OPERATIONAL
TECHNOLOGIES

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Overview

What is APM Prescriptive Maintenance?

Prescriptive maintenance is an asset maintenance strategy, that uses machine learning which detects changing operating conditions which can contribute to a failure condition, as well as enabling customers to intelligently schedule and plan maintenance.

4Sight are AspenTech reseller and implementation partner, with extensive experience in the successful deployment and adoption of the Aspen Mtell tool. Aspen Mtell is a world-renowned software, which has been implemented at the biggest MMM industries, as well as oil and gas.

The Mtell tool is an easy-to-use end-to-end solution. Agents are deployed live to monitor equipment in real time and will send an alert when changes in the behavior patterns are found. There are three types of agents which are built, and these are described below.

1. Hidden Failure Agent – An agent that allows for the treatment of sudden spikes and deviations from normal behavior, which are not linked to a recorded work order event. These can often be treated as a deviation from process operating conditions, or this can be due to an actual impending failure. This agent is not deployed live but can be monitored in the background for those "hidden failures".

2. Anomaly Agent – An agent which is trained based on normal behavior, by considering operating limits obtained from the customer, operating campaigns, seasonal changes and startups/shutdowns. This agent will trigger if any deviation from the trained normal behavior is detected.

3. Failure Agent – An agent which is trained on a specific failure pattern, which is linked to a recorded breakdown event. A failure agent can provide a lead time to failure.

The workflow employed when building these agents can be seen in Figure 1 below:

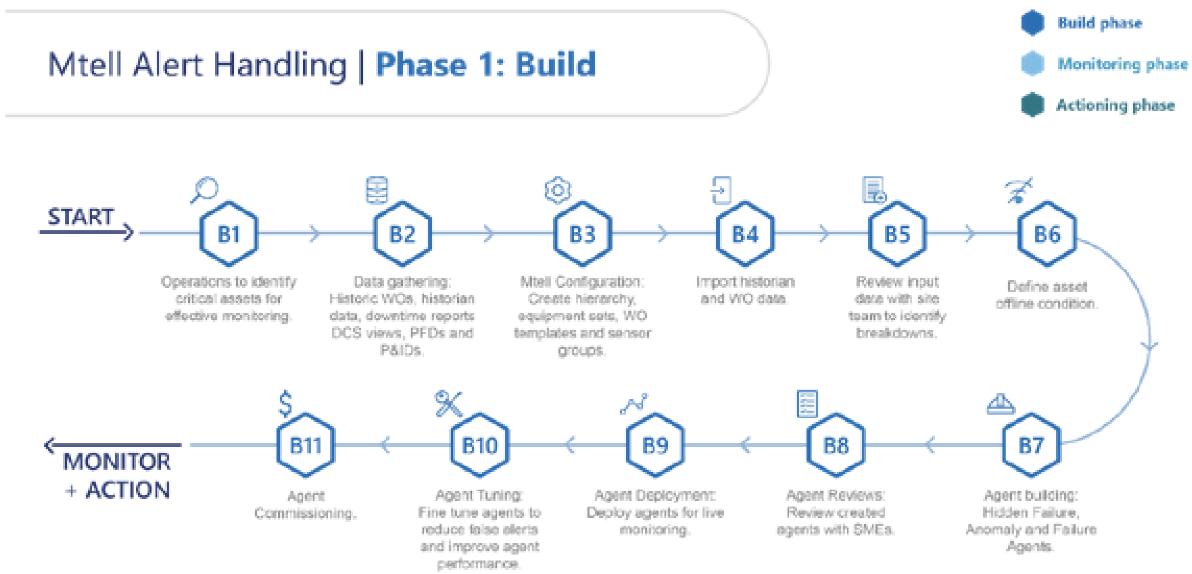


Figure 1: Building Phase Workflow

"Having the appropriate assets available is critical for successful operations; without this element in place, other efforts to optimize will falter."

4Sight OT APM BU Leader, Koos du Toit

Solution Objectives

After full integration and implementation of the project, the outcome shall enable you to achieve the following objectives:

- Long-term forecast and prediction of asset failures/upsets on a real-time basis.
- Estimate the time prior to failures/upsets.
- Detect early indications of abnormal behavior in the asset.
- Identify the conditions of failures/upsets.
- Advanced condition-based monitoring.
- Identify root cause of the failures/upsets

Solution Advantages and 4Sight Offerings

Most manufacturing industries face the sore reality of high maintenance costs due to unexpected equipment failure. These costs include procurement and delivery of spares, contractors/overtime, cost of repair to neighboring equipment that may have been damaged by the unexpected failure, etc.

Now, imagine a world where those maintenance costs can be substantially reduced. Prescriptive maintenance makes this possible. It allows your maintenance team to be proactive to impending failures, enabling a more thorough thought process, planning schedule and better utilization of resources.

Production and maintenance wars can be a thing of the past, because you can now plan your maintenance in such a way as to still meet production targets

Several benefits can be achieved by deploying the Mtell solution at your site. Listed below are the advantaged you can expect:

1. Safe working conditions due to planned maintenance
2. Reduced Downtime
3. Reduced maintenance costs
4. Coherent decision making
5. Effective utilization of resources

The 4Sight OT APM team has the expertise and experience in the successful implementation of the Mtell tool, has serviced some of the largest mines in the world and are involved throughout the lifecycle of the implementation. Figure 1 below illustrates the prescriptive maintenance solution offering from the APM team.

Figure 2: 4Sight OT Service

Architecture

Figure 2 indicates the implementation architecture on a high level.

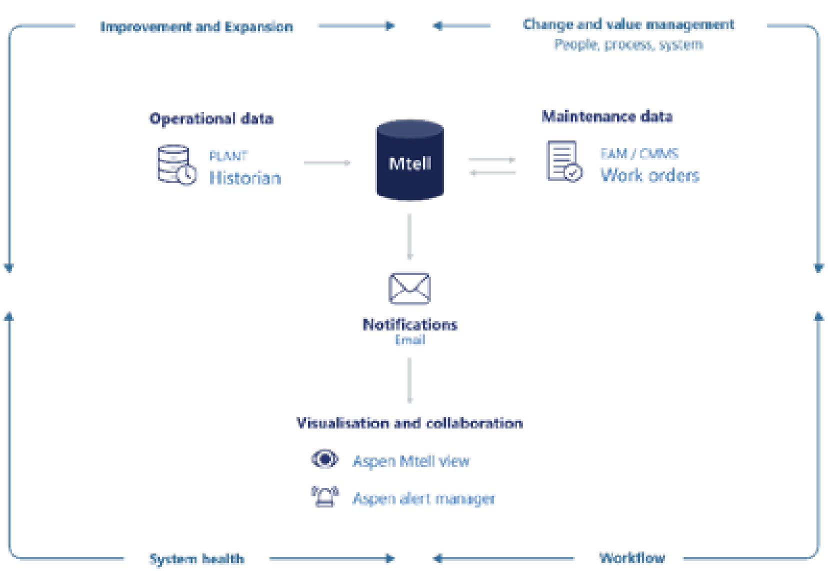


Figure 3: Mtell Architecture

Firewalls and Ports

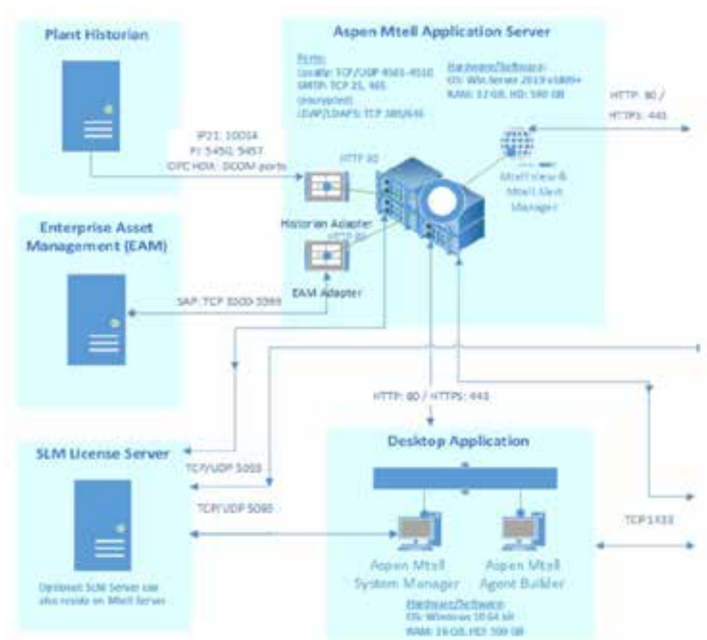


Figure 4 - Mtell Dataflow

Hardware & Software Requirements

Table 1 below provides the hardware requirements for a Mtell Implementation:

Table 1: Mtell application hardware requirements

Hardware	Description
Processor	Intel Cascade Lake-based Xeon processor with 8 cores or more per processor, 2.5GHz or faster
Server	Minimum: 1 Server Recommended:2 Servers, one for SQL database, other for Aspen Mtell Applications and IIS Web Server
Memory	32Gb Ram or higher
Hard Disk	500Gb, using NTFS file system
Network	100MB/sec (Gigabyte network recommended)

Table 2 below details the software supported by Mtell:

Table 2: Software supported by Mtell

Operating Systems (64-bit only)	
Window Server	Windows Server 2019
	Windows Server 2016
	Windows Server 2012 R2
Desktop	Windows 10
SQL Server	Microsoft SQL Server 2019 (Enterprise/Standard Edition)
	Microsoft SQL Server 2019 (Express Edition)
	Microsoft SQL Server 2017 (Enterprise/Standard Edition)
	Microsoft SQL Server 2017 (Express Edition)
	Microsoft SQL Server 2016 (Enterprise/Standard Edition)
	Microsoft SQL Server 2016 (Express Edition)
	Microsoft SQL Server 2014 (Enterprise/Standard Edition)
	Microsoft SQL Server 2014 (Express Edition)
	Microsoft SQL Server 2012 (Enterprise/Standard Edition)
	Microsoft SQL Server 2012 (Express Edition)
Runtimes	.NET Framework 4.8
	64-bit AdoptOpenJDK Java 11 LTS
	MSXML 6
	Microsoft Visual C++ Redistributable 2017
	Microsoft Visual C++ Redistributable 2015
Virtualisation	
	Microsoft Hyper-V (Server)
	VMware ESXi Hypervisor Server 6.x (Server)
	Microsoft Terminal Services (Desktop)
	Citrix XenApp 7.18 (Desktop)
Web Browsers	Microsoft Edge
	Google Chrome Evergreen Version 75+
Cloud Support	Azure VM – Microsoft
	Amazon VM (AWS)

Architecture Integration

To successfully integrate Mtell with the necessary site data sources, the following questions will have to be answered:

Table 3: Architecture integration considerations

Question or Activity	Responsible Party	Response
What historian and version?	4Sight	

Question or Activity	Responsible Party	Response
How many instances of each historian type?	4Sight	
What EAM system and version?	4Sight	
Will the deployment employ a live connection to the EAM system?	4Sight	
Will the deployment write maintenance notifications into the EAM system?	4Sight	
Deployment architecture – Will all modules reside on a single box or distributed on different machines, e.g., database server, web server, client machines, etc.?	Customer/4Sight	
Will any machines or other resources be in the cloud?	Customer/4Sight	
Will the database be a dedicated Mtell database, or will it be a shared corporate resource?	Customer/4Sight	
Where will the SLM server be located? Will it be shared with other AspenTech products?	Customer/4Sight	
Will the deployment use security (Mtell or AD)?	Customer/4Sight	
Is a security certificate available for the web server (https)?	Customer/4Sight	
How many concurrent users (System Manager, Agent Builder, Mtell View) are expected?	Customer/4Sight	
Remote Access provided?	Customer	
File sharing location	Customer	
Software License	Customer/4Sight	

Mtell Installation Timeline

Table 4 below highlights the steps that will be required to prepare the Mtell environment.

Table 4: Steps and timeline for Mtell environment preparation

Planning and Preparing for Implementation		Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8 >>
Procure VM to host Aspen Mtell Server	Customer								
Procure SQL Server to host Aspen Mtell Database	Customer								
Procure VM to host Aspen Mtell Desktop Application (Optional - For external VPN users)	Customer								
Prerequisites software requirement Installation	Customer								
Historian Integration Software requirement	Customer								
EAM Server integration software requirement	Customer								
Service accounts and permission procurement	Customer								
Open Firewall Ports	Customer								
Download AspenTech Media	Customer								
Download patches	Customer								

Table 5 below highlights the steps and timeline that will be required to implement and validate Mtell environment.

Table 5: Steps and timeline for implementation and validation of the Mtell environment

Implementation & Validation		**Day 1**	**Day 2**	**Day 3**	**Day 4**	**Day 5**	**Day 6**	**Day 7**	**Day 8 >>**
Install Mtell on Application Server	4Sight								
Install Mtell Desktop Application on User's Desktop	4Sight								
Connect to new SQL Server database	4Sight								
Connect to Historian Server	4Sight								
Connect to SAP Server	4Sight								

Table 6 below highlights the steps and timeline that will be required to rollout and validate the Mtell environment.

Table 6: Steps and timeline for rollout and validation of the Mtell environment

Rollout and Validation		**Day 1**	**Day 2**	**Day 3**	**Day 4**	**Day 5**	**Day 6**	**Day 7**	**Day 8 >>**
Validate Aspen Mtell server install	4Sight								
Create test agent and validate	4Sight								

Solution Implementation

Scope and Deliverables:

Using sensor time-series and maintenance data to be provided by the customer, 4Sight BluESP proposes to perform an online deployment of Aspen Mtell Prescriptive Maintenance for five critical assets as a Proof of Concept (POC). The consequences below can be used to aid in identifying the assets:

- Safety risk
- Revenue Loss
- Environmental impact
- Compliance impact
- Reputational impact

Project Schedule Timeline

A project consisting of five assets can take approximately 11 weeks and the timeline can be seen in figure 4 below.

Figure 5: Project schedule timeline

Methodology

The solution implementation will occur in seven sprints. Each sprint is described below:

Sprint 1: Configuration and Design

Sprint 2: Agent Creation and Deployment

Sprint 3: Review and Tune Initial Asset Agents

Sprint 4: Knowledge and Workflow Recommendations

Sprint 5: Review and Tune Further Asset Agents

Sprint 6: Monitor Live Equipment and Process

Sprint 7: Visualize and Manage Asset Health

Sprint 1-4 can be seen graphically in figure 5 below

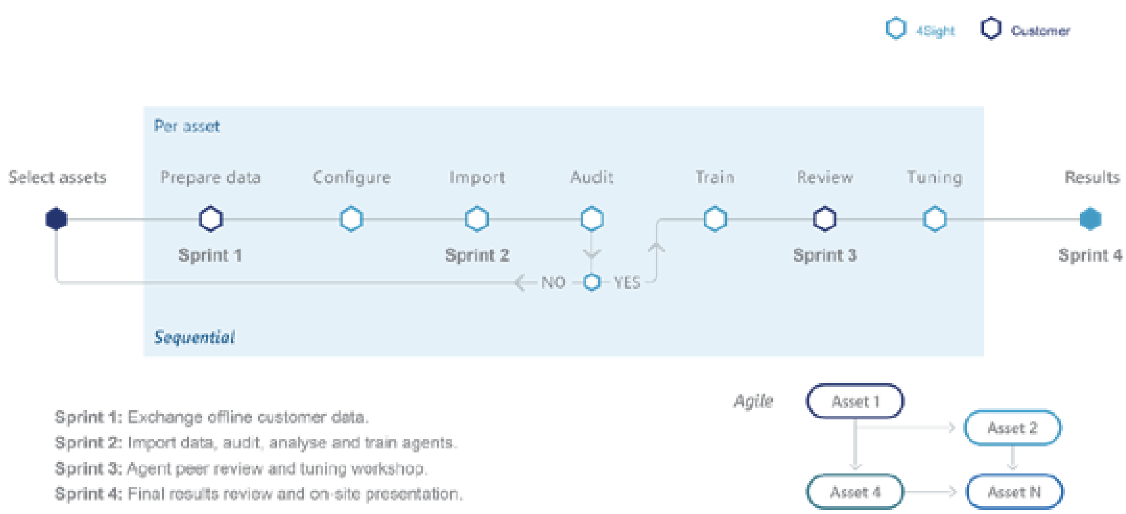


Figure 6: Sprint 1-4

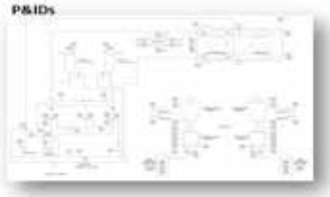
Data Requirements

Information regarding the selected assets will have to be provided. The requested data in table 7 below will either be used to configure and train agents or to determine Value Management KPIs and metrics.

Table 7: Requested data from customer

Asset Information required	Feedback
Asset Name	
Asset Function/Process	
Equipment Type (Static/Rotating)	
Plant Availability (%)	
Asset Availability (%)	
Criticality to Plant (High/Medium/Low)	
Standby unit available (Yes/No)	
Describe known Maintenance Issues, Failures and breakdown of Asset (failure modes)	
Mean time to Failure of Asset (Days/Weeks/Months)	
Mean time to Repair Asset (Days/Weeks/Months)	
Unplanned Maintenance/Repair of Asset - Duration and Frequency (Days/Weeks/Months/Annum)	
Total Maintenance & Repair Costs per Annum (Estimate)	
Available Machine & Process Sensors on Asset	
Please provide any other details related to the above where failure/breakdown has occurred	
Historian sensors data (upstream, asset, downstream) – Data Type: Real, Int	
PCS tag configuration (This configuration contains Eng Units, Scaling)	

P&IDs



PCS Screenshots

Workorders

Unplanned Maintenance Events

Work Order Data

For each asset, a list of unplanned maintenance and breakdown/failure events will have to be provided. The following fields in Table 8 (where available) will be used as a minimum to learn the asset's normal behaviour and failure signature for specific failure modes:

Table 8: Unplanned maintenance information requested from customer

Field	Field Description	Example
Functional Location	<EAM Asset reference>	
Work ID	<Workorder Notification Number>	231456
Created Date	<Date of failure>	3/7/2018 16:10:00 AM
Title	<Failure Mode>	Mill Oil Filters
Description	<Description of Failure Event>	Primary Mill Oil Filters Blocked
Type	<Classification of Unplanned Downtime - if available>	Type 2
Labor Hours	<Manhours incurred>	
Cost	<Cost incurred>	
Is Breakdown	<TRUE/FALSE>	TRUE
Breakdown Duration	<Hours>	
Is Order	<TRUE/FALSE>	TRUE
Problem Code	<Problem Code>	OIL_FILTERS
Cause Code	<Cause Code>	BLOCKAGE
Action Code	<Action Code>	REPAIR
Is Failure	<TRUE/FALSE>	TRUE

Figure 7 - Work Order Data required

Root Cause Analysis Reports

Where available, Root Cause Analysis reports will be used to provide further insights into failures that have occurred in the past.

Process Data required

Sensor historical data

The criteria below apply to all asset related sensors:

- Period 2 Years
- Analog tags
- Digital (discrete) tags only used for offline condition

- Any sensor that provides health & behavioral information of the assets (and sub asset components) as well as upstream and downstream sensors that can provide insights on how the system affects the asset or how the assets affect the system (Figure 7)

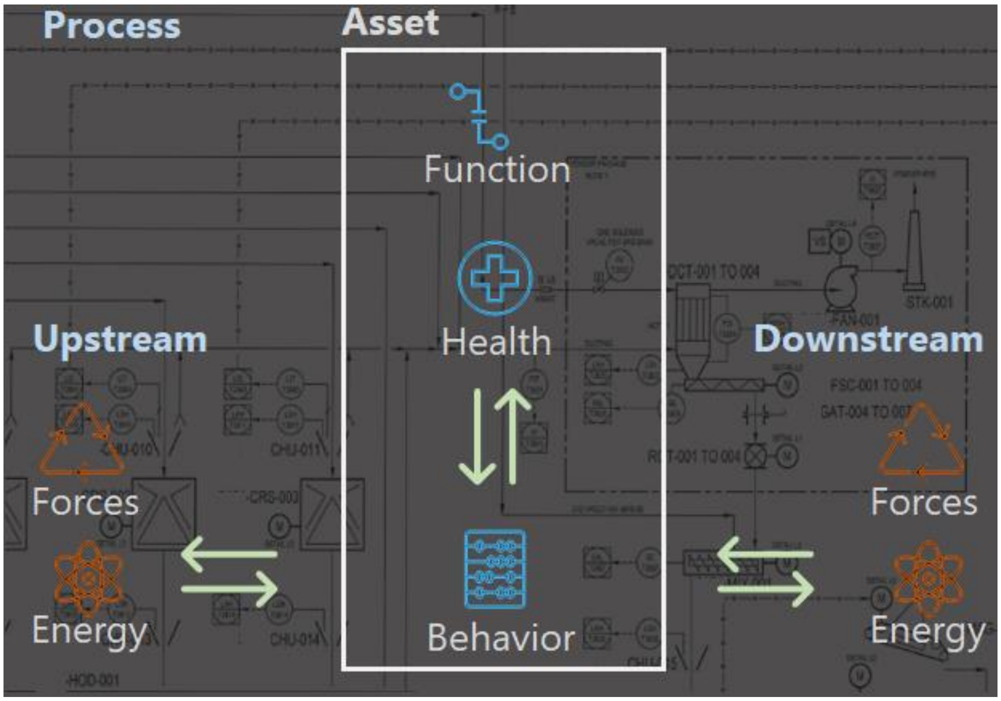


Figure 8: System interactions

Sensor Configuration Data

The following asset and associated sensor data will be required:

Table 9: Sensor Information Required

Asset	Required Data	Provided Data
	Equipment Name	
	Functional Location	
	Description	

Sensors	Required Data	Provided Data		
		Tag 1	Tag 2	Tag n
	Sensor Role			
	Engineering Unit			
	HiHi Limit			
	Hi Limit			
	Lo Limit			
	LoLo Limit			
	Tag Address			
	Data Source			

Offline Condition

The offline condition sensor:

- Specify when the asset is offline
- Condition always resolves to a Boolean result

Sensor Grouping

Sensor Groups are collections of specific sensors, allowing analysis of the time-series data streams from those sensors to be analyzed together, enabling focus on finding specific issues of a certain kind or in the subsystems of large, complex assets.

For example, the sensor groups for a compressor will contain a master sensor group containing all the sensors, and then smaller groups for the driver, each of the four compressor stages, the lubrication system, the upstream gas/liquid cooling/separation system, etc.

The allocation of sensors into specific groups represent subject matter expertise that guides the machine learning technology to find the appropriate correlations of patterns and events. Smaller, directed groups show much greater success in identifying signatures with greater precision and lead times.

Mtell Adoption

After deployment of agents, there are three main activities that must take place:

1. Alert Monitoring – Alerts which are received must be monitored, actioned or agents must be tuned if needed. The monitoring is done by both the customer and 4Sight BluESP via weekly cadence calls, which are used to vet and validate alerts.

2. Establishing a proper workflow - Another critical step that must take place is to make sure inference and prediction from Aspen Mtell is directly integrated with the maintenance and operations departments to make preventive, investigative and corrective action in case of an anomaly or a predicted failure. A procedure for an alert evaluation process must also be put in place, such that the work is structured, due to many of the alerts involving cross functional/ cross department activities. Thus, maintaining a proper workflow is of great importance.

3. Value tracking and dashboarding – In an effort to gain the adoption of the tool by the relevant stakeholders and garner their trust in the tool, we assist in guiding the customer in calculating the downtime hours saved and the value saved for the catches made through the tool and the maintenance teams.

Figure 8 below shows the Aspen Mtell adoption roadmap.

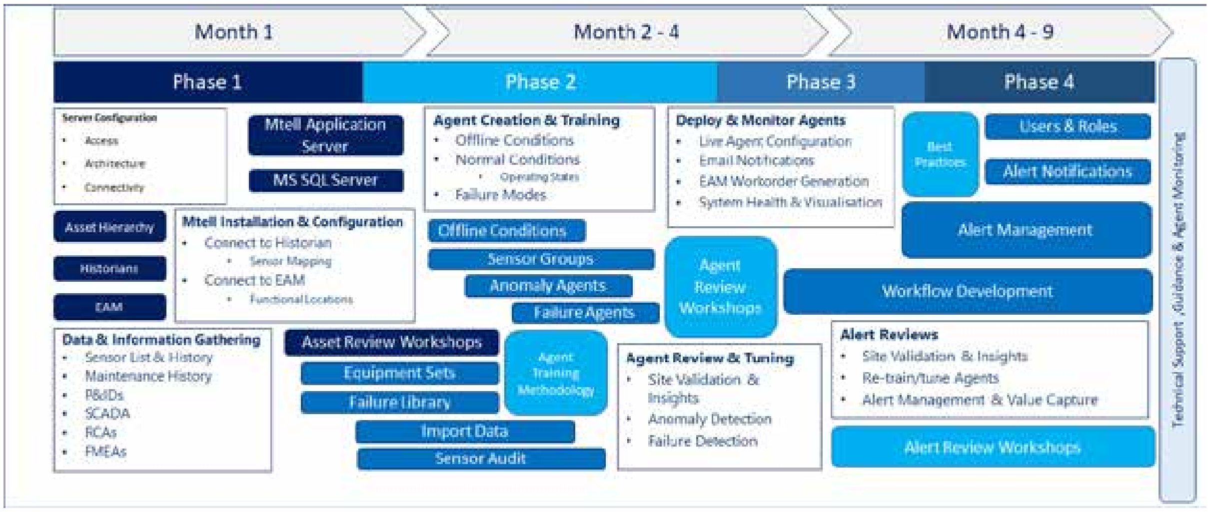


Figure 9: Mtell adoption roadmap

Alert Dashboard and Visualization

Mtell provides a rich toolkit of standard visualization screens. Please see the Mtell visualization and Dashboards below.

At the enterprise level, Aspen Mtell View provides an intuitive navigation scheme that quickly alerts users, guiding them rapidly and effectively to important and prioritized information. Federated views allow subject matter experts (SME's) in a remote monitoring center to oversee equipment at diverse locations simultaneously. The example screens shown in this section is based upon a quick walk through of the navigation metaphor, arrangement of screens, and various displays.

Such information is displayed in concise, consistent, clear, unambiguous ways with familiar metaphors, easy navigation elements, information groupings, color coded heat maps, and drilldown paths to assist rapid end user interpretation. Users can readily browse and search to find health and contextual maintenance information that pertains to the monitoring of equipment status. In addition, Aspen Mtell View will immediately alert the end user automatically of significant changes in equipment health presenting only the essential information to facilitate timely, rapid decision making.

Sample Aspen Mtell View Dashboards

Figure - 10 Main Mtell View

Figure - 11 Asset Heatmap Tree

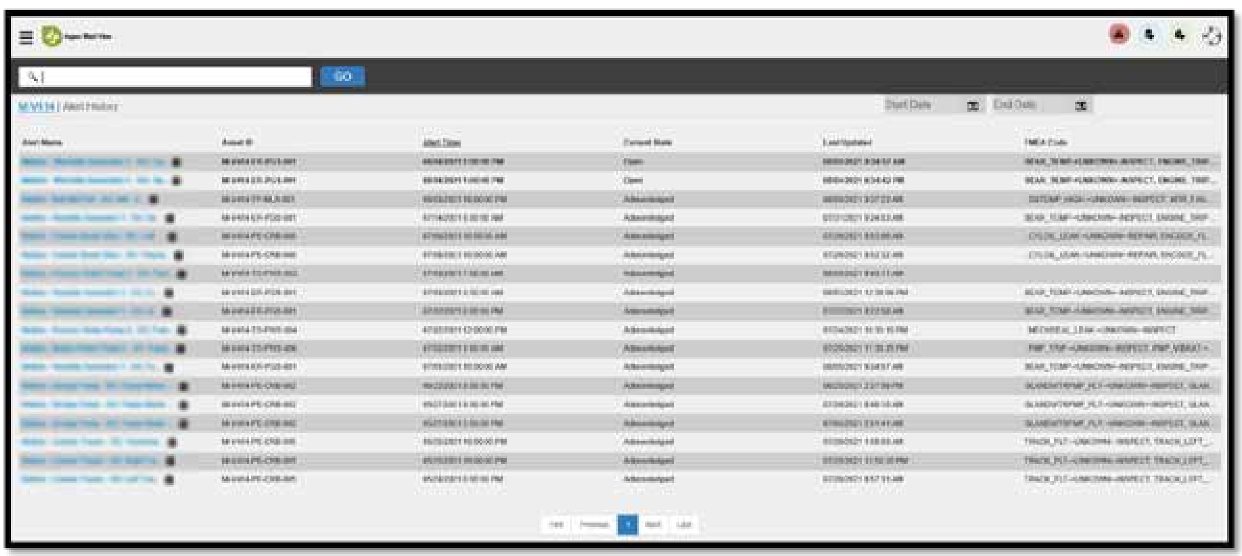


Figure - 12 Alerts History Dashboard

The alert monitoring process kicks off workflows depending on the action required. The figures below detail the workflow processes for the monitoring and actioning phases, respectively:

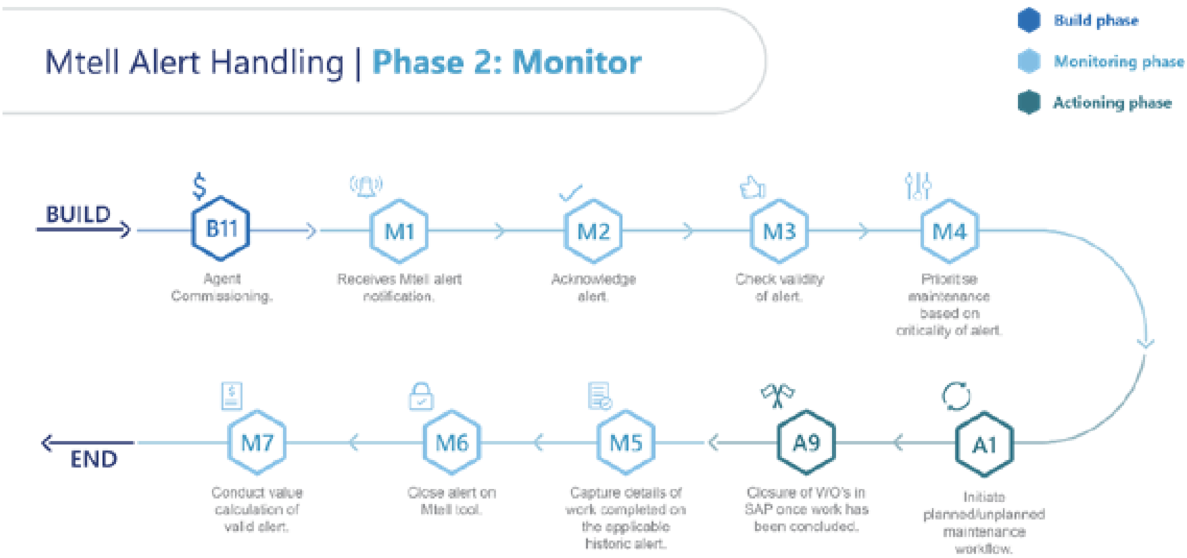


Figure 13: Monitoring Phase Workflow

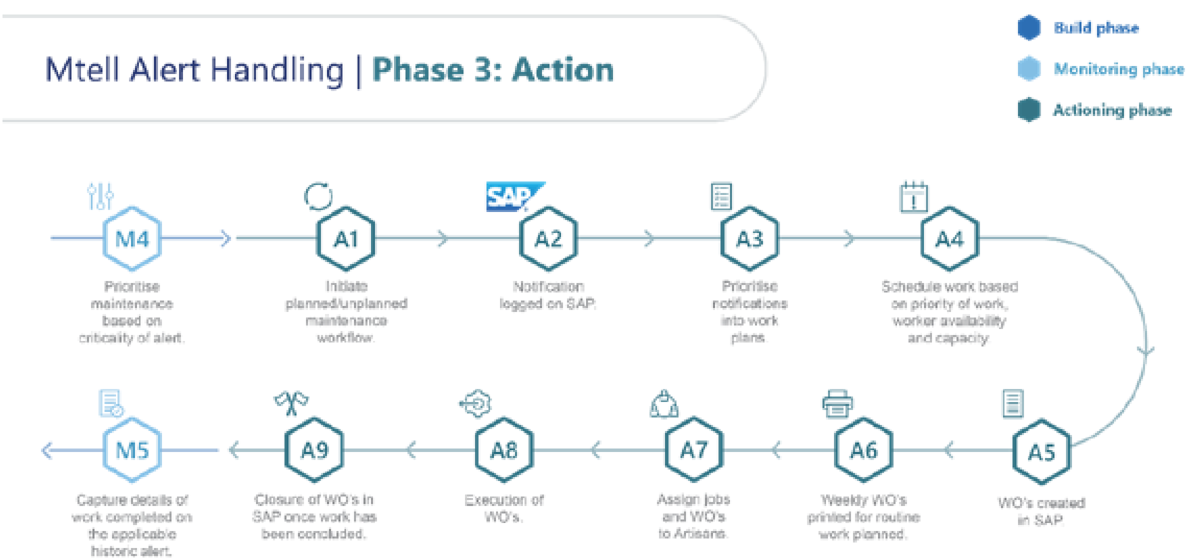


Figure 14: Actioning Phase Workflow

Customer RACI

We are happy to share our experience on the typical roles and responsibilities of Mtell users in organizations who have implemented Mtell. However, it would be the responsibility of the customer to make suitable changes within their businesses to adopt the Mtell applications and deploy it for a successful sustenance. Figure 14 below shows an example of a typical RACI.

Steps	Reliability Engineer	Asset Management Engineer - Reliability	Asset Management Engineer - Site	Senior Engineering Manager	Maintenance Engineer - Site	Production Manager	Reliability Coordinator	Planning Coordinator	Maintenance Coordinator	Scheduler	Planner	Instrumentation Technician - Software	Artisans	Clerk
2. BUILD														
Identify viable asset	R	A	I	I	C	I	C							
Gather the historian data in preparation for modelling	A	I	C		C	I	C					R		
Gather the P&ID/ PFD / DCS screenshots data in preparation for modellin	A	I	I			C	C					R		
Gather the EAM work orders and unplanned downtime data in preparation f	A	I	I				C	R						
Mtell equipment and data preparation	A	I	I		C		R							
Import sensor data from historian	C	I	I		A							R		
Import EAM and workorder data	C	I	I		A							R		
Review the input data with the site stakeholders to align asset data with rec	R	A	I		C		C	C	C			I		
Define asset offline conditions within Mtell	C	I	I		A							R		
Develop model agents (Hidden, Anomaly & Failure Agents)	C	I	I		A							R		
QA/QC of developed agents	A	I	I		C		R					C		
Fine tune developed agents	C	I	I		A							R		
Deploy agent for live monitoring	C	I	I		A							R		
Training	R	A			C		I	I				I		

Steps	Reliability Engineer	Asset Management Engineer - Reliability	Asset Management Engineer - Site	Senior Engineering Manager	Maintenance Engineer - Site	Production Manager	Reliability Coordinator	Planning Coordinator	Maintenance Coordinator	Scheduler	Planner	Instrumentation Technician - Software	Artisans	Clerk
3. MONITOR														
Receive Mtell alert notification when failure probability threshold is met	I	I	I		A			C	R					
Acknowledgement of the alert in Mtell	I	I	I		A			C	R					
Investigation to verify the validity of alert	I	I	I		A		C	C	R				C	
Prioritise maintenance work based on criticality and urgency of valid alert	I	I	I	I	A	C	C	C	R					
Capture details of work completed on the applicable historic alert	I	I	I		A			C	I					R
Close alert on Mtell tool	I	I		I	A		C	C	R					
Conduct value calculation of valid alert	R	A	I	I	C	C								
Training	R	A	C	C	I		I	I	I			I		I

Steps	Reliability Engineer	Asset Management Engineer - Reliability	Asset Management Engineer - Site	Senior Engineering Manager	Maintenance Engineer - Site	Production Manager	Reliability Coordinator	Planning Coordinator	Maintenance Coordinator	Scheduler	Planner	Instrumentation Technician - Software	Artisans	Clerk
4. ACTION														
Initiate maintenance workflow (planned and unplanned)	I				I		C	A			R			
Notification logged within EAM	I	I	I		A			C	R					
Prioritise the notification into work plans	I	I	I		A			C	R					
Schedule work based on priority of work, worker availability and capacity	I	I	I		C			A	C	R				
Works orders created in EAM					I			A	C		R			
Weekly works orders printed for routine work planned					I			A		C	R			
Assign jobs and works orders to Artisans					A			C	R	C	I		I	
Execution of works orders					I	I		I	A	C	C		R	
Closure of works orders in EAM when work is concluded								A	I	C	C			R
Training	R	A	C	C	C		C	I	I	I	I		I	I

Figure 15 - RACI Example

“We will walk beside you throughout your prescriptive maintenance journey, ensuring your success every step of the way” – 4Sight APM Team

Contact us today to start your prescriptive maintenance journey: