Conference :-
Heat Rate Efficiency Summit 2023

Topic :
Heat rate improvement of thermal power plants through real time, closed loop, advance process control based solutions

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3RD HEAT RATE EFFICIENCY SUMMIT 2023

Maintenance Best Practices for Efficiency

Sandeep Chittora

Complex interdependencies from coal to power

Highly complex interdependent operation should be in sync for successful profitable operation

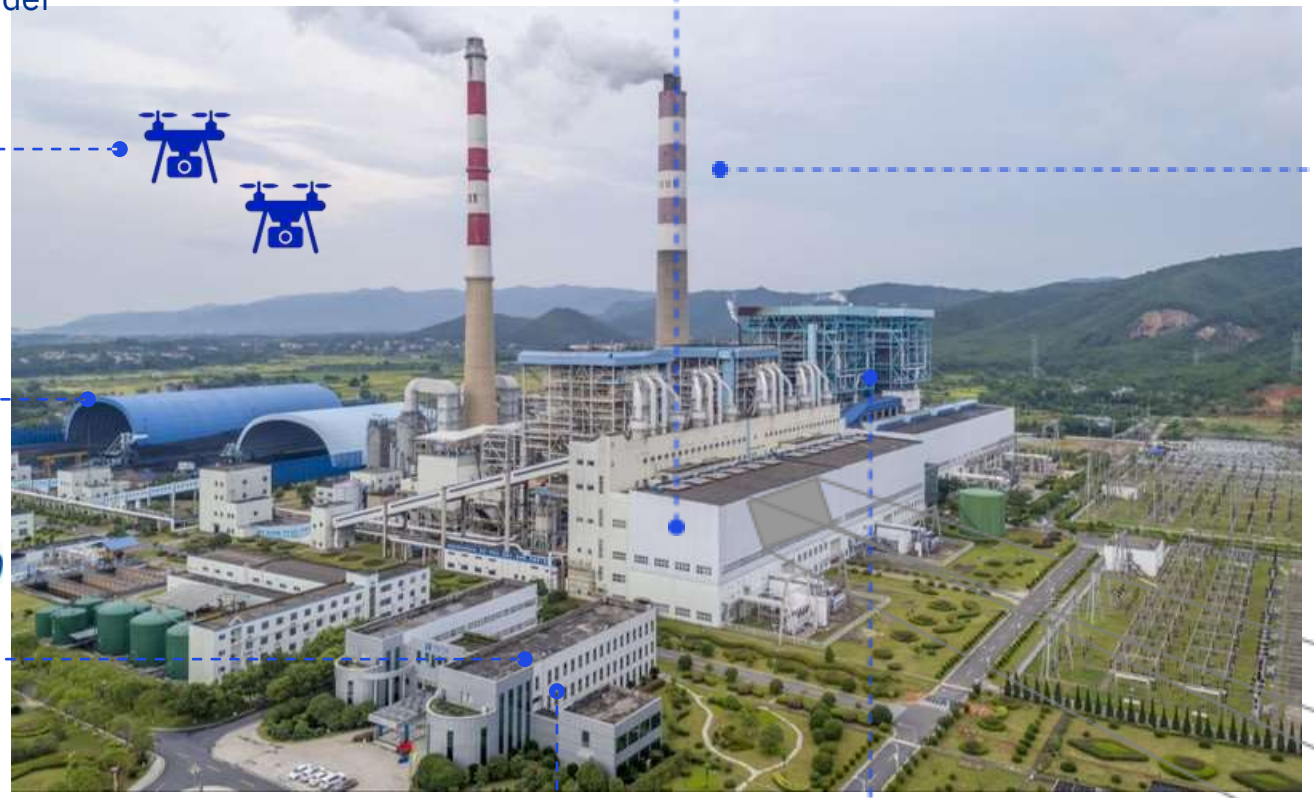
Procurement and Logistics	Flexible yet efficient operation	Plant Reliability and Maintenance	Power Procurement	Safety & Compliance
Different grade coals being used	Renewable integration resulting daily load changes	> 90 –100 % Availability requirements	Deviation Settlement Mechanism to ensure right quantity at right time	Ever increasing environmental compliances
GCV Variation from 2500 - 6500	Significant load fluctuations to meet captive demand	Forced Outages	Realtime Market	SOx < 200mg/Nm3
High Ash Content coal	Ramp Rates > 2%	OEM dependencies	Green Power Requirements	NOx < 300mg/Nm3
Opaque rail logistics	Of-design operation	Flame stability		Boiler / Condenser blowdown
GCV loss tracking	APC < 6 –7 %	High Inventory Costs		Ash Disposal
Biomass Co-firing	Heat rate < 2300 kcal/kWh	RCA / FMEA		PM < 50 mg/Nm3
- -	Co-generation	- -	-	- -
- -	- -	- -	-	- -
			-	

It is important to understand the complexities of producing reliable, efficient power

Power Plant 4.0 for flexible, reliable, efficient and sustainable

Predictive Analytics for dispatch planning bases stockyard

Drones to get ahead in merit order monitoring/ Hot spot detection. Incident Inspection for Boiler Tube Leakagesetc.



Advanced Combustion optimization to meet SOx, NOx, PM and environmental norm

Automated Predictive spare parts requirements to optimize inventory level and requisitions from suppliers

Remote expert centre to optimize real time performance with contextualized dashboards

AR / VR for visitors safety and workers training

RPA generated workflow management tools to create efficient Co-firing and Realtime orders reducing shutdown timefuel requirement and ash generation predictions

Digital Twins for continuous heat rate, auxiliary power optimization

Machine Learning models for start up advisory

Kind of maintenance your plant is having

- Corrective Maintenance (Run to Fail)
- Preventive Maintenance
- Condition Based Maintenance
- Predictive Maintenance
- Prescriptive Maintenance

Sowhich one is right for our assets?

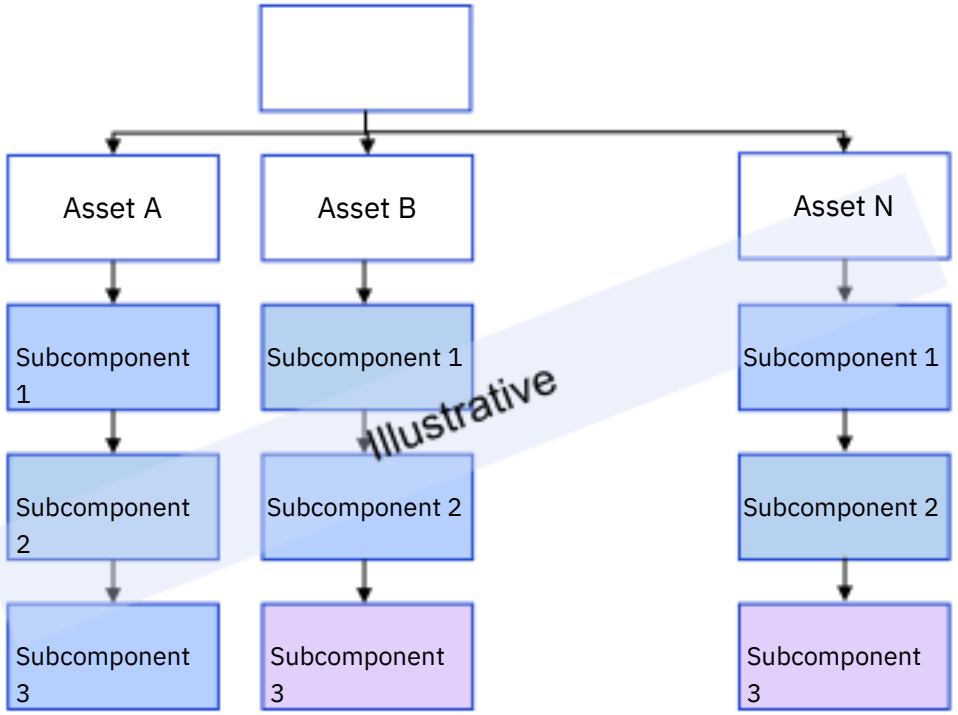
Depends …

A studysays*, “Potential of Predictive Maintenance though encouraging begins to evaporate due to, too little data, too little time, impact and savings”

Source: McKinsey Report, Predictive Maintenance: the wrong solution to the rightproblem in chemicals

Based on criticality, maintenance strategy to be created for equipment at the assembly, sub assembly or the component level

Maintenance strategy



- Define all the formal and informal maintenance tasks to be performed on equipment
- Identify the failure modes that each task is meant to prevent or detect
- Capture functions lost by each failure as appropriate
- Perform consequence analysis and task determination for specific failure conditions
- Develop mitigation plans for high probability failure incidents with significant impact to production capabilities

PM | CM | CBM

Equipment generation break down will be used to map the equipment till the level where it can be monitored from maintenance standpoint. Generally these will be till the assembly level..

Opportunities to optimize maintenance effort and improve [illegible] through Data driven equipment criticality assessment & FMEA

Equipment criticality assessment

i Consequence classification

Potential HSE impact	Potential generation impact: No loss	Partial loss	Unit trip
None	Low	Medium	High
First-aid	Low	Medium	High
Minor	Low	Medium	High
Major	High	High	High

ii Probability classification

MTBF	Probability of failure
>18 months	5
12-18 months	4
6-12 months	3
3-6 months	2
[illegible] months	1

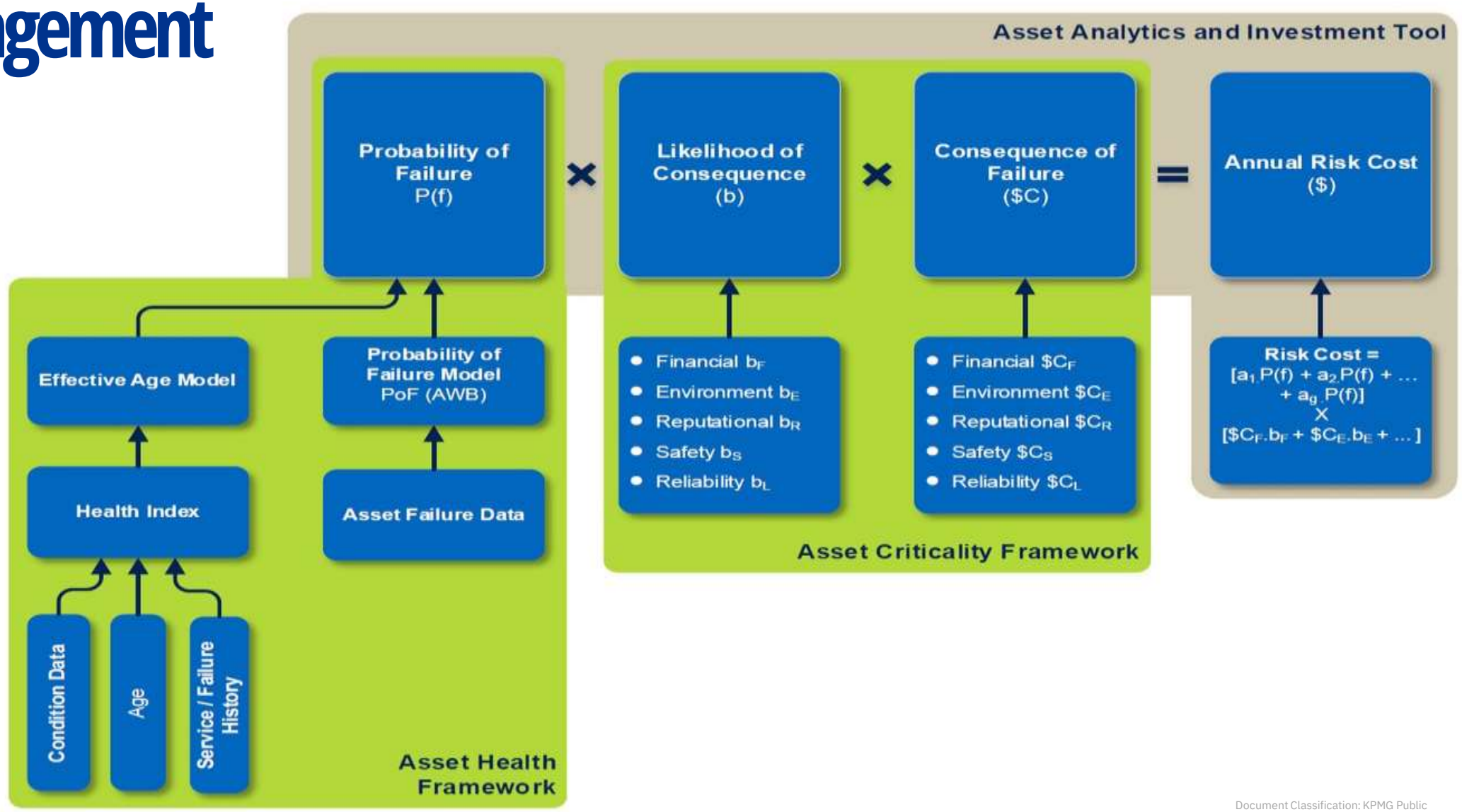
ILLUSTRATIVE

Equipment classification

Probability class	Consequence class: Low	Medium	High
5	C	B	A
4	C	B	A
3	C	B	A
2	B	A	A
1	A	A	A

- RCM evaluation covered 248 equipment
- Reduction in maintenance frequency schedule for 40+ equipment based on criticality assessment
- Further scope for reduction in maintenance load based on mitigation actions coming out of FMEA
- Process enabled for periodic auto-classification of equipment criticality based on failure data captured in maintenance management system
- Auto Trigger of Root Cause Analysis tickets based on maintenance tickets
- Outcomes of ECA and FMEA to drive maintenance philosophy

How will it integrate results in better Risk Management



Example –Boiler Tube Leakage –Avoid Predict Respond

Unplanned Outage can impact significant revenue loss

BTL –one effect many causesPossible ReasonsAvoid

•

- Changes in thermohydraulic behavior
- Changes in fuel type
- Material Damage
- Temperature Excursions

Available Solutions

- Thermodynamic study for Root Cause Analysis
- Temperature and Temperature gradient change
- Acoustic Based Detections
- Neural Network based Detection

KPMG Solution

•Temperature Profiling (Eco –RH/SH)

•Gradient Monitoring (overheating/ spray cooling)

•Erosion behavior models (flow patterns/Ash content)

↓

Failure Signature

↓

AI / ML Based learnt models to predict Boiler Tube Leakages and give early warnings

Avoid operational regime prone for Boiler Tube Leakages as far as possible

Predict

- Use state of art tools for early prediction of failures and use early warning system
- Control and operate the plant in case of early warnings in safer mode to avoid forced shutdown (possible planned shutdown)

Respond

- 100% avoidance to BTL is not possible, with the advancement of UAVs now there could be rapid action response to BTL thereby reducing outage time by 2-3 days and increase generation, ensures availability

Predictive Maintenance

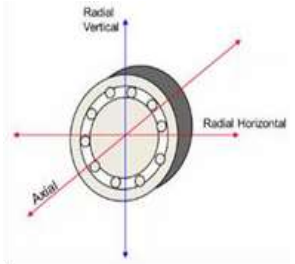
Vibration Monitoring in heavy machines, Construction equipment's , Industrial equipment's , Diesel & Gas generators, Marine Engines etc. is an important aspect of maintenance & safety

Typical problems that generate vibration

Misalignment	Reaction & Frictional forces Hydraulic forces
Unbalance	Bent shafts
Worn belts & pulleys Bearing Bad defects	Gear problems
Combustion	Housing Distortion
Reciprocating forces	Electrical problem

What & How we measure for Vibration analysis

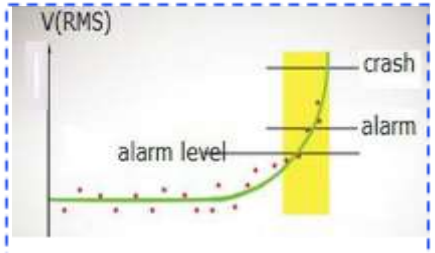
- Amplitude
- Frequency
- Phase



Vibration analysis formula with filters

$$V_{RMS} = \sqrt{\frac{1}{2}\sum_{j=k_1}^{k_2} S_j^2}\,,$$

- K1,k2 Harmonics
- Sj –Spectrum Amplitude



RMS Time Trend

Solution Overview

6 in 1 Non-Intrusive sensor mounting on engine and alternator
Ready to use predictive models with minimalistic learning

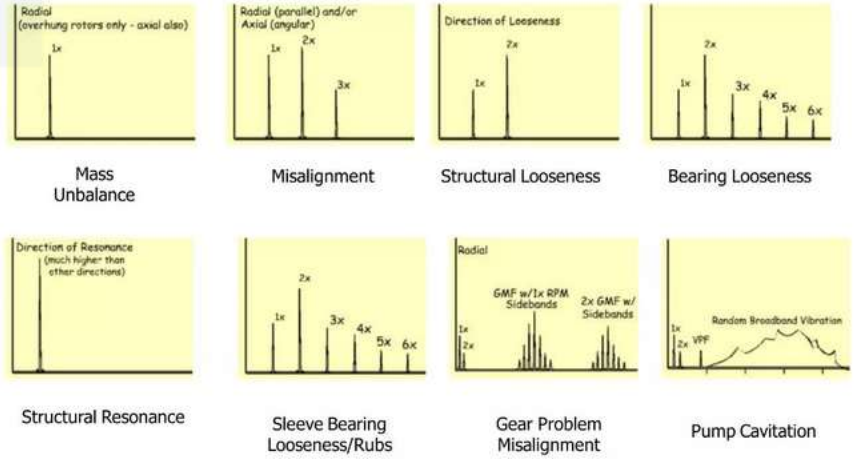
LoRa LTE Wi Fi

Predictive Analytics

IOT Platform

Centralized Data Storage

Predictive Analytics



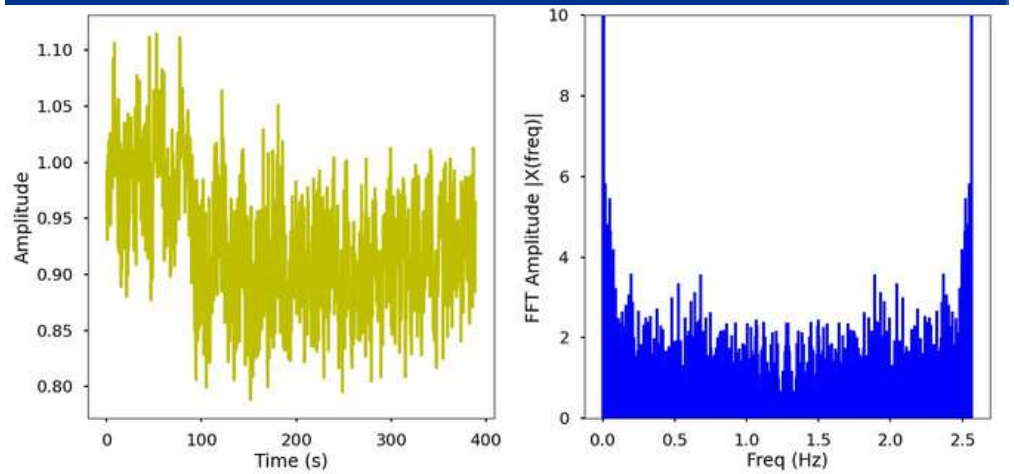
"The Vibrations produced in a machine are the best indication of the machine's health"

Case Study: Early detection from Vibration monitoring

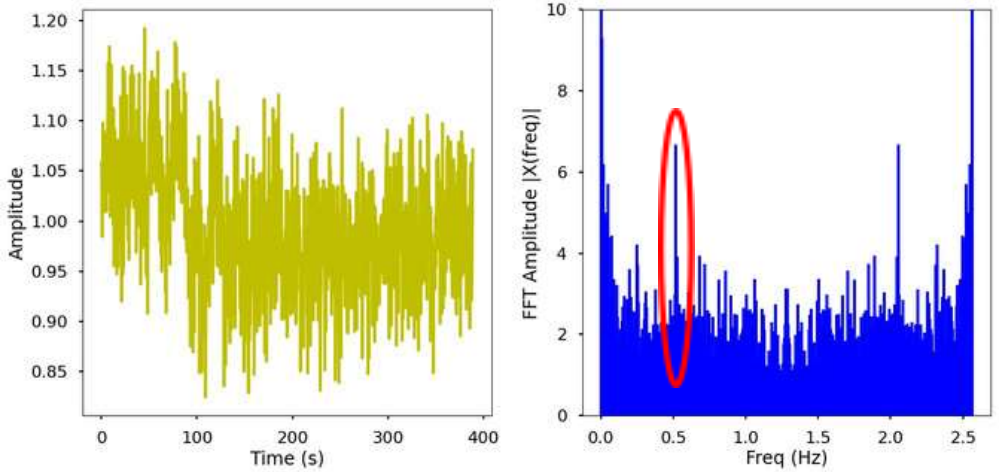
FFT Spectrums helps detect defects in rotating equipment like fans by analyzing vibration, amperage, power data from sensors

1.Data Collection: Tri axial accelerometers vibration sensors gathering per second data
2.Signal Transformation: Time-domain data is converted into the frequency domain using FFT, revealing vibration frequencies and corresponding amplitudes.
3.Frequency Analysis: The frequency spectrum is examined, linking specific frequencies and amplitudes to various fan defects like imbalance, misalignment, looseness, or bearing wear.
4.Defect Identification: Unusual peaks or amplitude changes in the frequency spectrum indicate defects. Comparing observed frequencies to known fault-related frequencies pinpoints the issue.
5.Early Warning systems: Early defect detection through FFT enables scheduling repairs or replacements before problems escalate, reducing unplanned downtime and costs.

Baseline



Real Time –Anomaly Detection



Data point: IDF_DE_Vibration_ xxxx-xx-xx

What is Asset Management

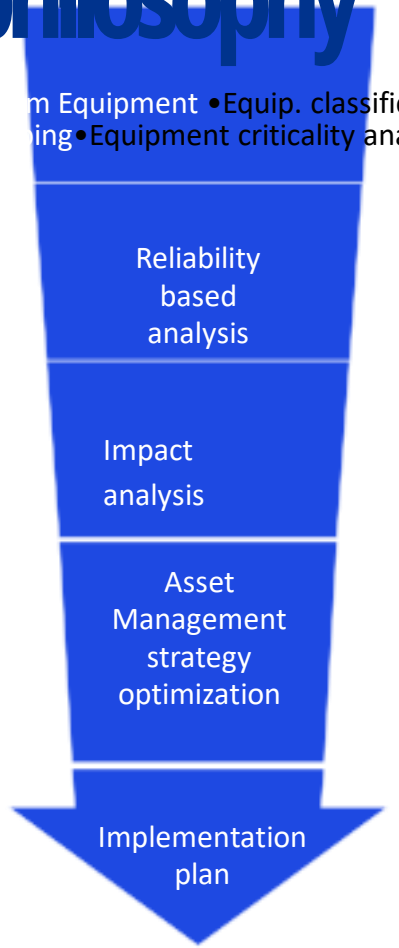
According to ISO 55000

“Speedy, Timely, Risk adjusted, Integrated Co-ordination of activities of an organization to Optimize Money Spend & Lower Risk to business on account of Asset Health such that “VALUE Created” from Operating assets is maximized”

Structured RCM approach & best in class tool-kit to identify areas of improvement in the current asset management philosophy

[illegible] TOOL KIT

m Equipment •Equip. classification, codification
ing•Equipment criticality analysis (ECA)



Reliability centered

maintenance

- Data driven FMEA (Failure Modes and Effect Analysis)
- exercise RCA for critical equipment

- Deep dive based on above analysis
  - PlannedMaintenanceactivityanalysis
    - Predictive maintenancerequirementanalysis
    - P-F intervalanalysisforschedule optimization

- Optimizationof asset management strategy based on deep dive analysis result and linked to equipment classification
- Spare parts management

- Implementation planfor recommended strategy:
  - Workflows
  - Governance, KPI
  - MIS
  - Upgradation of IT system

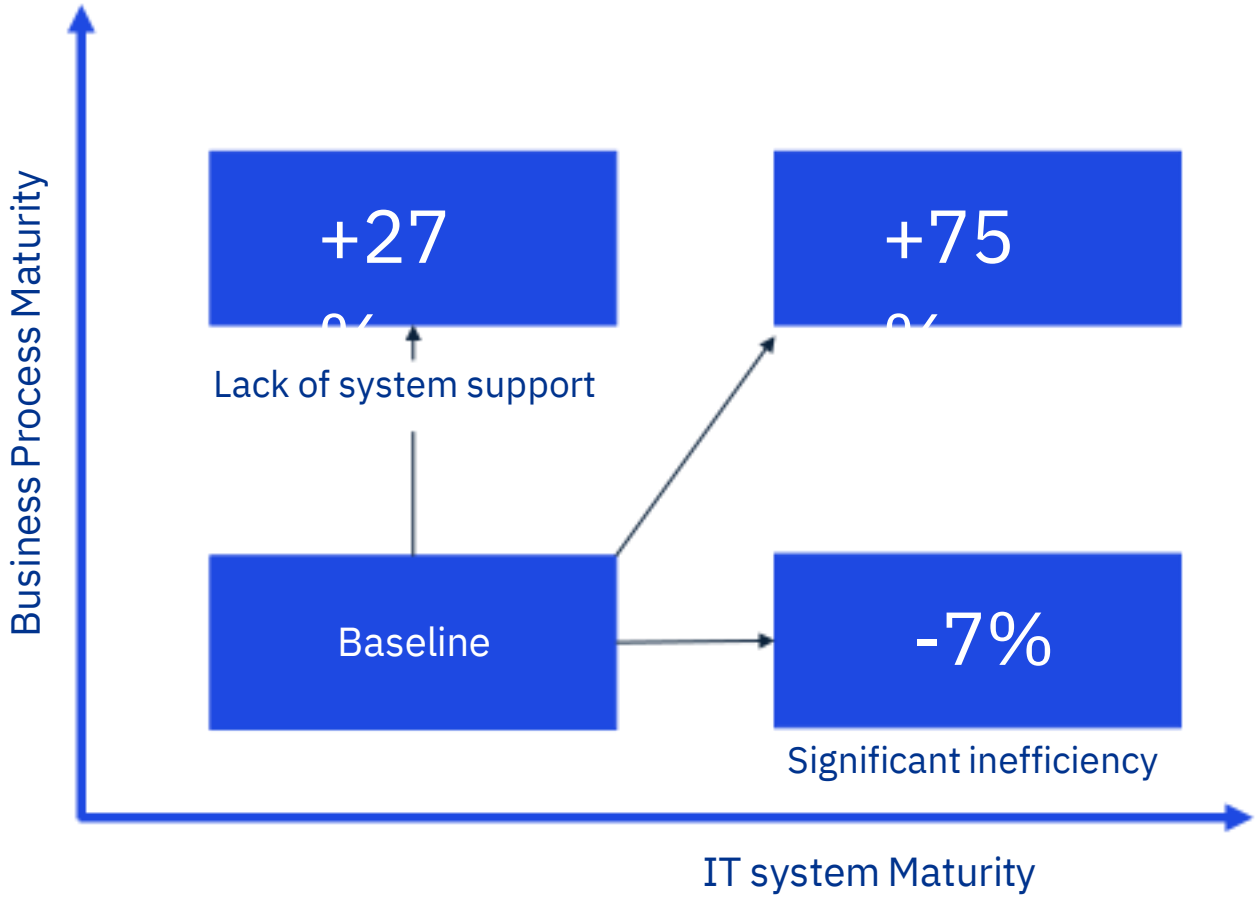
Reliability Centered Maintenance	Reliability Based Inspectio n
Design for Maintainabilit y	Life Cycle Costing
Fault Tree Analysis	Failure Mode & Effect Analysis
Failure Reporting & Corrective Action Systems	P-F interval analysis
Weibull Analysis	Reliability Block Diagrams
Highly Accelerated Lift Test	Monte Carlo

A Paradigm Shift
Asset Performance Management

APM is Technology Powered Reliability Engineering using AI/ML, IIoT

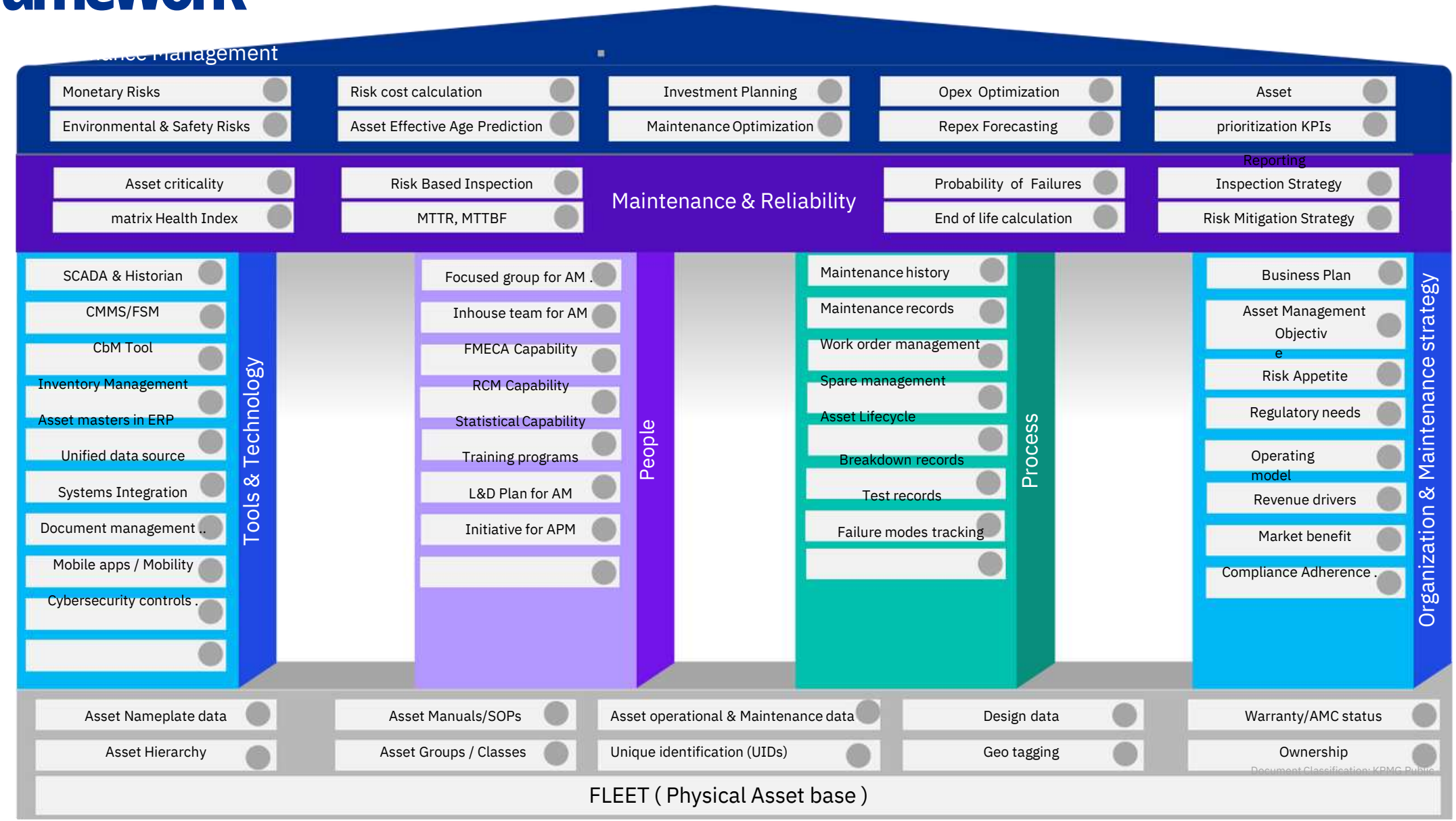
Artificial Intelligence should create -A--u--t-o--m--a--t-i-o-n--Augmentation

APM is Asset Management Enabler – How do we approach for it

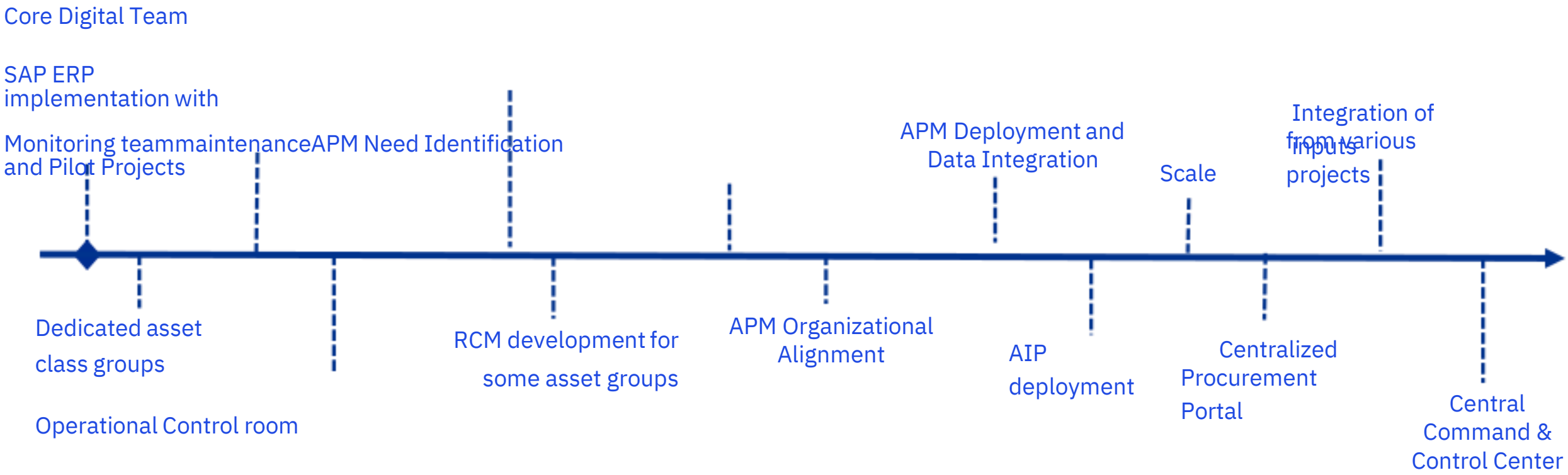


Adopted from Eric Brynjolfsson study “Productivity Paralysis”

KPMG's Asset Performance Management framework



Implementation Roadmap



Maintenance Best Practices Results

Category	Typical	Best in Class
Maintenance Cost as % of replacement asset value	6 -11%	2.0 -2.5 %
% -Planned Work	< 15%	90% 90%-
Schedule Compliance	50%	100%
Budget Compliance	< 60%	100%
Inventory Accuracy	Unknow	>95%
Accurate Maintenance Dashboards	n NA	100%

Key Learnings

- Best in class Maintenance is an attitude –start with right mindset
- No shoe fits all –Assess your priorities and act accordingly
- UnderstanddigitalasAugmentation not Automation
- Bestin class has been achieved, you can be the one or better

Thank You

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