DIAM Program – Desktop and Tablet

Application to investigate and mitigate problems in Nuclear Power Plants

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Background

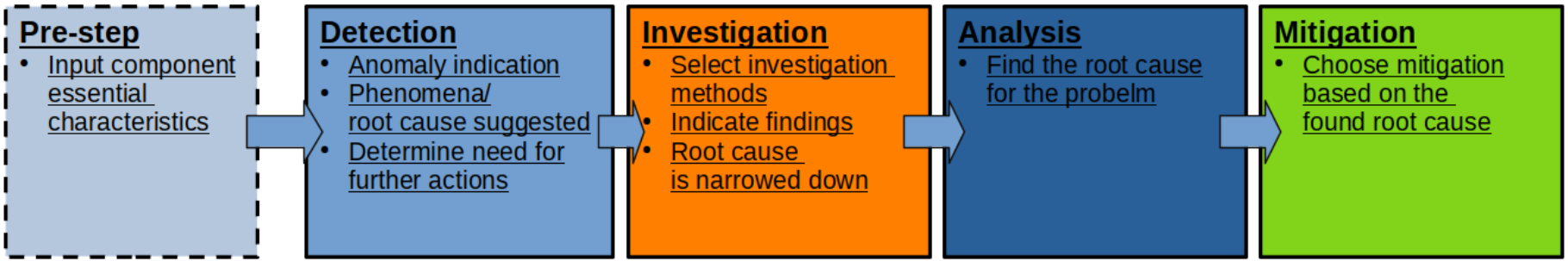
- Energiforsk Vibrations R&D program
- Participants from Nordic NPP operators
- Idea for DIAM Excel tool by Paul Smeekes from TVO
  - Systematical problem solving approach
  - Increase and knowledge transfer
- Master's thesis and R&D projects developing the Excel tool
  - Pipe vibration – Mikko Merikoski
  - Turbine and generator vibrations – Rainer Nordmann
  - DIAM-matrices for EDG vibrations – Antti Kangasperko and Wärtsilä
- After these projects the matricies were tuned by the Energiforsk Vibration group

DIAM Description

- General problem solving process
- DIAM stands for:
  - Detection
  - Investigation
  - Analysis
  - Mitigation

- Provides systematic approach to investigate anomalies
- Probability based suggestions for further actions are based on the weight function method

Excel sheets, Workflow and Responsibilities



Responsible party:

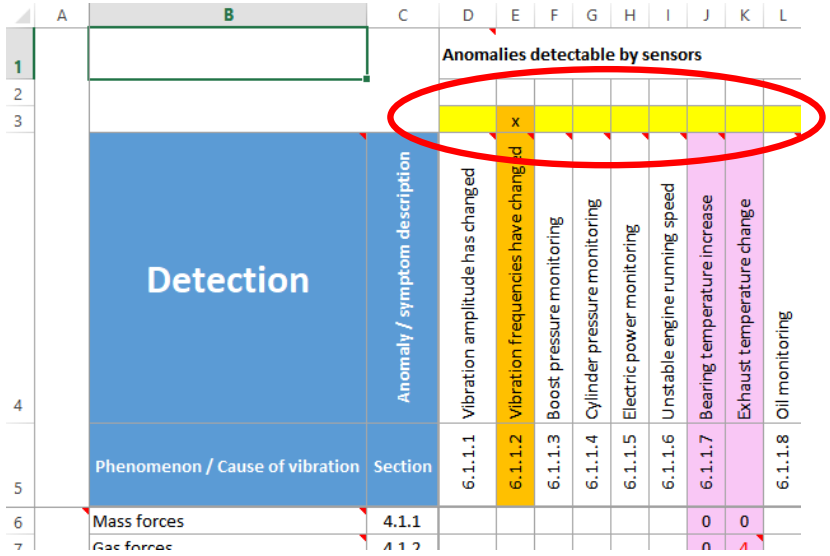
Power plant personnel

Supplier / 3rd Party

DIAM Problem solving with Excel

- One excel covers one type of component or problem
- Each step is associated with a matrix
- During a step necessary markings are made
- Markings affect the probabilities in current and further steps

1) Detection: Indicate anomalies
2) Investigation: Study suggested methods, perform investigations and indicate findings
3) Analysis: Study suggested analysis methods
4) Mitigation: Based on the analysis indicate the root cause of the problem. Possible mitigations are suggested.



Matrices in Excel

[Link to EDG DIAM]

Detection

	Anomaly / symptom description	Vibration amplitude has changed	Vibration frequencies have changed	Boost pressure monitoring	Cylinder pressure monitoring	Electric power monitoring	Unstable engine running speed	Bearing temperature increase	Exhaust temperature change	Oil monitoring	Narrowband noise	Broadband noise	Continuous noise	Transient noise	Amplitude modulating noise	Intermittent / hammering noise	Low frequency noise	High frequency noise	Crack	Leakage	Wear dust or wear marks	Component failure	Visible or noticable vibration
		Anomalies detectable by sensors								**Anomalies detectable by human senses**													
Mark here "x" if detected			x																				
Phenomenon / Cause of vibration	Section	6.1.1.1	6.1.1.2	6.1.1.3	6.1.1.4	6.1.1.5	6.1.1.6	6.1.1.7		6.1.1.8	6.1.1.9	6.1.1.10	6.1.1.11	6.1.1.12	6.1.1.13	6.1.1.14	6.1.1.15	6.1.1.16	6.1.1.17	6.1.1.18	6.1.1.19	6.1.1.20	6.1.1.21
Diesel engine																							
Mass forces	4.1.1							0	0		1	2		2		0	4		4	2	2	3	4
Gas forces	4.1.2							0	4			3	5	3		0	5	2	5	3	3	4	5
Crankshaft torsional critical speed	4.1.5	2	2				2	0	0	2	1	3	2	5		0	2	3	5	2	4	5	1
Misfiring	4.1.7	4	5	5	5	4	5	1	5	1	1	3	2	3	3	5	5		2		3	4	4
Diesel knock	4.1.8	1	2	1	4	1	2	1	3	3		2		1		4		3			2	1	1
Piston slap	4.1.9	2	2				1	0	0	5	3	1		5		3	4	4			5		1
Governor hunting	4.1.11	3	4	2	1	2	5	0	1		3	1	3	2	5	3	3				4	1	3
Magnetic forces	4.2.1							0	0		3	1	3		2	0		4	3	1	1	1	2
Static eccentricity	4.2.3	3	1			3		3	0	2	3	1	1		3	0	1	2	4		2	3	1
Dynamic eccentricity	4.2.4	4	1			3		3	0	3	3	1	1		3	0	1	2	2		2	2	3

Phenomenon / Cause of vibration	Diesel engine + mounted components	Generator + mounted components	Turbochargers	Base frame	Coupling	Bearing housing	Rotating auxiliary component	Piping	Not applicable or uncertain	Commonness	Severity	Product of probabilities, if no blanks	Relative probabilities	Commonness & Severity weighted probability	Commonness	Severity
	Anomaly location															
Mass forces	5	4	5	5	5	3	4	5	1	5	2	0				
Gas forces	5	4	5	5	5	3	4	5	1	5	3	0				
Crankshaft torsional critical speed	4	1	0	1	4	1		1	1	1	5	2	3 %	2 %	1 %	5 %
Misfiring	5	3	5	5	5	1		5	1	3	2	5	8 %	5 %	8 %	5 %
Diesel knock	3		2		2			1	1	1	2	2	3 %	1 %	1 %	2 %
Piston slap	4	1	1	1	2	1		1	1	2	1	2	3 %	1 %	2 %	1 %
Governor hunting	5	3	5	3	5	1		2	1	2	4	4	6 %	6 %	4 %	8 %
Magnetic forces	2	5	0	3	2	3		2	1	5	1	0				
Static eccentricity	3	5	3	4	3	4		3	1	3	4	1	2 %	2 %	2 %	2 %
Dynamic eccentricity	3	5	3	3	2	5		3	1	2	3	1	2 %	1 %	1 %	2 %

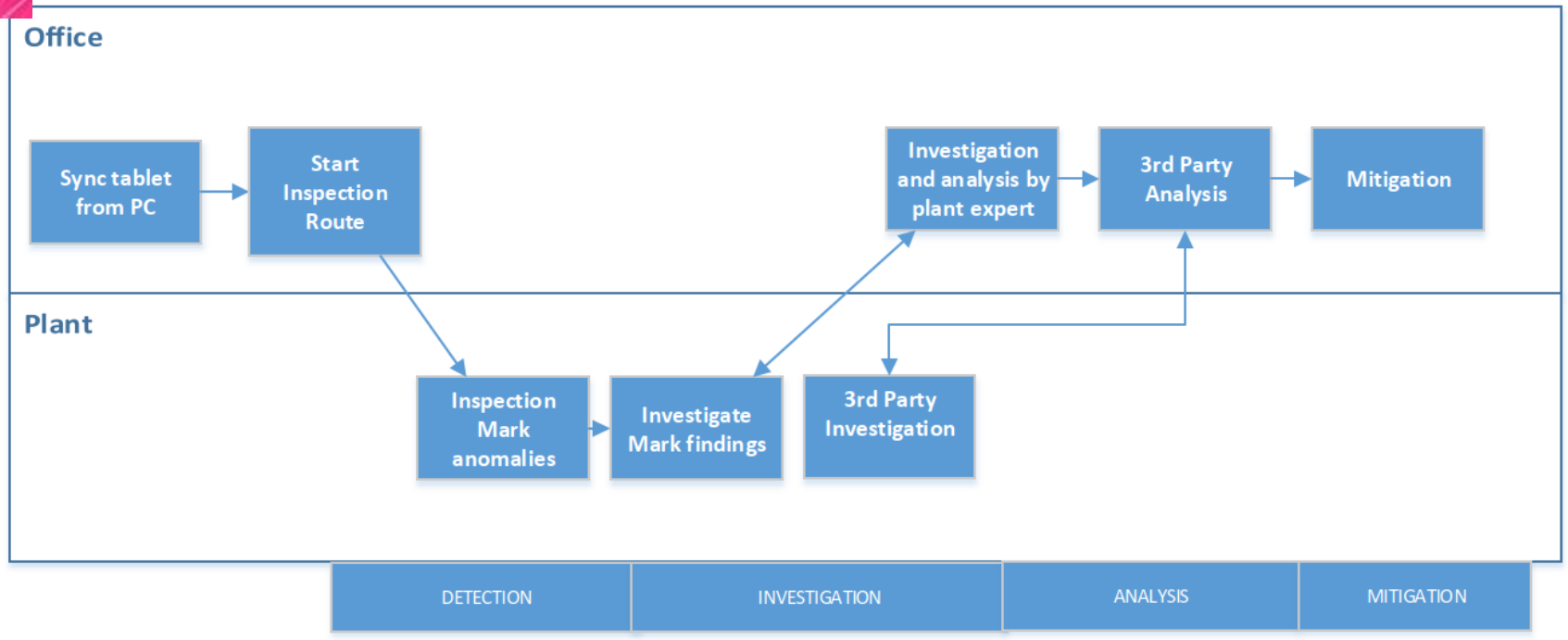
<---- Mark here "x" if not used in the plant

<---- Mark here "x" if detected

Integrated Desktop and Tablet Application

	Excel	Application
Data Storage / Database	Fragmented	Organized
Maintainability	Fragmented	Robust
User Guidance	None/Manual	Active
Visible Information	All	Significant only
Workflow	Simple	Flexible
Use of Historic Data	Difficult	Easy
User	Expert	Expert & Inspector

Application Workflow



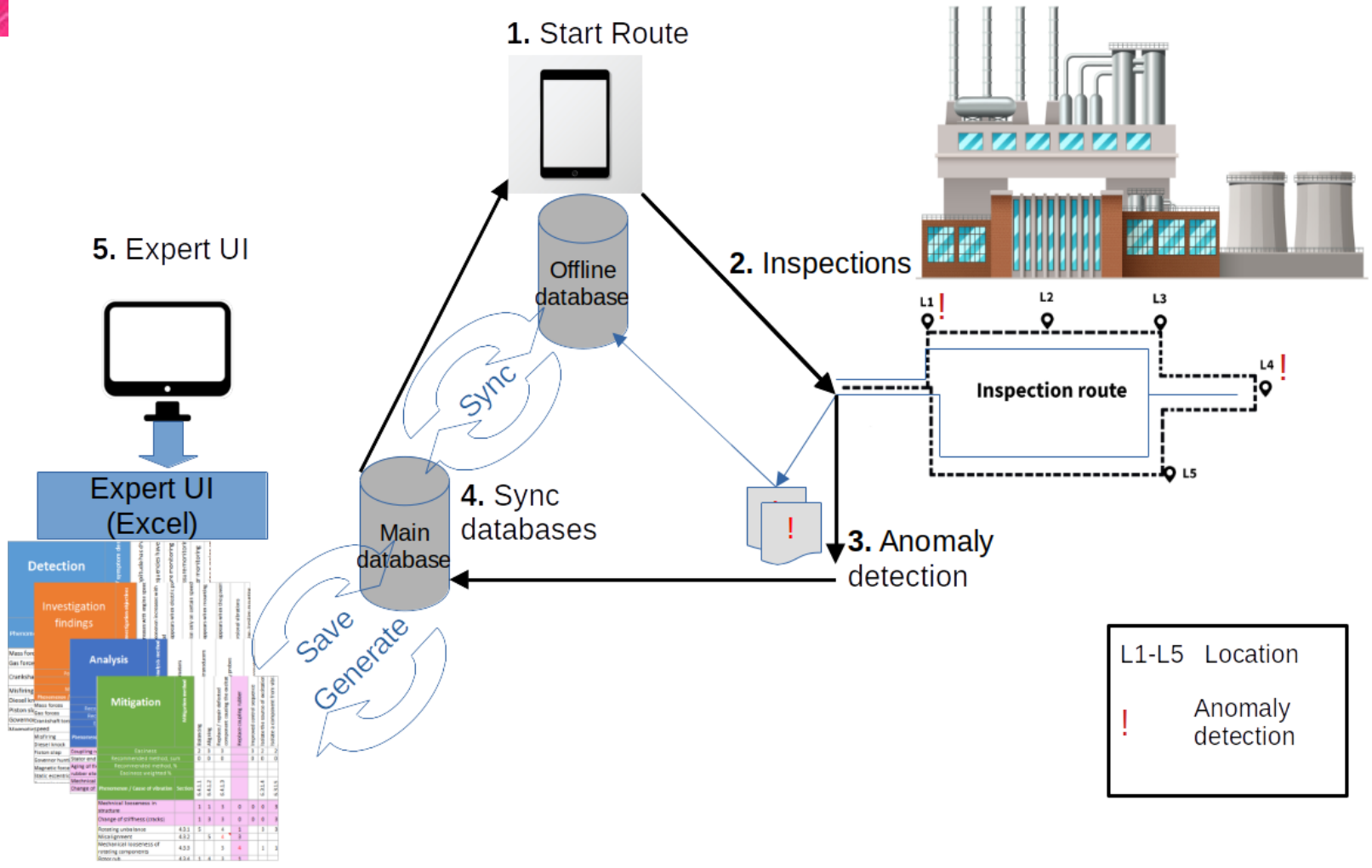
Surveyor / Power plant personnel

Maintenance personnel

Expert

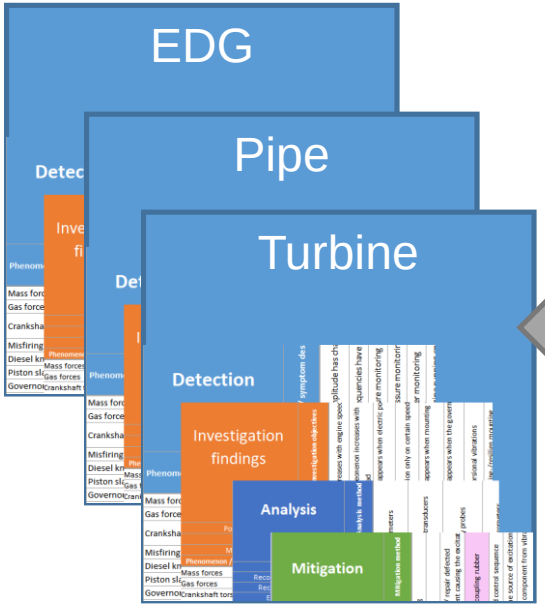
3rd Party Consultant

DIAM Tablet/PC Application



Preparations

DIAMs



...

Connect

Component Types:

Diesel generator (Nohab/Wärtsilä F216V)

Turbine

Pipe (straight pipe / bend)

...

Connect

Installed Component:

EDG1 (Nohab/Wärtsilä

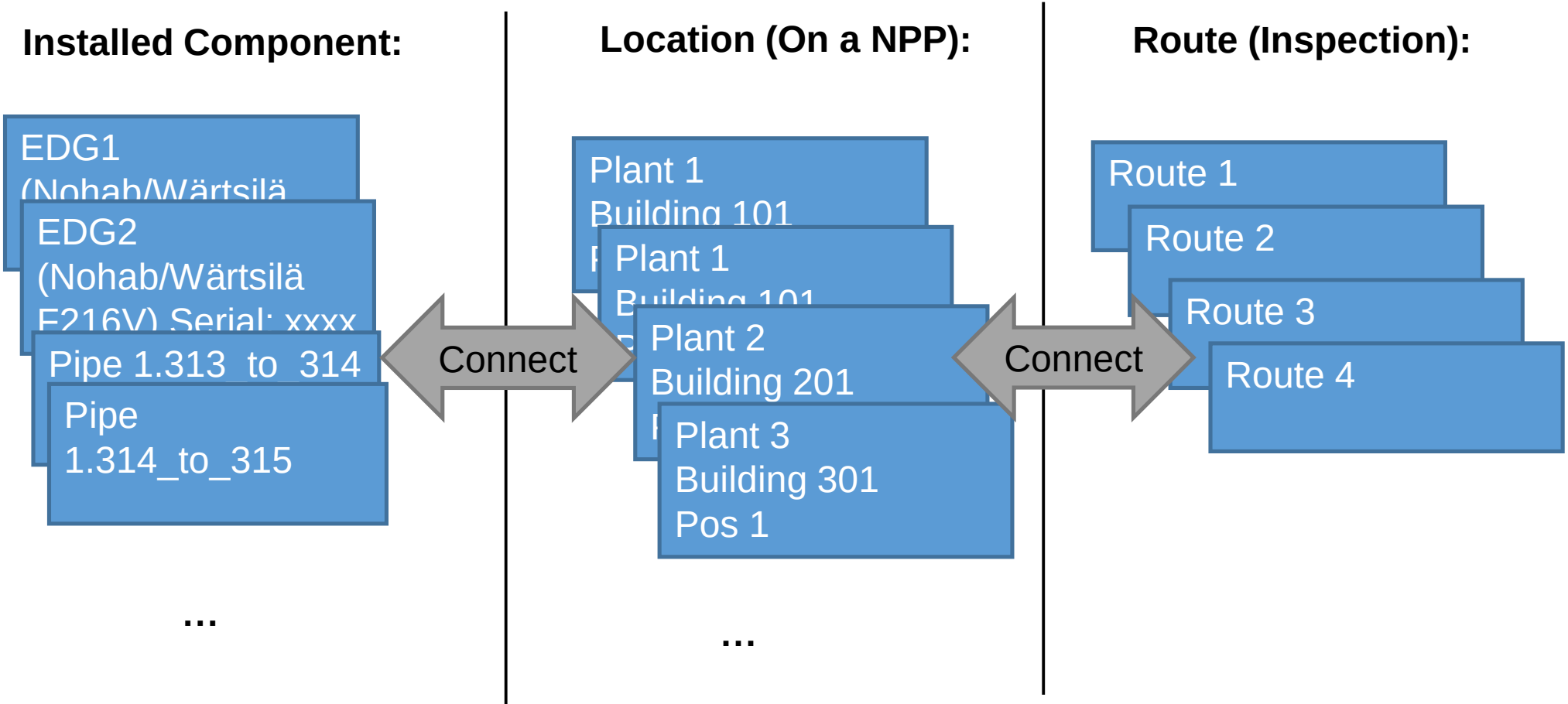
EDG2 (Nohab/Wärtsilä F216V) Serial: xxxx

Pipe 1.313_to_314

Pipe 1.314_to_315

...

Preparations



Hardware

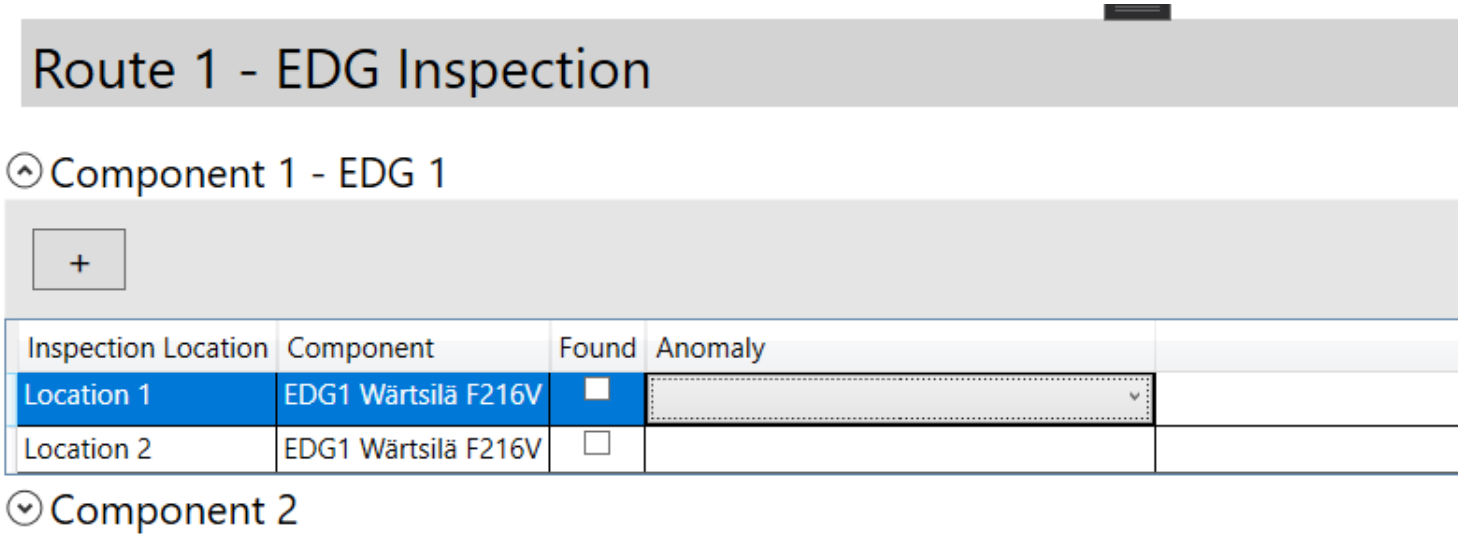
- Dell Tablet
  - 2-in-1
  - Can act as tablet or laptop
  - Standalone
  - Connectivity

Technical details

- Windows based software
- Written in C# programming language
- Database agnostic
  - Can be used and integrated with existing databases
  - SQLite was used in the pilot project

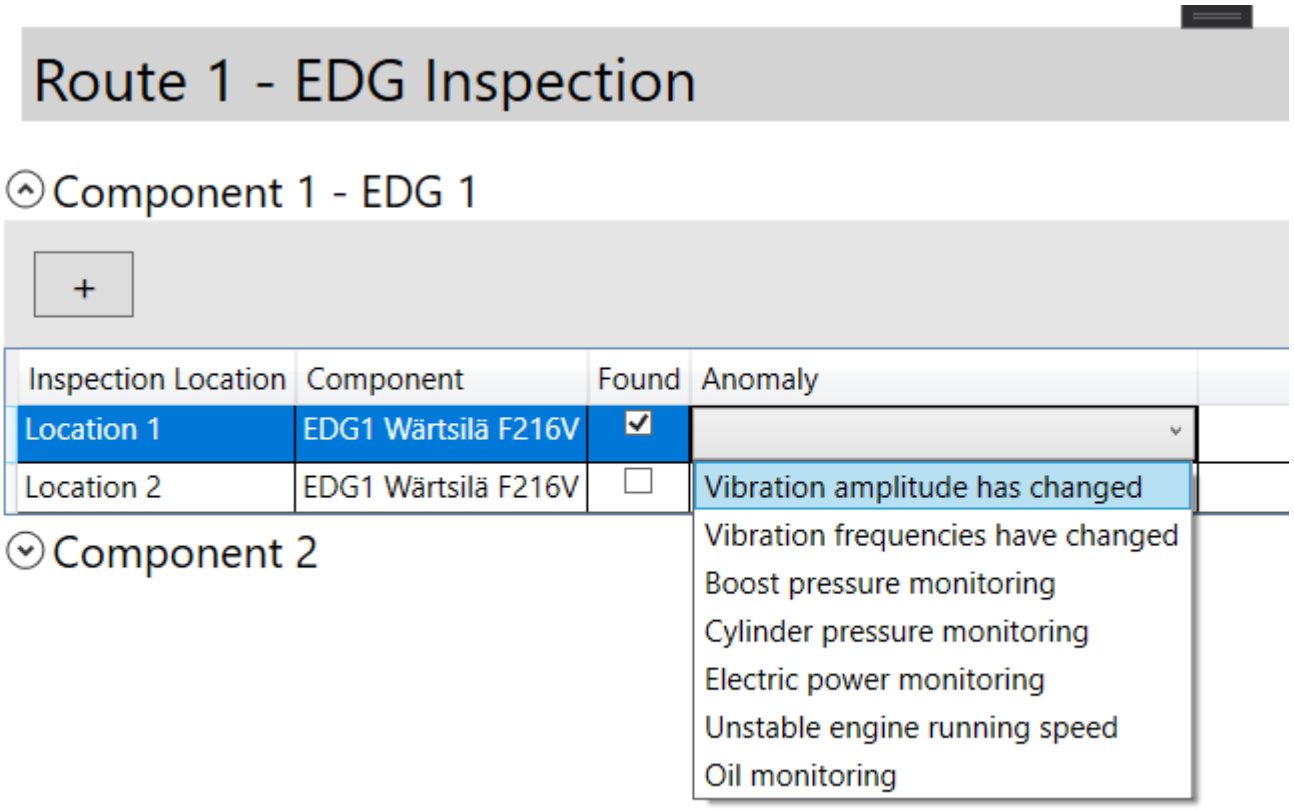
Tablet view

Exit Tablet View



Tablet view

Exit Tablet View



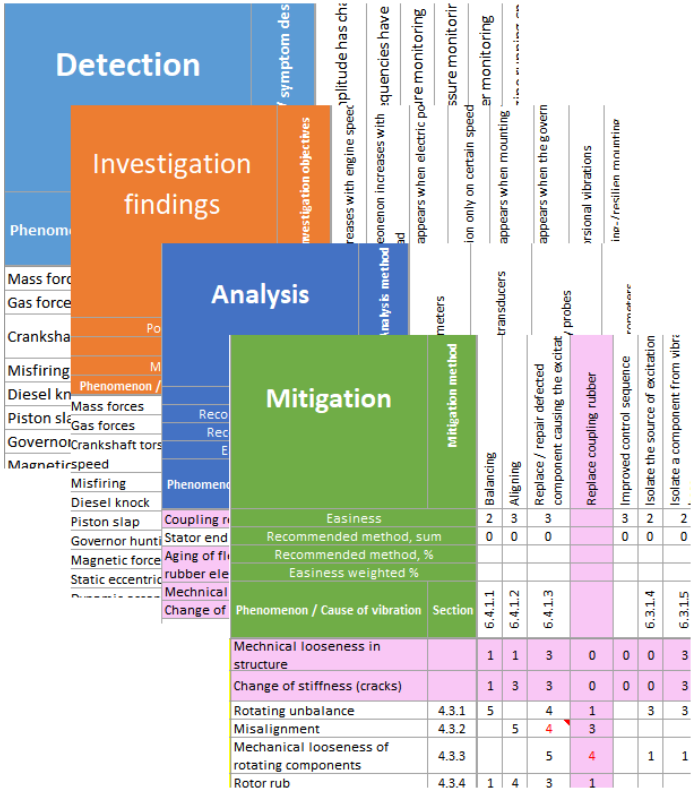
Desktop view

Route 1 – EDG 1:

Detection 1:
Anomaly: Vibration
Am

Detection 2:
Anomaly: Leakage

Investigation 1:
Finding: Vibration at 25 Hz



Thank you

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