls and firewall rules.
Access to infrastructure	Access to infrastructure such as server and firewalls should be restricted to authorized users.
User Access	User access should be controlled using role-based security groups within an application.
User Authentication	User Authentication should be applied by the corporate identity solution e.g. Active Directory.
Technology Independent	The design and usage of interfaces should not be dependent on the underlying technology.
Hardening	Servers should only have required essential software and services deployed and enabled. All ports should be closed. By default, servers should be able to broadcast only and not receive incoming data or requests.
DMZ	A Demilitarised Zone should be deployed for common services. May 2021 – A separate HLD/LLD is being developed to define the zoning and associated security tools.
Bastion Server	A bastion server should be deployed to ensure a single point of access to a controlled network. May 2021 – A separate HLD/LLD is being developed to define the zoning and associated security tools.

12 Integration Architecture

12.1 Integration Patterns

The following integration patterns will be used for integration between ISA95 levels 4,3,2.

ID	Pattern	Description	Security
1	Open Platform Communication (OPC) - UA	This SOA pattern will be used for real-time communication between ISA95 level-2 and level-3 systems. This pattern provides for both read and write requirements.	<ul style="list-style-type: none">• Encryption• Authentication• Auditing
2	RESTful Web Services	This SOA pattern will be used for interfaces between: ISA95 level-4 to level 3 systems using the B2MML document format. ISA95 level-3 to level-3 systems. All REST interfaces calls will be asynchronous unless there is a valid exception for the call to be synchronous. Asynchronous implies that a	<ul style="list-style-type: none">• HTTPS endpoints• Authentication

		'post' call will be made, followed by a 'reply' call back to the source system.	
3	Direct Database Connection	This pattern will be used for direct ISA95 level-2 Historian data read-only queries from ISA95 level-3 systems. The MES system will read process critical data directly from the level-2 historian as opposed to reading process critical data from the level-3 historian. The level-3 historian is to be used for reporting purposes only.	<ul style="list-style-type: none"> Database connection encryption Data at rest to be encrypted Authentication
4	TCP to Device	This pattern will be used for direct communications between ISA95 level-3 and IIoT devices. IIoT devices will only reside within the plant (IACS) network.	<ul style="list-style-type: none"> Encryption Authentication

12.1.1 Web Service Payload Standards

Type	Document Format	Data Format	API	Protocol
Level 4/3	B2MML	XML	REST	HTTPs
Level 3/3	B2MML if applicable	XML	REST	HTTPs

All web services to have header and data area.

12.2 Web Service Port and Protocol

Web services to use SSL/TLS (HTTPs) over port 443.

12.2.1 Web Service Authentication

Basic web service authentication will be used for all interfaces on the internal JM network. Basic Authentication is only allowed if SSL/TLS (HTTPs) is enabled.

Currently (July '21) there is no requirement for MOM interfaces to go external from the JM network. Should a need for external web service interfaces arise then the OAuth (2.0) authentication method must be used.

12.3 Interface Catalogue

Please refer to the [MOM Interface catalogue](#) for the complete list of MOM interfaces.

13 Service Architecture

13.1 IT Service Exceptions

There are no exceptions to the standard IT Service Architecture.



14 Appendix

14.1 Design Principles

May 2021 - The design principles listed here should reside in the Manufacturing Operations Reference HLD. This HLD to be created with the next applicable project vehicle.

14.1.1 Solution Principles

ID	Principle	Description
SOLP001	ISA95 Framework must be adhered to.	The ISA95 framework must always be adhered to in terms of functional modules. The exception being for tactical solutions in which case the tactical solution may only be implemented if there is a roadmap to move towards the strategic solution.
SOLP002	Applications must be loosely coupled.	Loosely coupled in the MO space indicates that applications should be able to operate for a defined period when dependant application is unavailable. For example, when Labware is unavailable TrakSYS must be able to continue running and any transactions should be queued and executed when Labware is available again. The main driver for determining loosely couple operations is where the physical process requires functionality hosted in a dependant application.
SOLP003	Application components should be design for reuse.	All application components should be designed for reuse in different sector implementations.
SOLP004	Safety functionality	The MES solution will not contain any safety related functions or contribute to interfaces where safety related data needs to be supplied as part of greater safety related process.
SOLP005	Level-2 Control	The MES solution will not perform any direct level-2 system or process control. Level-3 data that is required by a level-2 system may be supplied from the MES to the level-2 system, only if the data being supplied is verified by the level-2 control system before using the data in a process and or application functions.
SOLP006	Process Critical Data	Process critical data is data that is required for the process to operate normally as opposed to data that is only used for reporting purposes. Process critical data that need to come from another system through an interface should therefore always be retrieved from the source system.

14.1.2 Security Principles

The design for the MO solution uses a risk-based approach to design appropriately to protect, detect and respond to security threats. There is currently (May 2021) no 'JM enterprise architecture security principles' reference document available to refer to.

ID	Principle	Description
SECP001	Defence in depth	<ol style="list-style-type: none">1. User access Security – user access control, authentication and user permissions and role-based access control.2. Physical security – restricted access to data centres, local server rooms, servers and workstations. Physical ports should be locked down to prevent unauthorised activities such as plugging in USB sticks or external drives.3. Network security – design of the network aligned to the ISA-95 layering model to segregate networks into secure layers and zones within these layers.4. IEC62443 – for applicable sites the necessary risk assessments should be performed by the business and the required IEC62433 recommendation should be implemented.5. Application Security – applications must provide suitable security controls and role-based access control models.6. Data Security – The nature of data held in MO systems should not include personal or financially sensitive data. Data should be protected with all the above layers of security. All data in manufacturing information systems should be encrypted both at rest and in flight.
SECP002	Detect - Monitoring	Monitoring should be used to detect threats, unauthorised or unusual activity or potential security breaches. Firewalls will monitor and report on traffic passing through and data will be sent to Splunk which is the JM enterprise reporting tool.



SECP003	Respond	Alerts should be produced in response to detected threats and JM standard response procedures should be activated.
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14.1.3 Integration Principles

ID	Principle	Description
INTP001	Industry Standards Based	To ensure that the solution is portable, integrations should use industry established open standards such as those defined within ISA 95
INTP002	Open Technology Standards	To ensure that the solution is portable, integrations should use industry established open standards such as XML, JSON and the B2MML message structure.
INTP003	Service Based	Integrations should be service based
INTP004	Loose Coupling	As far as possible the solution should be integrated using loose coupling. This implies that the integration should not be directly dependent on the internal structure, functional design, or data models of the integrated systems.
INTP005	Design for Re-use	Interfaces should be designed with re-use in mind
INTP006	Abstraction	Solutions should be abstracted both in terms of functionality and data. Solutions should not be dependent on the technical implementation, internal processing methods or data models between systems. Layers should be abstracted to ensure that there are no dependencies between data models between solutions
INTP007	Middleware	Middleware such as message queues, service-bus and OPC technologies should be deployed to provide abstraction between solution architecture layers.
INTP008	Asynchronous REST Replies	Asynchronous REST Interface calls usually

14.1.4 Reporting Principles

ID	Principle	Description
RPTP001	ISA-95 Data Retrieval	Data may not be retrieved by skipping an ISA-95 level.
RPTP002	Data at Rest Encryption	All data at rest must be encrypted.
RPTP003	Data in Transit Encryption	All data in transit to be encrypted.
RPTP004	Report Data Classification	All report data to be classified according to the JM Data Classification Policy.
RPTP005	Data Replication	All report queries, except live dashboard reports, must be queried from a replicated data source; data for reports or importing into any data platform (including data lakes) may therefore not be queried directly from a transactional MES database.
RPTP006	Stored Procedures	Where possible all direct queries from replicated database sources must be performed through stored procedures.