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Work Order Risk Prioritisation (WORP) using Machine Learning

James Williams, Isogonal

EEA Asset Management Forum 2019

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WORP Summary

Why is it needed

60,000 assets, 75,000 work orders, and more work orders are being opened than are being closed.

WORP

An automated machine learning system that processes the field engineer's descriptions, classifies the work order by (asset, component, risk category), and predicts a **risk rating** and cost estimate

What it has enabled

$4-6 million removed from the annual predictive maintenance budget (2019), $150 000 saved annually vs. manual process (engineer time), and BI reports to assist with financial planning and work order scheduling

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Risk rating

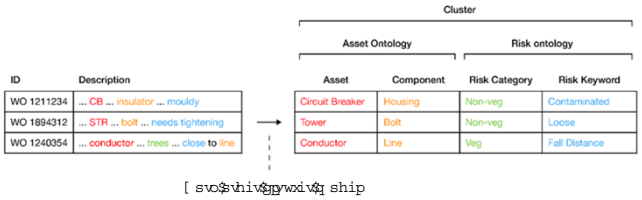
Based on the likelihood of failure and the cost of failure

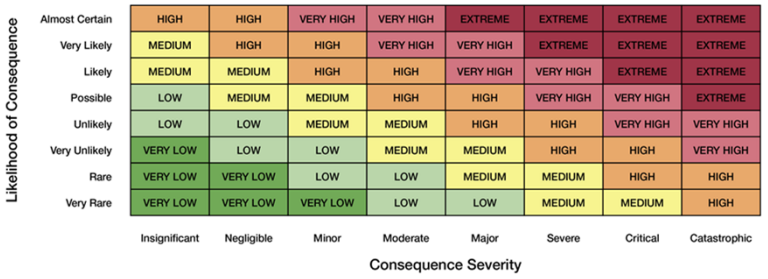
Relative risk score scaled to 0 - 1000

Categories

- Service Performance
- Direct Cost
- Workplace Safety
- Public Safety
- Environmental Safety

...uses Transpower's asset criticality assessment presented at EEA 2015, a dollar value for the cost of failure





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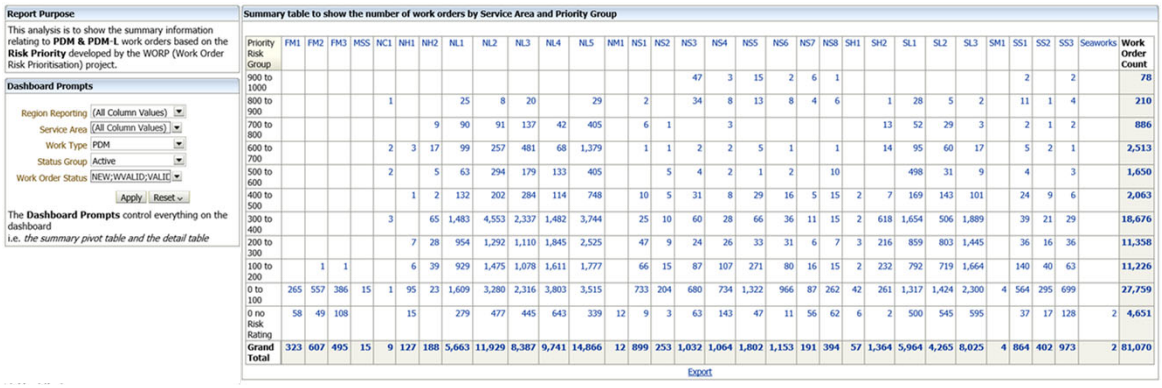
Financial Planning and Scheduling

BI reports of priority group vs. service area for RSM's and SDM's to use for planning

Updated daily



Report Purpose

This analysis is to show the summary information relating to **PDM & PDM-L** work orders based on the **Risk Priority** developed by the WORP (Work Order Risk Prioritisation) project.

Dashboard Prompts

Region Reporting (All Column Values)
Service Area (All Column Values)
Work Type PDM
Status Group Active
Work Order Status NEW;WVALID;VALID
Apply Reset

The **Dashboard Prompts** control everything on the dashboard
i.e. the summary pivot table and the detail table

Summary table to show the number of work orders by Service Area and Priority Group

Priority Risk Group	FM1	FM2	FM3	MSS	NC1	NH1	NH2	NL1	NL2	NL3	NL4	NL5	NM1	NS1	NS2	NS3	NS4	NS5	NS6	NS7	NS8	SH1	SH2	SL1	SL2	SL3	SM1	SS1	SS2	SS3	Seaworks	Work Order Count
900 to 1000																47	3	15	2	6	1							2		2		78
800 to 900					1			25	8	20		29		2		34	8	13	8	4	6		1	28	5	2		11	1	4		210
700 to 800							9	90	91	137	42	405		6	1		3						13	52	29	3		2	1	2		886
600 to 700						2	3	17	99	257	481	68	1,379		1	1	2	2	5	1		1		14	95	60	17		5	2	1		2,513
500 to 600						2		5	63	294	179	133	405			5	4	2	1	2		10			498	31	9		4		3		1,650
400 to 500							1	2	132	202	284	114	748		10	5	31	8	29	16	5	15	2	7	169	143	101		24	9	6		2,063
300 to 400						3		65	1,483	4,553	2,337	1,482	3,744		25	10	60	28	66	36	11	15	2	618	1,654	506	1,889		39	21	29		18,676
200 to 300							7	28	954	1,292	1,110	1,845	2,525		47	9	24	26	33	31	6	7	3	216	859	803	1,445		36	16	36		11,358
100 to 200			1	1			6	39	929	1,475	1,078	1,611	1,777		66	15	87	107	271	80	16	15	2	232	792	719	1,664		140	40	63		11,226
0 to 100	265	557	386	15	1	95	23	1,609	3,280	2,316	3,803	3,515		733	204	680	734	1,322	966	87	262	42	261	1,317	1,424	2,300	4	564	295	699		27,759
0 no Risk Rating	58	49	108			15		279	477	445	643	339	12	9	3	63	143	47	11	56	62	6	2	500	545	595		37	17	128	2	4,651
Grand Total	**323**	**607**	**495**	**15**	**9**	**127**	**188**	**5,663**	**11,929**	**8,387**	**9,741**	**14,866**	**12**	**899**	**253**	**1,032**	**1,064**	**1,802**	**1,153**	**191**	**394**	**57**	**1,364**	**5,964**	**4,265**	**8,025**	**4**	**864**	**402**	**973**	**2**	**81,070**

Export

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Feedback and improvements

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Types of feedback

General improvements to the system overall

Improving the accuracy and extensibility of the machine learning model

Improving user understanding

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Machine learning accuracy

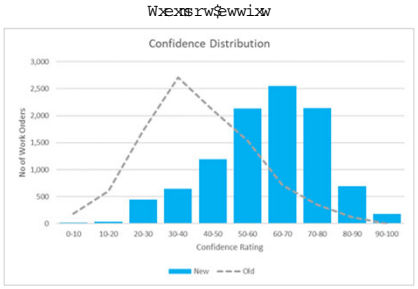
More detailed asset hierarchy that better represents the real world, additional training data, resulting in higher confidence in the predicted cluster

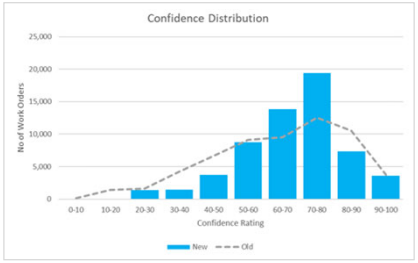
Previous model

- 140 asset specific components
- 900 clusters
- 23,000 training examples (labeled work orders)
- 1,800 comparisons (cluster likelihood of failure)

Updated model

- 210 asset specific components
- 1,200 clusters
- 26,000 training examples (labeled work orders)
- 3,500 comparisons (cluster likelihood of failure)





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Extensibility

Asset and risk hierarchy

Training

- Initial work order cluster examples 20181123
- More work order cluster examples 20190214
- …

Ranking

- Work order cluster likelihood ranking

Criticality

- Asset type criticality
- Location criticality
- Work order criticality

Pricing

- Closed work order cost examples 20181123

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Improving user understanding

Feedback 28,000 work orders have a risk rating between 0 and 100, making it hard to prioritise them individually.

Response This is partly due to incomplete asset specific criticality.

Add a filter to the BI report to flag work orders with incomplete asset specific criticality.

Improve coverage of asset specific criticality.

Feedback Vegetation work orders don't increase in risk rating over time as expected.

Response Interpolate the risk rating based on when the work order was opened or when the vegetation was last trimmed relative to the planned start date.

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What can go wrong?

Inconsistent or inaccurate work order descriptions result in wrong predictions and an unreliable risk rating

Incomplete or out of date asset specific criticality can underestimate the risk rating

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Future thinking

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What next?

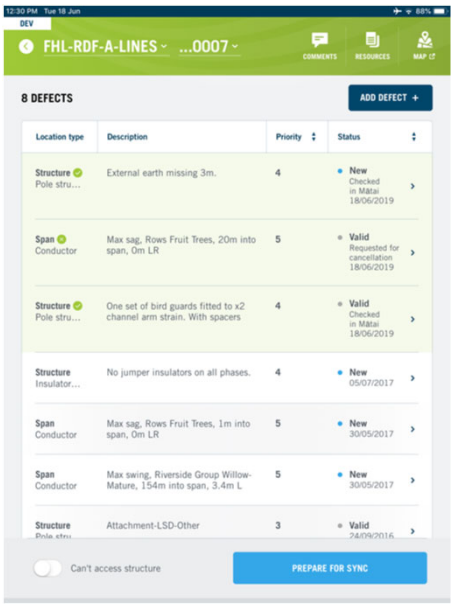
Mātai

Mobile application for condition assessment and data collection, used to add structured information to work orders as assets are inspected.

- Lines assets ready
- Stations assets development underway

Increase level of detail by recording and transcribing engineer's descriptions automatically

Include photos which can be used to check the visual condition, risk category



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Extra material
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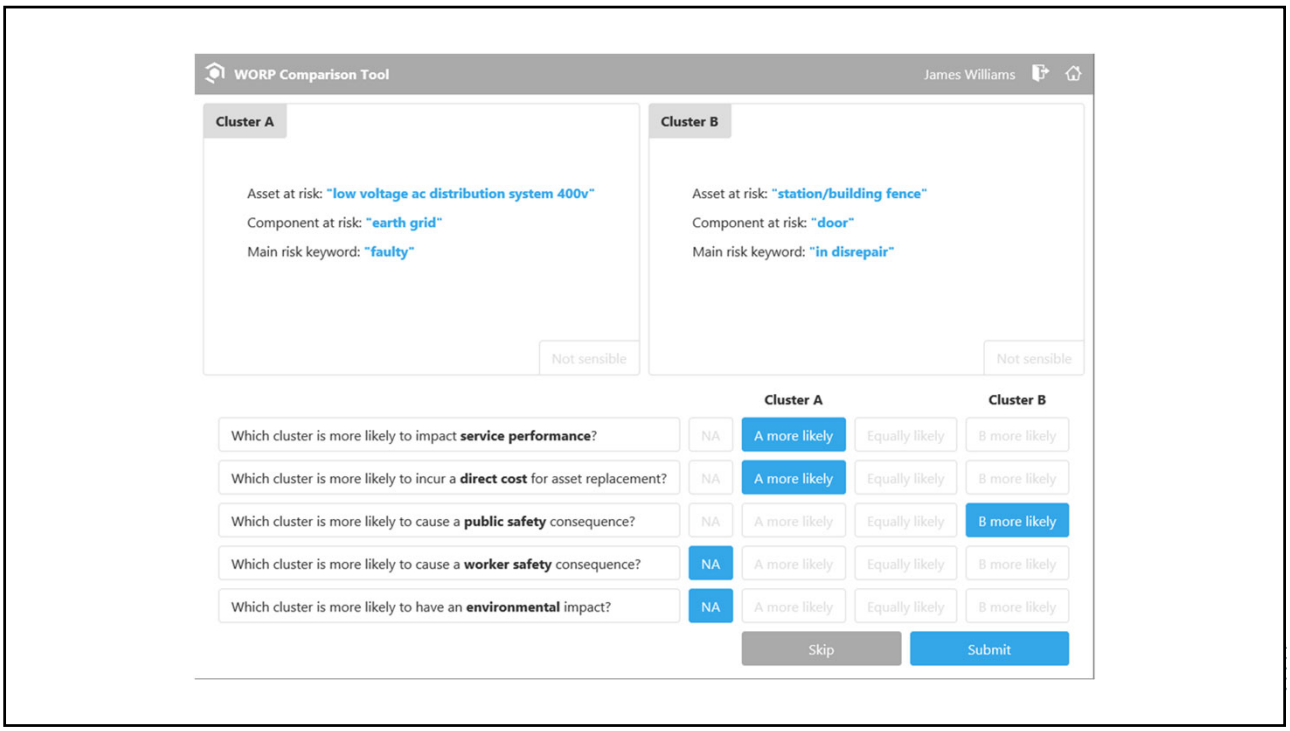
WORP Comparison Tool
James Williams
Cluster A
Asset at risk: "low voltage ac distribution system 400v"
Component at risk: "earth grid"
Main risk keyword: "faulty"
Not sensible
Cluster B
Asset at risk: "station/building fence"
Component at risk: "door"
Main risk keyword: "in disrepair"
Not sensible
Cluster A
Cluster B
Which cluster is more likely to impact service performance?
Which cluster is more likely to incur a direct cost for asset replacement?
Which cluster is more likely to cause a public safety consequence?
Which cluster is more likely to cause a worker safety consequence?
Which cluster is more likely to have an environmental impact?
NA
A more likely
Equally likely
B more likely
Skip
Submit

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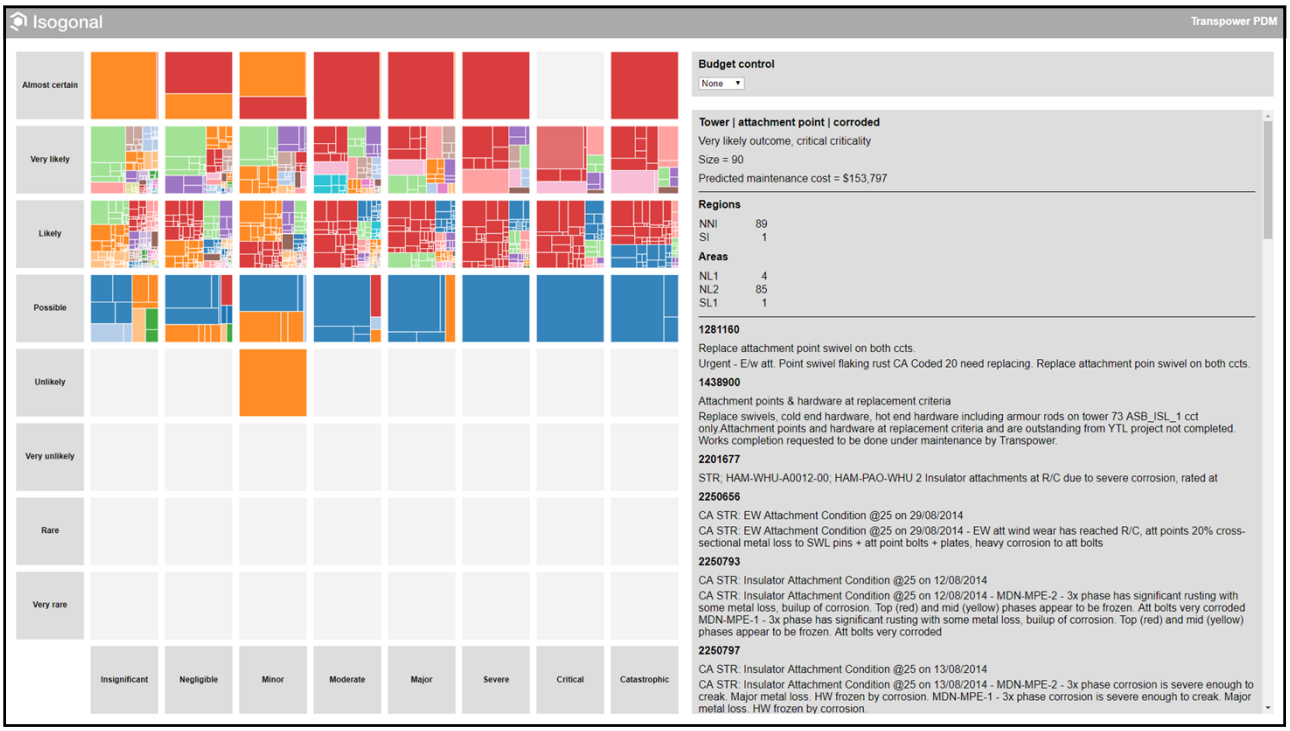
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Transpower PDM
Almost certain
Very likely
Likely
Possible
Unlikely
Very unlikely
Rare
Very rare
Insignificant
Negligible
Minor
Moderate
Major
Severe
Critical
Catastrophic
Budget control
None
Tower | attachment point | corroded
Very likely outcome, critical criticality
Size = 90
Predicted maintenance cost = $153,797
Regions
NNI 89
SI 1
Areas
NL1 4
NL2 85
SL1 1
1281160
Replace attachment point swivel on both ccts.
Urgent - E/w att. Point swivel flaking rust CA Coded 20 need replacing. Replace attachment poin swivel on both ccts.
1438900
Attachment points & hardware at replacement criteria
Replace swivels, cold end hardware, hot end hardware including armour rods on tower 73 ASB_ISL_1 cct only Attachment points and hardware at replacement criteria and are outstanding from YTL project not completed. Works completion requested to be done under maintenance by Transpower.
2201677
STR; HAM-WHU-A0012-00; HAM-PAO-WHU 2 Insulator attachments at R/C due to severe corrosion, rated at
2250656
CA STR: EW Attachment Condition @25 on 29/08/2014
CA STR: EW Attachment Condition @25 on 29/08/2014 - EW att wind wear has reached R/C, att points 20% cross-sectional metal loss to SWL pins + att point bolts + plates, heavy corrosion to att bolts
2250793
CA STR: Insulator Attachment Condition @25 on 12/08/2014
CA STR: Insulator Attachment Condition @25 on 12/08/2014 - MDN-MPE-2 - 3x phase has significant rusting with some metal loss, builup of corrosion. Top (red) and mid (yellow) phases appear to be frozen. Att bolts very corroded MDN-MPE-1 - 3x phase has significant rusting with some metal loss, builup of corrosion. Top (red) and mid (yellow) phases appear to be frozen. Att bolts very corroded
2250797
CA STR: Insulator Attachment Condition @25 on 13/08/2014
CA STR: Insulator Attachment Condition @25 on 13/08/2014 - MDN-MPE-2 - 3x phase corrosion is severe enough to creak. Major metal loss. HW frozen by corrosion. MDN-MPE-1 - 3x phase corrosion is severe enough to creak. Major metal loss. HW frozen by corrosion.

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