MULTI-HAZARD ASSESSMENT FOR THE SAFETY MANAGEMENT OF EMBANKMENT DAMS

First steps

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AGENDA

1 – Introduction
- ❑ The relevance of the theme

2 – RES Methodology
- ❑ The purpose of the methodology
- ❑ Implementation

3 – State of the Art
- ❑ Examples of use of the methodology

4 – The Goals

5 – Work Development
- ❑ Literature review – Basic earth/rock fill dam knowledge; rock engineering systems review
- ❑ Implementation of the methodology: graphical interface

6 – Chronogram

7 – References

1 – INTRODUCTION
The relevance of the theme

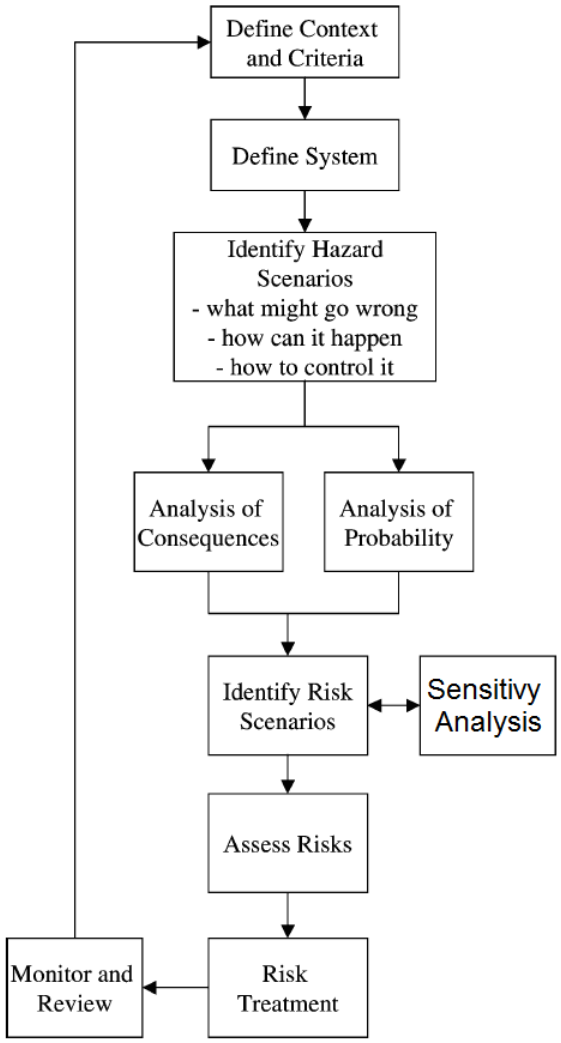
Landslide – Lewisville, Texas, USA (2015)

Internal Erosion – Piping – Tunbridge Dam, Tasmania, Australia

- Many embankment dams are nearing the end of their design life (e.g. in the U.S.) and facing increasingly climate challenging conditions.
- Current failure/deterioration detection methods include visual inspection performed by trained experts in dam safety, but are, however, scarce
- Visual inspection: neither the method nor the frequency guarantee that the failure is detected early enough to prevent damages (and eventually, collapse)
- Monitoring: the definition of the monitoring system should regard the different possible risks and their interrelations

Overtopping and breaching – Glashütte , Germany (2002)

1 – INTRODUCTION
The relevance of the theme



Generic representiation of the flow risk-based decision analysis
(Faber, M.H.; Stewart, M.G. (2003))

- The assessment of all relevant hazards is imperative for the planning, design and operation of dams.
- A specific hazard may trigger other sequential events, described as risk event chains or cascades.
- A comprehensive safety assessment and risk management should consider a multidisciplinary and multi-source evaluation.

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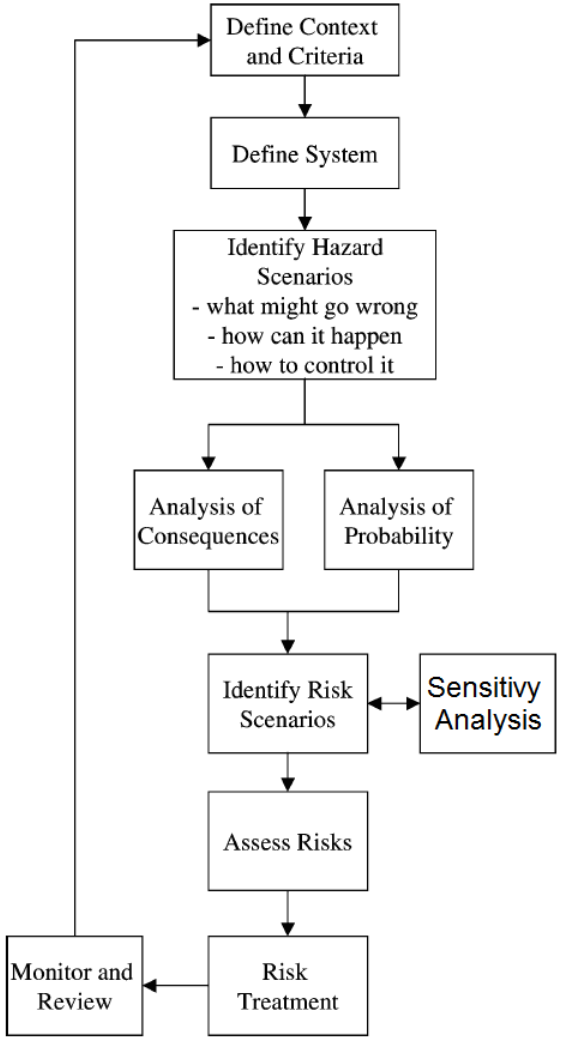

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- Experts have become very effective at modelling large dam systems' responses to single hazards, using them to increase safety.
- Current risk analysis does not clearly define / identify interrelations between events.
- Leading events are considered individually in the analysis.

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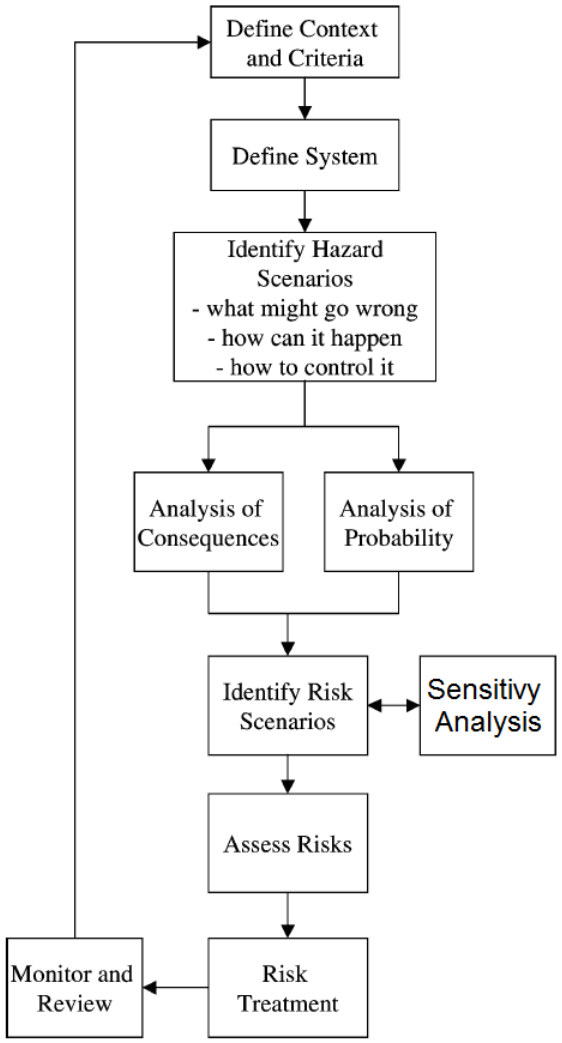

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- As Design, Construction, Maintenance and Surveillance know-how evolves and addresses single hazards increasingly well, the main source of risk may shift from isolated events – with low-probability and high intensity – to combinations of low-probability hazards, which associated can lead to highly intense risks or chains-of-events.

- Reservoir-hazard interrelations have to be identified and linked with appropriate parameters.

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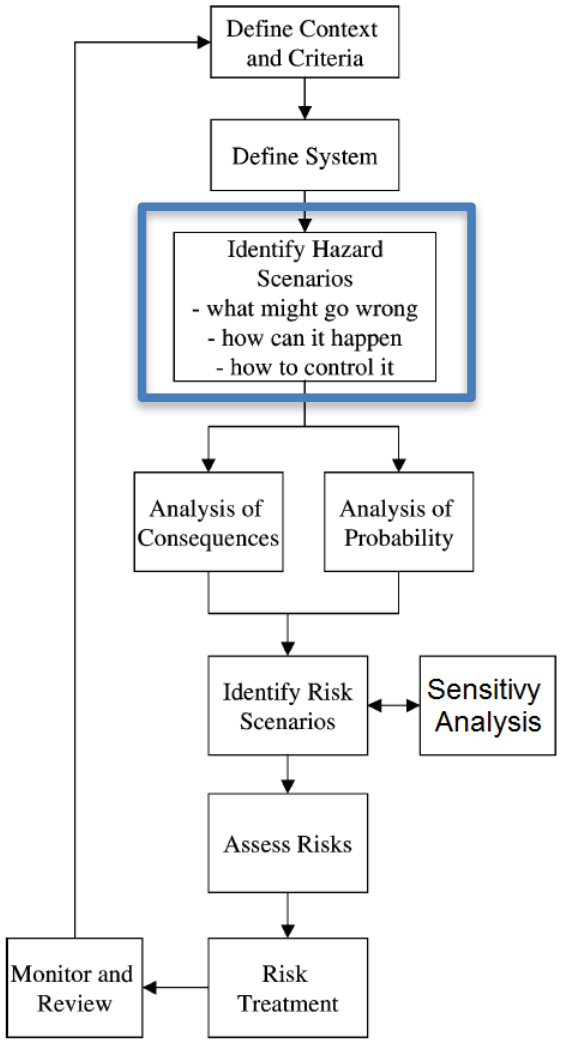

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2 – ROCK ENGINEERING SYSTEMS (RES) METHODOLOGY

The purpose of the methodology

- Rock Engineering Systems (RES) methodology was developed by Hudson (1992) as an all-encompassing procedural technique to approach increasingly complex rock engineering problems

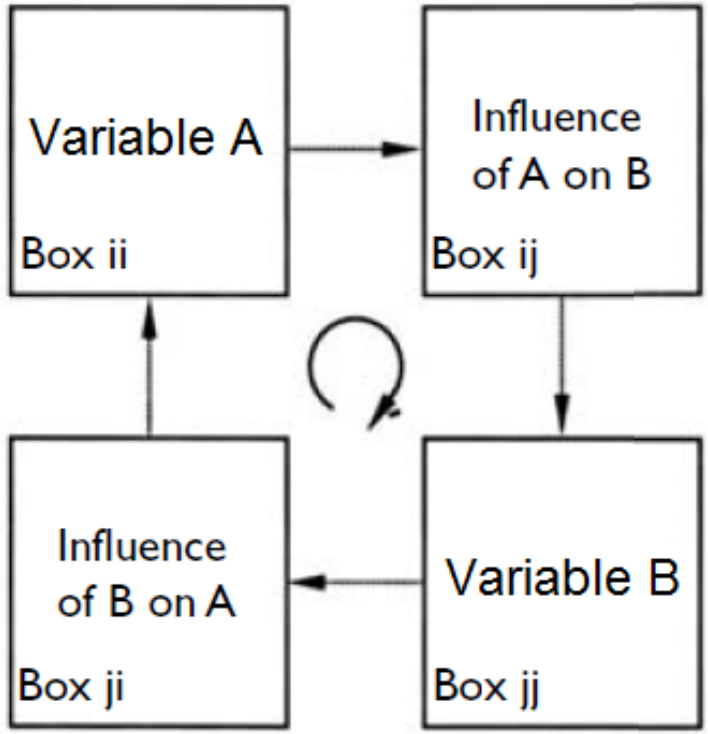
- A group of people working on a particular project often have a wealth of information between them, but no method of integrating this knowledge into a coherent whole. This methodology seeks to fill that gap.

- Ultimately, Rock Engineering Systems (RES) is a method for extracting knowledge about a particular rock engineering system, thus reducing epistemic uncertainty and hence, the risk.

2 – ROCK ENGINEERING SYSTEMS (RES) METHODOLOGY

The purpose of the methodology

- This epistemic uncertainty is reduced by the consideration of the interactions between variables, which reveals how interactive and dominant each variable is and the respective contribution

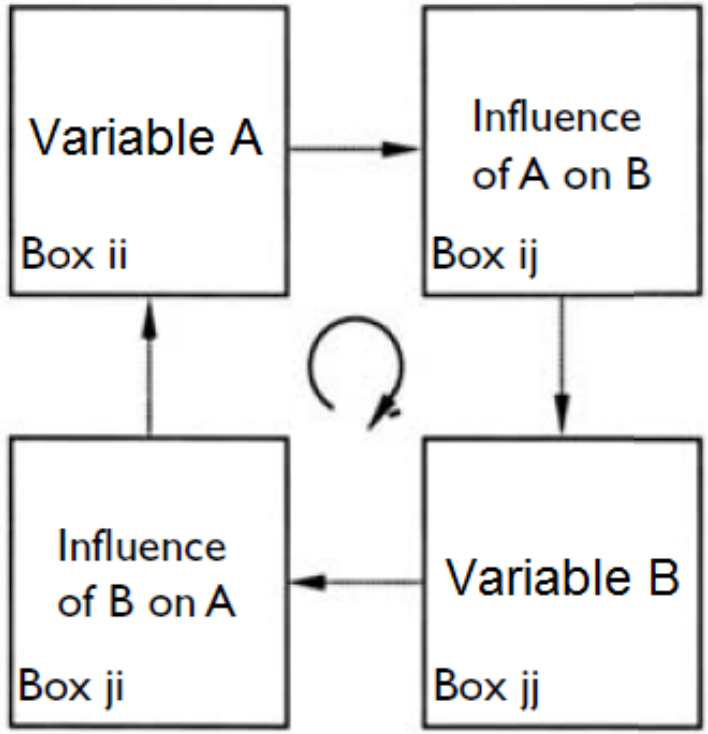


2 – ROCK ENGINEERING SYSTEMS (RES) METHODOLOGY

Implementation

- *Interaction Matrix*, in which the main variables that govern a particular system and scenario are selected and displayed along the leading diagonal. The variable's interactions are arranged in the off-diagonal terms.

- Matrix entries are coded according to the intensity of the interactions between parameters, using a pre-defined coding method.



2 – ROCK ENGINEERING SYSTEMS (RES) METHODOLOGY

- Cause-effect plots

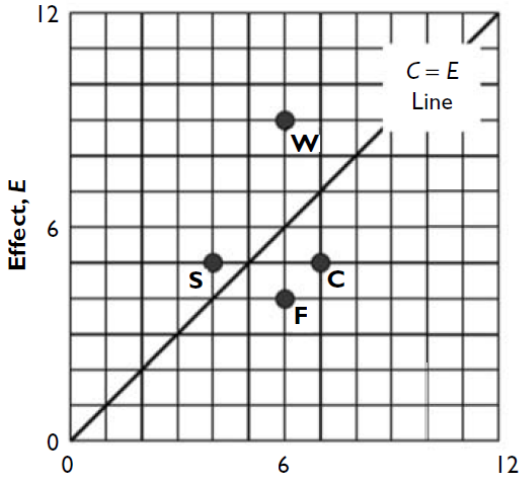
  Cause (C) the effect of the variable in the system and is quantified as the sum of the row values, once the matrix is coded.

  Effect (E) represents the system's effect in the variable P_i, and is determined as the sum of the column values.

- Interaction Intensity – Dominance plots

  Interaction Intensity represents how participative that particular variable is within the systems. The higher, the more active, and can be determined as the sum of the Cause and Effects (C+E).

  Dominance rates how influential a variable is. Positive values indicate influent variables and negative values represent a subordinate variable. It is determined as the difference between Causes and Effects (C-E).

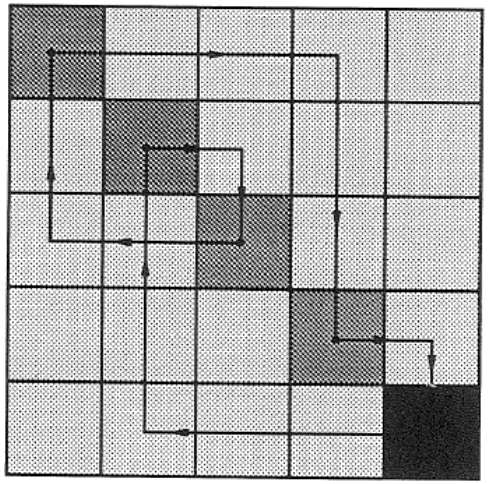


2 – ROCK ENGINEERING SYSTEMS (RES) METHODOLOGY

- Pathway analysis

  The ***Mechanism Pathways*** indicate (through the interaction matrix) the consequences of sequence of interactions rather than simply considering binary interactions.

  The distribution of pathway intensities can be computed and thus the most critical pathways recognized.



THE AIM IS TO EXTEND RES METHODOLOGY TO EMBANKMENT DAM ANALYSIS

3 – STATE OF THE ART

Examples of applications of the RES methodology include:

- Rock Slopes (e.g. to rank potentially unstable slopes)
- Tunnel Engineering (e.g. to attain a rock behavior index to assist on the choosing of the best tunneling method and support system)
- Artificial Neural Networks (ANN's) (e.g. conducting ANN analysis with databases compiled from past tunnel collapse sites in order to attain the most reliable interaction matrix)
- Index generation (in order to hierarchize or prioritize situations in relation to others)
- Embankment Dams (e.g. linking the reservoir system with the monitoring system)
- Many other fields not related to Civil Engineering (e.g. Power industry and Biology)

4 – THE GOALS

- Develop a multi-hazard assessment considering an holistic risk management of embankment dams;

Landslide – Lewisville, Texas, USA (2015)

Internal Erosion – Piping – Tunbridge Dam, Tasmania, Australia

Overtopping and breaching – Glashütte , Germany (2002)

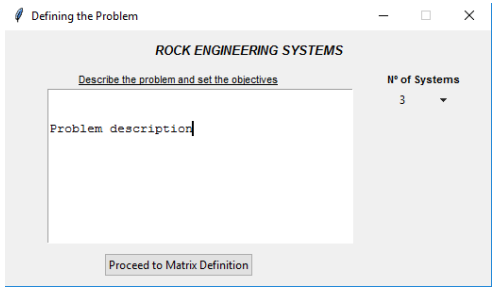
- Identify interrelations within and between systems of hazards and the dam system;

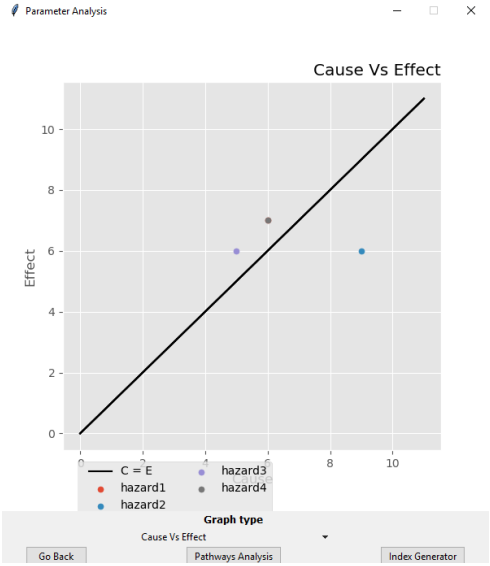
- Identify:
  - Precursors (triggers);
  - Safety barriers;
  - Design redundancies;
  - Monitoring, alert and alarm systems.

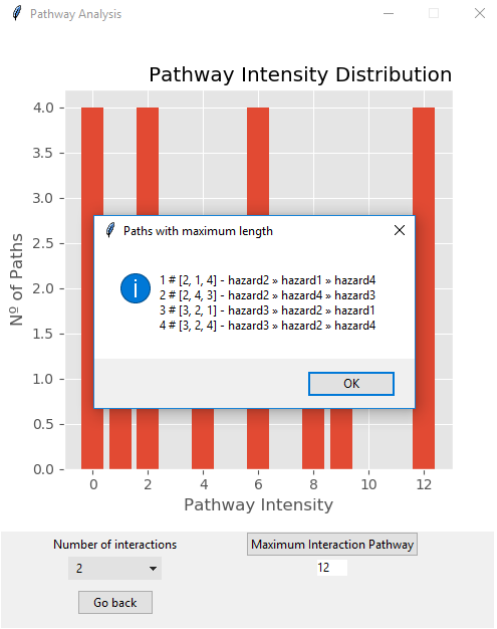
5 – WORK DEVELOPMENT

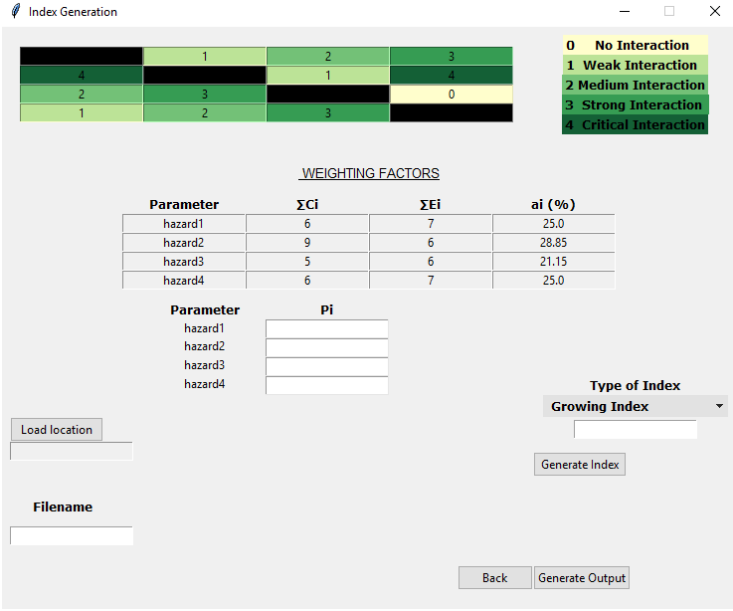
- Literature review – Reviewing general aspects concerning embankment dams; the specific method (RES) to be used and the scope of its application;

- Graphical interface to implement the methodology and visualize the output

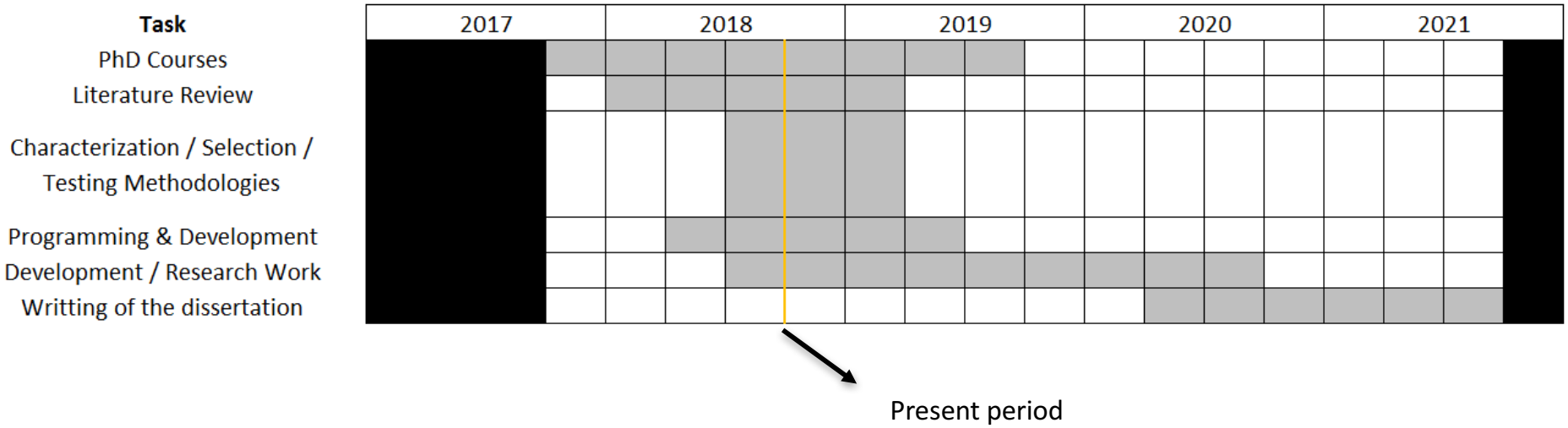








6 – CHRONOGRAM



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Thank you!