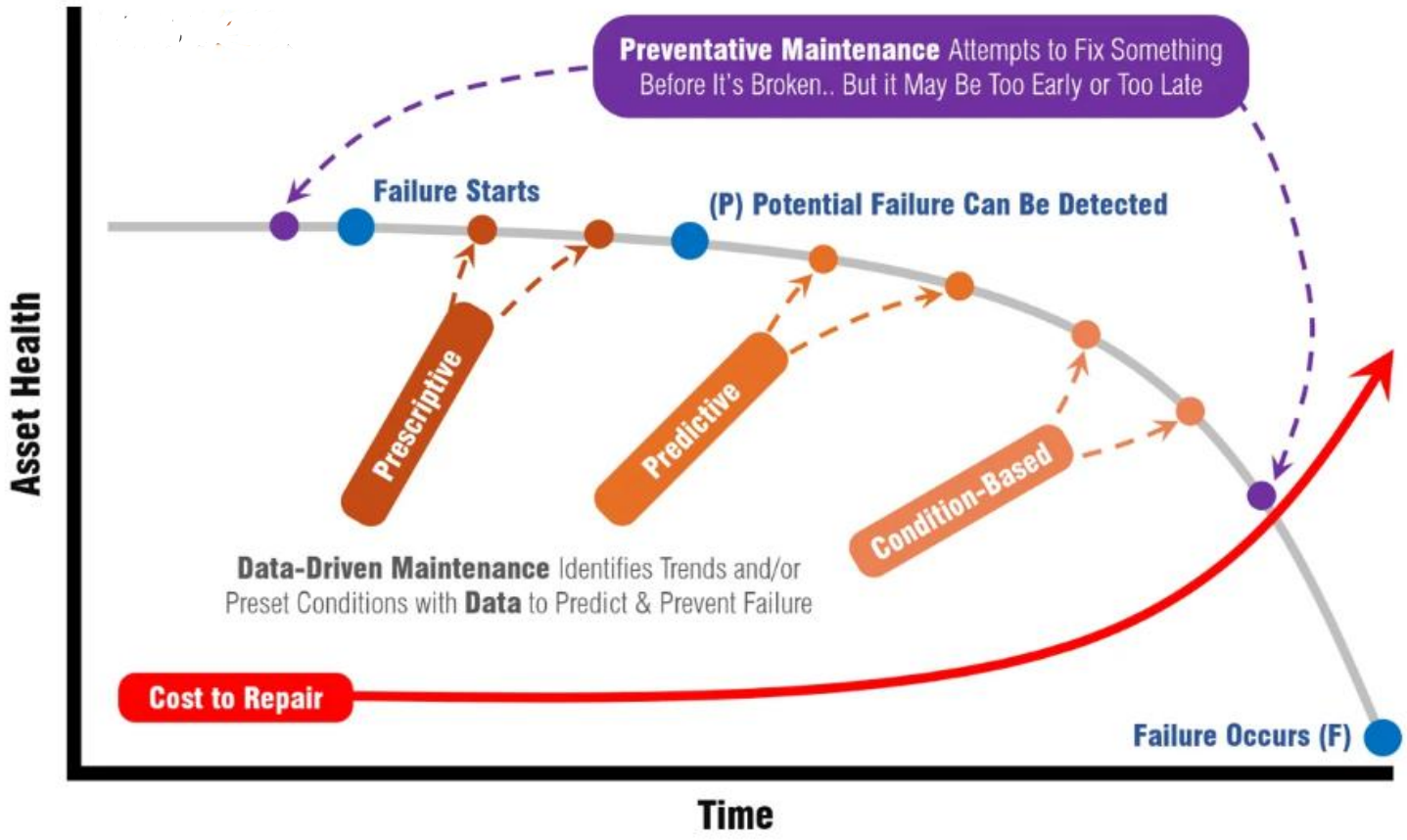
Asset Maintenance

Maintenance

- Reactive
- Preventive
- Condition-based
- Predictive
- Prescriptive



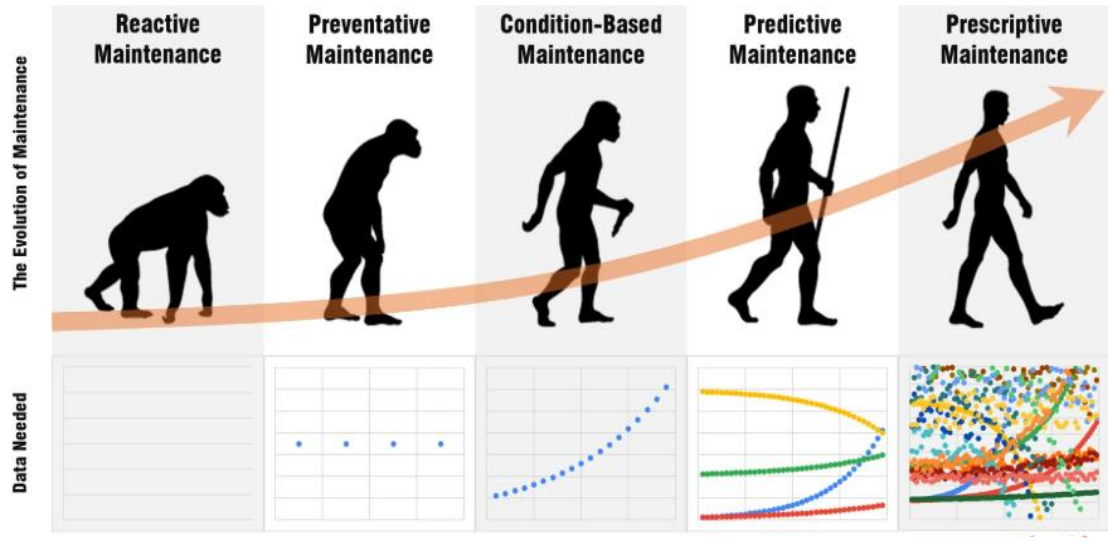
Reactive maintenance waits for the system to experience a functional failure before maintenance occurs, so this doesn't even appear on the P-F curve.

Preventative maintenance performs maintenance on some fixed schedule ideally aligned to be slightly shorter than the typical P-F interval for a particular machine. This will ideally let it catch a system while it is in the middle of the curve. The trouble is that the equipment may deteriorate too fast for the preventative maintenance schedule to correct it in time. Or, the preventative maintenance may be wasteful if it is "fixing" a perfectly fine piece of equipment.

Condition-based maintenance uses sensors and data with preset conditions or thresholds that when met will signal maintenance is needed. The trouble is that this requires a fairly noticeable amount of degradation to have taken place in order to hit these thresholds.

Predictive maintenance uses sensors and data to detect trends in the health of a system and predict when failure will occur. This allows it to detect the deterioration of a machine earlier than CBM and allows maintenance teams more time to schedule maintenance at a convenient time, knowing when the PdM predicted failure to occur.

Prescriptive Maintenance uses sensors, data, and advanced analytics to determine the route cause of a potential failure so specific corrective action can be prescribed. The advanced data and analytics needed for successful prescriptive maintenance also ensures the potential failure is identified even earlier which makes fixing the problem easier and less expensive.



Data-driven maintenance

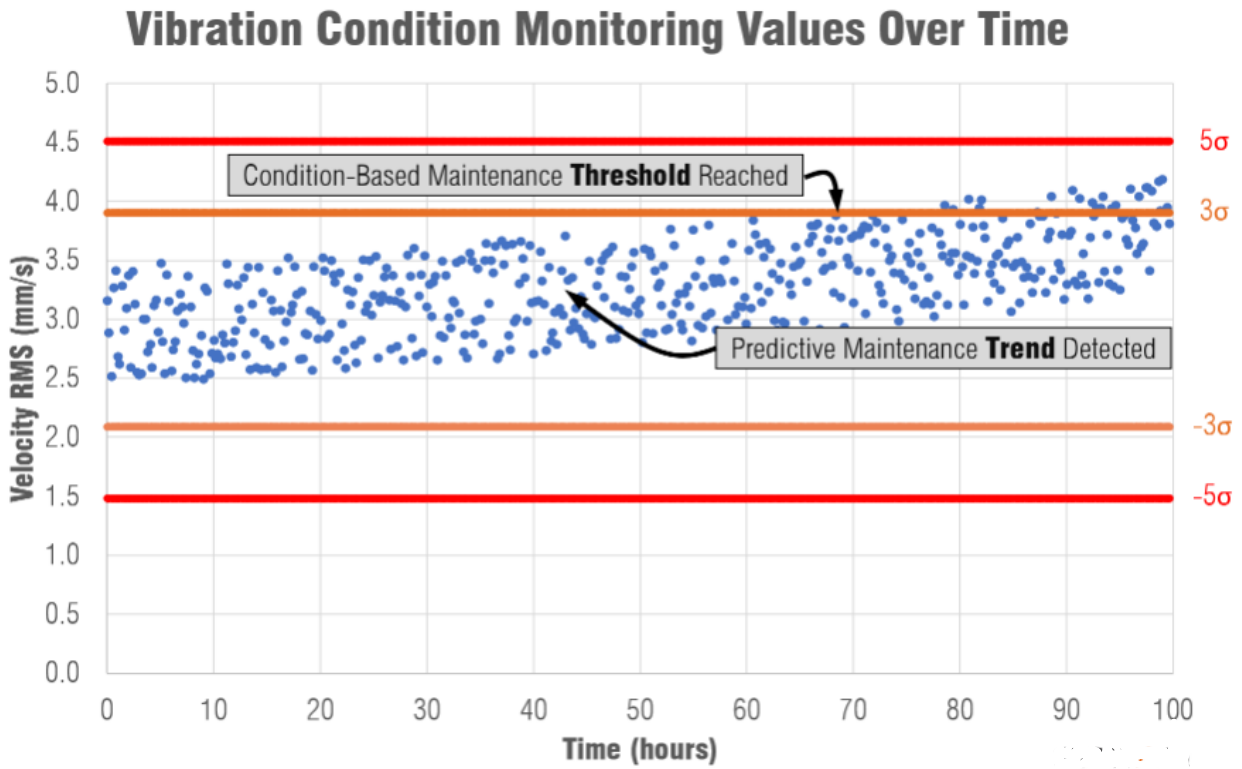
Condition-based maintenance will typically look at a single metric and check against preset thresholds.

Predictive maintenance typically looks at a handful of data sets and relies on slightly better analytics to pick up on various trends in the data and the health of the asset.

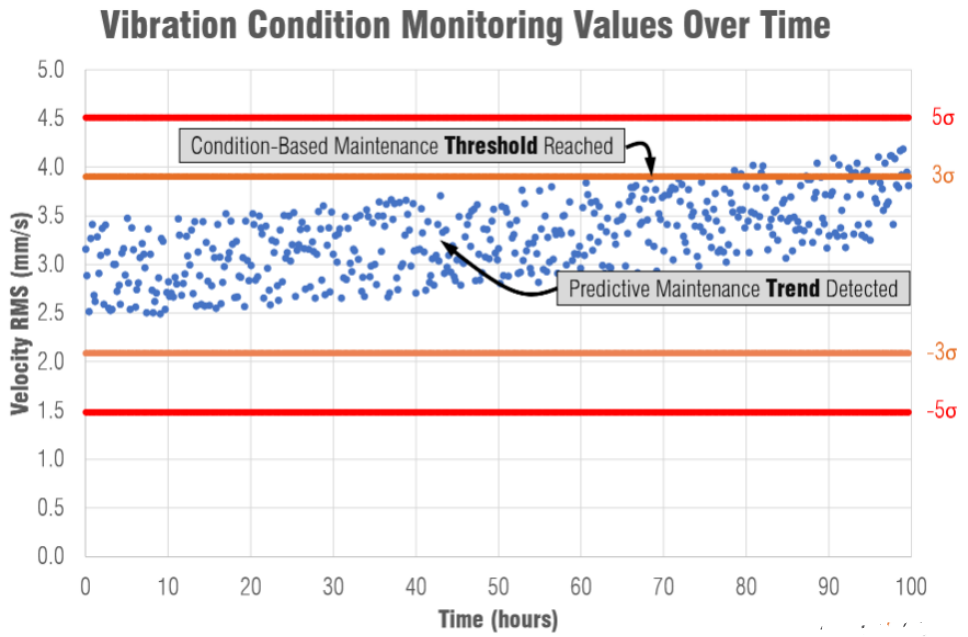
Prescriptive maintenance uses many data sets and metrics and likely some proprietary analysis techniques to determine the root cause of a potential failure.

Condition-based Maintenance

1. Establishing a baseline of a known good or healthy machine
2. Calculate a normal distribution of the data taken
3. Set warning levels at +/- 3 standard deviations and then alarms at +/- 5 standard deviations off the baseline levels

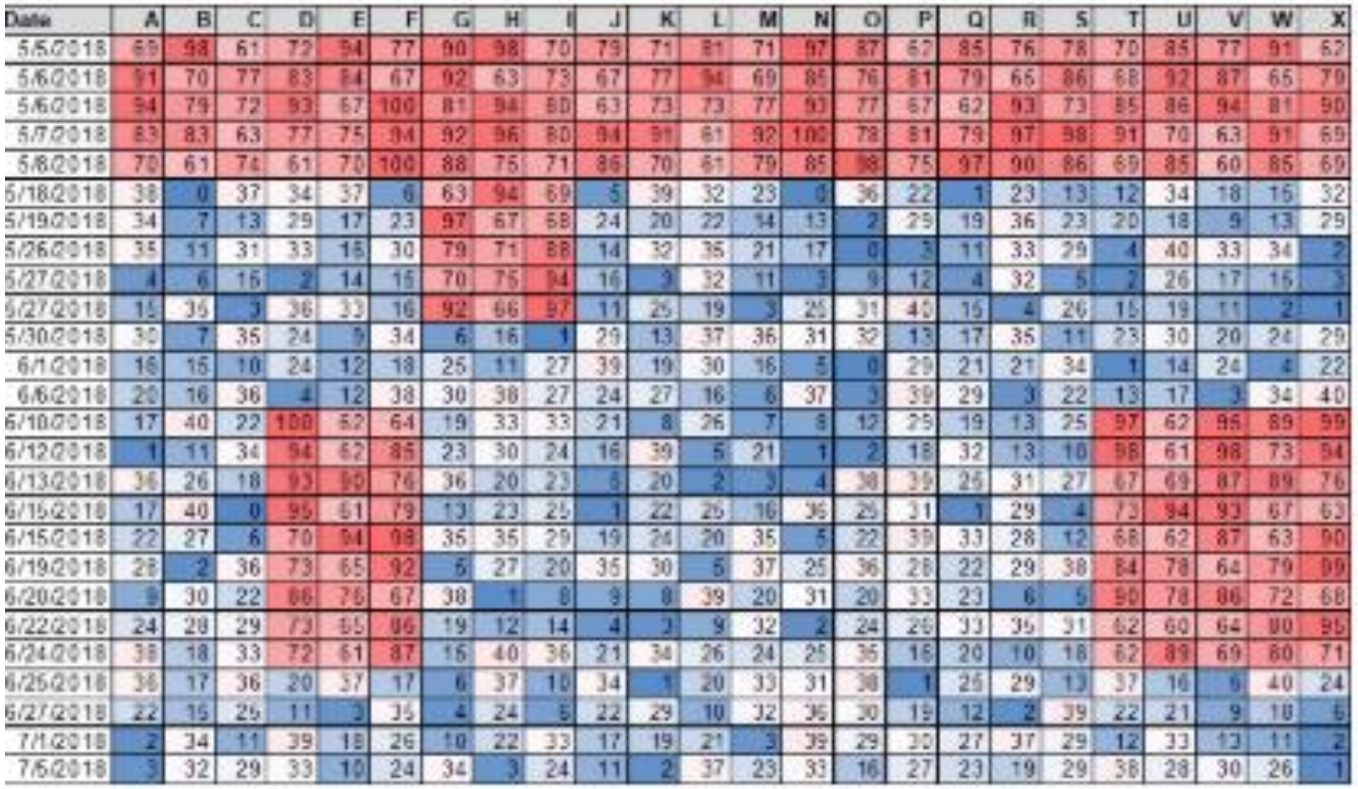


Predictive Maintenance



In the example above about condition-based maintenance, **there was clearly a trend in the data before it reached the warning level**. This trend is exactly what a more advanced algorithm would be able to detect and is more accurately considered "predictive." Predictive would then go that added step further and predict how much usable time remains in the asset to schedule maintenance -- it ***predicts when*** failure will occur.

Prescriptive Maintenance



Date	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X
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5/6/2018	91	70	77	83	84	67	92	63	73	67	77	94	69	85	76	81	79	65	86	68	92	87	65	79
5/6/2018	94	79	72	93	67	100	81	94	80	63	73	73	77	93	77	67	62	93	73	85	86	94	81	90
5/7/2018	83	83	63	77	75	94	92	96	80	94	91	61	92	100	78	81	79	97	98	91	70	63	91	69
5/8/2018	70	61	74	61	70	100	88	75	71	86	70	61	79	85	88	75	97	90	86	69	85	60	85	69
5/18/2018	38	0	37	34	37	6	63	94	69	5	39	32	23	0	36	22	1	23	13	12	34	18	15	32
5/19/2018	34	7	13	29	17	23	97	67	68	24	20	22	14	13	2	29	19	36	23	20	18	9	13	29
5/26/2018	35	11	31	33	15	30	79	71	88	14	32	35	21	17	0	3	11	33	29	4	40	33	34	2
5/27/2018	4	6	15	2	14	15	70	75	94	16	3	32	11	3	9	12	4	32	5	2	26	17	15	3
5/27/2018	15	35	3	36	33	16	92	66	97	11	25	19	3	25	31	40	15	4	20	15	19	11	2	1
5/30/2018	30	7	35	24	5	34	6	16	1	29	13	37	36	31	32	13	17	35	11	23	30	20	24	29
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6/12/2018	1	11	34	94	62	85	23	30	24	16	39	5	21	1	2	18	32	13	10	98	61	98	73	94
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6/15/2018	22	27	6	70	94	98	35	35	29	19	24	20	35	5	22	39	33	28	12	68	62	87	63	90
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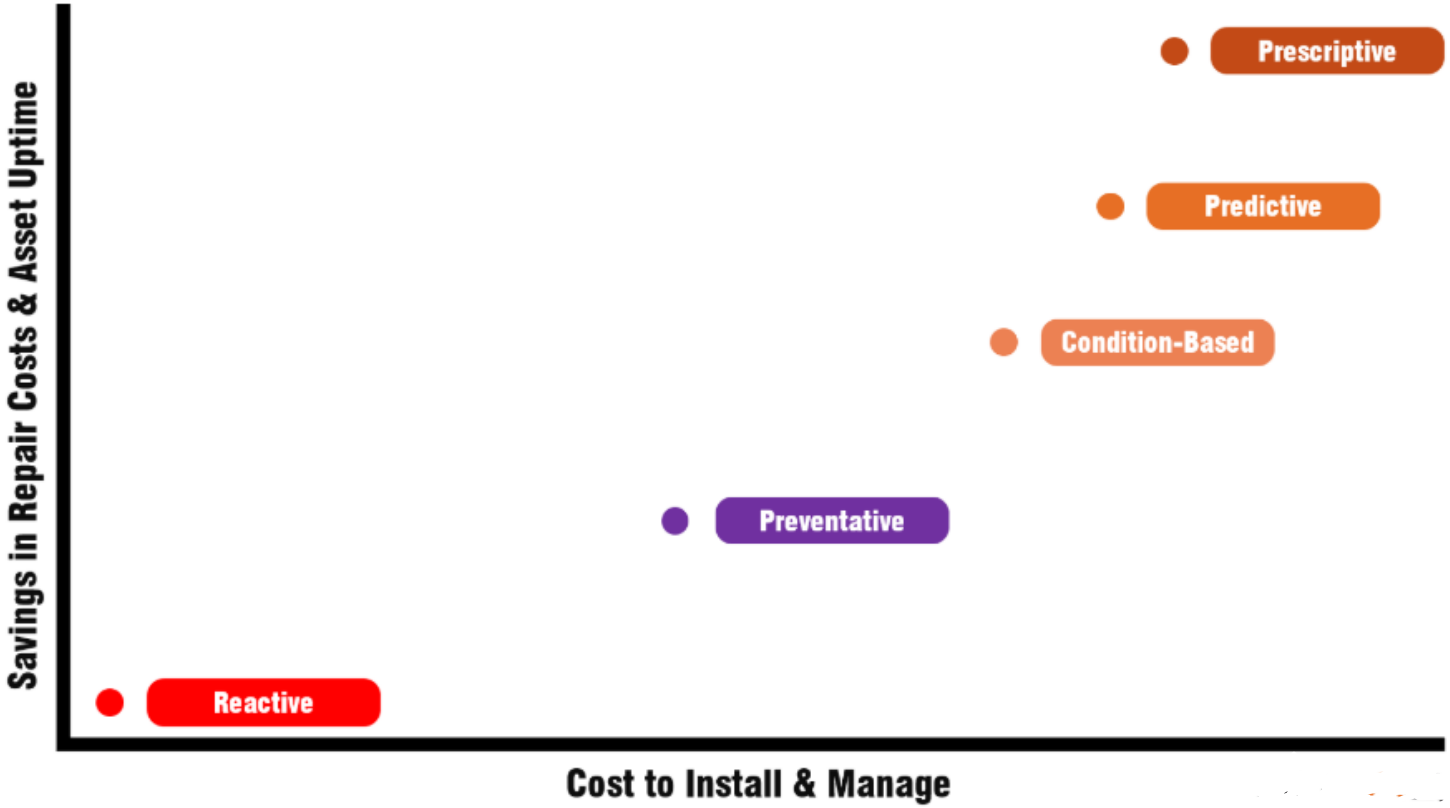
Single Pressure Trace Per Flight Used to Determine Health of Over 20 Subsystems

Cost of & Return on Investment



Maintenance Strategy based on Asset Type