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IN THE ARAB COUNTRIES

UNDER THE THEME
"MANAGING MAINTENANCE WITHIN INDUSTRY 4.0"
CONICIDE WITH THE 16TH ARAB MAINTENANCE EXHIBITION

Verifying Your Condition Monitoring Programs

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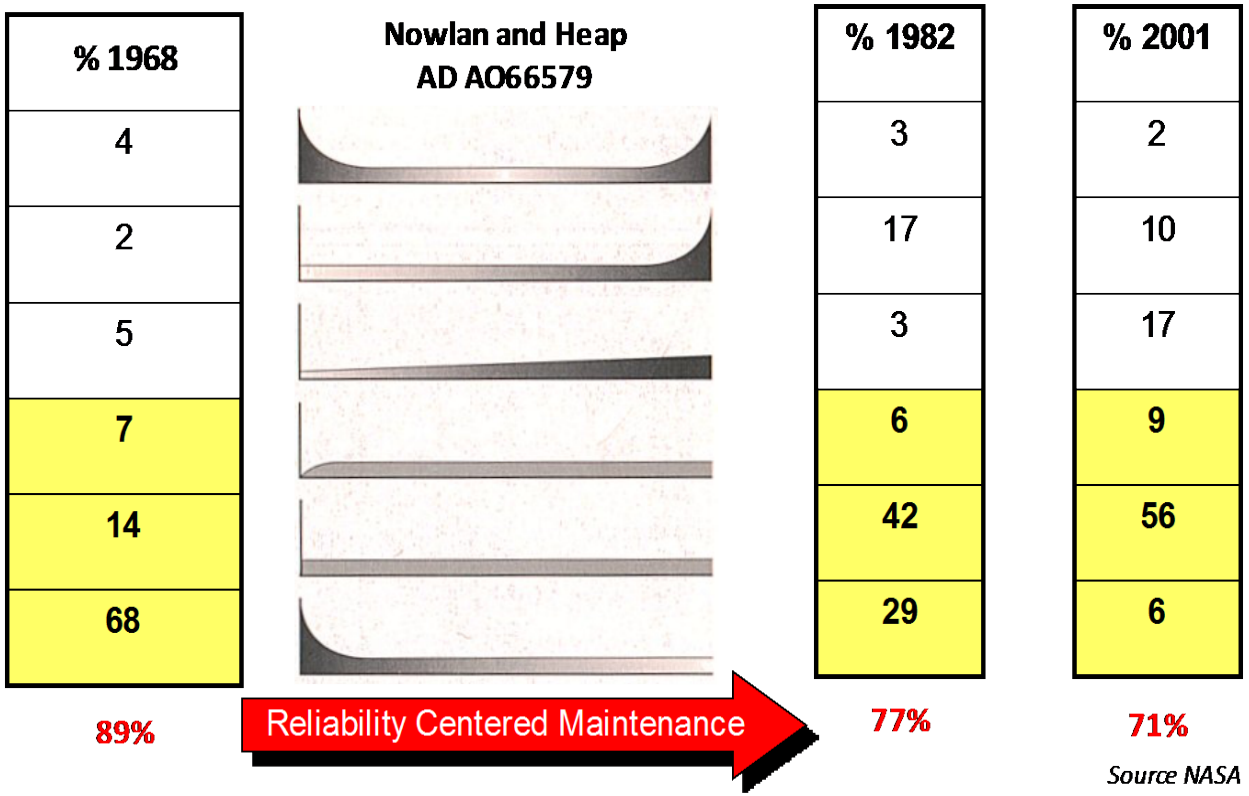
Coverage

- Role of preventive maintenance programs
  - Purpose of the condition monitoring program
- The condition monitoring process model
  - Why this model is so important
- Setting Condition Based Maintenance Task Periods
  - A verified risk based formula from MIL-STD-2173
  - Issues of sensitivity and data accuracy
- A solution to resolving data measurement
  - Role of James T Reasons work in assessing human error/violation
- A case study of outcomes achieved
- Summary

1978 Reliability Centered Maintenance Report

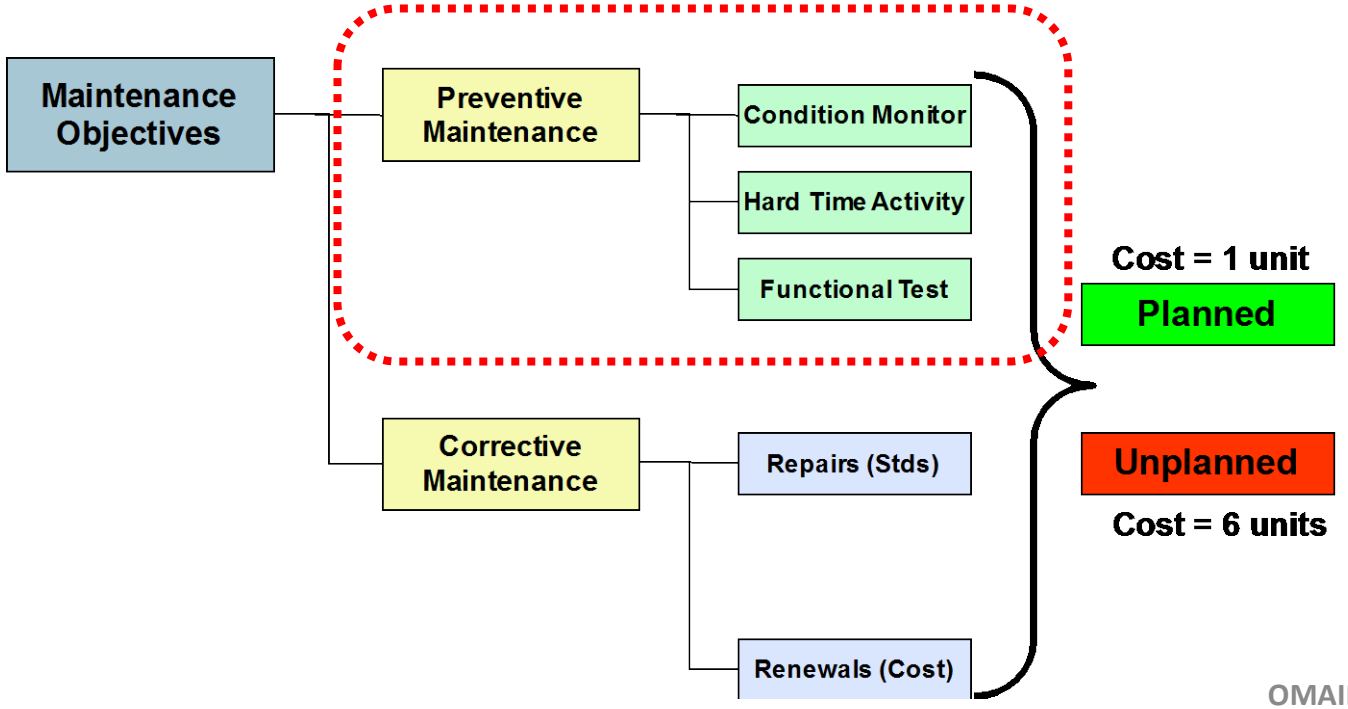
The 1978 Nowlan and Heap Report for US DoD titled reliability centered maintenance noted:

- Most equipment had and still has a random failure pattern characteristic
- Condition monitoring is considered the best solution



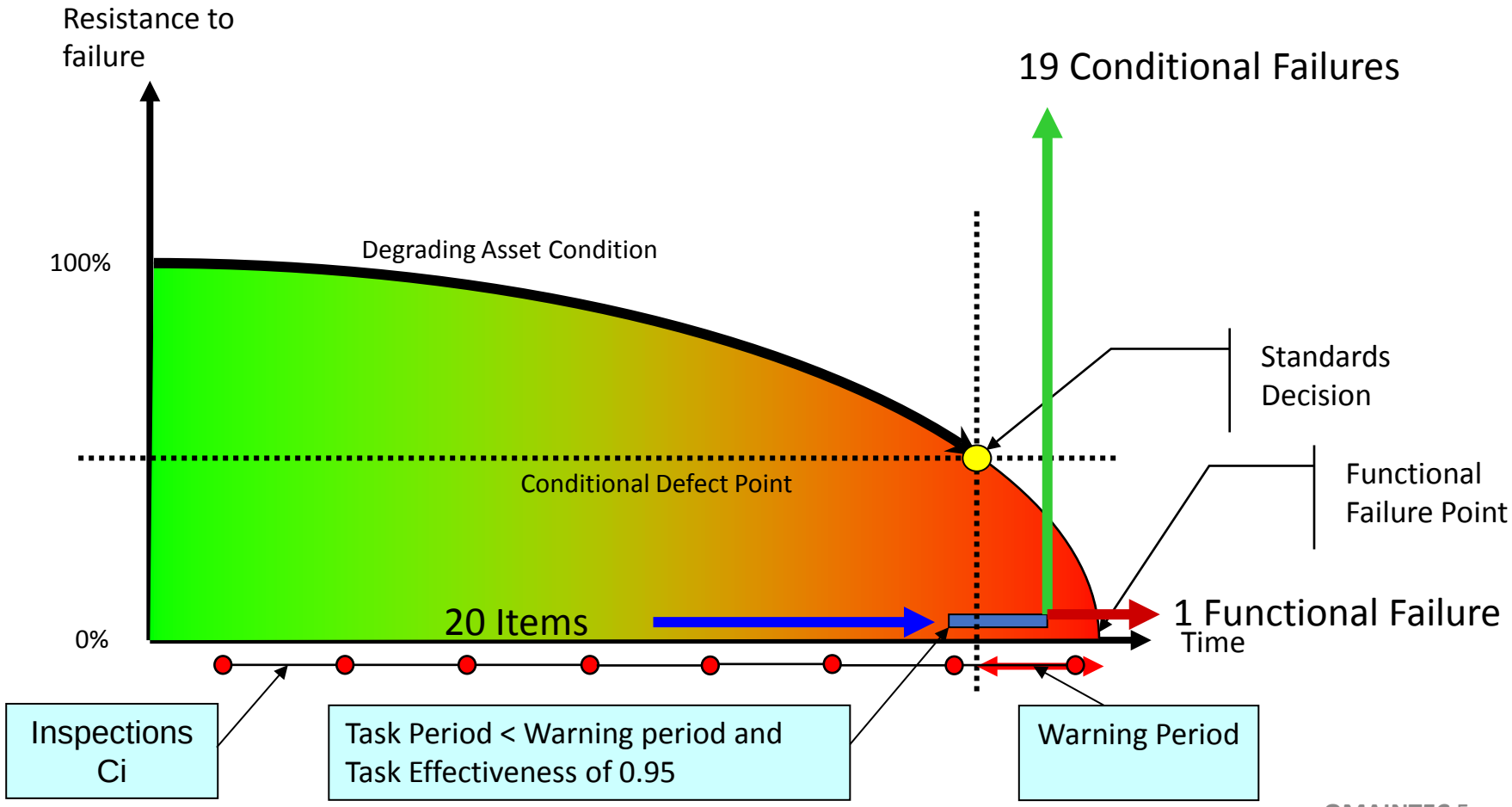
AM Council – Types of maintenance

- Maintenance is all activities necessary to retain an item in or return it to a serviceable condition
- Maintenance types were derived from the Nowlan and Heap report
- Role of preventive maintenance programs is to achieve inherent/desired levels of safety and reliability designed into the equipment.



Condition Monitoring Process Model

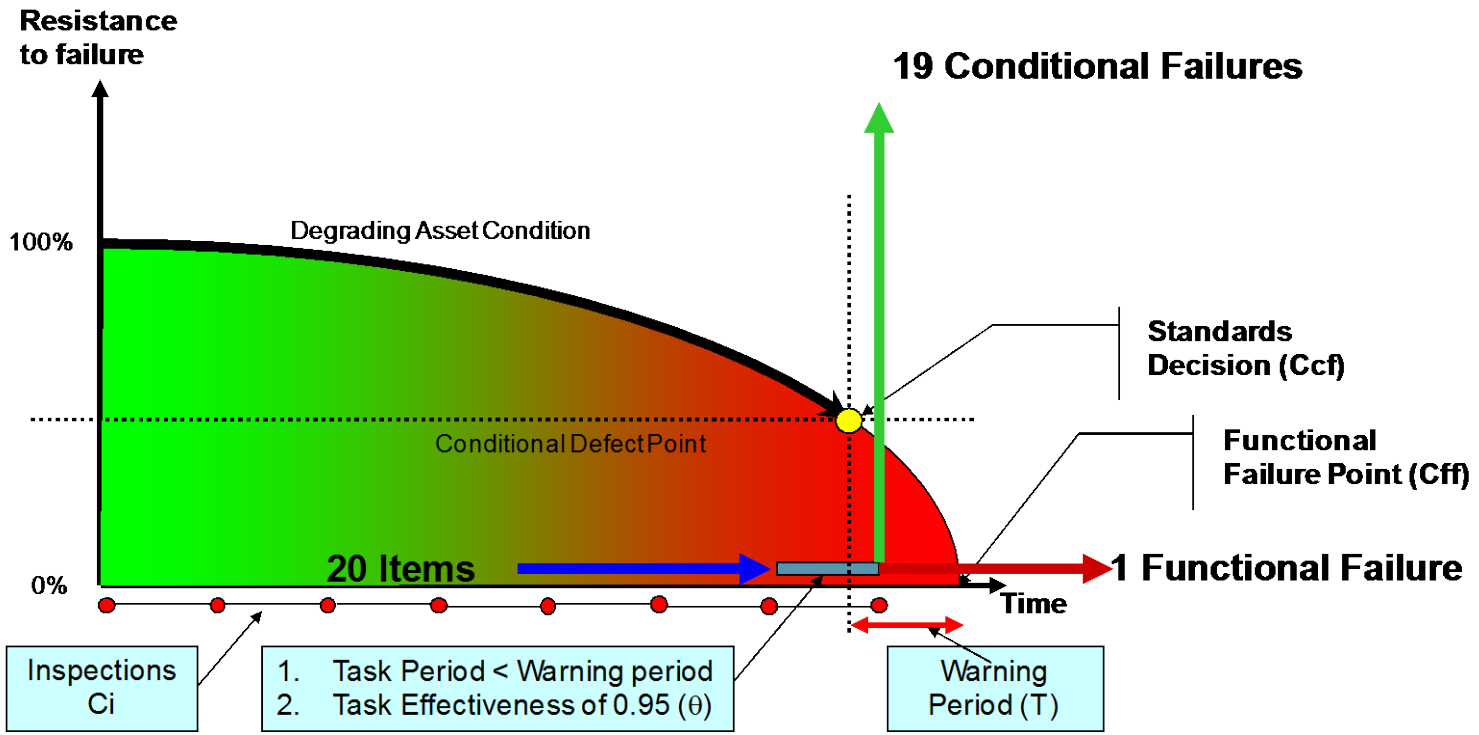
- Drawn from the Nowlan and Heap report
- Describes 6 variables related to likelihood and consequence



MIL-STD-2173AS Reliability Centered Maintenance

Task Period – T/n

$$n = \frac{\ln\left[\frac{\frac{-MTBF}{T} * C_i}{(Cff - Ccf)*\ln(1-\theta)}\right]}{\ln(1-\theta)}$$

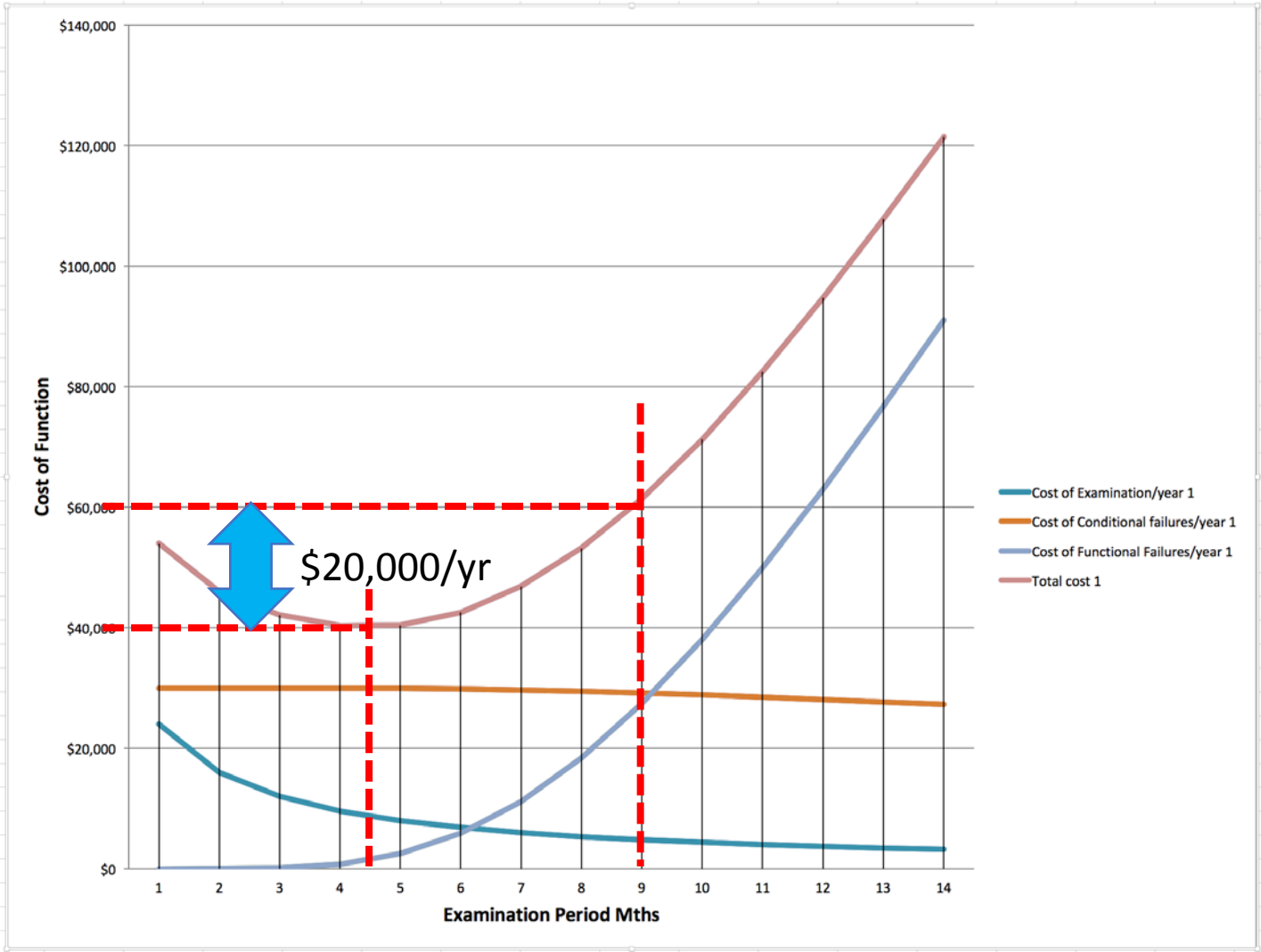


Optimising scenario and cost sensitivity

Variables	0
Cost of examination	$40
Cost of Failure (Cond)	$1,500
Cost of Failure (Funct)	$50,000
MTBF mths	60
Warning period mths	12
Task effectiveness %	95%
Population	100
Optumim Number of exams	2.20
Optimum Period Mths	5.46
Days	166

Cost of Examinations/Yr	$8,797
Cost of Conditinal Failures/yr	$29,959
Cost of Functional Failures/Yr	$1,507
Total Cost/Year	$40,262

Number of Functional Failures/Yr	0.03
Number of Conditional Failures/Yr	19.97
Failures/Yr	20.00



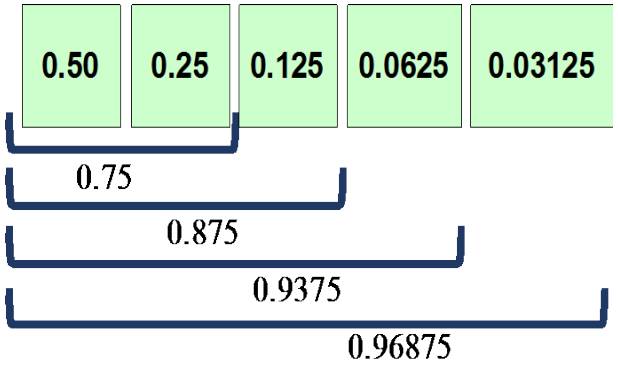
Some data matters and some does not!

- Financials have little impact
- Technicals have some impact
- Organisational really matters

$$n = \frac{\ln\left(\frac{T}{-MTBF * C_i}\right)}{\ln(1-(Cff * Ccf))}$$

Variables	0	1
Cost of examination	$40	$40
MTBF mths	60	60
Task effectiveness %	95%	50%
Cost of Failure (Cond)	$1,500	$1,500
Cost of Failure (Funct)	$50,000	$50,000
Population	100	100
Warning period mths	12	12
Optumim Number of exams	2.20	7.39
Optumim Period Mths	5.46	1.62
Days	166	49
Difference	-70.25%	

		Change multiple/Task period Vary		
Formula Variable	Start Value	1.5	5.0	10.0
Cost Inspection	$40	7%	32%	54%
Cost Conditional Failure	$1,500	0%	2%	5%
Cost Functional Failure	$50,000	-6%	-20%	-26%
Mean time between Failures (mth)	60	7%	32%	54%
		0.75	0.50	0.25
Warning Time (mth)	12.00	-22%	-44%	-68%
		0.90	0.75	0.50
Task Effectiveness	0.95	-20%	-48%	-70%



Verifying the estimated task period

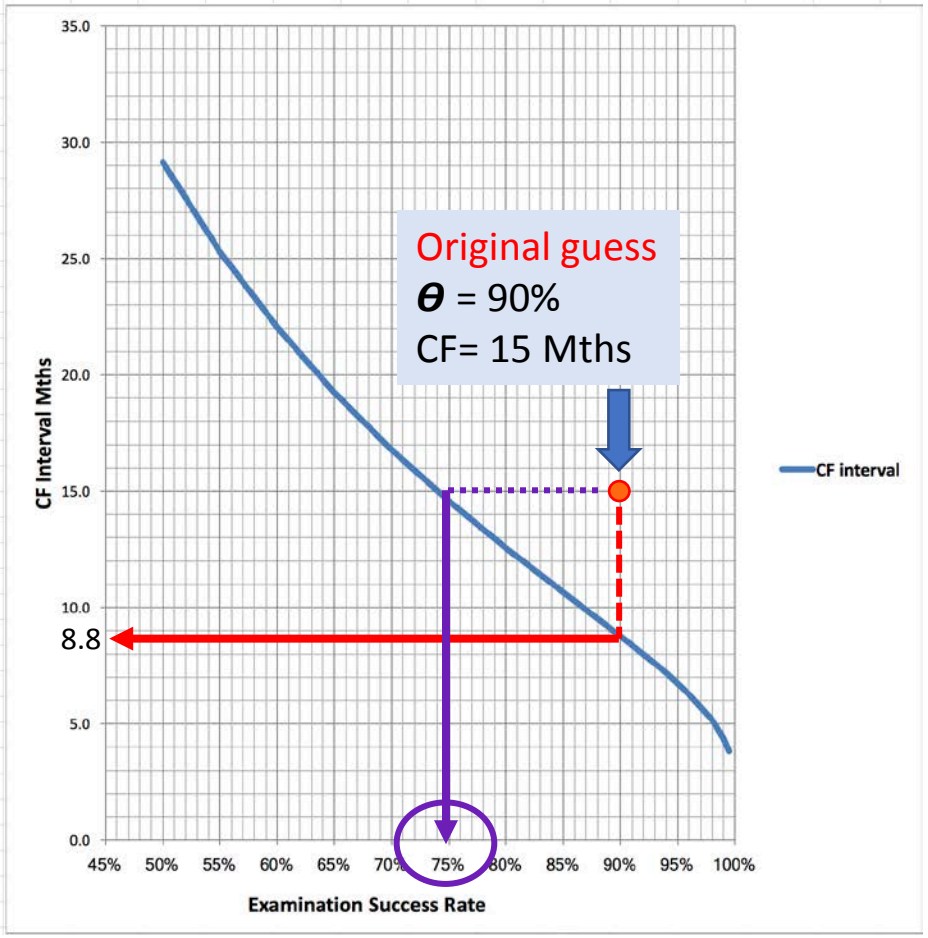
Process Steps

1. Guess T and task success ***θ***
2. Find Task Period (Guess)
3. Use Task Period
4. Collect new failure data
5. Create a Reality Curve
6. Update MTBF results
7. Update task effectiveness (Reason value)
8. Determine new value of T (CF Interval)
9. Produce new plan (Voila)
10. But we are not in control!

Actual Failure Data	
Number of Functional Failures	2
Number of Conditional Failures	56
Actual Task Interval Months	6

IF	Examination Success Rate	90%
THEN	CF Interval Mths	8.8

IF	Examination Success Rate	50%
THEN	CF Interval Mths	29.1



Role of human error and violation – James T Reason

To err is human:

- Recognition failures
- Memory lapses
- Slips of action
- Errors of habit
- Mistaken assumptions
- Knowledge based errors

To adapt is also human

- Violations *(routine breaking rules, optimising and situational adaption)*

These actions are, of themselves, not bad – they are NORMAL!.

*"Our assets and their support systems must be designed to be tolerant of these **expected** human error"*

Assessing task effectiveness - Reason

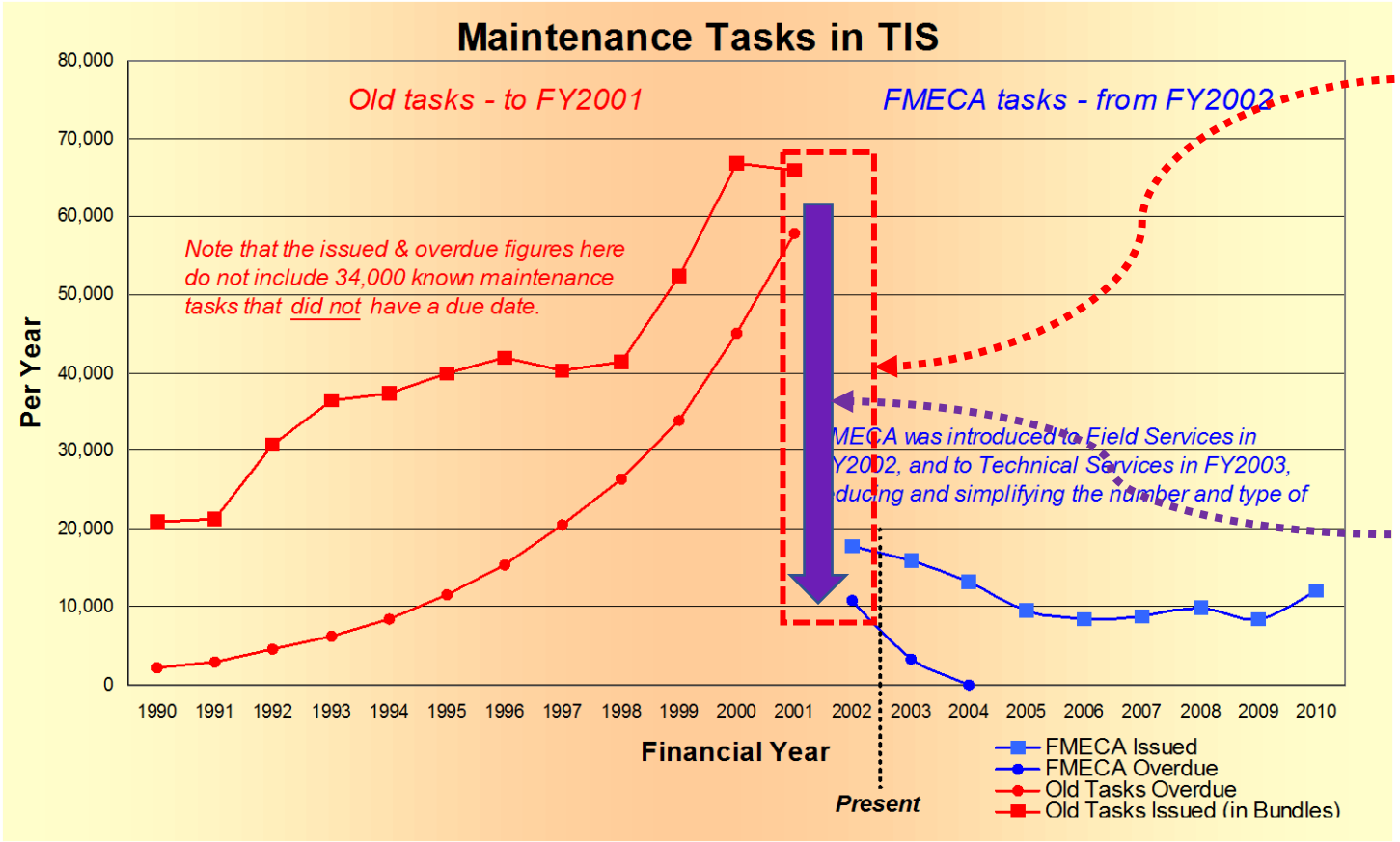
Task effectiveness can be a combination of human **error** and **violation**

- Select the task scenario description (design)
- Select the behaviour (culture)
- Assess combined task effectiveness
- Recalculate Task Period
- Make the savings!

Seq	Task Description	Effect	Violation Behaviour	Effect
1	Totally unfamiliar Performed at speed No idea of possible consequences	0.45	Compliance unimportant Easy to violate Little inducement to comply	0.65
3	Complex task High level of comprehension High level of skill	0.84	Personal benefit from non-compliance Moderate to high likelihood of detection	0.82
6	Routine task – highly practices Rapid delivery Low level of skill	0.98	Socially unacceptable Chance of detection high Chance of bad outcome high	0.9998

#	No Error	No Violation	Success!
1	0.45	0.65	0.29
3	0.84	0.82	0.69
6	0.98	0.9998	0.9798

Does it work? - Outcomes achieved!



FMECA/RCM Process applied

Results Achieved

- Process used in the initial program to test guesses (2001-2002)
- Then used to verify and update the program 10 years later
- Finally used to verify task effectiveness for improvement potential
- Savings over life were in excess of 65%

Verifying Your Condition Monitoring - Summary

Use a risk based quantitative analysis method.

Use best information at the time to set task period baseline.

Deliver tasks to that baseline and collect data to verify the outcome.

Re-do the analysis and take the verified savings.

Thank you for this opportunity to share