ASSET MAINTENANCE STRATEGY DEVELOPMENT

Slide 2: Introduction

Slide 3: Flow chart outlining asset maintenance strategy development process

Slide 4: Flow chart outlining functional failure mitigation logic

Slide 5: Worksheet '3. Maintenance Strategy Development' - Outline Groups Closed *(images)*

Slides 6&7: Worksheet '3. Maintenance Strategy Development' - Outline Groups *(images, 2 slides)*

Slide 8: Worksheet '4. Recommended Maintenance Actions' *(image)*

Slide 9: Worksheet '6. Associated Dropdown Lists' *(image)*

Slide 10: Examples of Embedded Notes in Worksheet '3. Maintenance Strategy Development'

Introduction

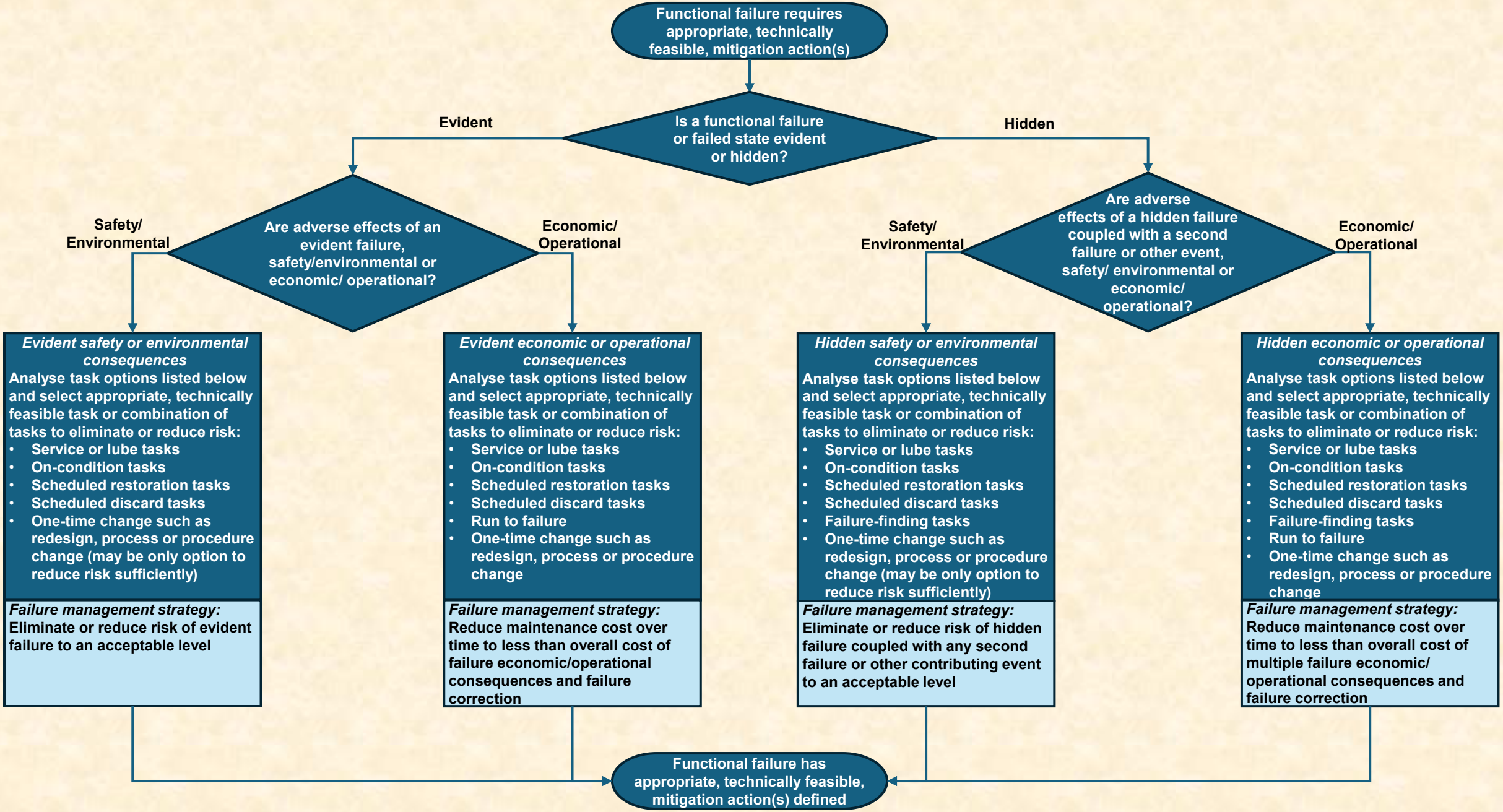
- Presentation outlines asset maintenance strategy development using ***'MMAPS Asset Maintenance Strategy'*** workbook***, '3. Maint Strategy Development'*** worksheet based on RCM, FMEA, FMECA(Qualitative) & RCA principles.
- Workbook comprises the following worksheets:
  - ***'1. Review Process Flow Chart'***
  - ***'2. Functional Failure Mitigation Logic'***
  - ***'3. Maint Strategy Development'***.
  - ***'4. Recommended Maint Actions'***
  - ***'5. MMAPS Risk Hazard Matrix'***
  - ***'6. Associated Dropdown Lists'***
- Analysis worksheet's features include;
  - Multiple embedded Word files and worksheet cell explanatory notes re RCM / FMEA theory and worksheet usage. Embedded files are opened by double clicking respective icons.
  - Automatic shading of active rows and columns on selection to reduce entry errors.
  - Outline grouping of worksheet columns with second tier data (on which top tier data columns depend) to keep worksheet size manageable in terms of data entry and report printing etc.
  - Frequent use of cell dropdown lists to reduce effort and improve effectiveness. Columns with dropdown lists are shaded light green.
  - Frequent use of cell formulae to reduce effort and improve effectiveness. Columns with dropdown lists are shaded light blue.
- Slide 3 is a flow chart outlining the principal steps involved in asset maintenance strategy development.
- Slide 4 is a flow chart outlining functional failure mitigation decision logic.
- Slide 5 is an image of ***'3. Maint Strategy Development'*** worksheet with all outline groups closed.
- Slides 6 & 7 show images of the various ***'3. Maint Strategy Development'*** worksheet outline groups expanded.
- Slide 8 is an image of ***'4. Recommended Maintenance Actions'*** worksheet.
- Slide 9 is an example of an embedded note in ***'3. Maint Strategy Development'*** worksheet.
- Slide 10 is an image of ***'6. Associated Dropdown Lists'*** worksheet.

ASSET MAINTENANCE STRATEGY DEVELOPMENT WORKBOOK

Based on RCM, FMEA, FMECA(Qualitative) & RCA Principles using 'MMAPS Asset Maintenance Strategy Workbook' (MS Excel)

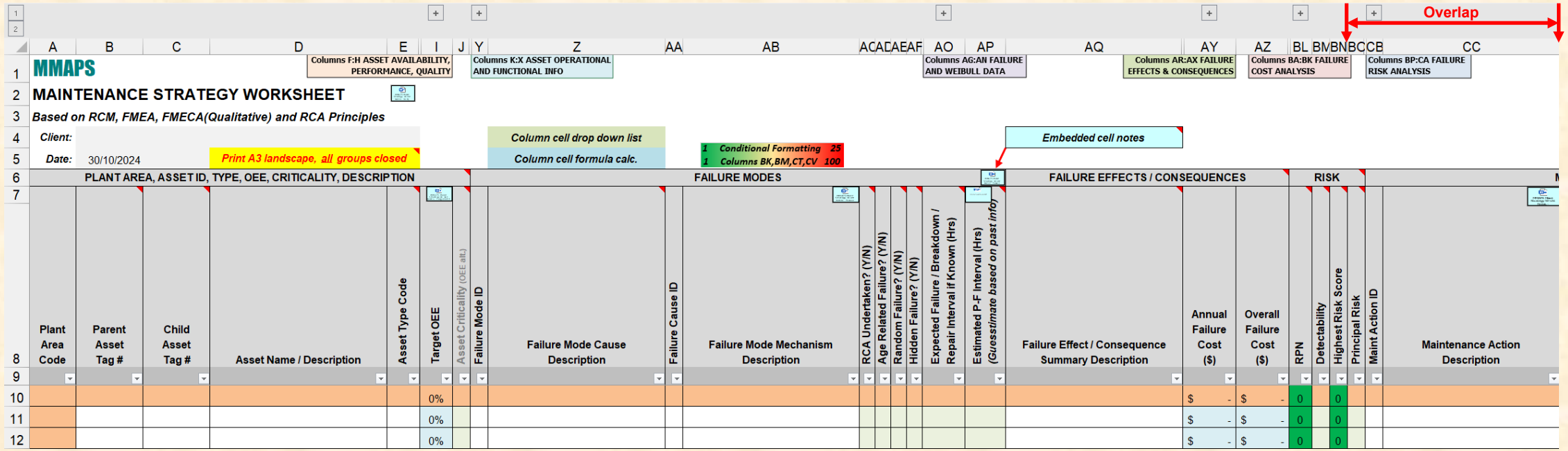
ASSET MAINTENANCE STRATEGY DEVELOPMENT WORKBOOK

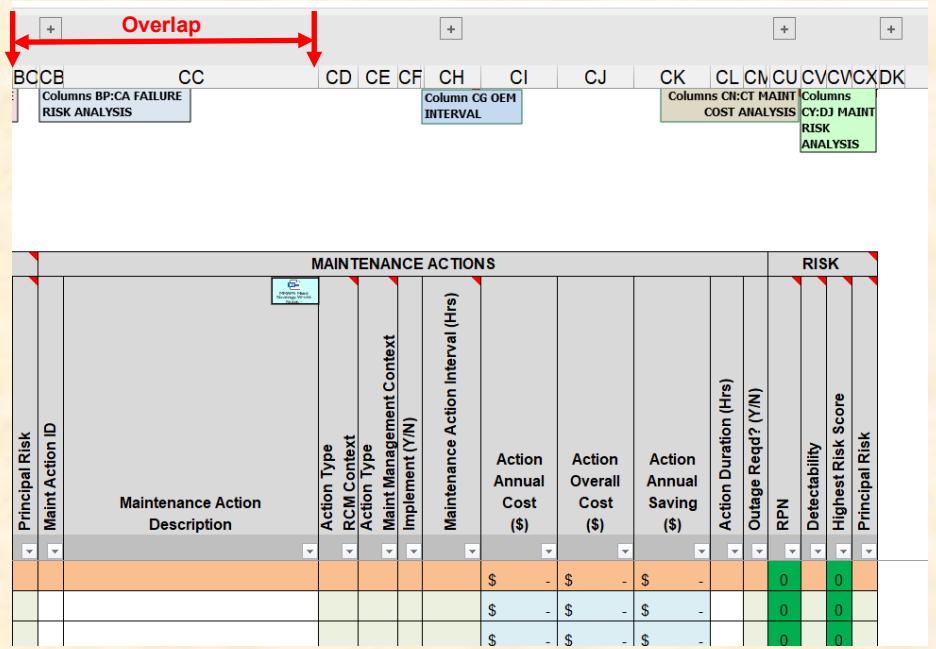
FUNCTIONAL FAILURE MITIGATION DECISION LOGIC



ASSET MAINTENANCE STRATEGY DEVELOPMENT WORKBOOK

WORKSHEET '3. MAINTENANCE STRATEGY DEVELOPMENT' - OUTLINE GROUPS CLOSED





Worksheet 3. Maint Strategy Development

- **All outline groups closed**
- **Image overlap marked with red arrows**

ASSET MAINTENANCE STRATEGY DEVELOPMENT WORKBOOK

WORKSHEET '3. MAINT STRATEGY DEVELOPMENT' - OUTLINE GROUPS - SLIDE 1/2

Col F-G-H Group

Col K-L-M-N-O-P-Q-R-S-T-U-V-W-X Group

Col AG-AH-AI-AJ-AK-AL-AM-AN Group

Col BP-BQ-BR-BS-BT-BU-BV-BX-BY-BZ-CA Group

Col AR-AS-AT-AU-AV-AW-AX Group

Col BA-BB-BC-BD-BE-BF-BG-BH-BI-BJ-BK Group

Target Availability (%)	Target Performance (%)	Target Quality (%)	Date Installed	Installed Condition	Running Hours to Date (Hrs)	Expected Remaining Useful Life (Hrs)	Expected Total Usefull Life (Hrs)	Operating Context ID	Operating Context Desription	Regulatgory Requirements	Associated Protection Systems & Devices	Function ID	Function Description	Function Type	Functional Failure ID	Functional Failure Description
							0									
							0									
							0									

Failures during Year 5 BP	Failures during Year 4 BP	Failures during Year 3 BP	Failures during Year 2 BP	Failures during 6-12months BP	Failures during 0-6months BP	Beta	Eta

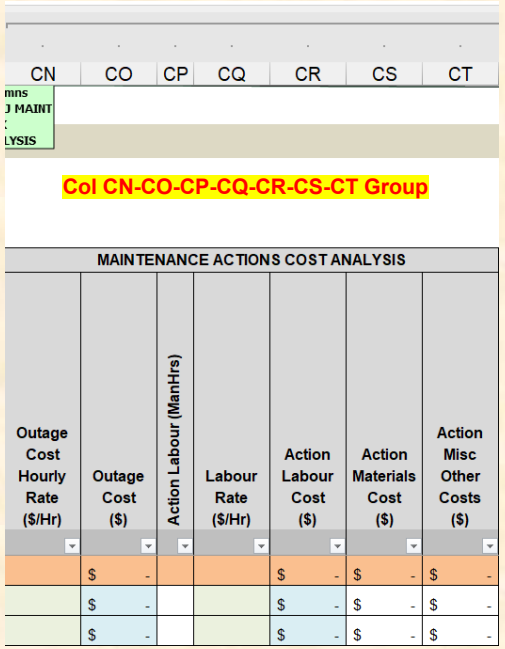
People Risk - Severity	People Risk - Likilhood	Environment Risk - Severity	Environment Risk - Likilhood	Equipment Risk - Severity	Equipment Risk - Likilhood	Production Risk - Severity	Production Risk - Likilhood	Quality Risk - Severity	Quality Risk - Likilhood	Reputation Risk - Severity	Reputation Risk - Likilhood

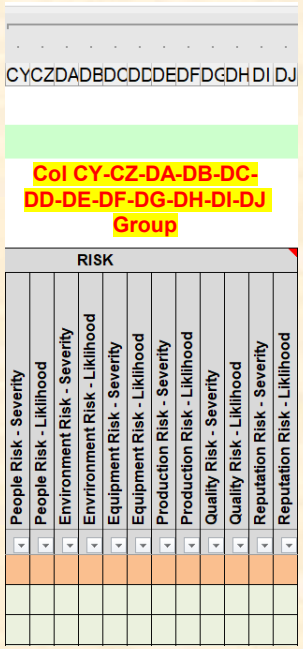
Failure Occurrence / Timing / Frequency	Failure Evidence	Failure Effects on Safety	Failure Effects on Environment	Failure Effects on Operations & / or Production	Failure Damage & Consequential Damage	Failure Corrective Action

Annual Operating Time (Hrs)	Approximate Interval Between Failures (Hrs)	Outage? (Y/N)	Outage Duration (Hrs)	Outage Cost Rate ($/Hr)	Outage Cost ($)	Failure Labour (ManHrs)	Failure Labour Rate ($/Hr)	Failure Labour Cost ($)	Failure Materials Cost ($)	Failure Misc Costs ($)
					$ -			$ -	$ -	$ -
					$ -			$ -	$ -	$ -
					$ -			$ -	$ -	$ -

ASSET MAINTENANCE STRATEGY DEVELOPMENT WORKBOOK

WORKSHEET '3. MAINT STRATEGY DEVELOPMENT' - OUTLINE GROUPS - SLIDE 2/2





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Column H OVERALL FAILURE COST

Column N Overall Action Cost

RECOMMENDED MAINTENANCE ACTIONS

Based on RCM, FMEA, FMECA(Qualitative) and RCA Principles

Client:

Date: 30/10/2024

Plant Area Code	Parent Asset Tag #	Child Asset Tag #	Asset Description	Target OEE	Failure Mode Cause Description	Annual Failure Cost ($)	Overall Failure Cost ($)	RPN	Principal Risk	Maintenance Action Description	Action Annual Cost ($)	Action Annual Saving ($)	Action Overall Cost ($)	RPN	Principal Risk
				0%		$ -	$ -	0			$ -	$ -	$ -	0	
				0%		$ -	$ -	0			$ -	$ -	$ -	0	

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MAINTENANCE STRATEGY DROP DOWN LISTS

LabourRate *(Client Specific)*	

OutageRate *(Client Specific)*	

Yesor No
Y
N

Interval	
40	40 Hr Week
80	40 Hr/W Fortnight
160	40 Hr/W Month
320	40 Hr/W 2-Month
480	40 Hr/W 3-Month
640	40 Hr/W 4-Month
960	40 Hr/W 6-Month
2080	40 Hr/W Year
3120	40 Hr/W 18-Month
4160	40 Hr/W 2-Year
6240	40 Hr/W 3-Year
8320	40 Hr/W 4-Year
10400	40 Hr/W 5-Year
20800	40 Hr/W 10-Year
168	24 Hr/D Week
336	24 Hr/D Fortnight
720	24 Hr/D Month (30D)
1440	24 Hr/D 2-Month (30D)
2160	24 Hr/D 3-Month (30D)
2880	24 Hr/D 4-month (30D)
4320	24 Hr/D 6-Month (30D)
8760	24 Hr/D Year (365D)
13080	24 Hr/D 18-Month
17520	24 Hr/D 2-Year (365D)
26280	24 Hr/D 3-Year (365D)
35040	24 Hr/D 4-Year (365D)
43800	24 Hr/D 5-Year (365D)
87600	24 Hr/D 10-Year (365D)

AssetCriticality *(Client Specific)*	
unacceptable	1
Production or service lost completely for <1day or safety or environmental impact tolerable	2
Production or service reduced by >50% for >1day or safety or environmental risk high	3
Production or service reduced by >50% for <1day or safety or environmental risk medium	4
Production or service reduced by <50% for >1day or safety or environmental risk low	5
Production or service reduced by <50% for <1day or safety or environmental risk very low	6
low	7

Plant Area *(Client Specific - customise for each Client)*	

Asset Type *(Client Specific - customise for each Client)*	

Severity / Consequences	
Insignificant	1
Mild	2
Moderate	3
Significant	4
Catastrophic	5

Liklihood /	
Low	1
Low-Medium	2
Medium	3
Medium-High	4
High	5

Function Type	
Primary	P
Secondary	S

Detectability	
Detectable	1
Probably detectable	2
Possibly detectable	3
Undetectable	4

Maintenance Type (RCM)	
Service or lube tasks	SLT
On-condition tasks	OCT
Sched restoration tasks	SRT
Sched discard tasks	SDT
Run-to-failure	RTF
Failure-finding tasks	FFT
One-time change	OTC

Maintenance Type	
Service or lube	SL
Preventive	PM
Inspection	INSP
Predictive	PdM
Condition Monitoring	CbM
Corrective	CM
Fix on Fail	FOF
Modification	MOD
Redesign	RED

Principal Risk Effect	
Safety	S
Environmental	E
Economic/Operational	EO

Installed Condition	
New	N
Used	U
Refurbished Fully	RF
Refurbished Partly	RP

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Maintenance Strategy Workbook
Maintenance Strategy Worksheet
RCM, FMEA, FMECA(Qualitative) and RCA Principles Section Notes

Based on principles presented in 'SAE JA1012 2002 – A Guide to the Reliability-Centred Maintenance (RCM) Standard' and 'RCM3: Risk Based Reliability Centred Maintenance - Basson'

RCM, FMEA, FMECA(Qualitative) and RCA Principles
This maintenance strategy worksheet is based on **RCM, FMEA, FMECA(Qualitative)** and **RCA** principles.

RCM (Reliability Centred Maintenance) is a process used to determine minimum, safe levels of maintenance, engineering and other related risk management strategies required to optimise an asset's safety and environmental integrity and cost-effective operational capability in its operating context over its life cycle, in accordance with the asset operator's functional and operational expectations.

RCM requires the consideration of eight questions regarding each asset or system under review:

1. What is the operating context of the asset or system (i.e. operating conditions and how used)?
2. What are the functions and associated performance standards of the asset or system in its present operating context?
3. What are the ways in which the asset or system may fail to fulfil its functions (i.e. functional failures or failed states)?
4. What are the causes of each functional failure or failed state (i.e. failure modes)?
5. What are the effects and consequences of each functional failure when it occurs?
6. What are the risks and risk levels associated with each functional failure?
7. What can be done proactively to reduce intolerable risks to tolerable levels?
8. What can be done to reduce or manage risks in a cost-effective manner?

FMEA (Failure Modes and Effects Analysis) is a process used to:

1. Identify and fully understand potential failure modes, failure causes and failure effects for assets, processes, and systems.
2. Assess risks associated with identified failure modes, failure causes and failure effects and prioritise issues for mitigative or corrective action.
3. Identify, define, and implement mitigative or corrective actions and thereby reduce asset, process and system risks to tolerable levels.

FMECA Failure Modes, Effects and Criticality Analysis) is an extension of FMEA by including criticality analysis whereby failure mode probability/ likelihood and severity are assessed enabling failure modes to be ranked according to their respective criticality.

RCA (Root Cause Analysis) is a process used to identify fundamental or root causes of problems or failures in order to identify appropriate solutions. This involves defining the problem, understanding the process, identifying possible causes, collecting data (evidence), analysing data (evidence), identifying possible solutions, selecting solutions, implementing solutions, evaluating effects, and institutionalising change.

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Maintenance Strategy Workbook
Maintenance Strategy Worksheet
Target OEE Column Notes

OEE or 'overall equipment effectiveness' is a single measure of an asset's **availability** to produce, **performance** re output or production rate and **quality** of output or production.

Availability is the ratio of Actual Production Time to Potential Production Time.

I.e., **Availability = Actual Production Time / Potential or Possible Production Time**

Performance is the ratio of Actual Output to Theoretical Output.

I.e., **Performance = Actual Output / Theoretical Output**

Quality is the ratio of good or compliant output or production to total good or compliant output or production.

I.e., **Quality = Good (Compliant) Output / Total Output**

OEE = Availability ratio x **Performance** ratio x **Quality** ratio

100% OEE means only good (compliant) product is manufactured, as fast as possible, with no stop or down time

85% OEE is considered world class

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Maintenance Strategy Workbook
Maintenance Strategy Worksheet
Functional Failure Column Notes

Functional Failure (or Failed State)
(based on 'SAE JA1012 2002 – A Guide to the Reliability-Centred Maintenance (RCM) Standard')

A functional failure is a state in which a physical asset or system is unable to perform a specific function to a desired level of performance. All failed states associated with each function should be identified.

Every asset has more than one function, each of which could fail in isolation so any asset can suffer from a variety of failed states. For this reason, it is more accurate to define failure in terms of the loss of specific functions, rather than failure of a complete asset.

Functional failures may be **total or partial**. A function performing at less than the desired minimum performance standard is a partial failure. E.g., a pump may pump nothing at all which is a total failure or at less than the desired rate which is a partial failure.

Performance standards associated with some functions incorporate **upper and lower limits** and an asset has failed if it performs above the upper limit or below the lower limit. In these cases, the breach of the upper limit needs to be documented separately to breach of the lower limit because failure modes and / or consequences associated with exceeding the upper limit are usually different from those associated with a breach below the lower limit. E.g., machining tolerances.