

Document type: Presentation  
Document number: FSD1021435  
Date: 2017-10-19  
Number of pages: 20

Issued by: Mikko Merikoski



# Energiforsk

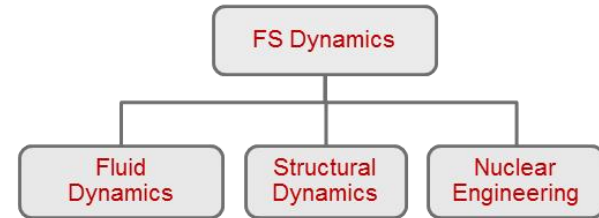
Pipe vibrations in nuclear power plants

[info@fsdynamics.fi](mailto:info@fsdynamics.fi)  
[www.fsdynamics.fi](http://www.fsdynamics.fi)

# FS Dynamics

## FS Dynamics' Organization

- Founded in 2004 in Sweden
- Headquarters in Gothenburg
- 10 offices in 6 countries
- Corporation + 6 subsidiaries
  - FS Dynamics Denmark founded 2009
  - FS Dynamics Finland founded 2010
  - FS Dynamics Norway founded 2013
  - FS Dynamics Portugal founded 2016
  - FS Dynamics UK founded 2016
- 180 employees, 35 in Finland



# Contents

1. Introduction
2. Workflow of DIAM-Matrix tool
3. DIAM-Matrices
4. Conclusions

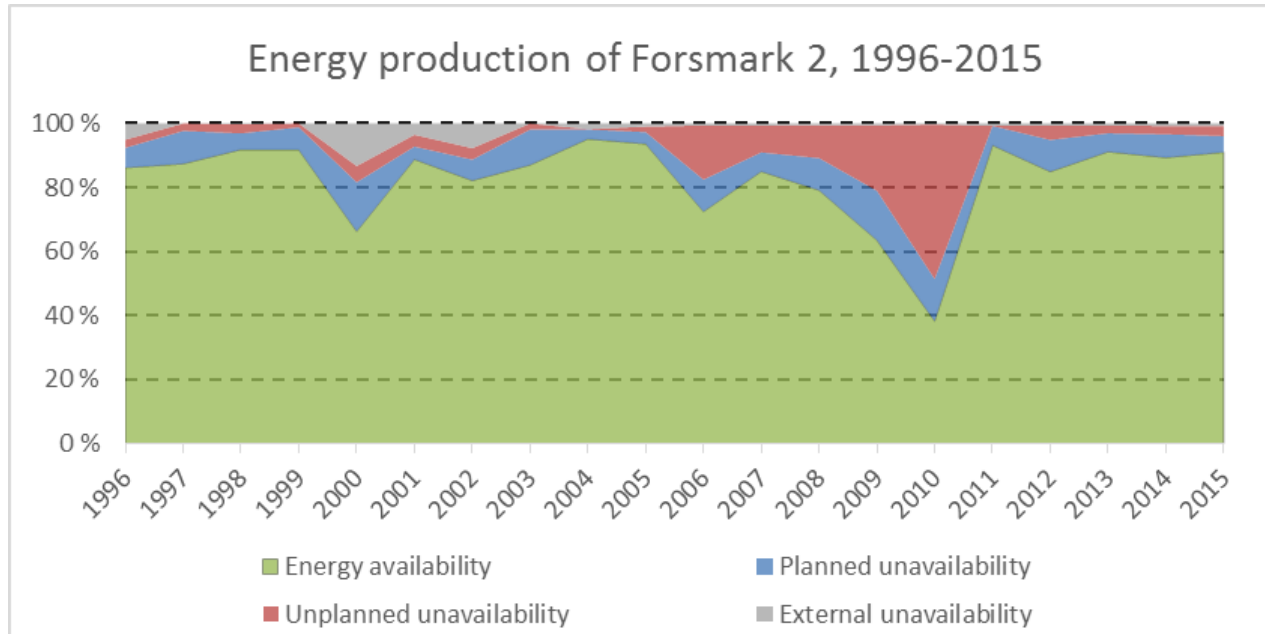
# Contents

1. Introduction
2. Workflow of the DIAM-Matrix tool
3. DIAM-Matrices
4. Conclusions

# Introduction

- The project was carried out as master's thesis
  - Finished in August
- Target of thesis was:
  - Gather knowledge related to pipe vibrations
  - Simple tool for solving pipe vibration problems
  - Knowledge transfer to young professionals
- Research methods:
  - Literature review and interviews

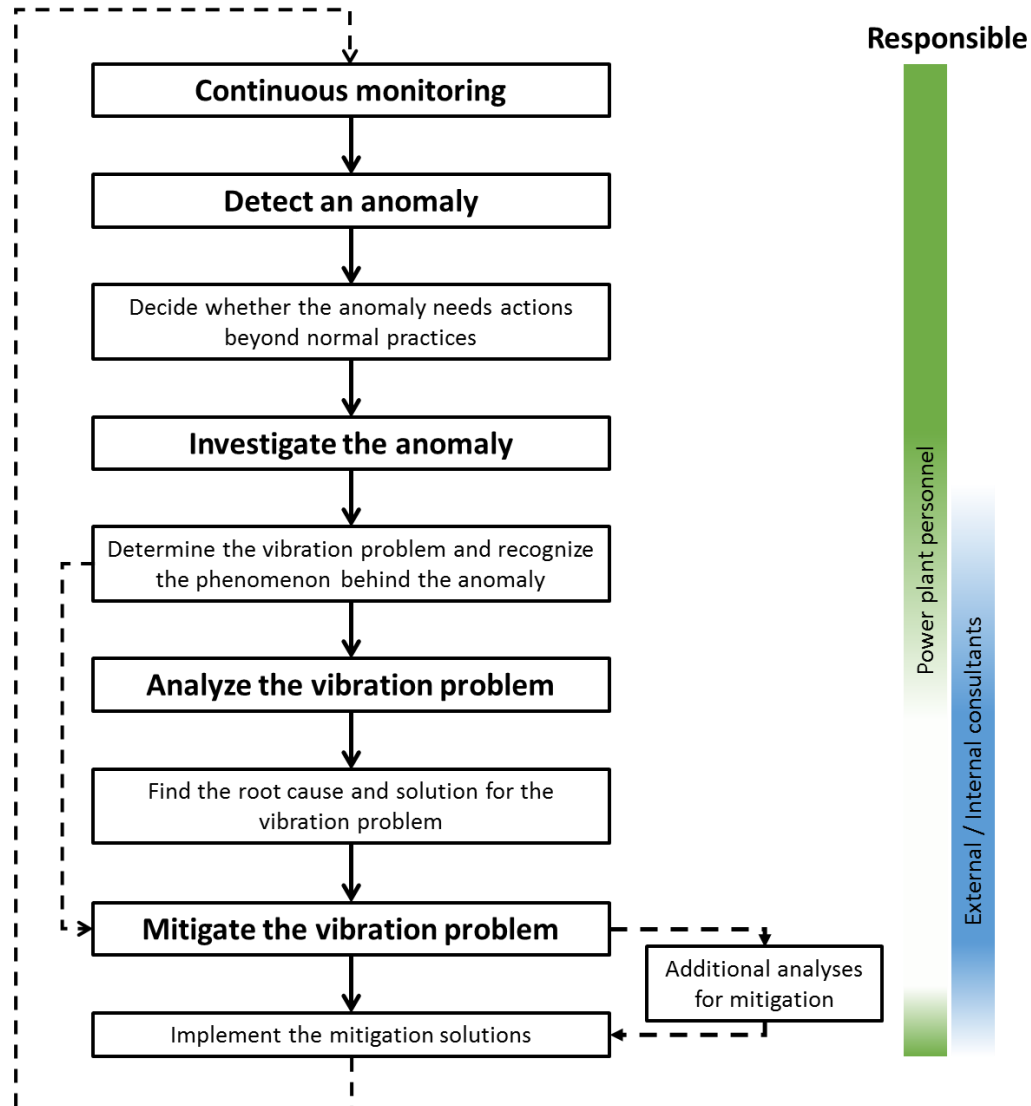
# Costs of pipe vibrations



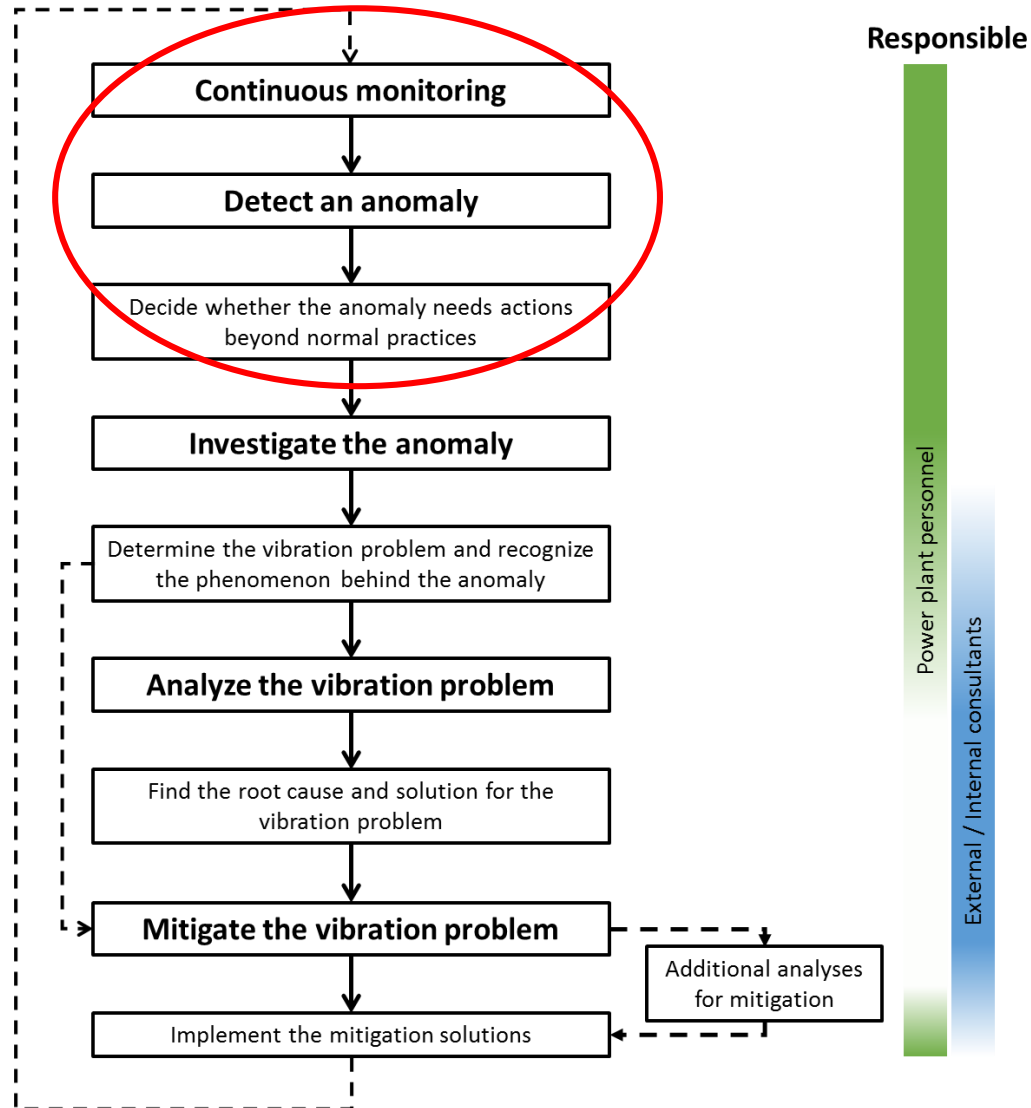
- One day:
  - $24\text{h} * 1\,158\,000\text{kW} * 0,02\text{€/kWh} = 555\,840\text{€}$
- Half a year: 101,4 M€

# Contents

1. Introduction
- 2. Workflow of the DIAM-Matrix tool**
3. DIAM-Matrices
4. Conclusions

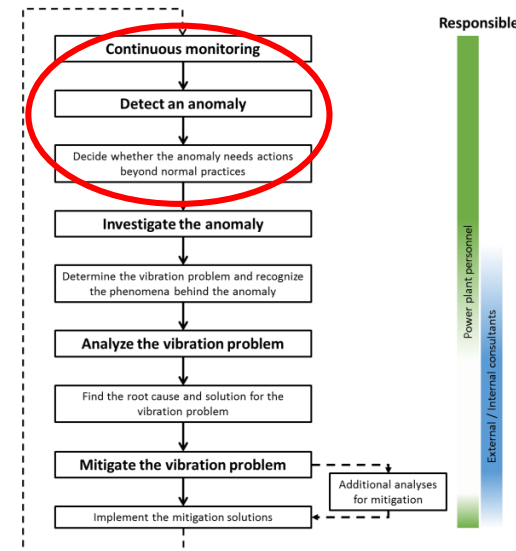


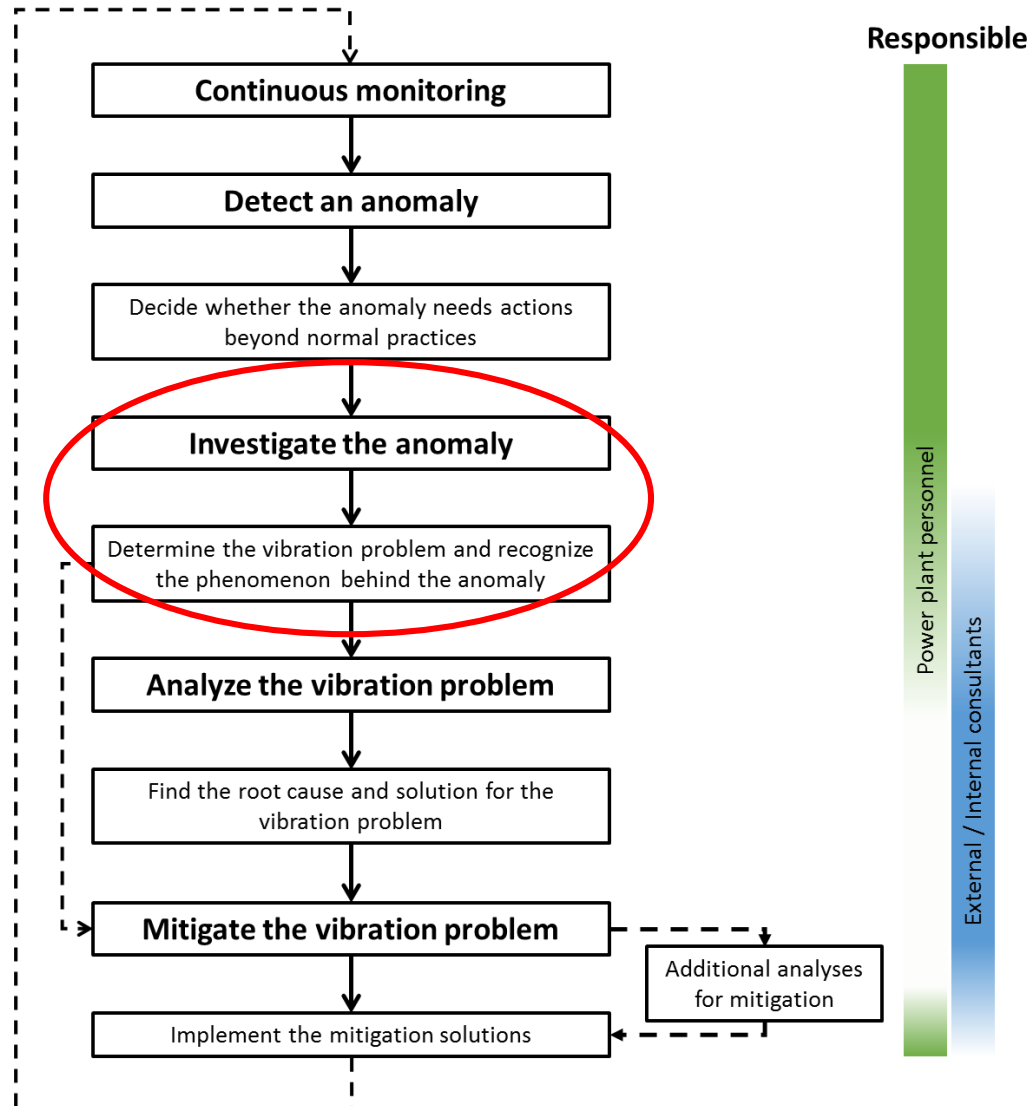




# ”Detection”-phase

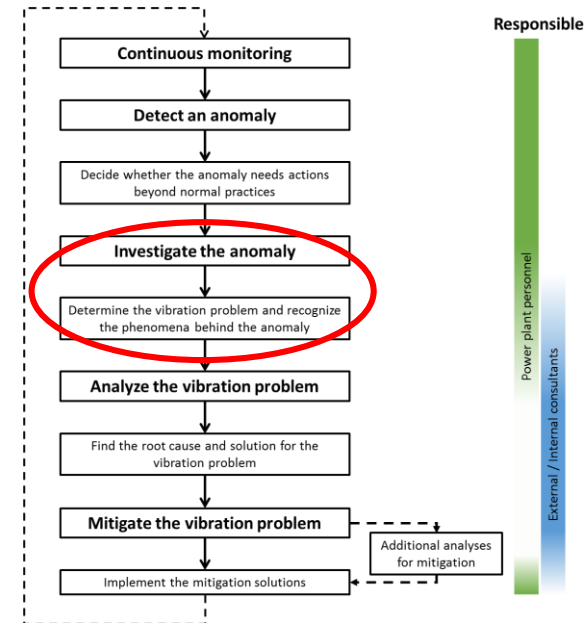
- An anomaly is detected by continuous monitoring
  - Normal operation of the plant
  - Inspections, measurements, checks
  
- Anomalies are indicators of vibration problems
  - Alarms, leaks, noises, cracks, damages
  
- Already the anomaly can reveal a lot
  - Frequency range
  - Narrowband / broadband / impulse
  - Continuous / short-term



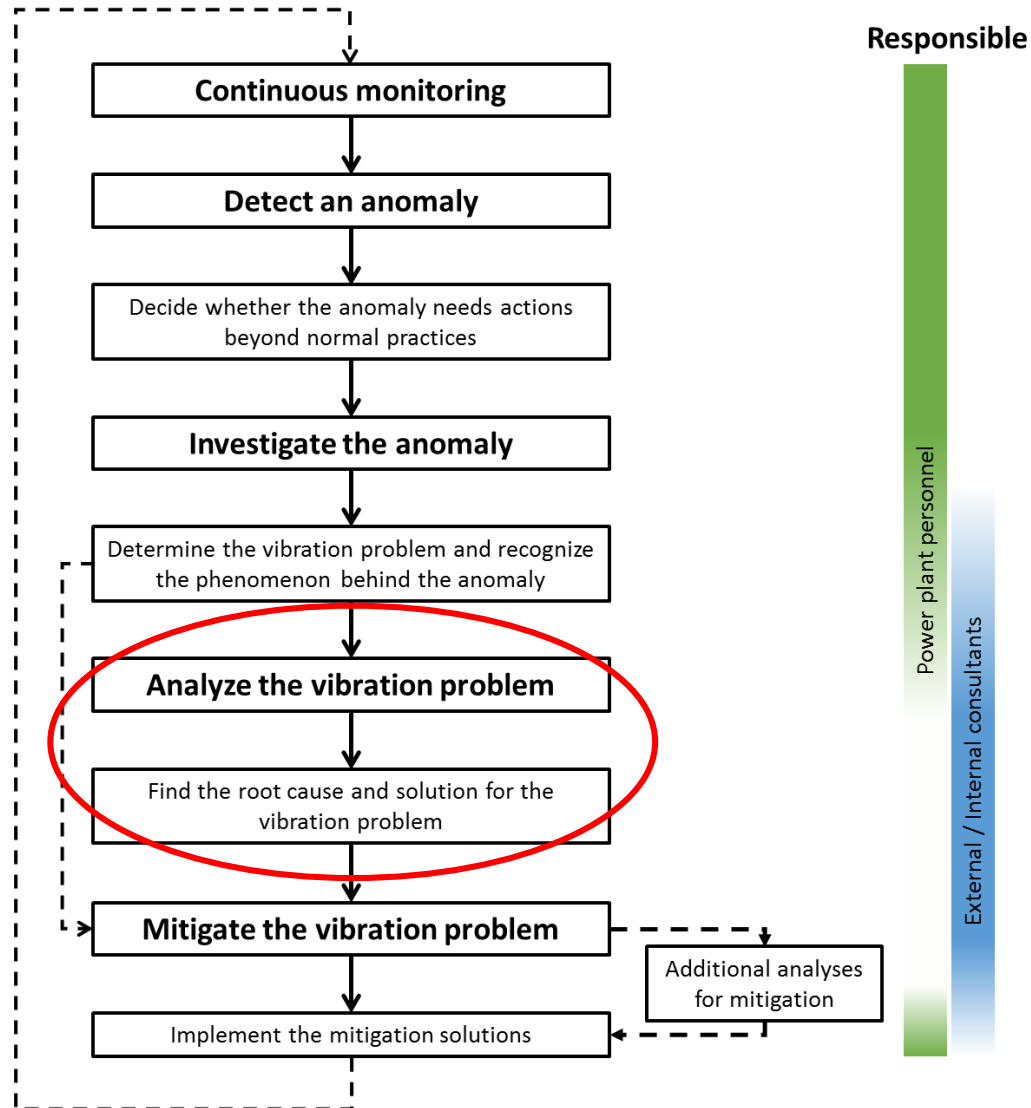


# ”Investigation”-phase

- **Verification of the detected anomaly**
  - What vibrates?
  - Problematic frequencies / frequency ranges
  - Correlation between variables and vibration
  
- **Investigation methods**
  - Simple measurements, tests and checks
  - Focus of the matrices in investigation

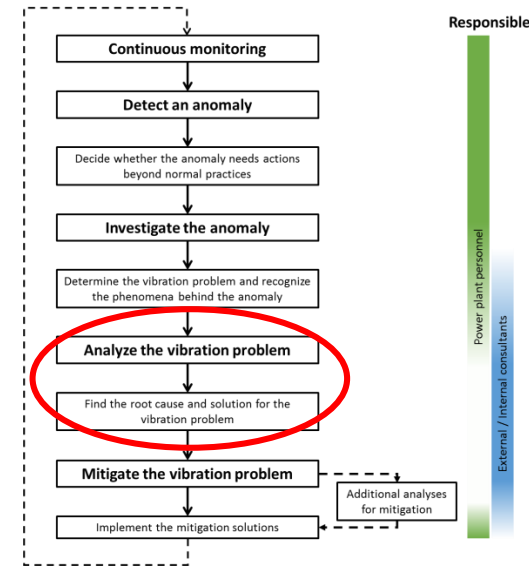


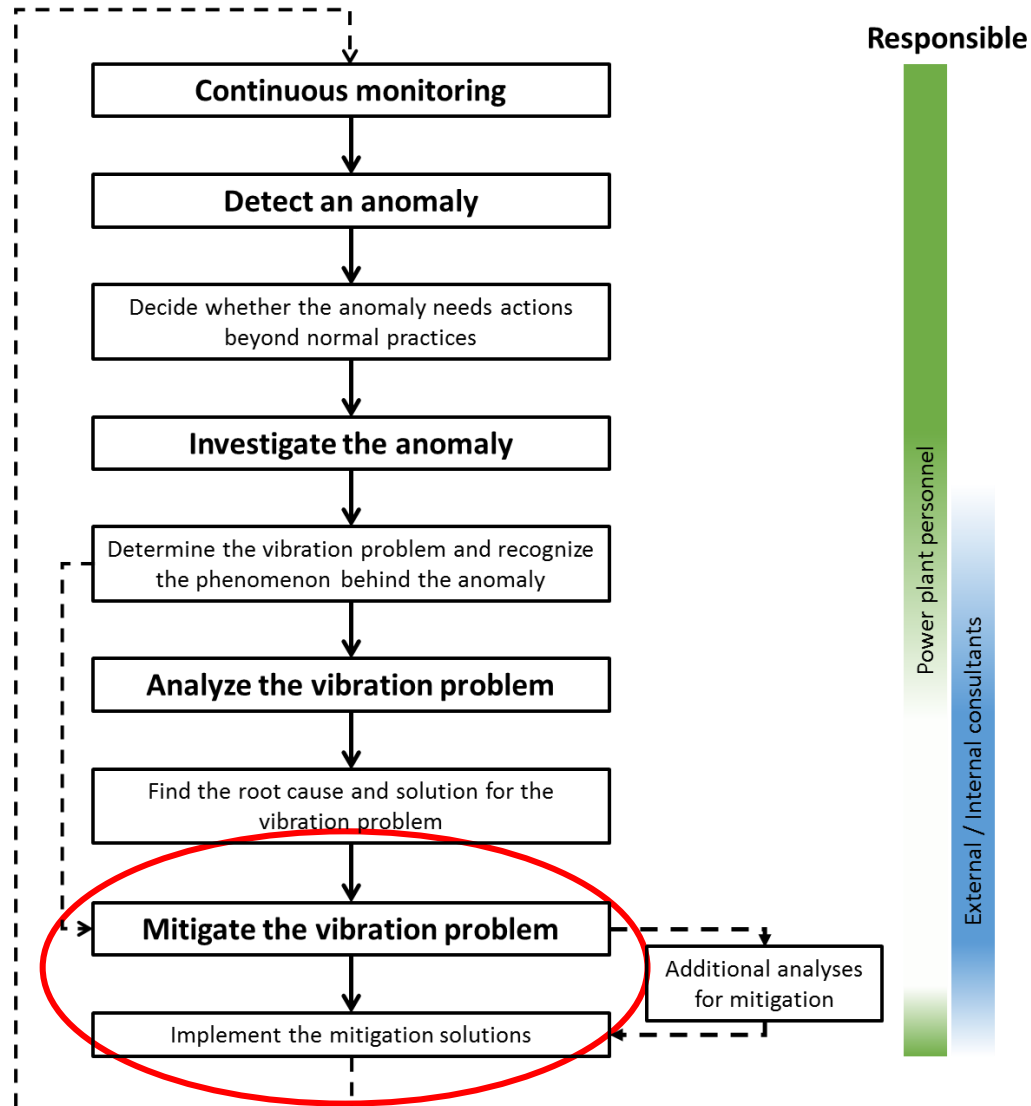
- **Goal is to find out the phenomenon causing the problem**
  - Rule out phenomena which did not cause the anomaly
  - In “Analysis”-phase it is possible to focus directly on right phenomenon



# ”Analysis”-phase

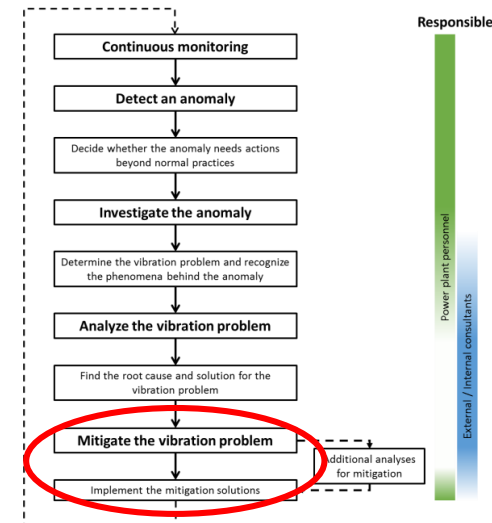
- More precise research
  - Measurements (frequencies, modes, phases)
  - Simulations
  - Scale models
  
- Requires large amount of time and knowledge
  
- Goal is to find out the root cause and solution
  - Root cause is the design error causing the vibration problem
  - Root cause is required for effective mitigation
  - Also the solution (mitigation method) should be analyzed





# ”Mitigation”-phase

- **Choosing the mitigation method**
  - Best mitigation method depends on the phenomenon
  - Some methods can be used even if the phenomenon is unknown
  
- **Goal is to mitigate the vibration to safe level**
  - Mitigation for excitation
  - Mitigation for response
  
- **Mitigation is not always needed**
  - Safe operation ensured with analyses
  - Reinforcing the component suffering from vibration





# Contents

1. Introduction
2. Workflow of the DIAM-Matrix tool
- 3. DIAM-Matrices**
4. Conclusions



# Contents

1. Introduction
2. Workflow of the DIAM-Matrix tool
3. DIAM-Matrices
- 4. Conclusions**

# Conclusions

- **Main benefits of DIAM-Matrix tool:**
  - Systematic method for solving pipe vibration problems
  - Tool guides the user through the process
  - Faster solving of pipe vibration problems
- **Improvements:**
  - Developing the probabilities in the matrices
  - Computer program with the matrices and thesis integrated