
Fundamentals of Asset Management

*Step 7. Optimize Operations & Maintenance
(O&M) Investment*

A Hands-On Approach

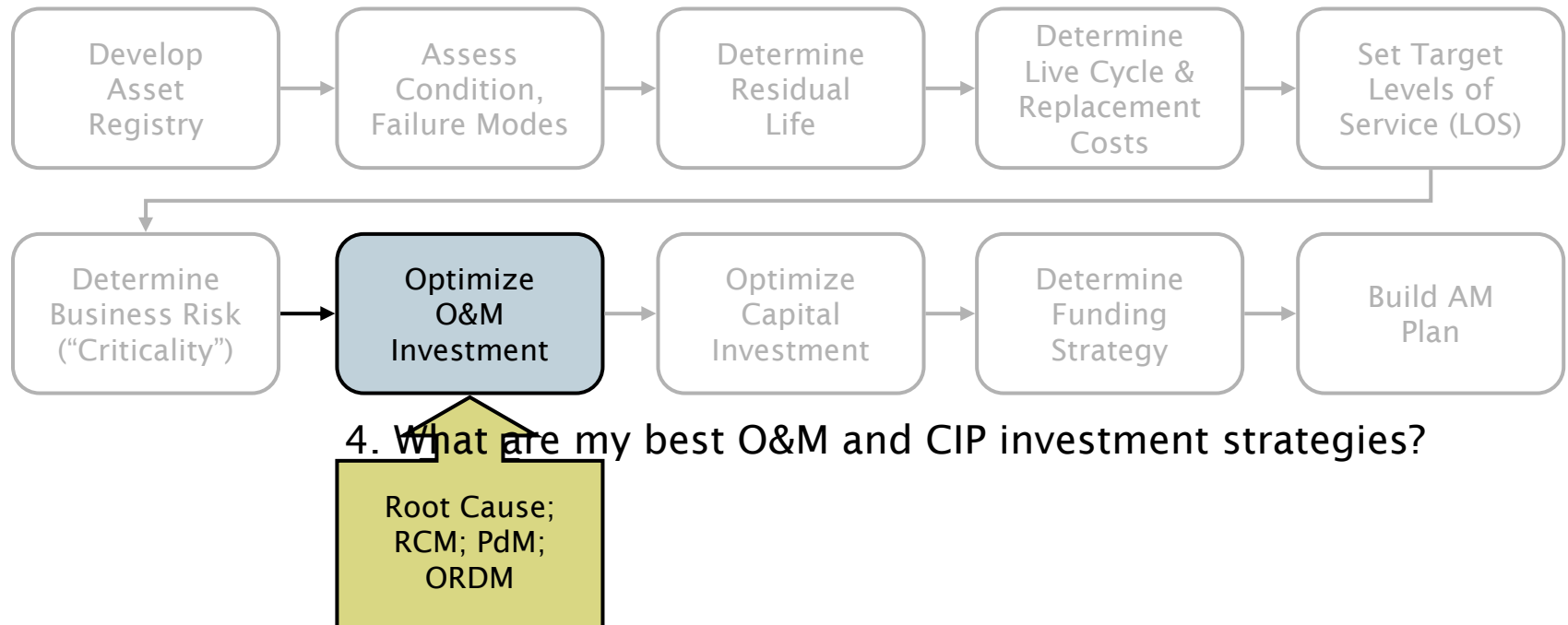
Tom's bad day...



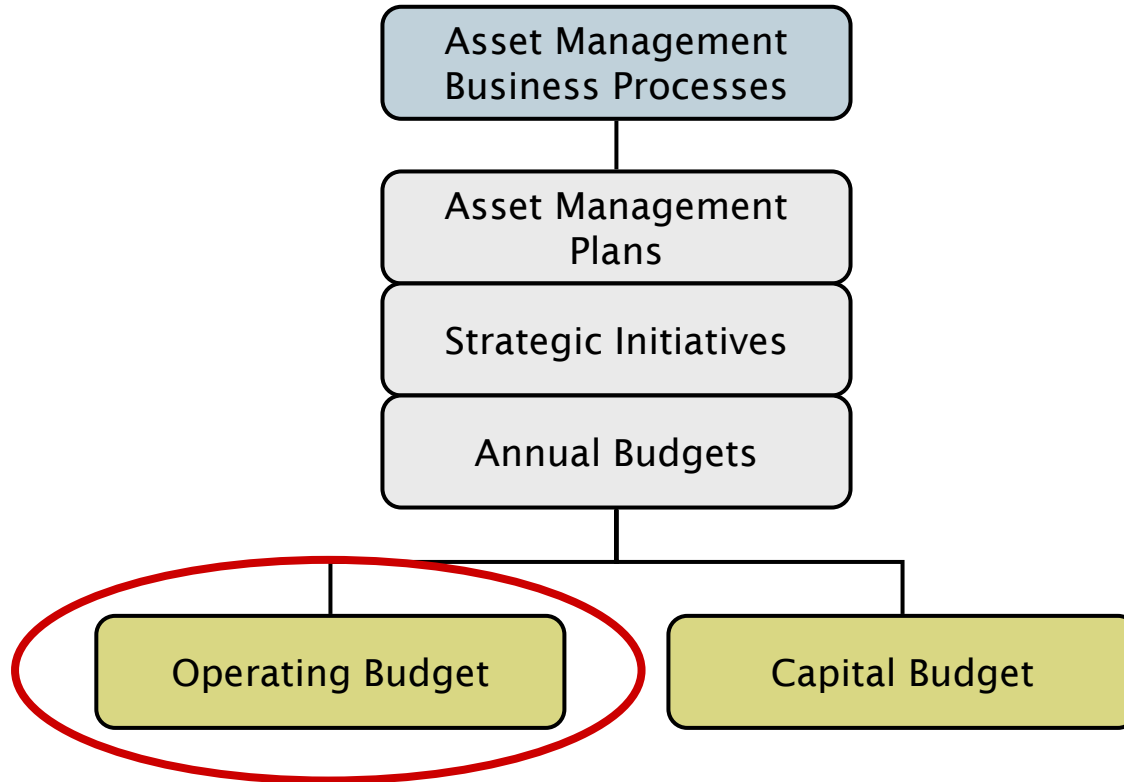
Fourth of 5 core questions

4. What are my best O&M and CIP investment strategies?
 - What alternative management *options* exist?
 - Which are the *most feasible* for my organization?

AM plan 10-step process



Recall view 4: Management framework

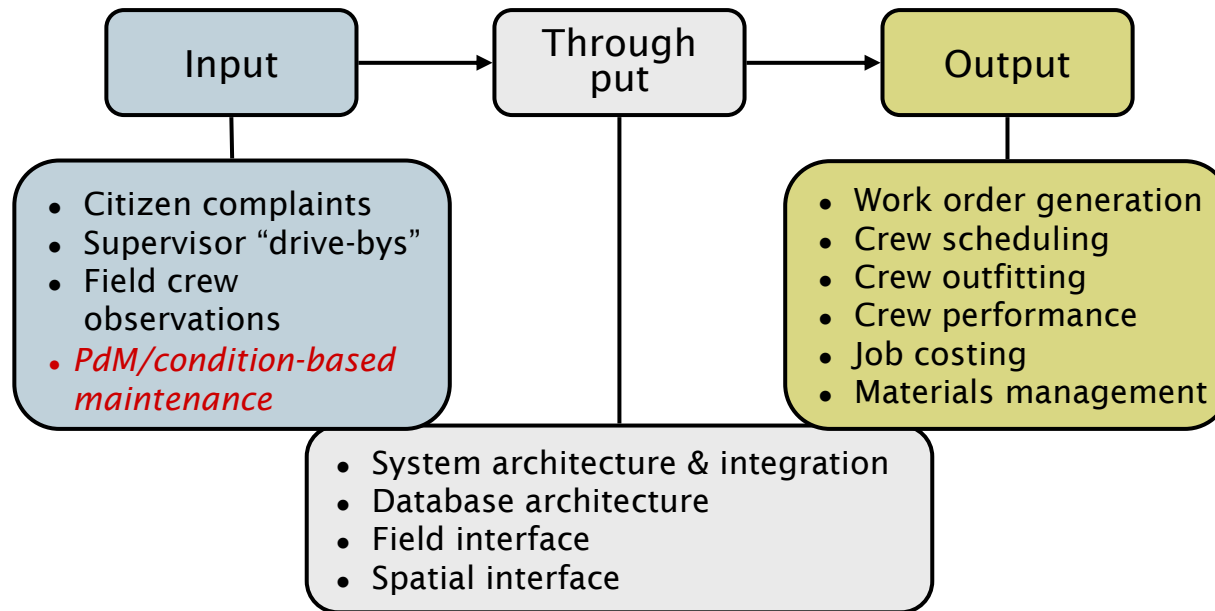


Definition

Maintenance - normal support, periodic and minor in nature, required to sustain performance and functionality of an asset consistent with design, manufacturer, and operational requirements

What triggers a work order?

Computerized Maintenance Management System (CMMS)



Importance Of The Work Order: Asset Level

WORK ORDER

Type: PM or UM

- Estimated bill of quantities
- Actual
 - Labor
 - Plant
 - Materials
- Procedure followed
- Failure mode noted
- Primary cause of failure

Memos

- Impact on customers
- Unproductive time
- Other issues

Tells us planned (PM) or unplanned (UM) maintenance costs

Builds life cycle cost history; ties to warehouse management

Tells us actual direct costs of activity

Tells us the activity used; necessary for activity analysis

Useful in *failure mode analysis*

Necessary for *causal analysis*

Indirect costs on business; impact on customers (*consequence analysis*)

Used in *efficiency analysis*

Data feedback enables substantive analysis

Bottom-line maintenance “KPIs” from an AM perspective

<i>Metric</i>	<i>Definition</i>	<i>Target</i>
Availability	The portion of time that a plant or major system is available for producing output of the required quality and quantity	95 – 99%
% Failure analysis	The portion of equipment downtime events that undergo a thorough analysis of failure modes, effects, and root causes	85 – 100%
% Planned work	The portion of corrective maintenance work hours that are planned and scheduled in advance (not unplanned breakdowns)	85 – 95%
% Overtime	The portion of maintenance work hours that are performed at an overtime rate	5 – 8%
Relative maintenance cost	Annual maintenance spending as a percentage of asset replacement value of the plant being maintained	1.5 – 2.5%
Technician productivity	The percent of work hours spent on productive activities versus nonproductive (rework, waiting for parts, etc)	70 – 85%
% Rework	The portion of maintenance work that has to be redone due to poor installation, shoddy workmanship or incorrect diagnosis	2 - 5%

Importance of the work order: Portfolio level

WORK ORDER

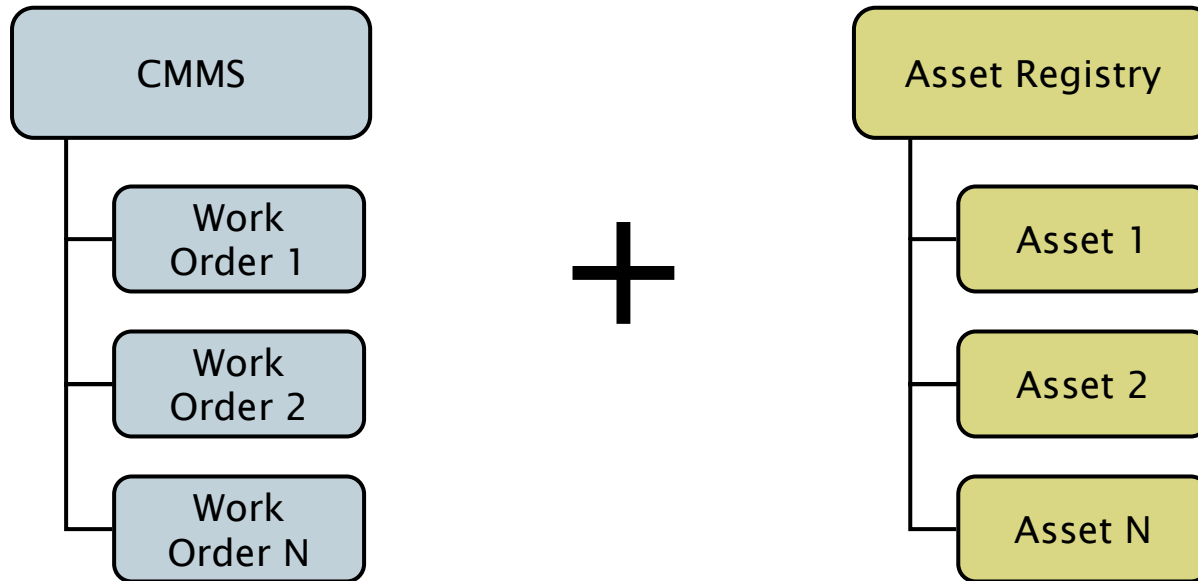
Asset details

- Type
- Category
- Size
- Condition
- Performance history
- Failure modes

Asset-linked costs enable significant analysis...

1. What type of sewer suffers the greatest number of blockages caused by tree roots?
2. How many failures are experienced by water mains of different ages in different ground conditions?

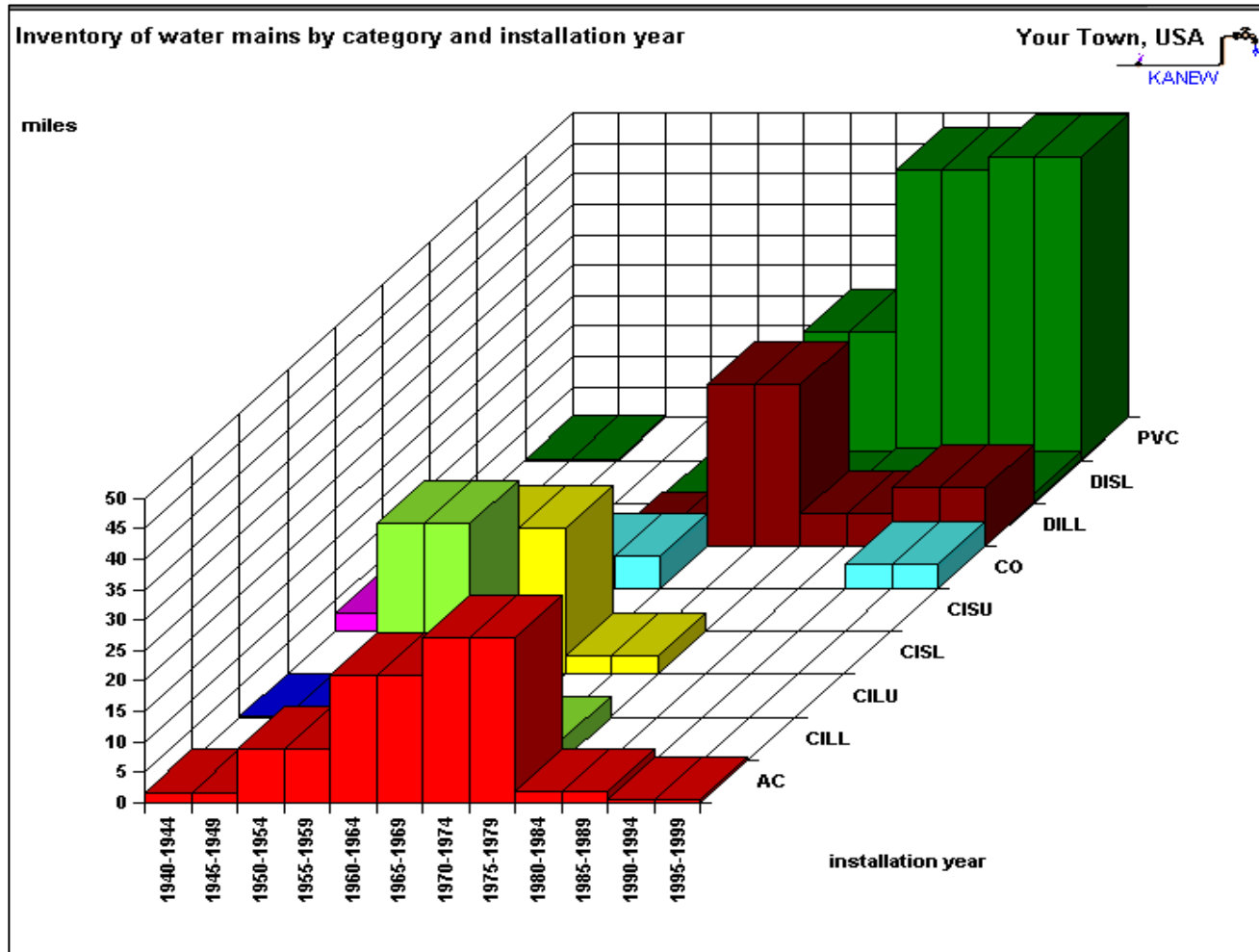
What Distinguishes EAMS from CMMS?



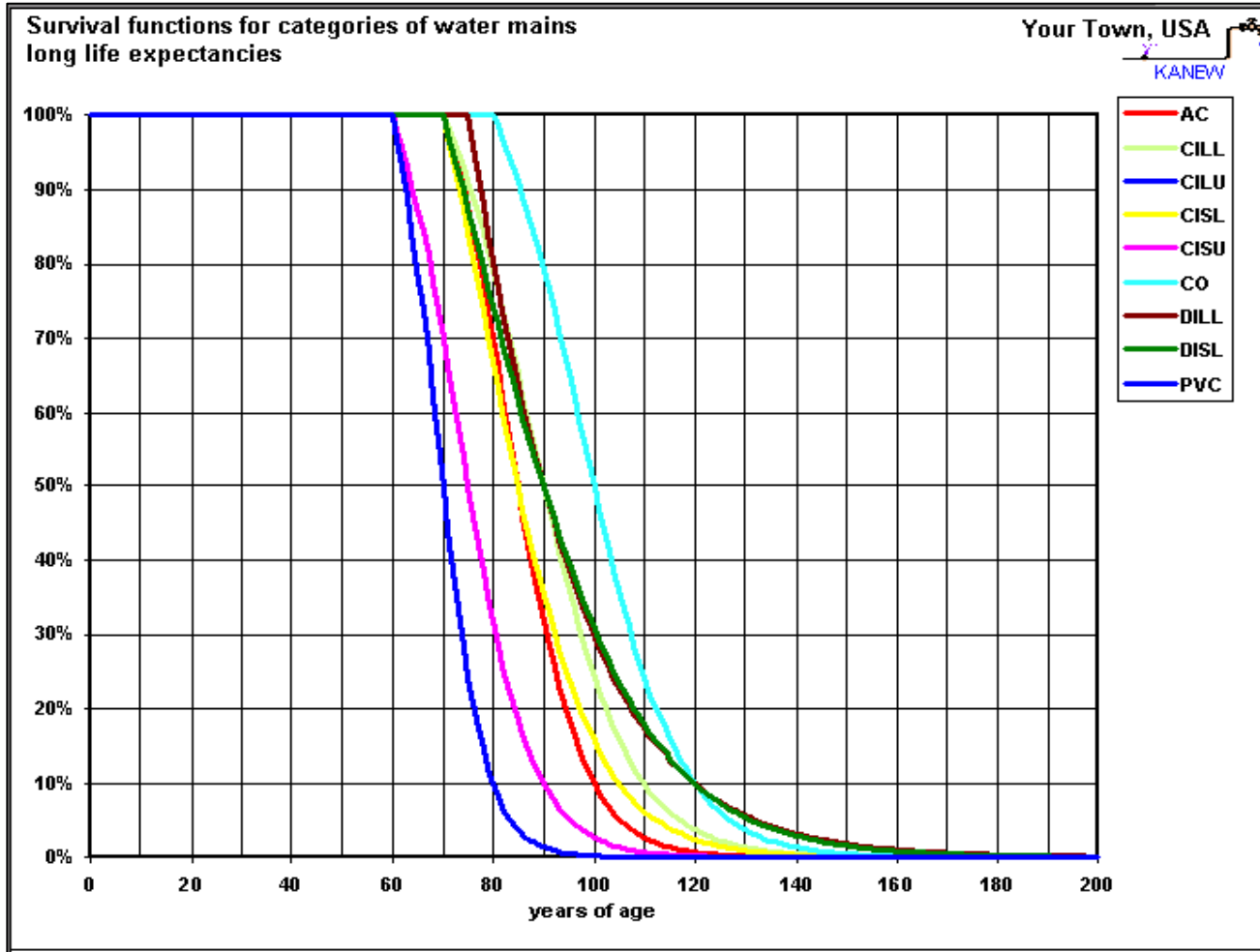
Focus is on the *maintenance work order* and maintenance performance for a defined period

Focus is on an *asset's performance* over its life cycle and on aggregate performance of asset groups

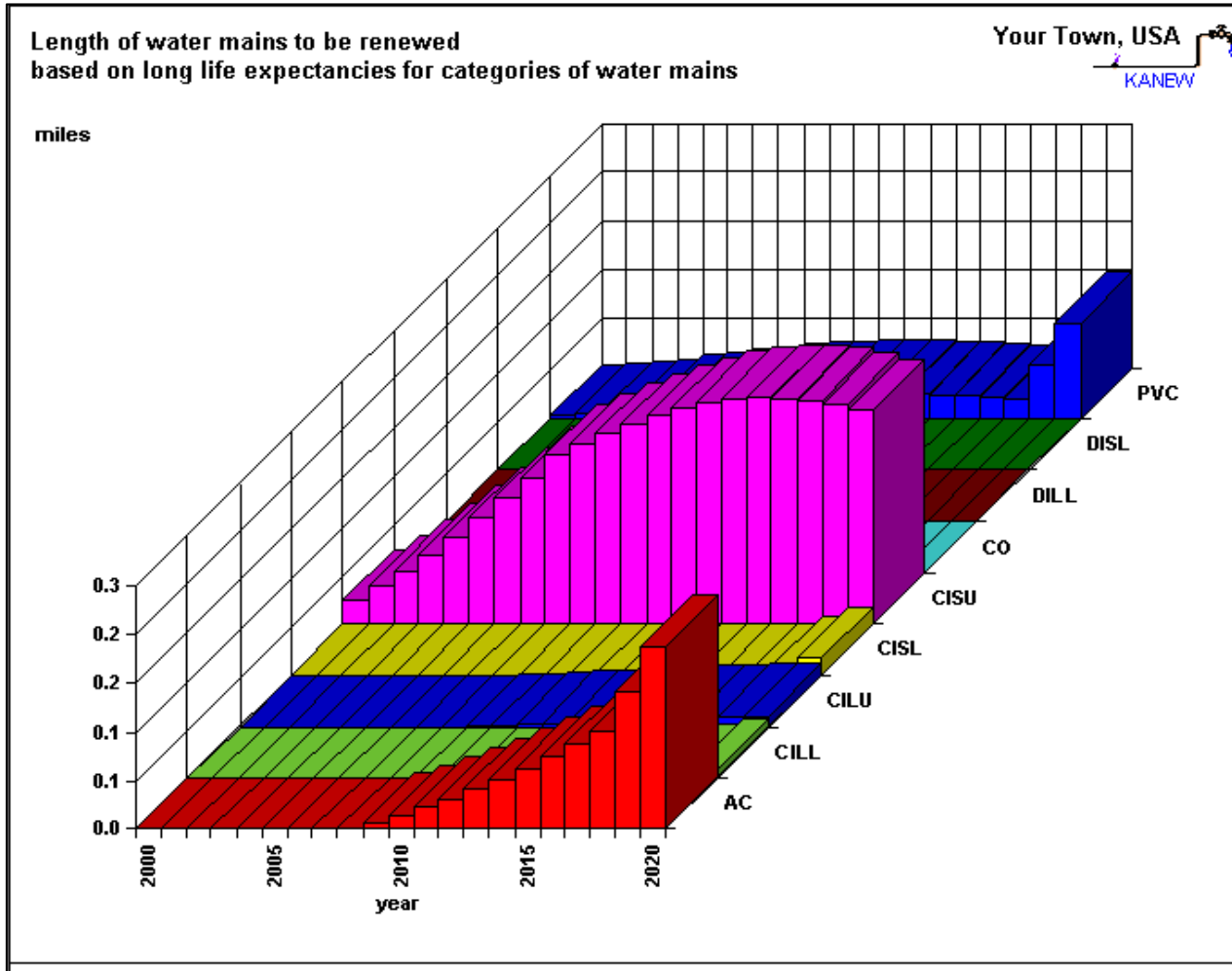
The asset portfolio view - 1



The asset portfolio view - 2



The asset portfolio view - 3

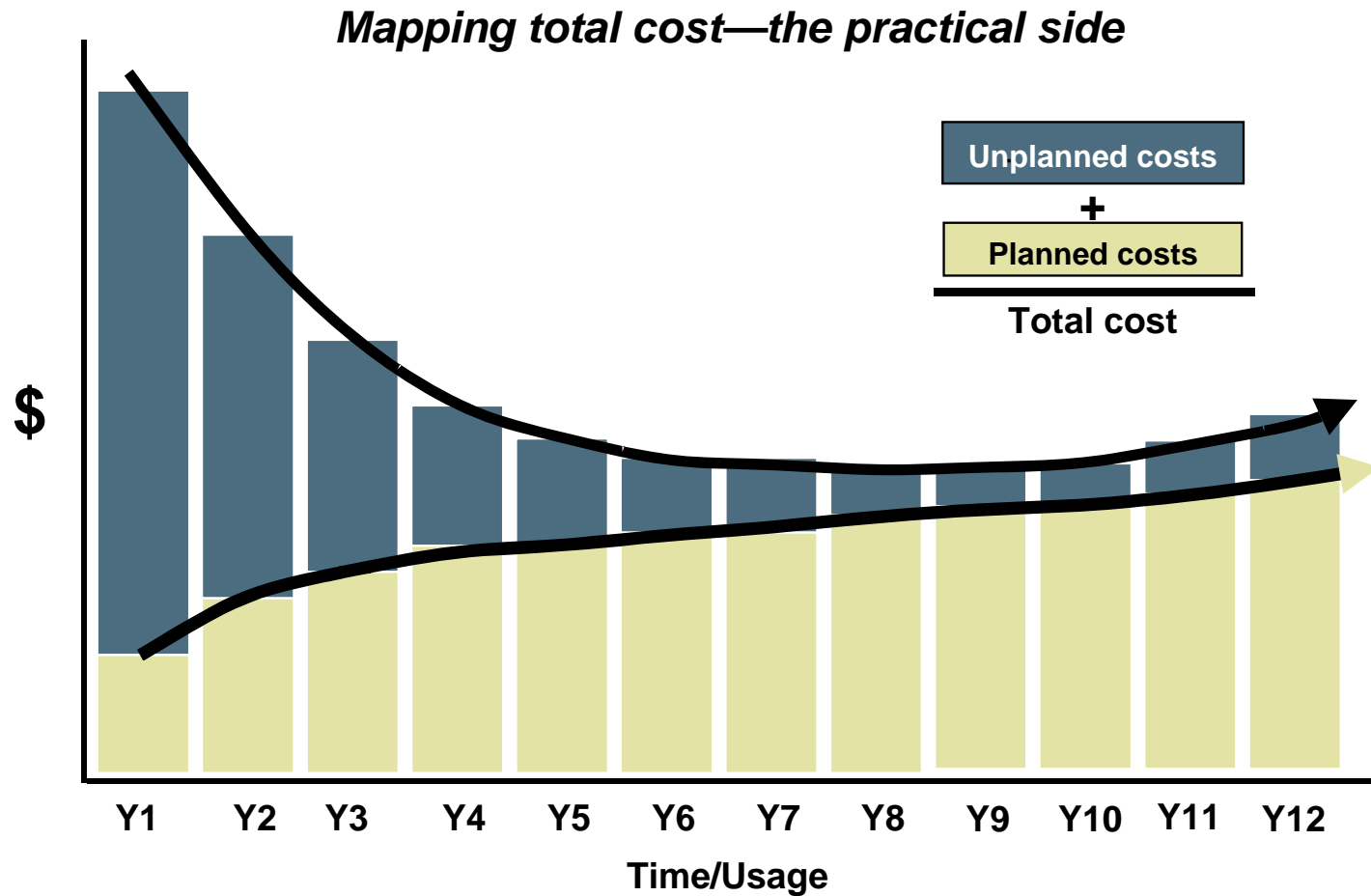


The Cost of Maintenance

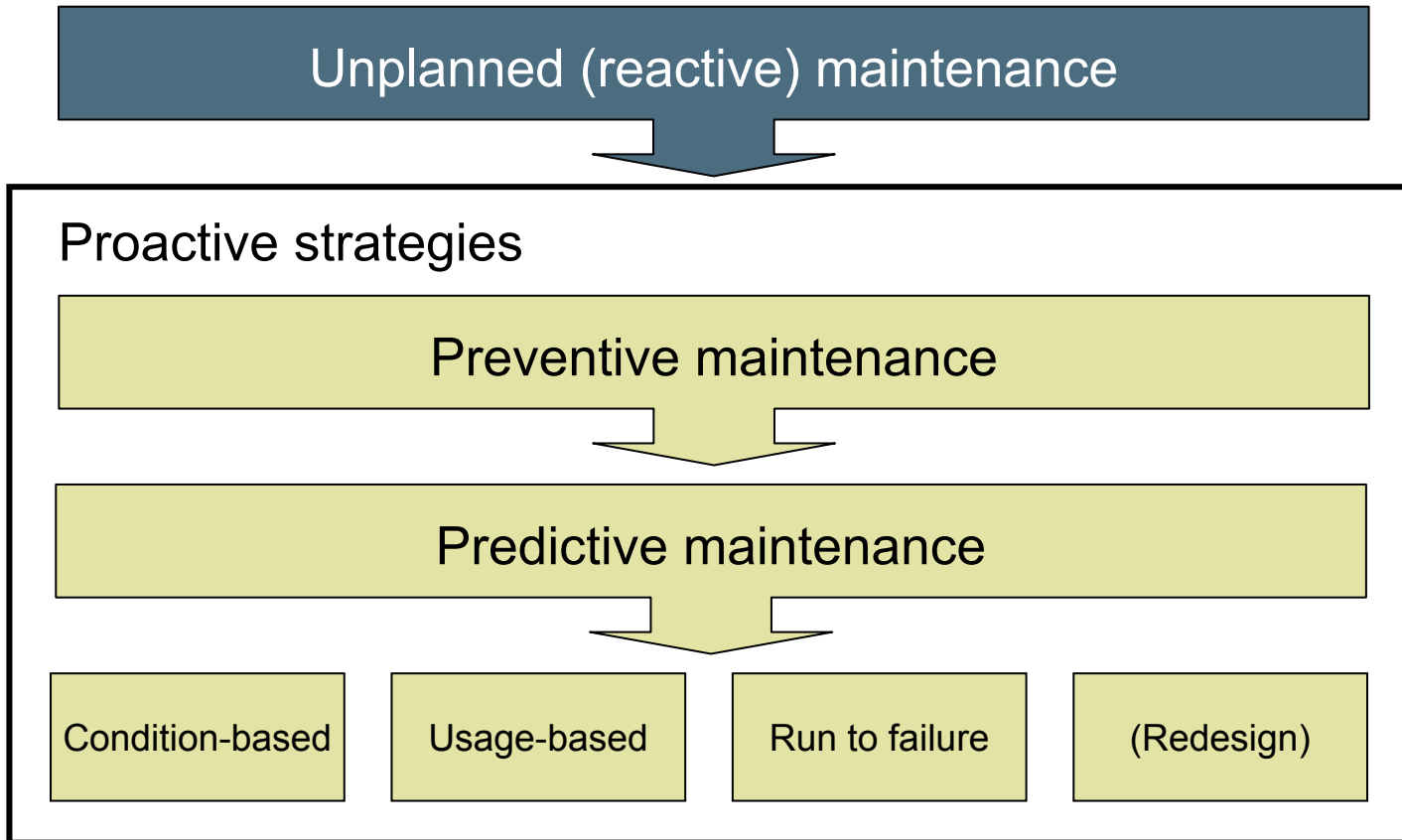
Rule of thumb

Roughly speaking, planned maintenance costs *one-third less* than unplanned maintenance for the same task

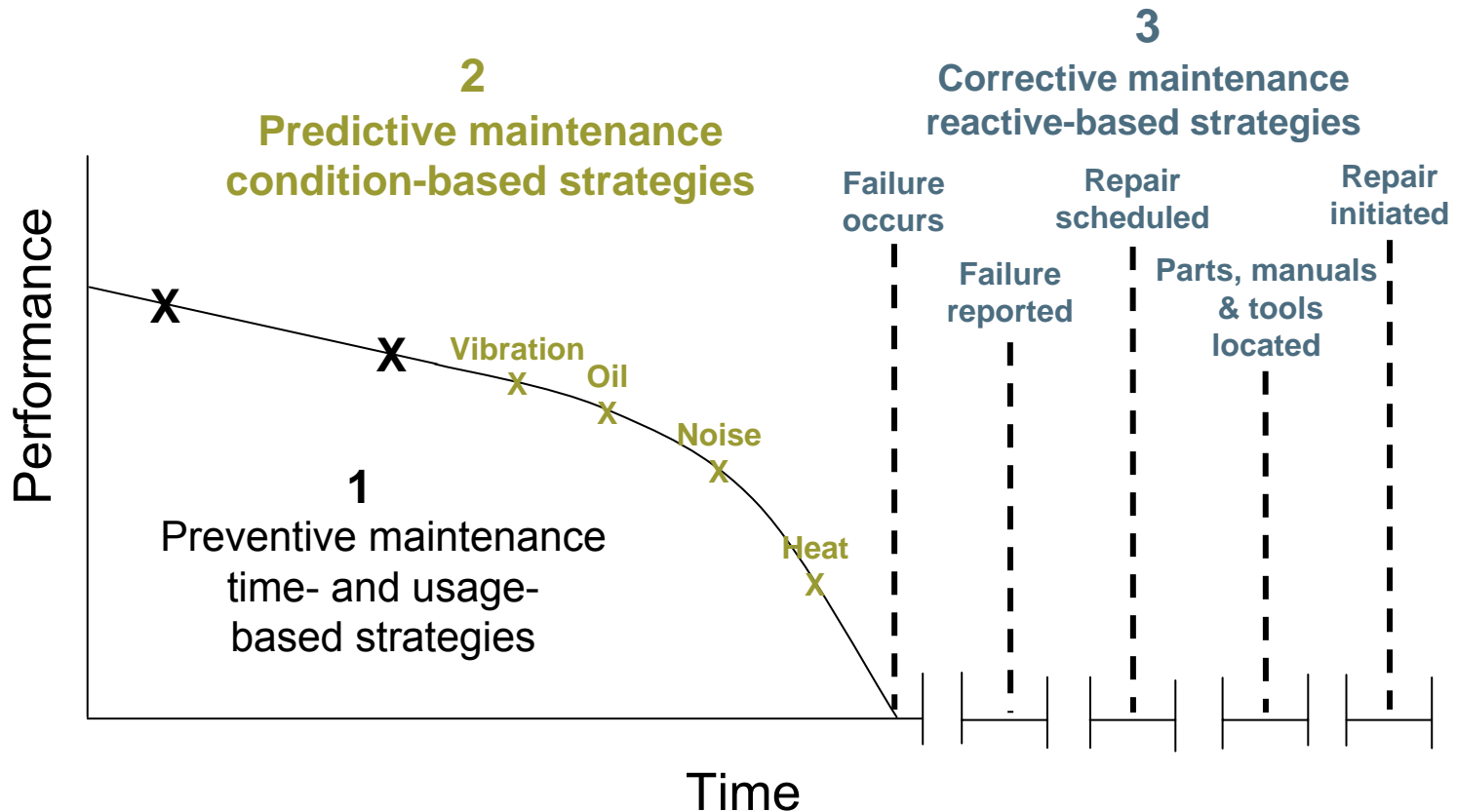
Transition to Planned Maintenance



Evolution of maintenance techniques



Fitting maintenance strategies to failure curve



Cost comparison strategies & tactics—the maintenance toolbox

Core strategies		
Total productive maintenance	Reliability centered maintenance	Zero breakdown maintenance

Operational tactics			
Design reliability analysis	Asset condition assessment	Early equipment management	Maintenance prevention
Accelerated deterioration elimination	Infrastructure, equipment, & component standardization	Commodity configuration management	Design for serviceability
Failure lead-time analysis	Demand criticality classification	Location failure analysis	Standardized failure codes

Total productive maintenance

- Embraces both asset design and maintenance
- Goal is to maximize Overall Equipment Effectiveness (OEE), where
$$\text{OEE} = \text{availability} \times \text{performance efficiency} \times \text{“first-time-through” quality}$$
- Focuses on developing a comprehensive asset management plan for each asset for the life of the asset
- Ties maintenance objectives to the value chain (set-up time, lack of materials, poor quality, equipment functional failures, etc.)

Zero breakdown maintenance

Comprised of six core strategies

1. Eliminate continuing deterioration by establishing basic equipment conditions
2. Eliminate continuing deterioration by complying with conditions of use
3. Restore equipment to its optimal condition by restoring deterioration
4. Restore processes to their optimal condition by abolishing conditions that cause accelerated deterioration
5. Lengthen equipment lifetimes by correcting design weaknesses
6. Eliminate unexpected failures by improving operating and maintenance skills

Zero breakdown maintenance

Strategies are deployed in four steps

1. Reduce variation in failure intervals
2. Lengthen equipment life
3. Periodically restore deterioration
4. Predict equipment life from its condition

Reliability-centered maintenance—the seven fundamental questions

1. What are the functions and associated performance standards of the asset in its present operating context?
2. In what ways does it fail to fulfill its functions?
3. What causes each functional failure?
4. What happens *mechanically* when each failure occurs?
5. In what way does each failure matter?
6. What can be done to predict or prevent each failure?
7. What should be done if a suitable proactive task cannot be found?

Techniques

- Function and performance standards
- Functional failures
- Failure modes
- Failure effects
- Failure consequences
- Proactive tasks

Intervention action—RCM

Item Analysis _ □ ×

PUMP

Significant for Analysis: Criticality: Risk Assessment:

Quantity / system:

Analyst:

Date:

MEA Type:

Description:

Pump No. 1 and Pump No. 2 are Flygt LL3602/835 Submersible Pump Sets located in Pump Station RW1. The pumpset comprises a 230kW, 415VAC, 50Hz drive unit and 1600l/s pump unit. The drive unit consists of a stator housing, stator, end sleeve, bearing housing, mechanical seal and connection cover. The upper support bearing is a grease lubricated single row roller bearing and the main bearing assembly comprises two single row ball bearings and a single row roller bearing, all grease lubricated. The hydraulic unit consists of a pump housing with mechanical seal, impeller and suction housing. The pump housing cavity is oil filled to provide cooling of the drive unit and hydraulic unit mechanical seals. A rubber wear ring is fitted to the suction cover to mate with the outer periphery of the impeller.

ITT Flygt indicate that the pumps are configured with sensors for stator winding temp (PTC140), stator housing leakage (FLS), main bearing temp (PT100), water

Protective Devices & Failsafes: Redundancy:

Stator winding and main bearing overtemp indications. Two pumps each capable of 138 Mv/d, system peak load 130 Mv/d.

Failure Modes:

Cable connections burned.	NC	«
Main bearing overtemp warning failed.	CC	«
Motor overheat warning failed.	CC	«
Pump corroded.	CC	«
Pump does not run.	CC	«
Pump impeller damaged/eroded.	NC	«
Pump suction obstructed.	CC	«
Pump unit wear ring worn beyond limits.	NC	«
Reduced output from pump.	NC	«
Stator windings overheat.	NC	«
Water contamination of cooling oil.	NC	«
Water contamination of cooling oil.	CC	«
Water in junction box.	NC	«
Water in oil housing sensor (CLS30) failed.	CC	«
Water in stator sensor failed.	CC	«

FNo:	Functions:	P/S:	E/H:
▶ 1	Pump effluent at required rate (33ML/d to 130ML/d).	P	E
*			

FFNo:	Functional Failures:
▶ 1A	Fails to pump effluent.
▶ 1B	Pumps effluent at reduced rate.
*	

References

Notes

Intervention action—RCM, cont.

FMECA - FLEXIBLE COUPLING

Failure Mode: Bolts loose. Failure Cause: Fatigue.

Local Effect: Drive failure.

Next Effect: Drive failure.

End Effect: Vessel out of service.

Reasoning:

Is the failure evident to the operator in the course of normal duties?	Yes
Will the failure cause a functional loss or secondary damage that could have a direct adverse effect on safety?	No
Will the failure result in loss of emergency or backup function?	No
Will the failure result in direct adverse effect on the environment?	No
Will the failure result in loss of function?	Yes
Is a lubrication or replenishment task applicable and effective?	No
Is an On Condition task applicable and effective?	Yes
Is the perceived cost of failure greater than the perceived cost of preventive maintenance?	Yes

Detectable by: Performance loss.

Predictable by: Visual surveillance.

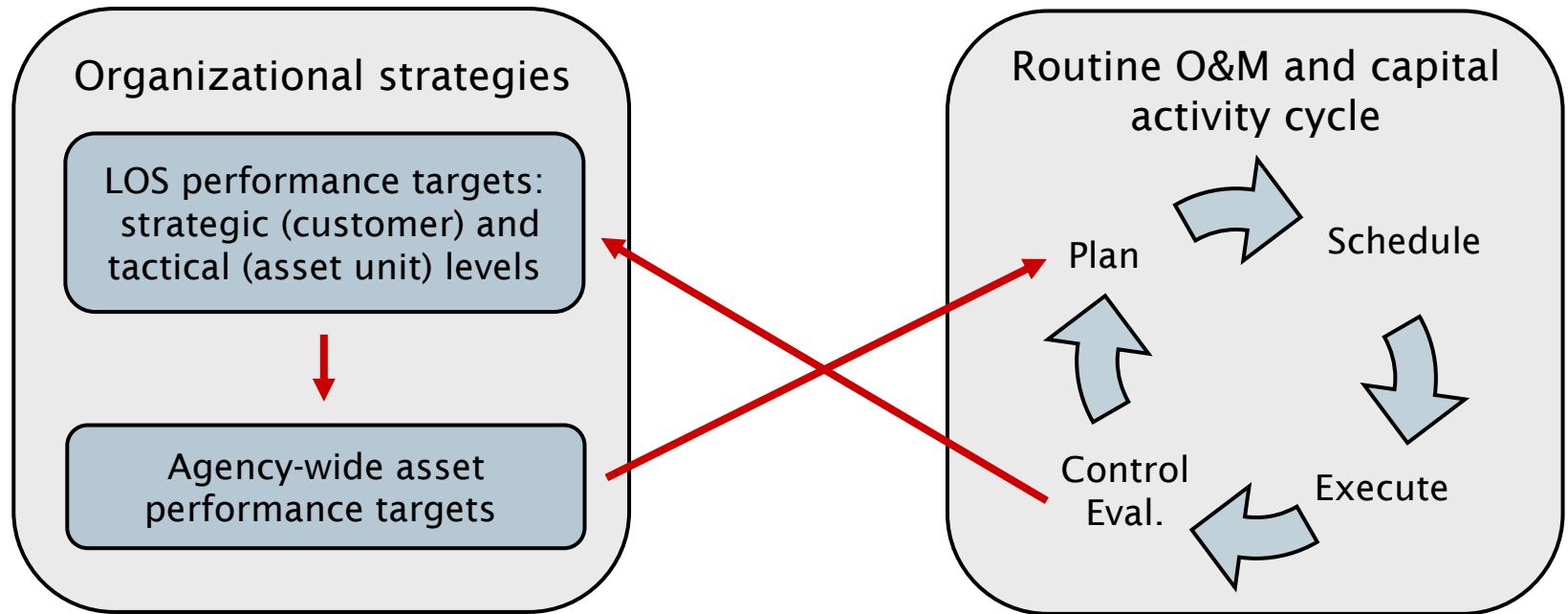
Consequence: Function Age Exploration: No Redesign: No

Evaluation: Drive failures on 604 installations were common. Recommend this task be retained for 620 engines until failure pattern is determined.

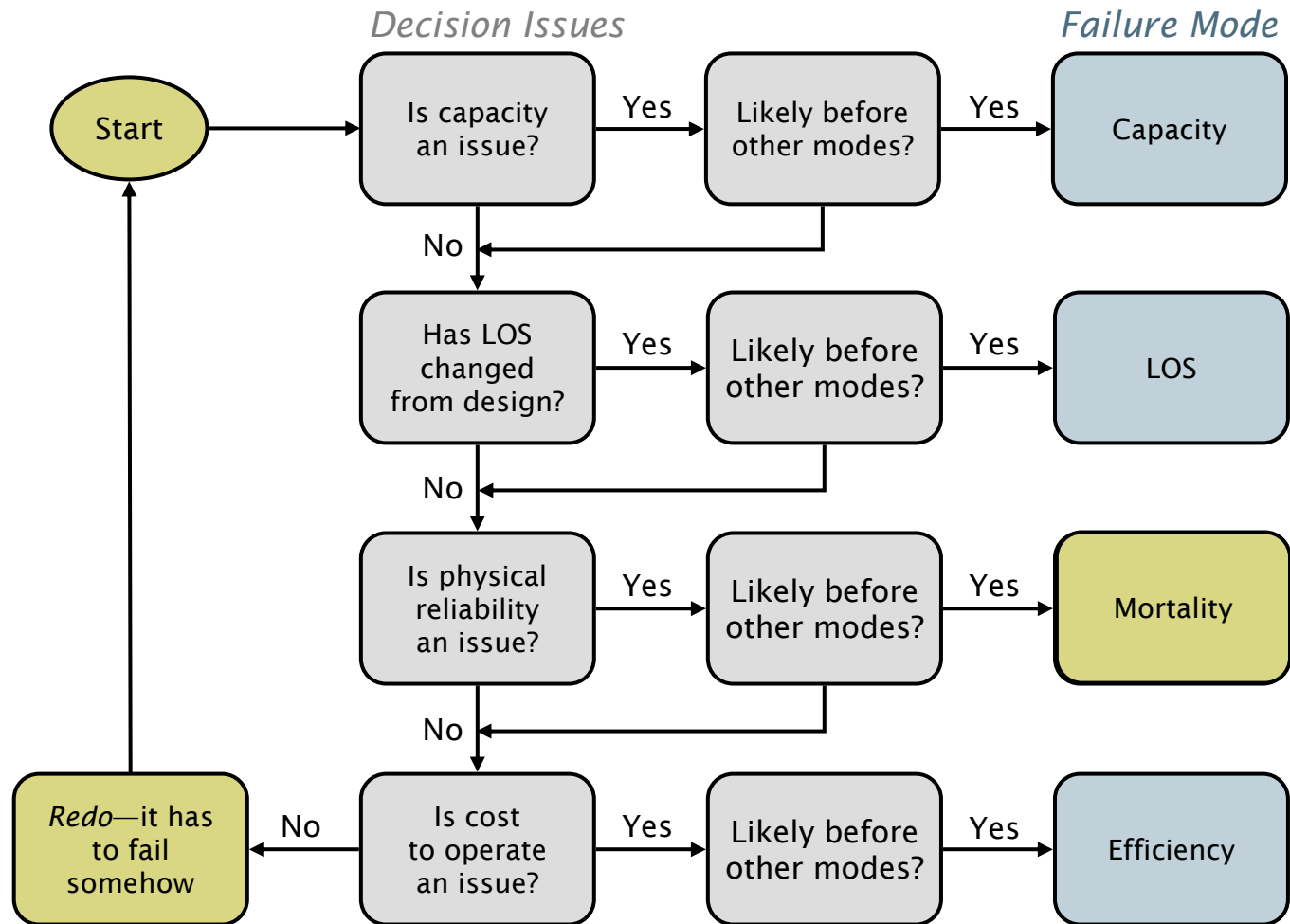
PMT tasks:

Check flexible coupling for cracking and insecurity of bolts.	1000 HR	FLEXIBLE COUPLING
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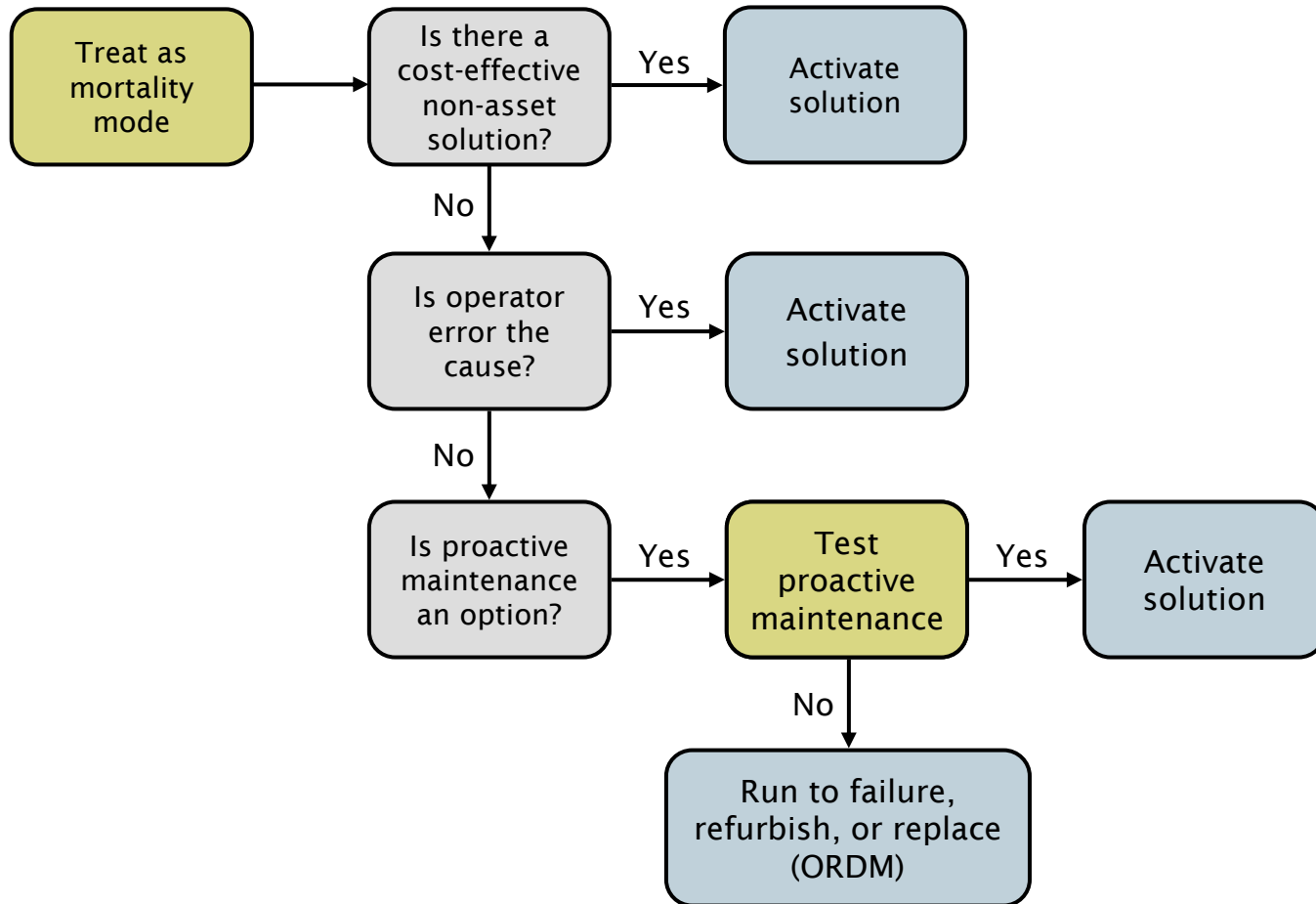
Alignment of routine O&M activities with organizational strategies



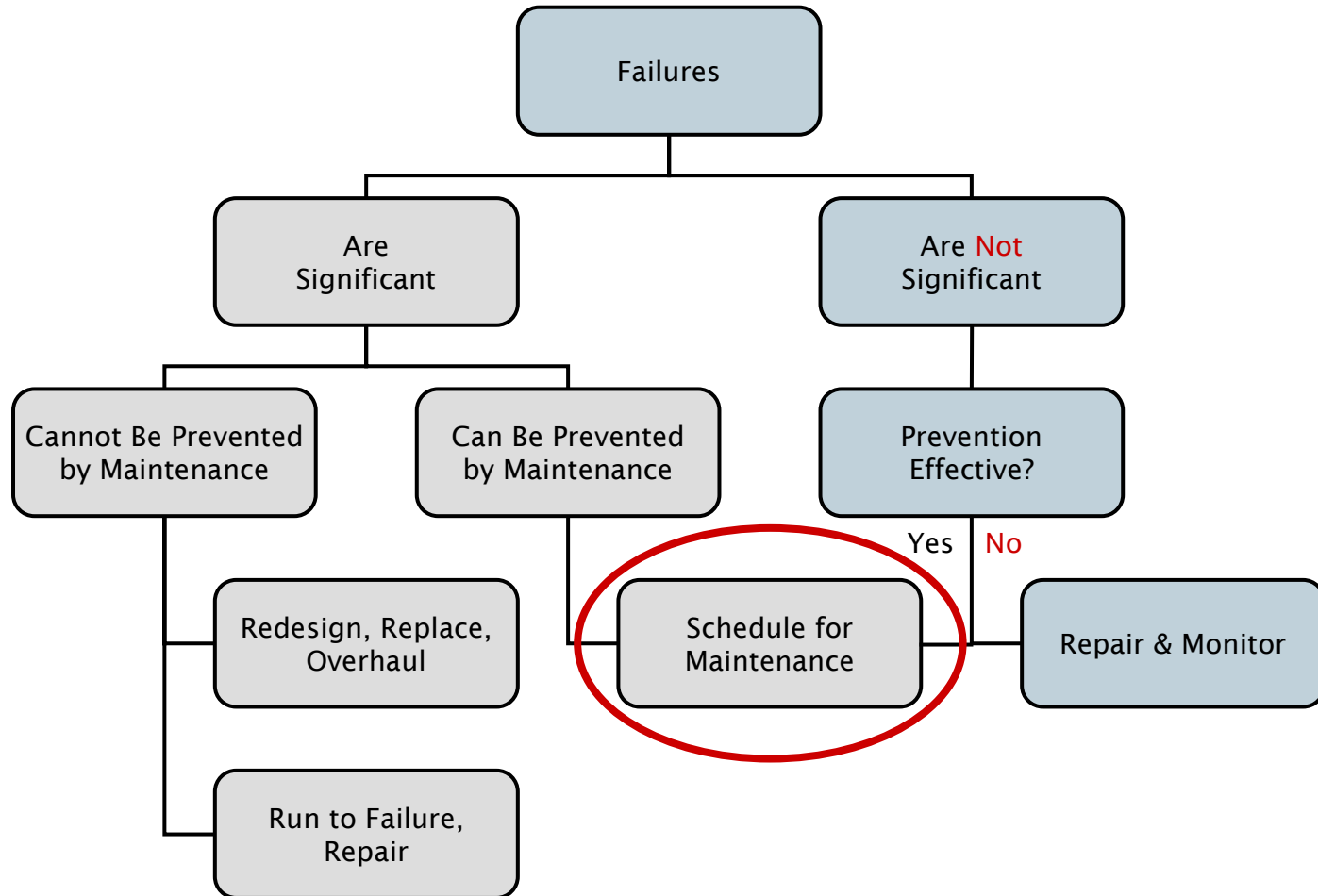
Using failure modes to determine probability of failure



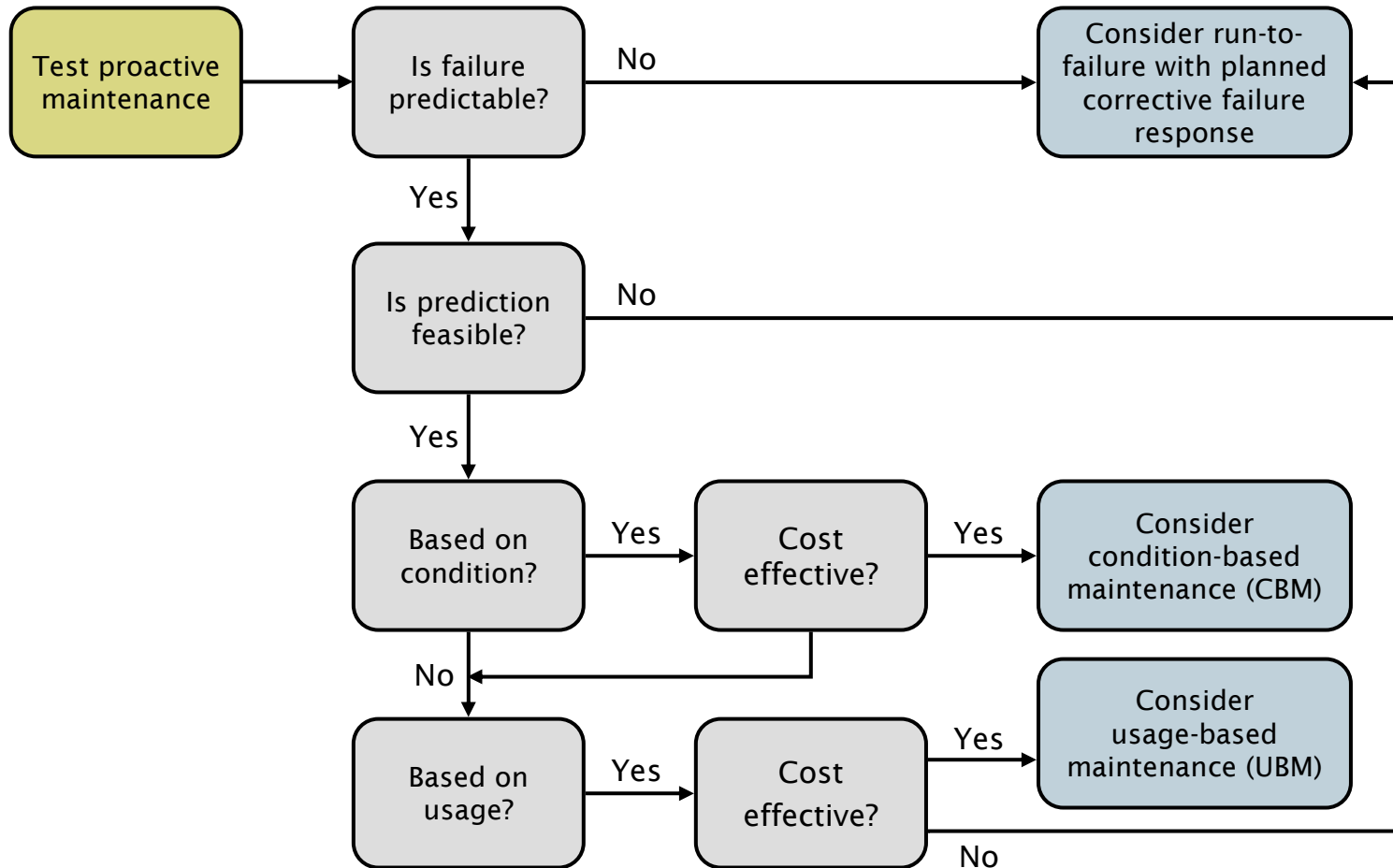
Tactical-level failure modes



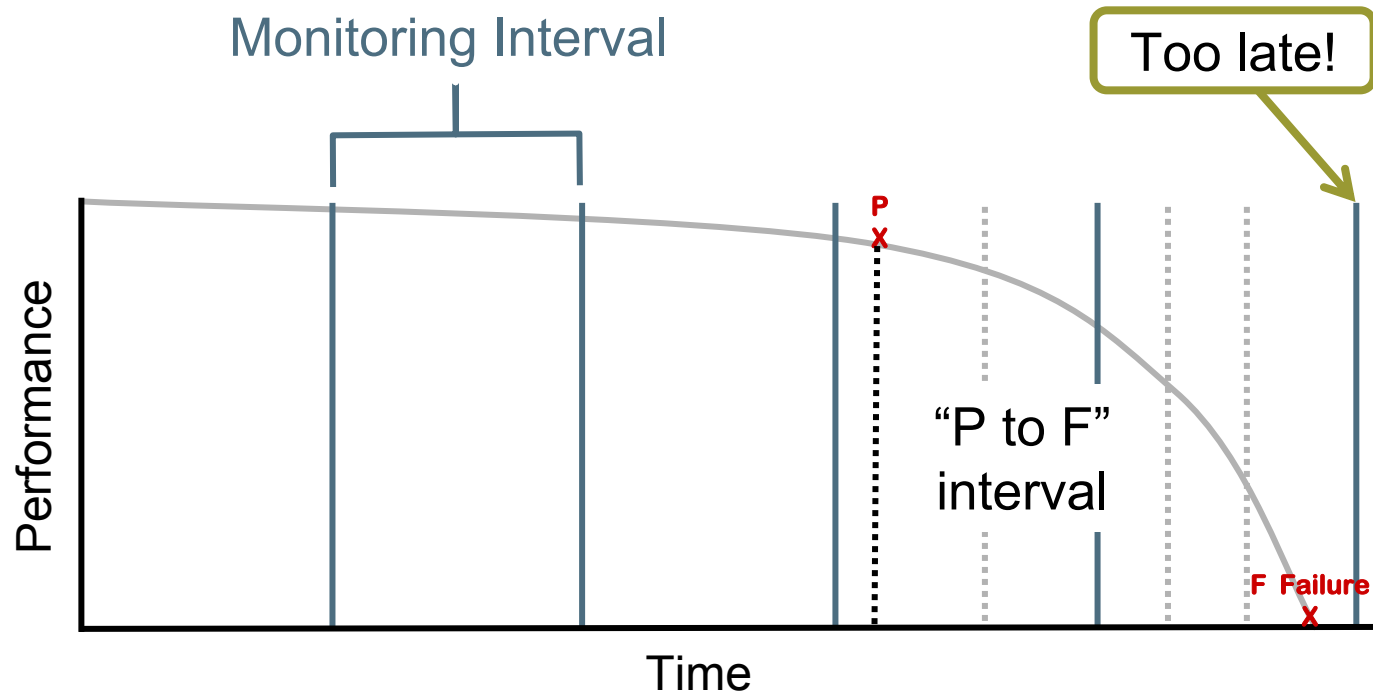
Failure mode-based management logic



Mortality failure mode: Determining appropriate maintenance tactics

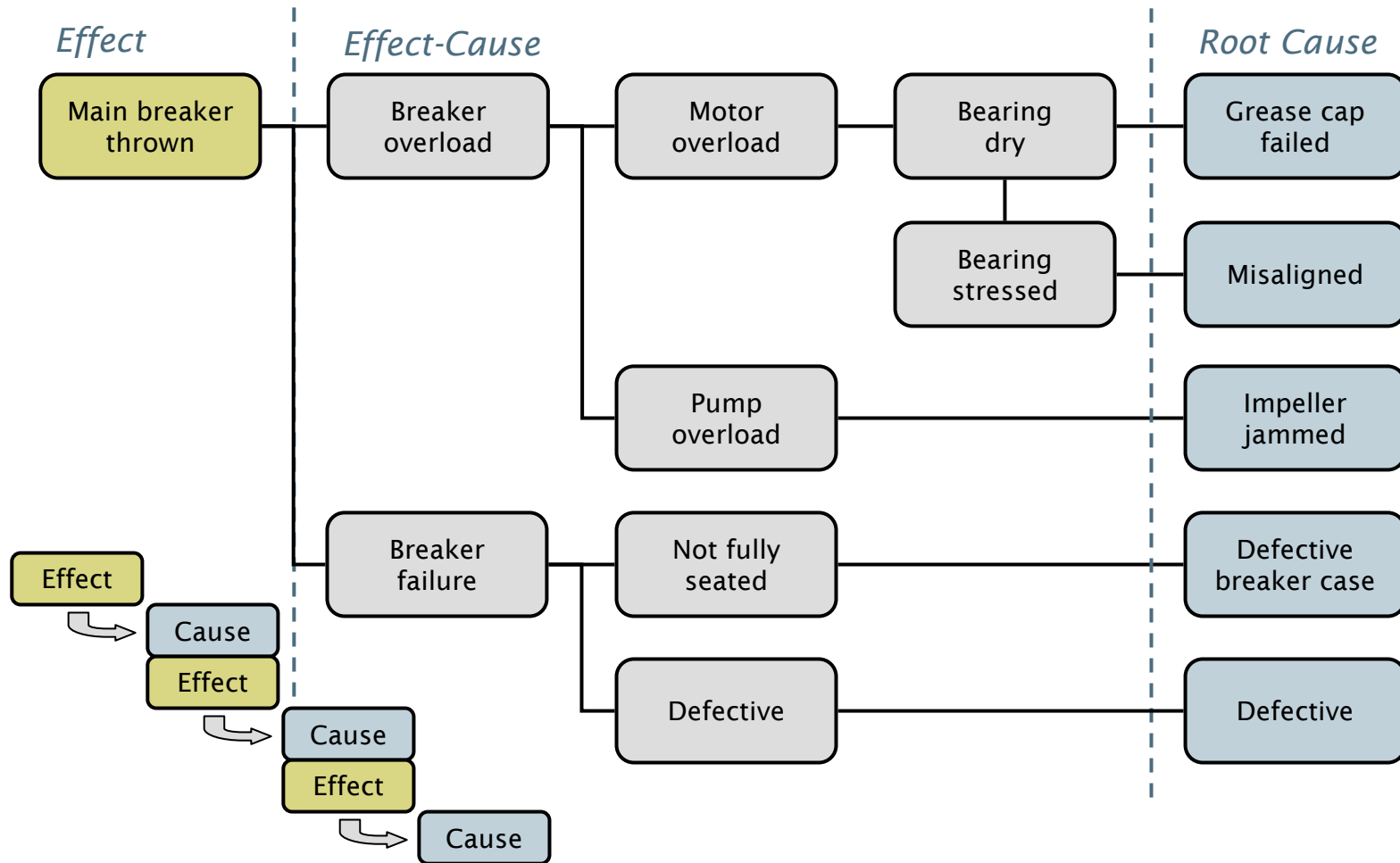


Predictive maintenance and the monitoring interval

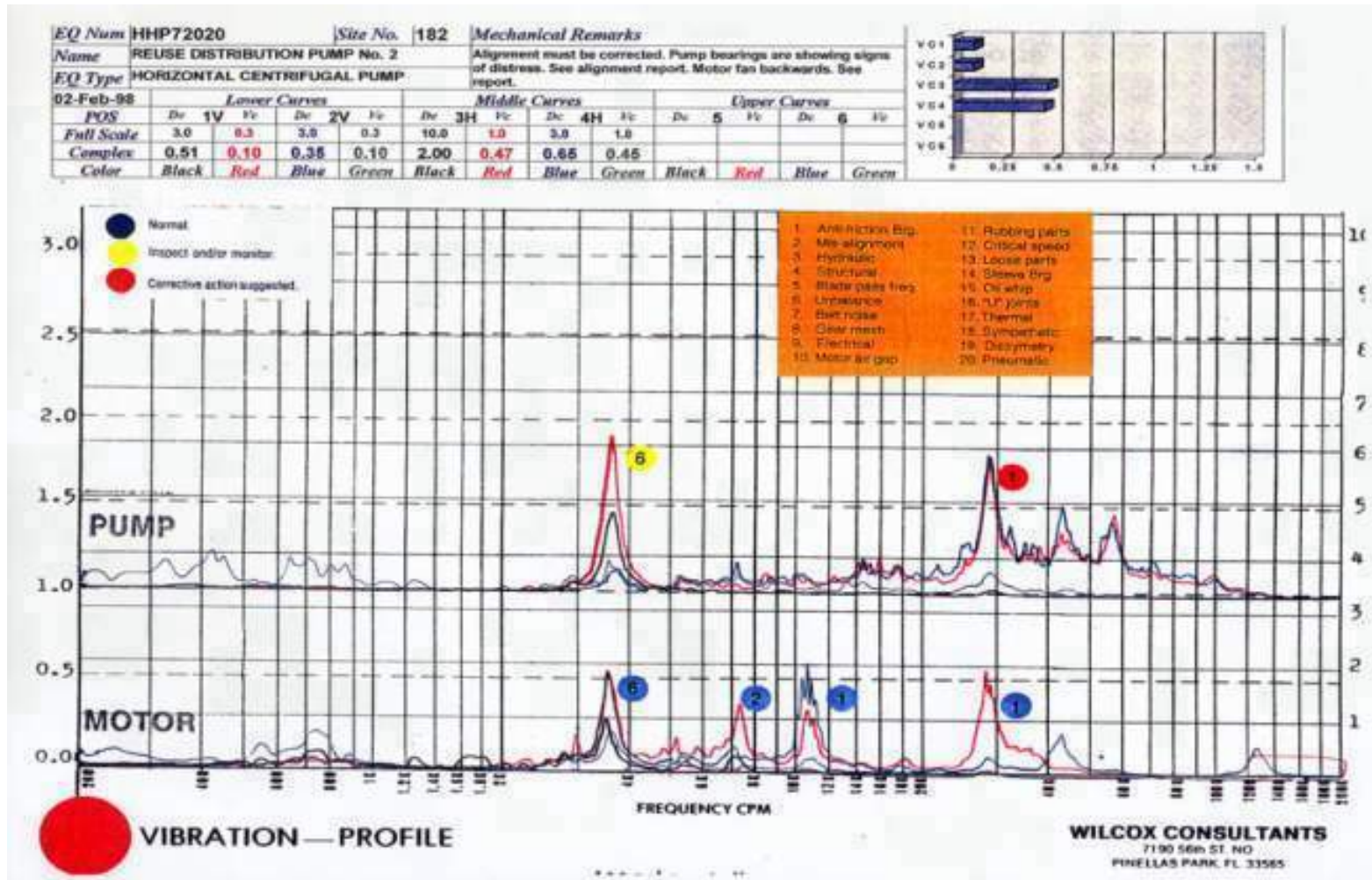


Can the progression of the failure be detected? Is there typically enough time to respond? Does consequence exceed cost of cure?

Cause and effect diagram—what to monitor



Condition-based maintenance: Vibration analysis



Power evaluation

Sample County - Waste Water Utilities Systems																
Sewage Lift Stations - Electrical Report - Data as Recorded, June, 1998																
Equip. Number	Voltage Line to Line			Amperage			Voltage Drops			Power Data				Horsepower and Load Percent		
	A to B	B to C	C to A	A	B	C	A	B	C	KVA	KVAR	KW	PF	Calc.	Rated	Percent
20LS-RSP-002	244.0	243.0	244.0	24.2	23.7	24.3	0.09	0.08	0.09	9.7	6.9	6.8	90.0	9.1	15.00	60.7
ABLS-RSP-001	474.0	473.0	475.0	24.1	25.1	25.7				17.5	2.8	17.2	98.7	23.1	25.00	92.4
ABLS-RSP-002	474.0	474.0	475.0	27.5	26.7	29.1				18.8	3.2	18.5	98.8	24.8	25.00	99.2
ABLS-RSP-003	474.0	475.0	475.0	25.4	25.8	29.5				17.8	2.9	17.6	98.7	23.6	25.00	94.4
BELS-RSP-001	239.0	240.0	242.0	59.8	52.6	65.7	0.19	0.19	0.18	23.9	12.7	20.3	84.9	27.2	25.00	108.8
BELS-RSP-002	240.0	242.0	240.0	50.5	51.3	55.4	0.16	0.16	0.18	21.5	13.6	16.7	77.6	22.4	25.00	69.8
BGLS-RSP-001	242.0	241.0	242.0	8.5	8.6	8.8	0.30	0.30	0.36	3.6	2.4	2.7	74.5	3.6	3.00	120.0
BGLS-RSP-002	242.0	241.0	242.0	9.4	9.3	9.6	0.24	0.18	0.17	3.9	2.1	3.3	84.2	4.4	3.00	146.7
BLLS-RSP-001	479.0	475.0	468.0	3.9	3.8	3.9	0.08	0.08	0.07	3.0	2.0	2.3	75.3	3.1	2.00	155.0
BLLS-RSP-002	482.0	483.0	485.0	4.0	3.9	4.0	0.08	0.08	0.13	3.1	2.1	2.3	73.9	3.1	2.00	165.0
CMLS-RSP-001	457.0	456.0	458.0	6.6	6.6	7.2	0.40	0.40	0.42	5.1	3.6	3.7	71.3	5.0	7.50	66.7
CMLS-RSP-002	457.0	458.0	458.0	6.0	6.0	6.1	0.27	0.27	0.63	4.7	3.8	2.7	58.0	3.6	7.50	48.0
DWLS-RSP-001	486.0	485.0	486.0	22.1	22.9	24.0	0.14	0.21	0.14	19.0	10.9	15.6	82.0	20.9	20.00	104.5
DWLS-RSP-002	486.0	486.0	485.0	21.3	22.0	22.8	0.18	0.14	0.15	18.3	10.7	14.8	81.1	19.8	20.00	99.0
FDLS-RSP-001	239.0	239.0	239.0	21.1	22.1	22.8	0.21	0.25	0.20	9.0	6.8	6.1	68.2	8.2	10.00	82.0
FDLS-RSP-002	240.0	239.0	240.0	23.9	24.0	25.6	0.26	0.26	0.31	10.0	7.0	7.1	70.9	9.5	10.00	95.0
FRLS-RSP-001	212.0	213.0	215.0	4.9	5.4	5.9	0.23	0.22	0.26	2.0	1.5	1.3	66.5	1.7	2.00	85.0
FRLS-RSP-002	212.0	213.0	215.0	5.2	5.8	6.1	0.25	0.25	0.27	2.1	1.5	1.4	70.0	1.8	2.00	95.0
FSLS-RSP-001	239.0	240.0	240.0	33.7	36.8	42.7	0.14	0.14	0.13	14.8	10.3	10.6	71.7	14.2	15.00	94.7
FSLS-RSP-002	239.0	239.0	240.0	31.4	34.7	39.5	0.17	0.16	0.19	13.9	10.7	8.9	63.9	11.9	15.00	79.3
H6LS-RSP-001	244.0	242.0	242.0	8.2	8.8	9.5	0.82	0.79	0.73	3.8	2.5	2.9	74.7	3.9	3.00	130.0
H6LS-RSP-002	242.0	242.0	241.0	10.2	9.5	10.0	0.49	0.81	0.60	4.1	2.9	2.9	70.8	3.9	3.00	130.0
HCLS-RSP-001	242.0	242.0	243.0	28.4	27.1	26.0	0.12	0.10	0.12	11.2	9.0	6.7	59.3	9.0	15.00	60.0
HCLS-RSP-002	243.0	242.0	243.0	28.3	28.9	25.8	0.12	0.11	0.12	11.2	8.8	7.1	63.6	9.5	15.00	63.3
HKLS-RSP-001	241.0	241.0	242.0	60.3	60.1	36.2	0.45	0.30	0.72	27.1	20.6	17.7	65.1	23.7	40.00	59.3
HKLS-RSP-002	240.0	241.0	241.0	62.4	63.2	65.0	0.23	0.36	0.69	26.6	15.8	21.3	60.2	28.6	40.00	71.5
HSLS-RSP-001	208.0	208.0	208.0	240.3	26.2	28.1	0.19	0.19	0.28	9.0	5.8	6.9	76.5	9.2	10.00	92.0
HSLS-RSP-002	208.0	208.0	208.0	24.1	26.4	27.7	0.17	0.16	0.20	9.0	5.7	6.7	77.4	9.0	10.00	80.0
JHLS-RSP-001	244.0	243.0	243.0	50.9	52.4	51.6	0.21	0.69	0.19	21.4	15.4	14.9	69.6	20.0		
JHLS-RSP-002	245.0	244.0	245.0	44.1	42.9	45.1	0.36	0.54	0.32	18.4	12.7	13.4	72.7	18.0		
MWLS-RSP-001	241.0	240.0	241.0	11.0	11.6	12.4	0.19	0.13	0.14	4.7	2.5	4.0	84.8	5.4	7.50	72.0

Prepared by Wilcox Consulting Inc. - Madeira Beach Office - 11/8/00

Page 1

Most condition indicators are not visible to the unaided eye

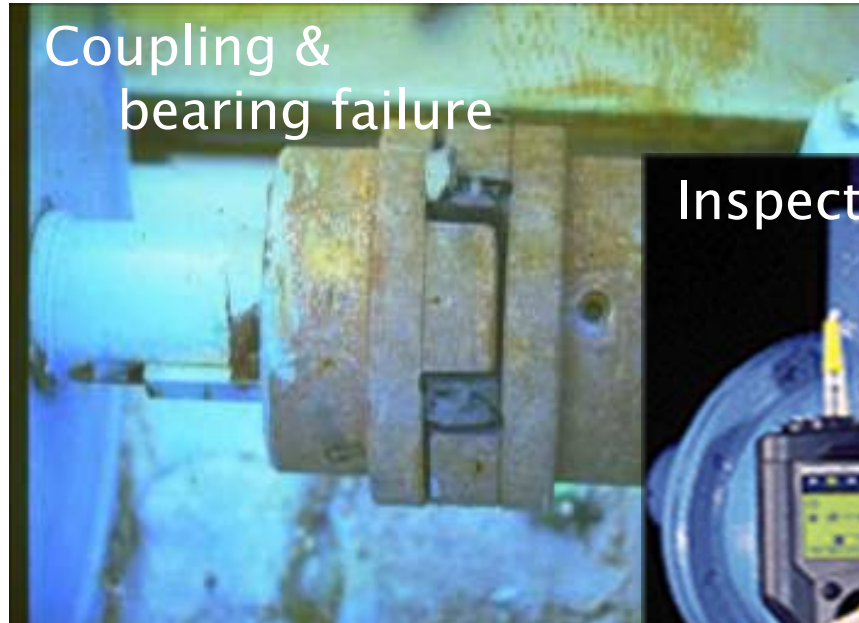
Visual inspection



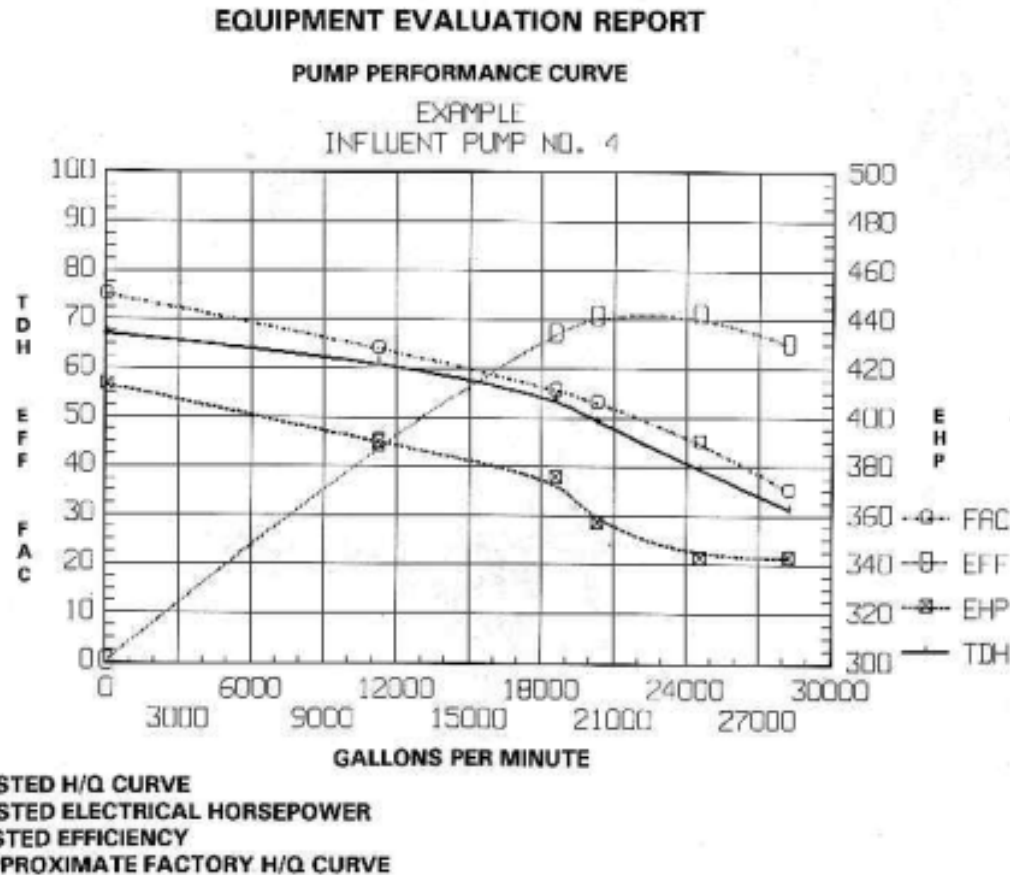
Infrared view



Alignment of inspection and correction data




Baseline machine performance tests



Baseline at handover sets life cycle benchmark. Conforms to factory test curves?

Status sheet (summary)

EQUIPMENT STATUS SHEET
CITY OF ** OMITTED **, FLORIDA



SITE NO. 192 REUSE DISTRIBUTION PUMP No. 2 UNIT 2
EQUIP. NO. HEP 72020 GROUP NO. HCP DATE: 02/02/98

DRIVER				DRIVEN			
MANUFACTURER	D. S. ELECTRIC MOTORS	MANUFACTURER	PAISHANKS MORSE	MODEL	44KA		
WATTS/HP	325.60	SIZE		TYPE/RATIO			
RPM	3570	H/Q		RPM			
VOLTAGE	460	SERIAL NO.	002206-0				
AMPERAGE	145	MODEL NO.					
PHASE/CT	3 / 40						
TYPE/FRAME	TCL / 444 TS						
SERIAL NO.	A0425201300-2						
MODEL NO.	H12217, BEARINGS: 6313						

VOLTS A-E	465.0	AMPS A	120.2	V DROP A	0.05	KW	92.5	KVAR	23.0
VOLTS B-C	477.0	AMPS B	130.1	V DROP B	0.05	KVA	94.6	PF	97.8
VOLTS C-A	481.0	AMPS C	133.4	V DROP C	0.05	% I.D.	99.2	LHP	124.0

ELECT. REMARKS: All thermal and electrical conditions are normal. There are no apparent thermal anomalies. The electrical load is satisfactory.

10c	15c	20c	25c	30c	35c	40c	45c	50c	55c	60c	65c
0.51	0.10	0.75	0.10	2.00	0.47	0.65	0.45				

MECHAN. REMARKS: Alignment must be corrected. Pump bearings are showing signs of distress. See alignment report. Motor fan backwards. See report.

ALIGNMENT: MAXIMUM RADIAL = 0.2 MAXIMUM PARALLEL = 42.2
COORDS: VTS R SLE R SHM S A/G R P/Y R OIL R OVERALL R

Overall condition

Picture of machine

Description

All nameplate data

Electrical data

Vibration data

Alignment data

Equipment status list

Severity color code

EQUIPMENT SUMMARY REPORT - STATUS LIST
June, 1998

Equipment Number	Site Number	Overall	Vibration	Electrical	Thermo-graphy	Alignment	Physical	Oil
LOCEQ	SITENO	GACC	VIBC	ELEC	THRC	ALGC	PHYC	OILC
20LS-RSP-001	113A	G	N	N	N	N	R	N
20LS-RSP-002	113B	Y	Y	B	B	N	B	N
ABLS-RSP-001	101A	Y	B	B	B	N	B	N
ABLS-RSP-002	101B	Y	Y	B	B	N	B	N
ABLS-RSP-003	101C	Y	B	N	N	N	R	N
ABTP-ADU-001	201	B	B	Y	B	N	B	B
ABTP-ADU-002	202	Y	N	N	N	N	B	B
ABTP-ADU-003	203	B	N	N	N	N	B	B
ABTP-ADU-004	204	R	N	N	N	N	B	B
ABTP-BC1-001	205	R	N	N	N	N	B	R
ABTP-BC1-002	206	R	N	B	B	N	B	R
ABTP-BC1-002	207	R	B	B	B	N	B	R
ABTP-MAC-001	225	N	B	B	B	N	B	N
ABTP-PFP-001	226	N	B	B	B	N	B	N
ABTP-SFP-001	223	N	N	N	N	N	N	N
ABTP-SFP-002	227	N	N	Y	B	N	Y	N
ABTP-SFP-002	224	N	R	R	B	N	R	N
ABTP-TBF-001	211	N	N	B	B	N	B	N
ABTP-TBF-002	212	N	N	B	B	N	B	N
ABTP-TBF-003	213	N	B	B	Y	N	B	N
ABTP-TBF-004	214	N	N	B	B	N	B	N
ABTP-TBF-005	215	N	Y	Y	B	N	Y	N
ABTP-TBF-006	216	N	N	Y	B	N	Y	N
ABTP-THK-001	220	R	N	N	N	N	N	R
ABTP-THK-002	221	B	B	R	R	N	R	N

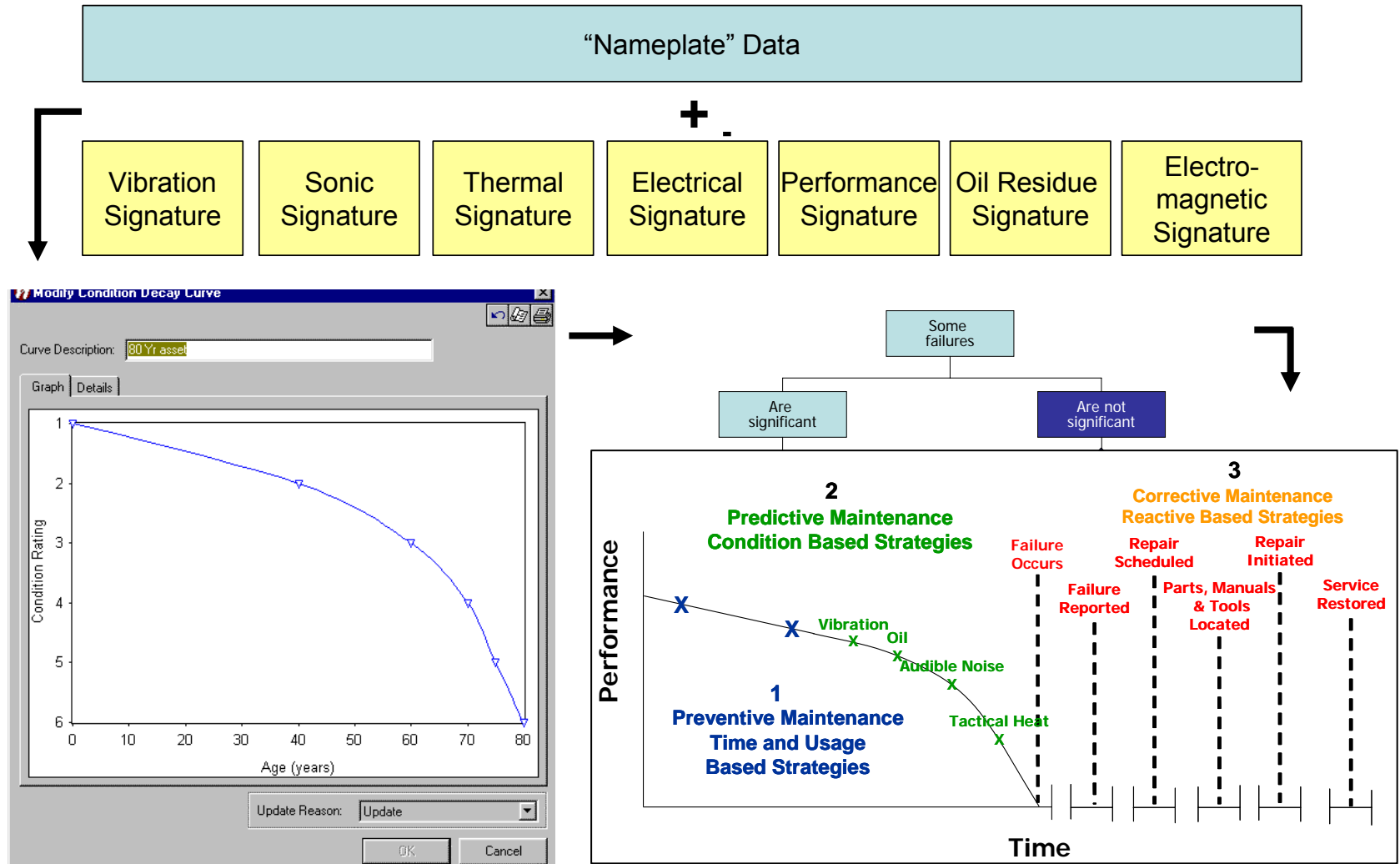
Failure codes

- Use cause-effect diagrams to create codes
- Define codes by class of asset
- Use “drop-down” list

Failure Code

- Coupling failure
- Lube fault
- Misaligned
- Operator error
- Overloaded
- Water damage
- Worn

Condition-based maintenance



Toward a maintenance strategy business case

Table 6.6
Mitigation Strategies: Reuse Scheme Only Failure Modes

	Maintenance Scenario A		Maintenance Scenario B		Maintenance Scenario C	
Maintenance Budget	Maintenance Budget \$15,000		Maintenance Budget \$7,000		Maintenance Budget \$3,500	
Probability Improvement cause by maintenance	0.5 Reduction		Same Probability		1.3 Increase	
System / sub-system / component	<i>Improved Probability of Failure</i>	<i>Business Risk Exposure (\$)</i>	<i>Improved Probability of Failure</i>	<i>Business Risk Exposure (\$)</i>	<i>Improved Probability of Failure</i>	<i>Business Risk Exposure (\$)</i>
Delivery Channel	0.010	\$ 302	0.010	\$ 302	0.010	\$ 302
Pump Station						
1 pump fails	0.150	\$ 648	0.300	\$ 1,296	0.390	\$ 1,685
2 pumps fail	0.050	\$ 684	0.100	\$ 1,368	0.130	\$ 1,778
3 pumps fail	0.025	\$ 761	0.050	\$ 1,523	0.065	\$ 1,980
All pumps fail	0.005	\$ 302	0.010	\$ 605	0.013	\$ 786
Control System						
Power supply / sub-station	0.050	\$ 1,512	0.050	\$ 1,512	0.050	\$ 1,512
Rising Main						
Pressure or pipe deflection	0.030	\$ 907	0.030	\$ 907	0.030	\$ 907
Adjacent construction work	0.050	\$ 1,512	0.050	\$ 1,512	0.050	\$ 1,512
Massive earth movement	0.050	\$ 2,268	0.050	\$ 2,268	0.050	\$ 2,268
Ground movement	0.050	\$ 2,268	0.050	\$ 2,268	0.050	\$ 2,268
HOR Storage						
HORS structure	0.050	\$ 1,368	0.050	\$ 1,368	0.050	\$ 1,368
Variable Gate - Outlet 5W	0.050	\$ 342	0.100	\$ 684	0.130	\$ 889
Variable Gate - Outlet to eastern carrier	0.050	\$ 342	0.100	\$ 684	0.130	\$ 889
Penstocks - Actuator Fail	0.050	\$ 342	0.100	\$ 684	0.130	\$ 889
Penstocks - Manual Override	0.050	\$ 342	0.100	\$ 684	0.130	\$ 889
External Factors						
Power Failure	0.200	\$ 3,024	0.200	\$ 3,024	0.200	\$ 3,024
Total		\$ 16,925		\$ 20,689		\$ 22,947
Sum of Maximum Value		\$ 8,474		\$ 8,485		\$ 8,942

Conclusion

Justifiable maintenance between \$1,500 and \$3,500 per annum.

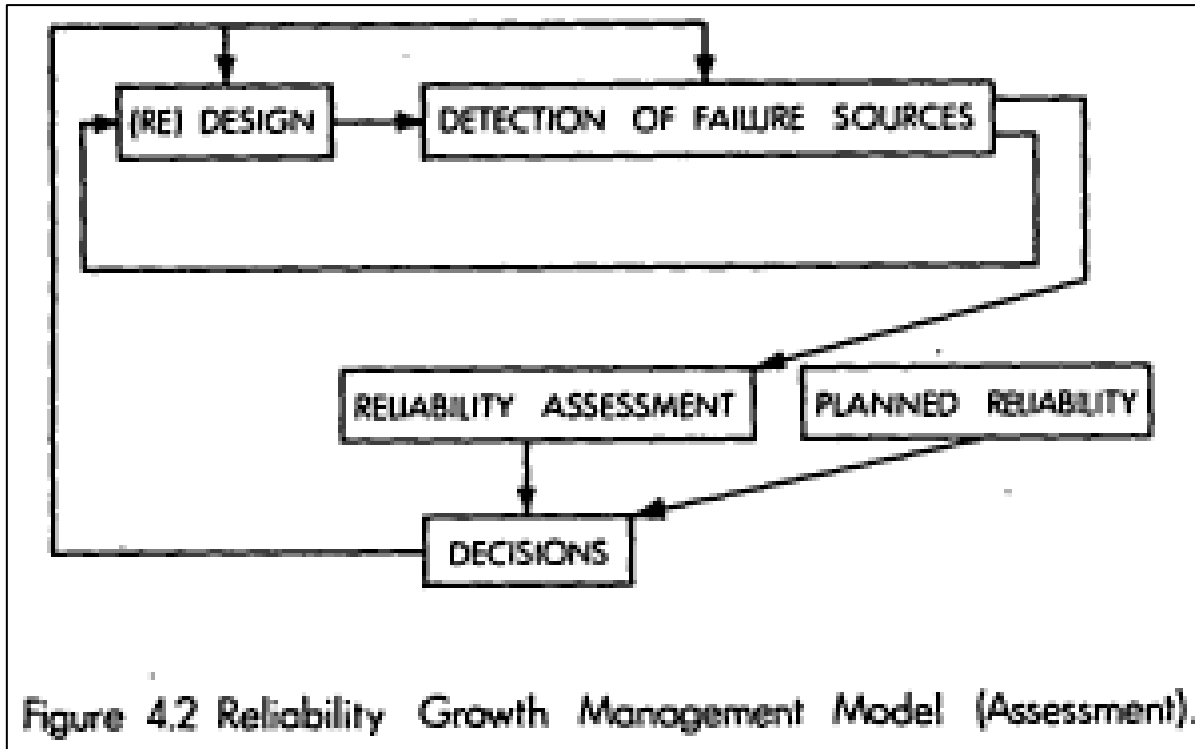
Major components of asset data

Used to *create an asset ID*...

- Physical attributes
- Geo-reference
- O&M manuals
- Drawings and photos
- Life cycle costs
- Knowledge and strategy

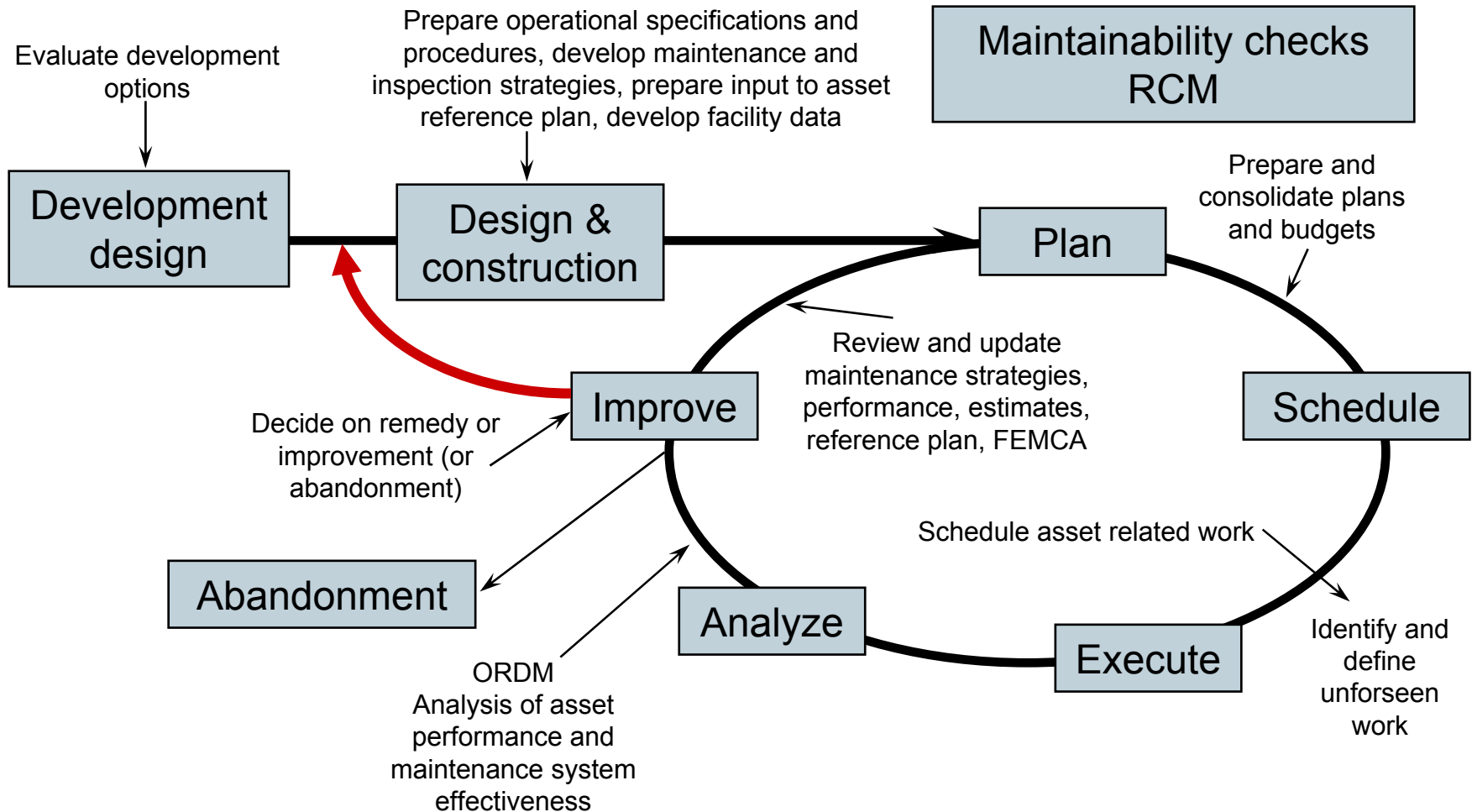
Primary Cost Unit	Minor code	Number of Units	\$/Unit	Allocated Cost
Direct Labor				
	Direct Pay	2.5 hours	\$42.00	\$105.00
	Overhead			
	Benefit Burden			
	FICA, etc			
Materials				
	Vehicle			
	Pipe			

Tying together failure, reliability, and design



Military Handbook 189, Reliability Growth Management 1981

Linking maintenance and design



Key points from this session

Given my system, what are my best O&M strategies?

Key Points:

- Reactive emergency maintenance can be the most expensive type of maintenance and should typically make up no more than 20% to 25% of total maintenance effort
- Preventive and predictive-based pro-active strategies should comprise the bulk of the effort
- Assets, especially dynamic assets, leave discernable clues as to their capacity to perform.
- The most cost effective maintenance strategy for a given asset is determined by the likelihood of failure and the consequence of failure.
- “Run to failure” may well be the most cost-effective maintenance strategy for a given asset, but only when coupled with a carefully developed failure response plan.

Associated Techniques:

- Condition-based monitoring plans and deployment
- Reliability Centered Management
- Root cause analysis
- Asset maintenance strategies (zero breakdown, total productivity, reliability centered maintenance)
- Failure response plans

Tom's spreadsheet

Microsoft Excel - EPA Seminar Master.xls

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Asset Register and Hierarchy					What is the State of My Assets?			Required LOS?		Which Are Most "Critical"?		
Installed Date	Asset Class	Original Cost	Estimated Effective Life	Condition Rating	Annual Dep	Accum Dep	Current LOS?	Minimum Condition	Backup Reduction (Redundancy)	Probability of Failure	Consequence of Failure	
Year		\$	Years	1 to 10	\$	\$			%	Rating	1 to 10	
Act or Est	Tab A	Act or Est	Calculated	Tab A	Calculated	Calculated		Tab A	Tab D	Calculated	Tab C	
Sanitation System												
Disposal System												
Treatment Plants												
Collection Systems												
Sever Mains												
Pump Station												
Incoming Sewer												
Pipes									Avg 1500 cfm; peak 2100cfm			
1963	3	\$ 1,725	100	6	\$ 17	\$ 742		2	0%	4	5	
Manhole												
1963	3	\$ 340	100	5	\$ 3	\$ 146		2	0%	4	5	
Influent Gate Valve												
1986	5	\$ 442	30	8	\$ 15	\$ 235		2	0%	7	5	
Incoming Power												
Pole & Transformer									20 kw peak			
2006	4	\$ -	40	1	\$ -	\$ -		2	0%	0	5	
Connection												
2006	7	\$ -	35	1	\$ -	\$ -		2	0%	0	5	
Control system												
Incoming Telephone												
1985	8	\$ 85	25	7	\$ 3	\$ 71		2	0%	8	2	
PLC												
1983	8	\$ 8,600	25	8	\$ 344	\$ 7,912		2	0%	9	2	
Manual controls												
1978	8	\$ 425	25	7	\$ 17	\$ 476		2	50%	5	2	
Land & Improvements												
Land												
1950	10	\$ 630	300	1	\$ 2	\$ 118		4	0%	2	1	
Access Road												
1963	1	\$ 12,500	75	5	\$ 167	\$ 7,167		4	0%	6	1	
Landscaping												
2000	1	\$ 595	75	6	\$ 8	\$ 48		3	0%	1	1	
Security fence												
1963	1	\$ 1,360	75	7	\$ 18	\$ 780		2	0%	6	3	
Sub Structure												
Cassion Outer												
1963	1	\$ 30,600	75	6	\$ 408	\$ 17,544		3	0%	6	4	
Upper Floor												
1963	1	\$ 4,250	75	6	\$ 57	\$ 2,437		3	0%	6	4	
Dry well												
1963	1	\$ 6,800	75	6	\$ 91	\$ 3,899		3	0%	6	4	
Landings and Stairs												
1963	9	\$ 4,250	60	7	\$ 71	\$ 3,046		2	0%	7	4	
Wet Well												
1963	1	\$ 5,100	75	6	\$ 68	\$ 2,924		3	0%	6	4	
Shaped floor												
1963	1	\$ 850	75	6	\$ 11	\$ 487		3	0%	6	3	
Sump pump												
1963	4	\$ 595	40	6	\$ 15	\$ 640		2	0%	10	4	
Pumps												
Drive shafts												
2006	6	\$ 12,560	35	1	\$ 359	\$ -		2	TBD	10	TBD	
Pumps												
2006	4	\$ 29,750	40	1	\$ 744	\$ -		2	TBD	10	TBD	

Ready

start Modules 2 Duncan Rose - Inbox ... Webpage has expire...

EPA 0 Overview.ppt Day 1.EPA.Revised.ppt Microsoft Excel - EPA ...

10:43 AM Tuesday 4/10/2007