Using risk based maintenance

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Lloyd's Register EMEA

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Improving offshore facilities management, operations and maintenance

Lloyd's Register – A Group Overview

- Celebrated our 250 year anniversary in 2010
- 8,000 employees of 90 nationalities
- 237 offices globally
- Four business divisions:
  - Marine
  - Energy
  - Management Systems
  - Transportation
- 2011/12 turnover £893m
- A Registered Charity
- Supports the Lloyd's Register Educational Trust (LRET)

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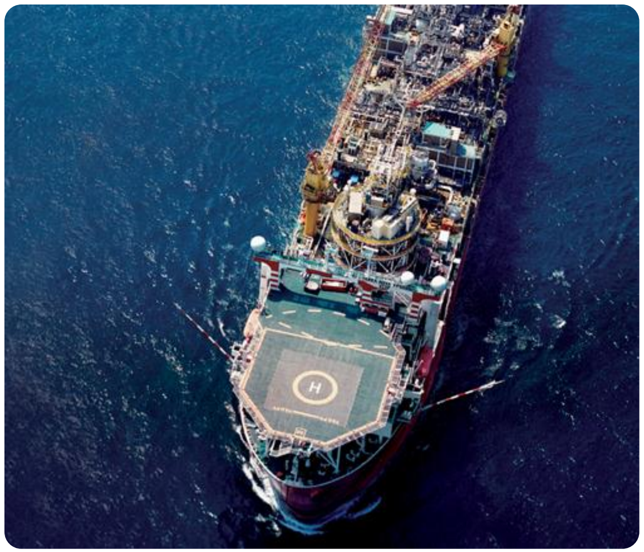
LIFE MATTERS

Energy - Upstream



Example applications:

- fixed offshore platforms
- pipelines (offshore / onshore)
- semi-submersibles / drilling ships
- FPSO / FSO / FLNG

Example services:

- optimised risk-based inspection
- fitness for service
- classification guidance
- design appraisal
- cnformance assessment

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Energy - Downstream

Example applications:

- storage (tank farms, underground gas storage)
- petrochemicals
- bulk chemicals

Example services:

- optimised risk-based inspection
- life extension studies
- corrosion risk assessment
- risk consultancy

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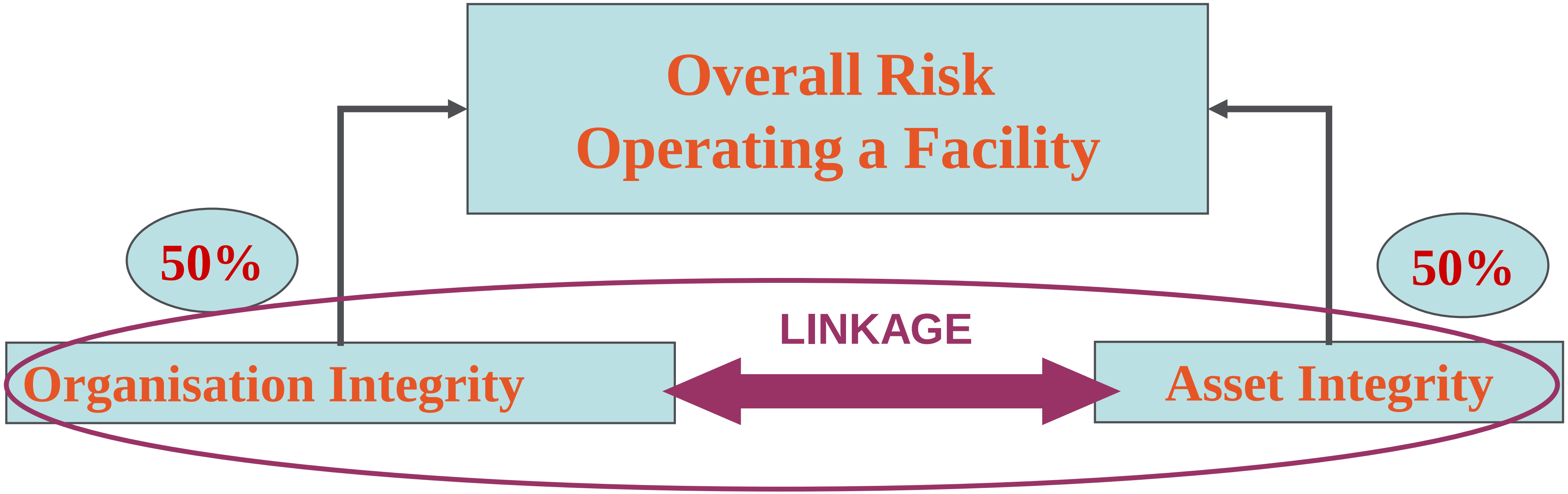
Organisational risk



15%

Chemical Company 1
"85% of availability losses over previous 5 years were associated with Mechanical Integrity related failures. "

85%

66%

Oil Company 2
"Approximately one third of all the major and high potential incidents reported in the group are related to integrity management – in other words, incidents where there has been loss of containment or failure of an engineering system."

33%

… the Issues

AM Policy & Strategy Development

Risk Management

AM Leadership

Sustainable Performance/Development

Procurement

Human Resources

Knowledge Management System

Maintenance & Reliability

AM Organisation & Communications

HSE & Risk Management System

Asset Production Operations

Quality Management System

Measurement & Continuous Improvement

Knowledge Management

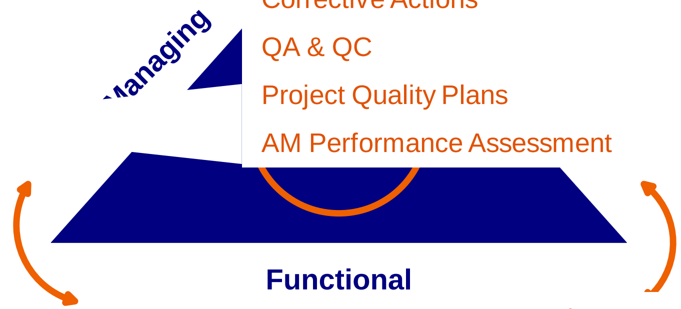
Engineering & Project Management

Asset Performance Management

1.0 APM Managing Elements

- 1.1 AM Policy & Strategy Development
- 1.2 AM Organisation & Communications
- 1.3 HSE & Risk Management Systems
- 1.4 Quality Management System
- 1.5 Asset Production Operations

Leadership Commitment to Quality
Quality Process Model
Measurement & Control
Corrective Actions
QA & QC
Project Quality Plans
AM Performance Assessment



2.0 APM Functional Elements

- 2.1 APM Leadership
- 2.2 Engineering & Project Management
- 2.3 Maintenance & Reliability
- 2.4 Risk Management
- 2.5 Knowledge Management
- 2.6 Measurement & Continuous Improvement

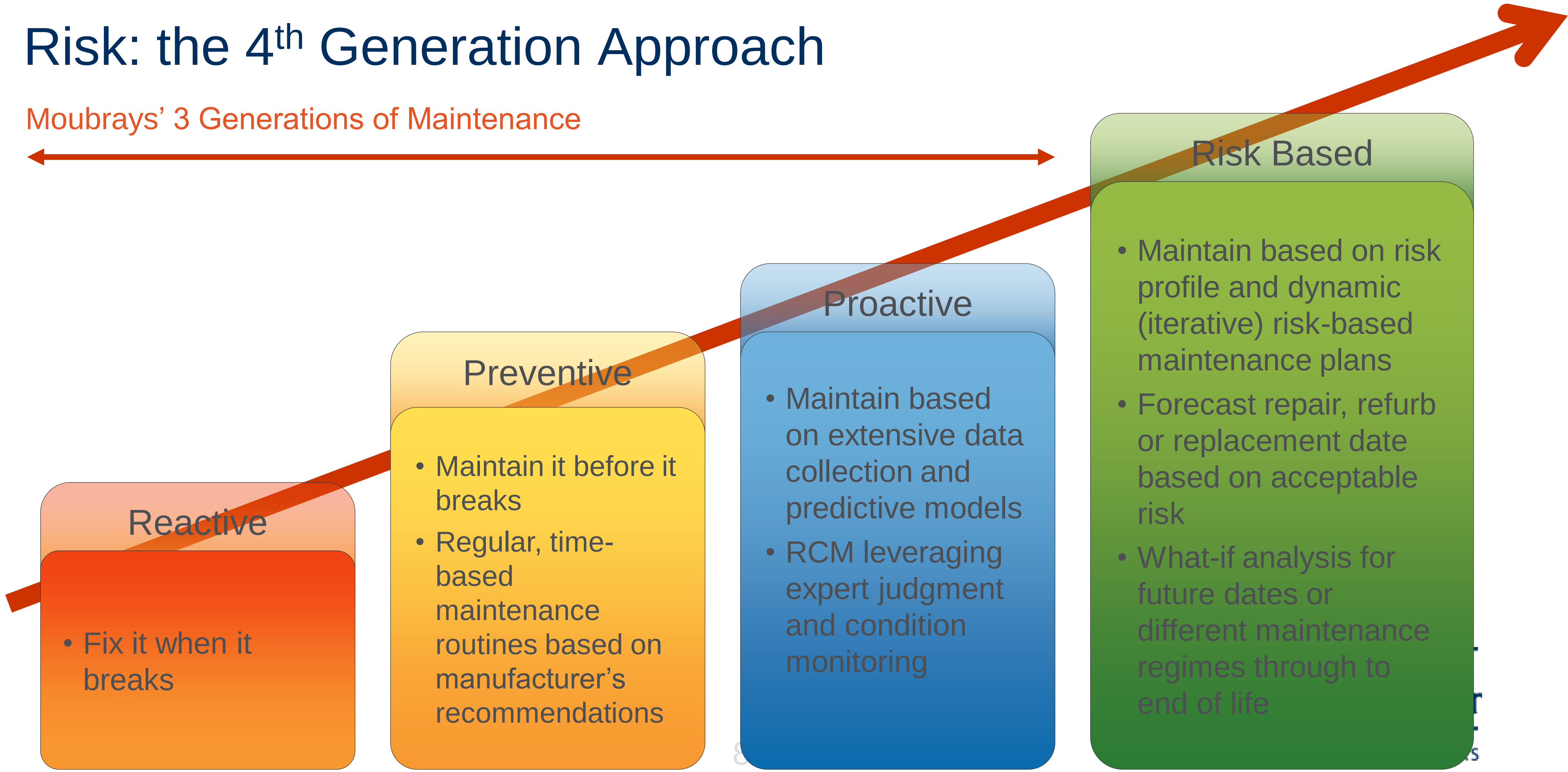
3.0 APM Supporting Elem

- 3.1 Human Resources
- 3.3 Knowledge Management
- 3.4 Sustainable Development

Maintenance Objectives
Maintenance Plans & Budgets
Work Selection
Application of New Technology
CMMS Reporting
Maintenance & Reliability Improvement
Spares Management
Maintenance Deferral
Reporting
Fitness for Service Assessments
Contractor Management
Emergency Work

Risk based maintenance software for reliability improvement

Risk: the 4th Generation Approach



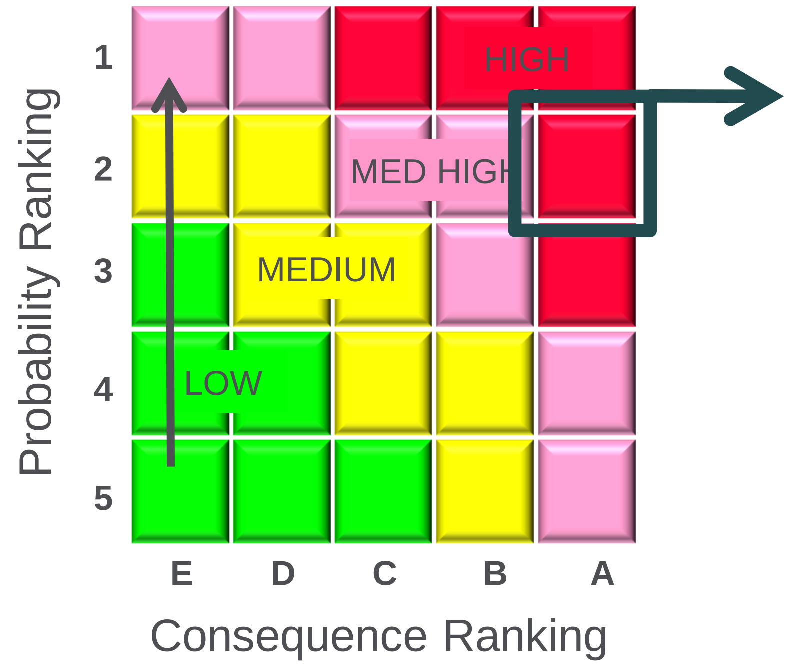
Why this approach?

- Improve critical asset availability
- Optimise maintenance costs
- Analyse future risks and maintenance costs
- Provide justification for equipment renewal and repairs
- Promotes regulatory compliance

Knowledge Based Asset Integrity (KBAI™)

Likelihood of Failure
(events per year)

- Equipment type and items used
- Age, usage, environment, etc
- Equipment condition (based on visual inspection, past maintenance, failure causes and condition monitoring, etc)



Maintenance and Inspection Task Plan optimised to the equipment and the business
(£ impact per event)

- Includes industry best practices
- May increase or decrease current maintenance

Consequence of Failure
(impact per event)

- Disruption to business
- Environmental + Health and Safety impacts
- Reputation – Public/Political

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Case study – Port Cranes

- **Breakdown duration reduced**
  - Quay Side crane (QS) -24%;
  - Rubber Tyred Gantry cranes (RTG) -12%
- **Maintenance cost savings: QS 17%; RTG 32%**
- **Significant commercial operational benefits**:
  - Crane efficiency enhanced
  - Containers handled and related safety all improved
  - Equals: Reduced ship delays

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Case study – Oil refinery piping

- Pilot study on fixed equipment on eight process units led to \$1.5m in turnaround cost savings and \$7m in risk reduction
- Rolled out to 6 further refineries resulting in over \$160m in risk reduction and on-going savings in turnaround plans. Achieved within 3 years.
- Key lesson learned is the need to continually audit and manage the system to ensure the alignment of people processes and technology

Identifying the <u>DELIVERED</u> RISK REDUCTION VALUE

Finding this CUI problem was estimated to save the refiner \$2MM. An additional \$4MM in lost production was avoided when RBMI identified exchanger problems before they could affect the safe operation of the refinery. This added up to over \$6.373 MM in reduced risk all within 3 months of completing the project.

I.C. Risk Distribution

70	1	13	6	9	42	0
91	2	14	5	14	58	0
65	3	27	5	5	28	0
174	4	30	4	20	109	11
104	5	24	4	3	69	4
		E	D	C	B	A
504		108	24	51	306	15

Combined Risk Distribution

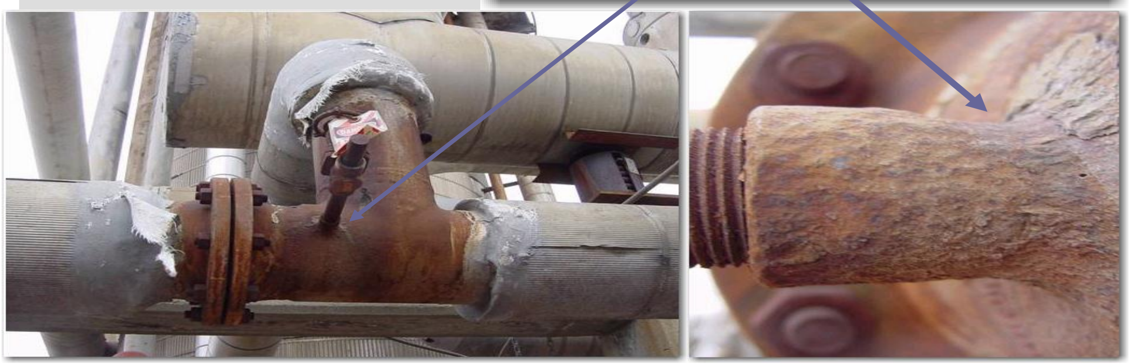
79	1	19	6	9	45	0
106	2	22	6	14	63	1
61	3	21	5	5	30	0
165	4	31	3	20	100	11
93	5	15	4	3	68	3
		E	D	C	B	A
504		108	24	51	306	15

E.C. Risk Distribution

11	1	5	1	1	4	0
29	2	10	5	0	13	1
17	3	6	0	0	11	0
254	4	53	9	23	158	11
193	5	34	9	27	120	3
		E	D	C	B	A
504		108	24	51	306	15

Environ. Cracking Distribution

0	1	0	0	0	0	0
0	2	0	0	0	0	0
0	3	0	0	0	0	0
4	4	0	0	0	2	2
0	5	0	0	0	0	0
		E	D	C	B	A
4		0	0	0	2	2



The small branch connection on the line was found to be corroded nearly through-wall. Continued operation without finding and repairing the damaged connection would have resulted in a failure with potentially serious effect.

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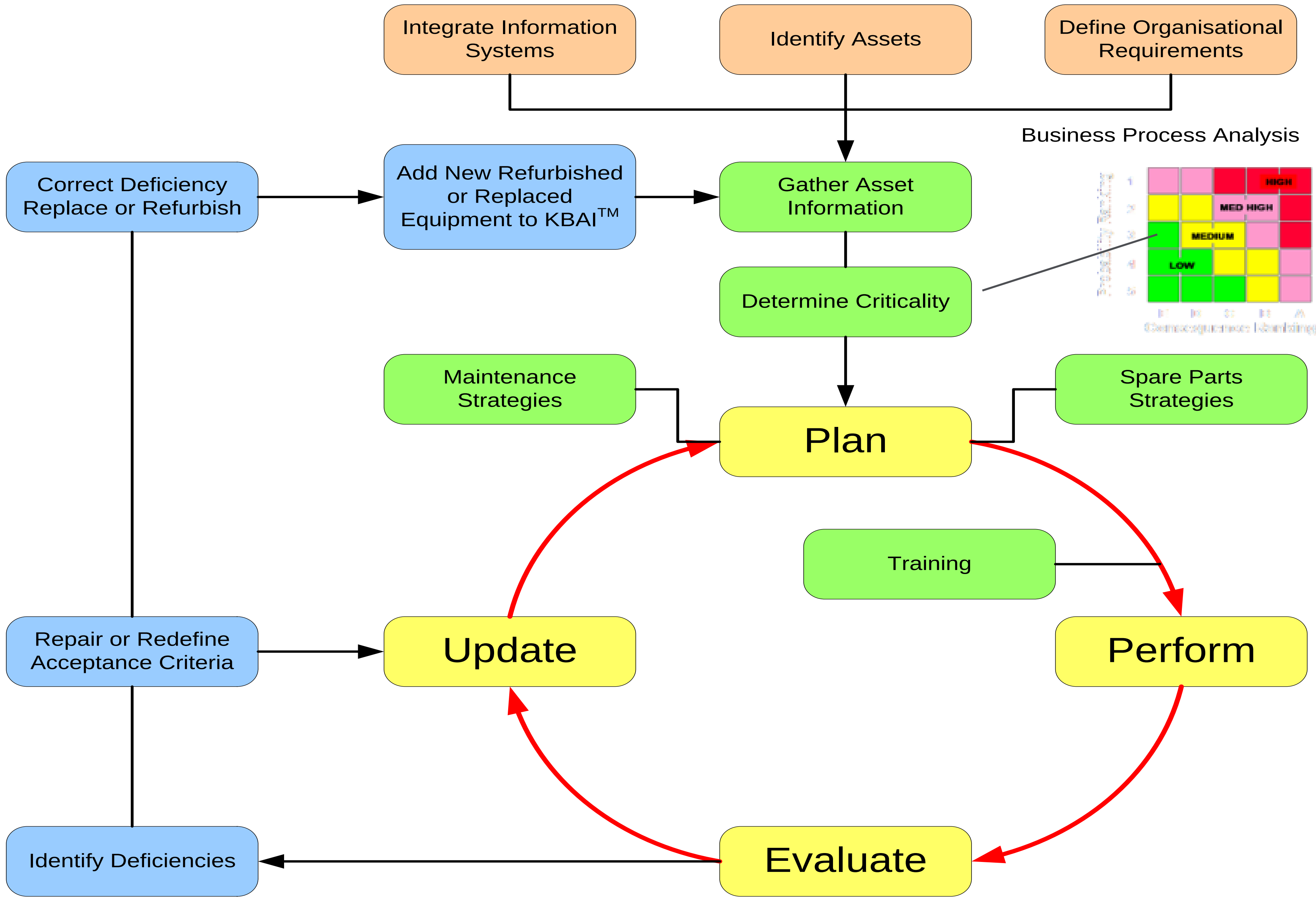
Case study – Elevators

- 511 elevators at Royal Mail Group
- Many used to move mail as part of sorting process
- **Planned maintenance cost savings - 51%**
- Reduced reactive maintenance events - 60% target on key elevators
- **Improved elevator availability and quality of service**
- For first time, prediction of number of elevator breakdowns
- **Reduction in consequential losses – estimated £5m per year**

Royal Mail

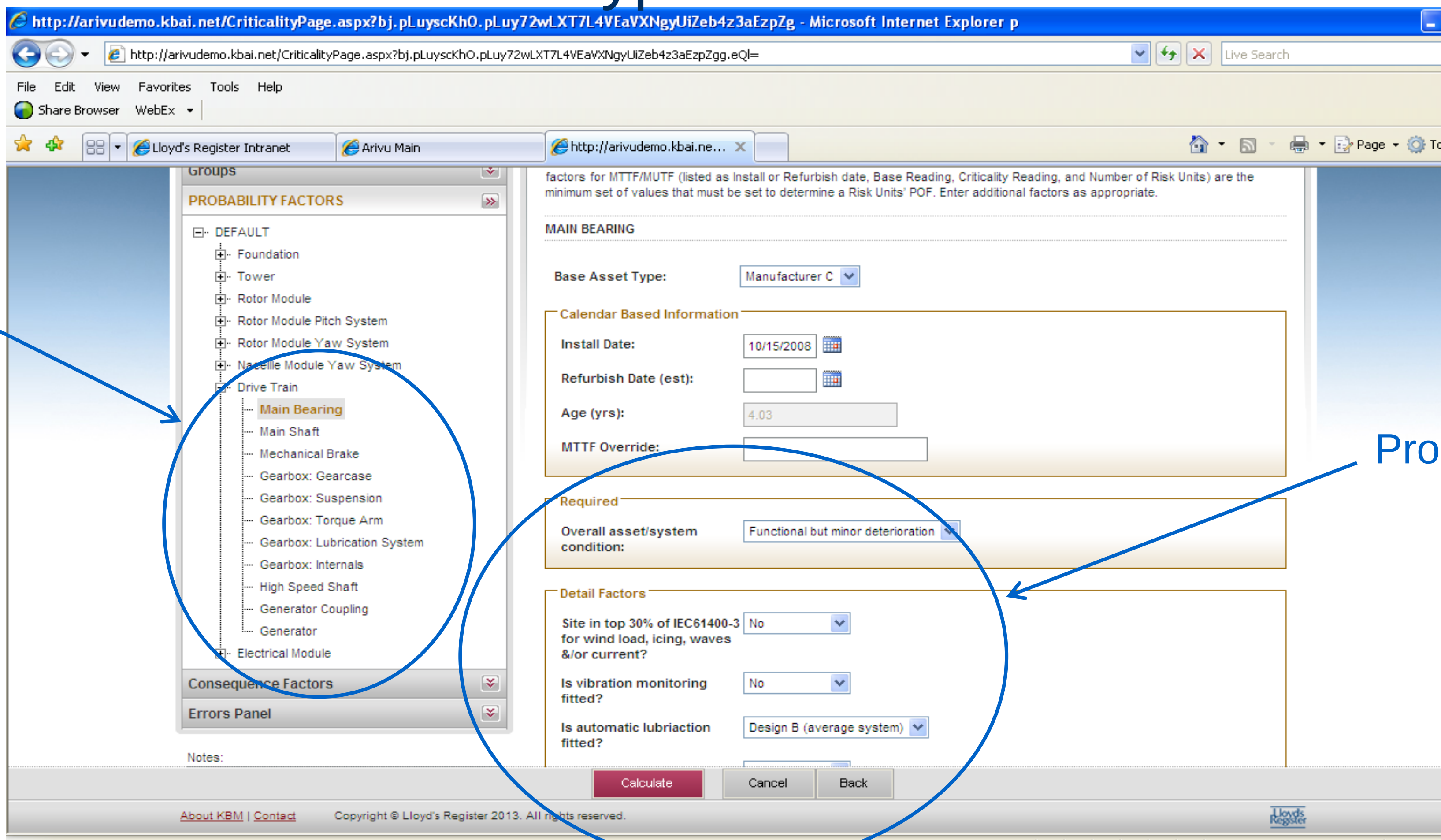
The Process



Integrate Information Systems
Identify Assets
Define Organisational Requirements
Business Process Analysis
Correct Deficiency Replace or Refurbish
Add New Refurbished or Replaced Equipment to KBAI™
Gather Asset Information
Determine Criticality
HIGH
MED HIGH
MEDIUM
LOW
Maintenance Strategies
Spare Parts Strategies
Plan
Training
Update
Perform
Repair or Redefine Acceptance Criteria
Evaluate
Identify Deficiencies

Configuration: Risk Units & Probability Factors are identified for each asset type

Risk Units



Probability Factors

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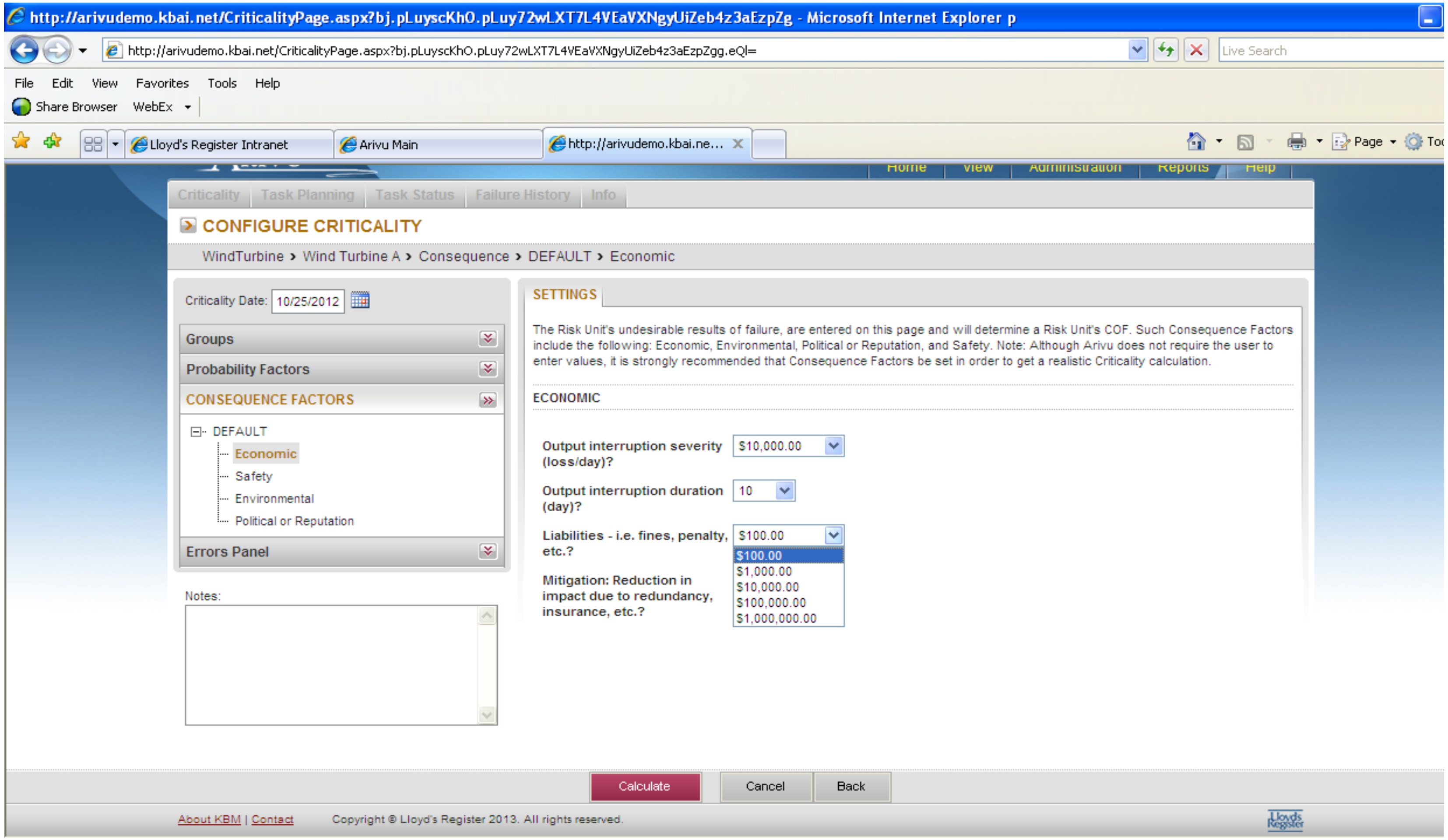
Configuration: Consequence factors - Economic, Safety, Environmental & Reputational



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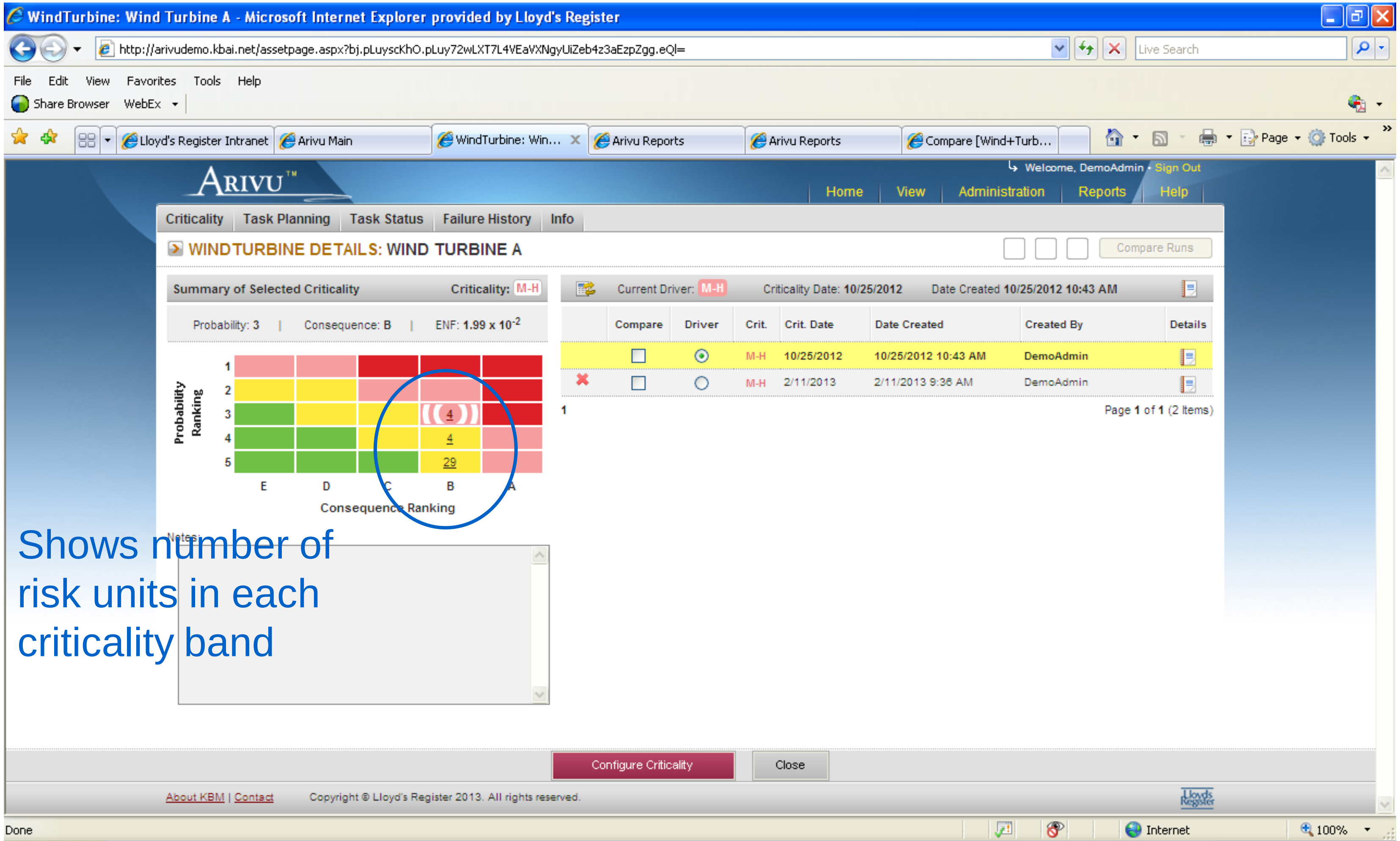
This year 4 risk units in the asset are medium-high criticality



Shows number of risk units in each criticality band

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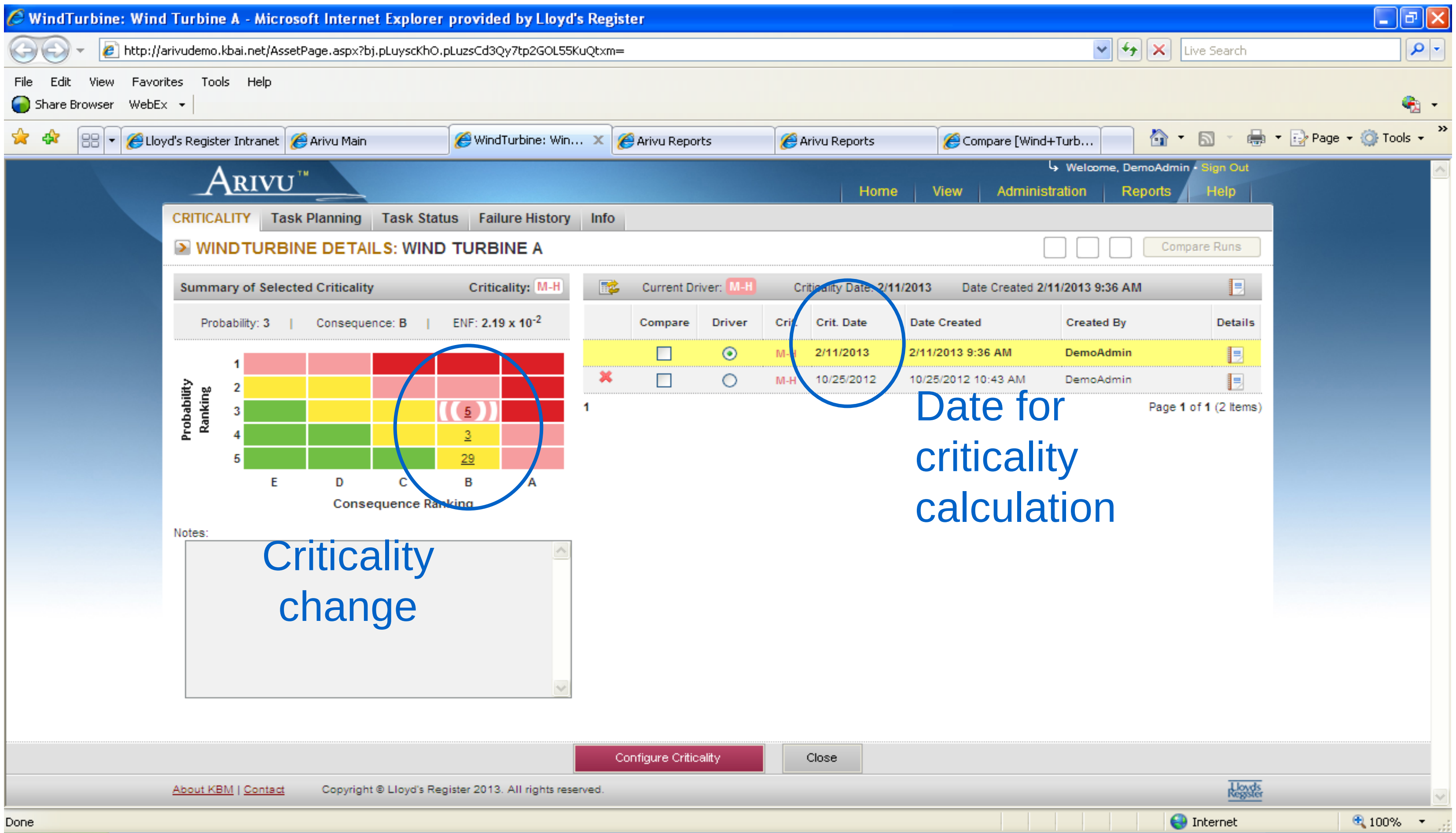
Next year prediction shows criticality has further changed for one risk unit – undertake pre-emptive work on this



LIFE MATTERS

Use ‘Reports’ to identify changes required to reduce individual criticalities and ENFs

Arivu Reports - Microsoft Internet Explorer provided by Lloyd's Register

Criticality Run Detail

Probability Group/Consequence Group	Risk Unit	ENF	Consequence	Probability	Criticality
⊟ DEFAULT/DEFAULT		0.021876	B	3	M-H
	Drive Train>>Gearbox: Gearcase	0.00016	B	5	M
	Drive Train>>Gearbox: Internals	0.00008	B	5	M
	Drive Train>>Gearbox: Lubrication System	0.00005	B	5	M
	Drive Train>>Gearbox: Suspension	0.00016	B	5	M
	Drive Train>>Gearbox: Torque Arm	0.00018	B	5	M
	Drive Train>>Generator	0.00061	B	5	M
	Drive Train>>Generator Coupling	0.01143	B	3	M-H
	Drive Train>>High Speed Shaft	0.00016	B	5	M
	Drive Train>>Main Bearing	0.00003	B	5	M
	Drive Train>>Main Shaft	0.00016	B	5	M
	Drive Train>>Mechanical Brake	0.00003	B	5	M
	Electrical Module>>Electrical Module	0.00061	B	5	M
	Foundation>>Bolts	0.00003	B	5	M
	Foundation>>Jacking Brackets	0.00009	B	5	M
	Foundation>>Sub - Structure	0.00009	B	5	M
	Foundation>>Transition Piece	0.00009	B	5	M
	Nacellle Module Yaw System>>Yaw system	0.00468	B	4	M

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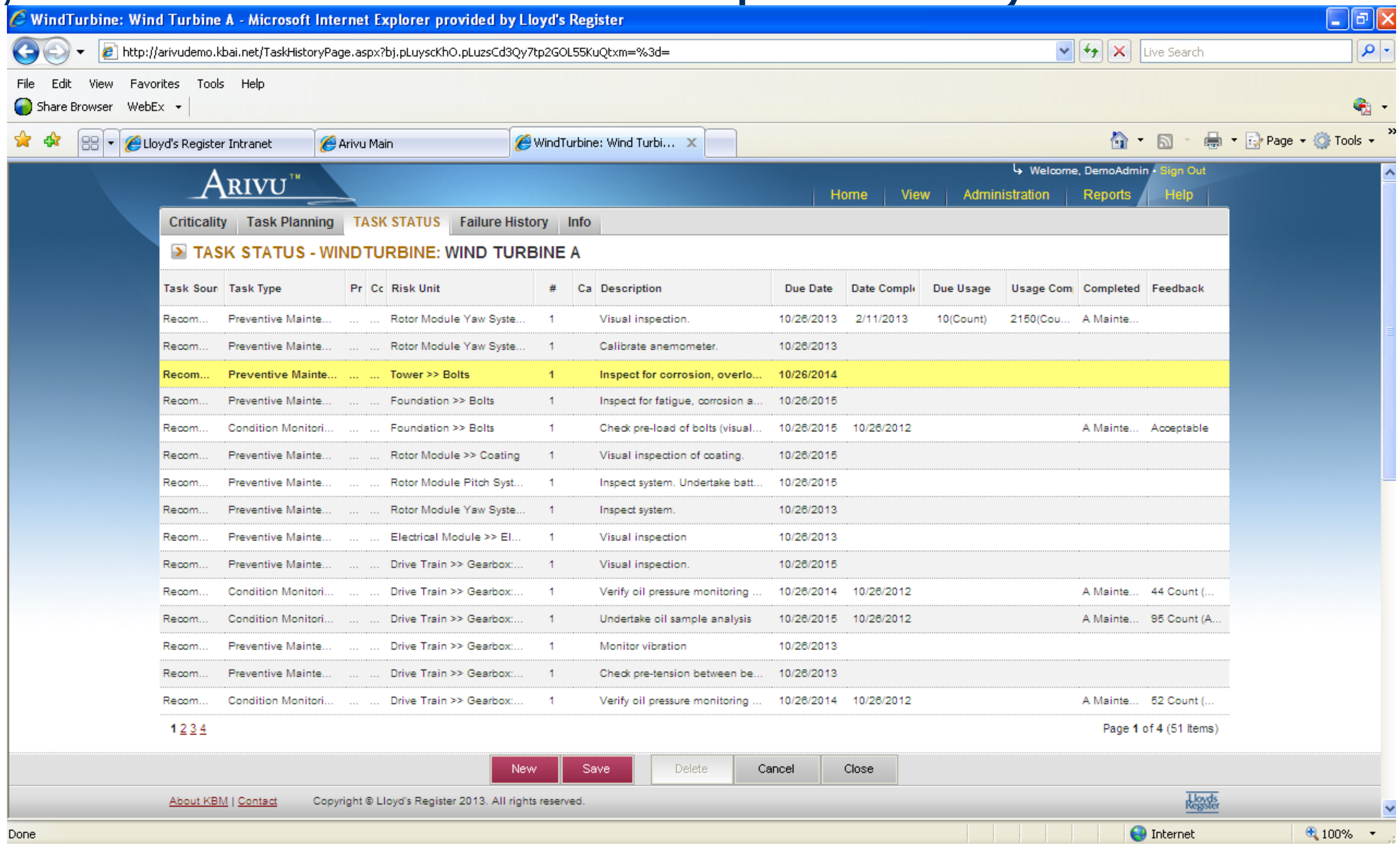
Failure history, completed tasks, usage data, condition data, feedback etc – modifies probability



Task Sour	Task Type	Pr	Cc	Risk Unit	#	Ca	Description	Due Date	Date Compl	Due Usage	Usage Com	Completed	Feedback
Recom...	Preventive Mainte...	...	...	Rotor Module Yaw Syste...	1		Visual inspection.	10/26/2013	2/11/2013	10(Count)	2150(Cou...	A Mainte...	
Recom...	Preventive Mainte...	...	...	Rotor Module Yaw Syste...	1		Calibrate anemometer.	10/26/2013					
Recom...	Preventive Mainte...	...	...	Tower >> Bolts	1		Inspect for corrosion, overlo...	10/26/2014					
Recom...	Preventive Mainte...	...	...	Foundation >> Bolts	1		Inspect for fatigue, corrosion a...	10/26/2015					
Recom...	Condition Monitori...	...	...	Foundation >> Bolts	1		Check pre-load of bolts (visual...	10/26/2015	10/26/2012			A Mainte...	Acceptable
Recom...	Preventive Mainte...	...	...	Rotor Module >> Coating	1		Visual inspection of coating.	10/26/2015					
Recom...	Preventive Mainte...	...	...	Rotor Module Pitch Syst...	1		Inspect system. Undertake batt...	10/26/2015					
Recom...	Preventive Mainte...	...	...	Rotor Module Yaw Syste...	1		Inspect system.	10/26/2013					
Recom...	Preventive Mainte...	...	...	Electrical Module >> El...	1		Visual inspection	10/26/2013					
Recom...	Preventive Mainte...	...	...	Drive Train >> Gearbox:...	1		Visual inspection.	10/26/2015					
Recom...	Condition Monitori...	...	...	Drive Train >> Gearbox:...	1		Verify oil pressure monitoring ...	10/26/2014	10/26/2012			A Mainte...	44 Count (...
Recom...	Condition Monitori...	...	...	Drive Train >> Gearbox:...	1		Undertake oil sample analysis	10/26/2015	10/26/2012			A Mainte...	95 Count (A...
Recom...	Preventive Mainte...	...	...	Drive Train >> Gearbox:...	1		Monitor vibration	10/26/2013					
Recom...	Preventive Mainte...	...	...	Drive Train >> Gearbox:...	1		Check pre-tension between be...	10/26/2013					
Recom...	Condition Monitori...	...	...	Drive Train >> Gearbox:...	1		Verify oil pressure monitoring ...	10/26/2014	10/26/2012			A Mainte...	52 Count (...

Summary – Using Risk Based Maintenance

- Structured approach to bring various elements of information and data together to make more informed maintenance decisions including pre-emptive change out of components
- Improves reliability
- Software helps manage the process especially with large volumes of disparate data
- Use to update prediction utilising operational experience
- Provide effective failure mode management in response to changing equipment condition
- Operating knowledge is retained even if staff change
- Consistent with requirements of PAS 55 (ISO 55000)

Questions?

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