Probabilistic Pathways for Energy System Planning

WP3 - Process enhancement identification and definition

May 2024

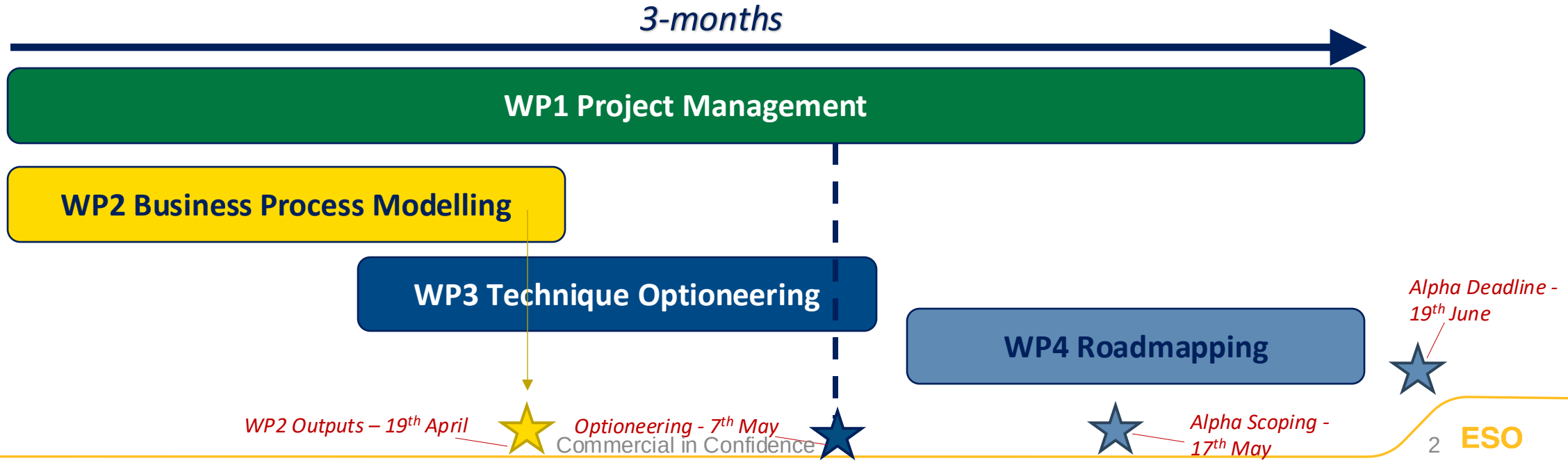
ESO

Overview

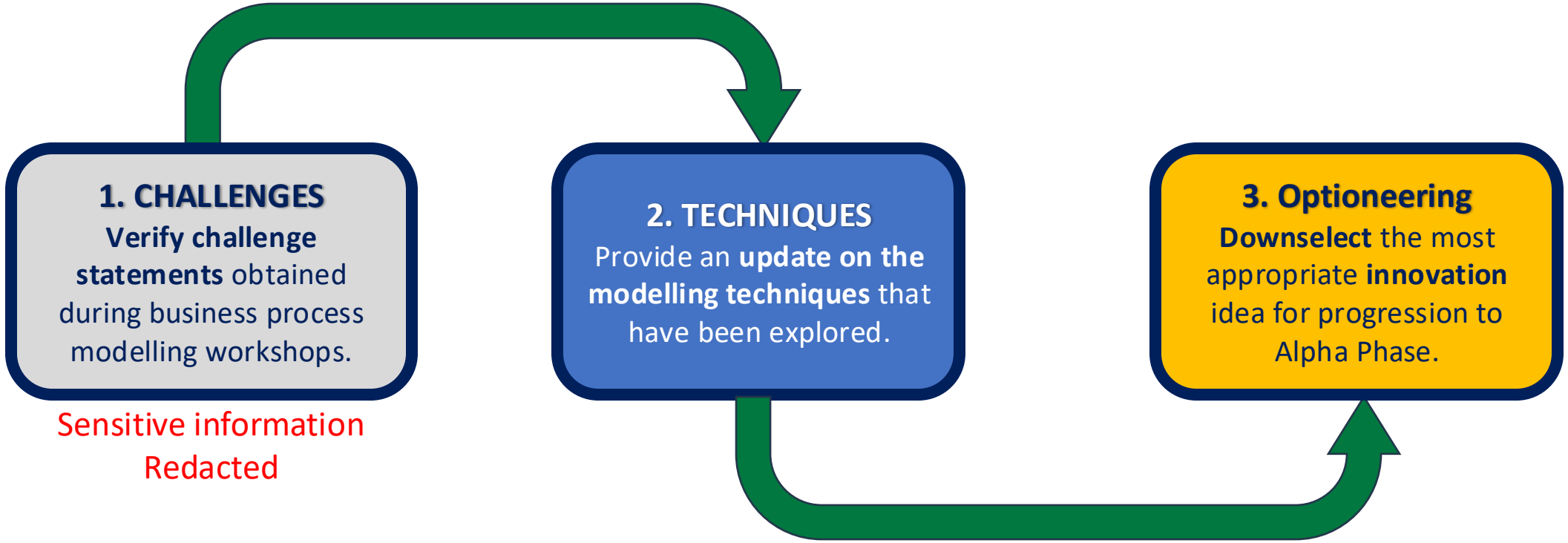
'One of National Grid ESO's key responsibilities is planning the GB's future grid infrastructure to assure security, sustainability, and affordability of supply. As the energy transition accelerates, complexity and uncertainty associated with long-term planning and decision-making grows'

Discovery Project Objective:

Identify, assess, and prioritise opportunities for advanced computational process enhancements within the existing and future network planning processes.



Workshop Objectives

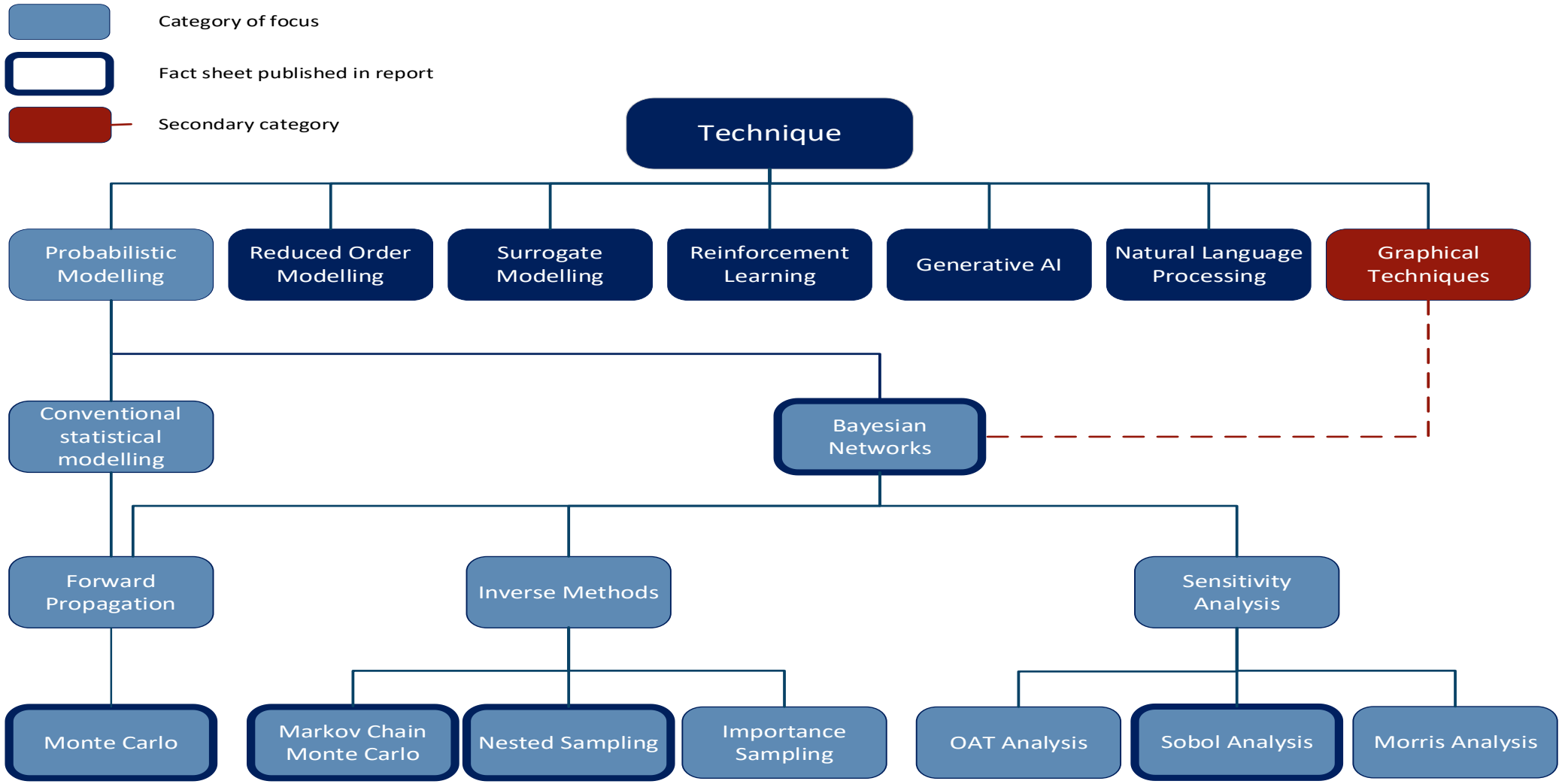


Sensitive information Redacted

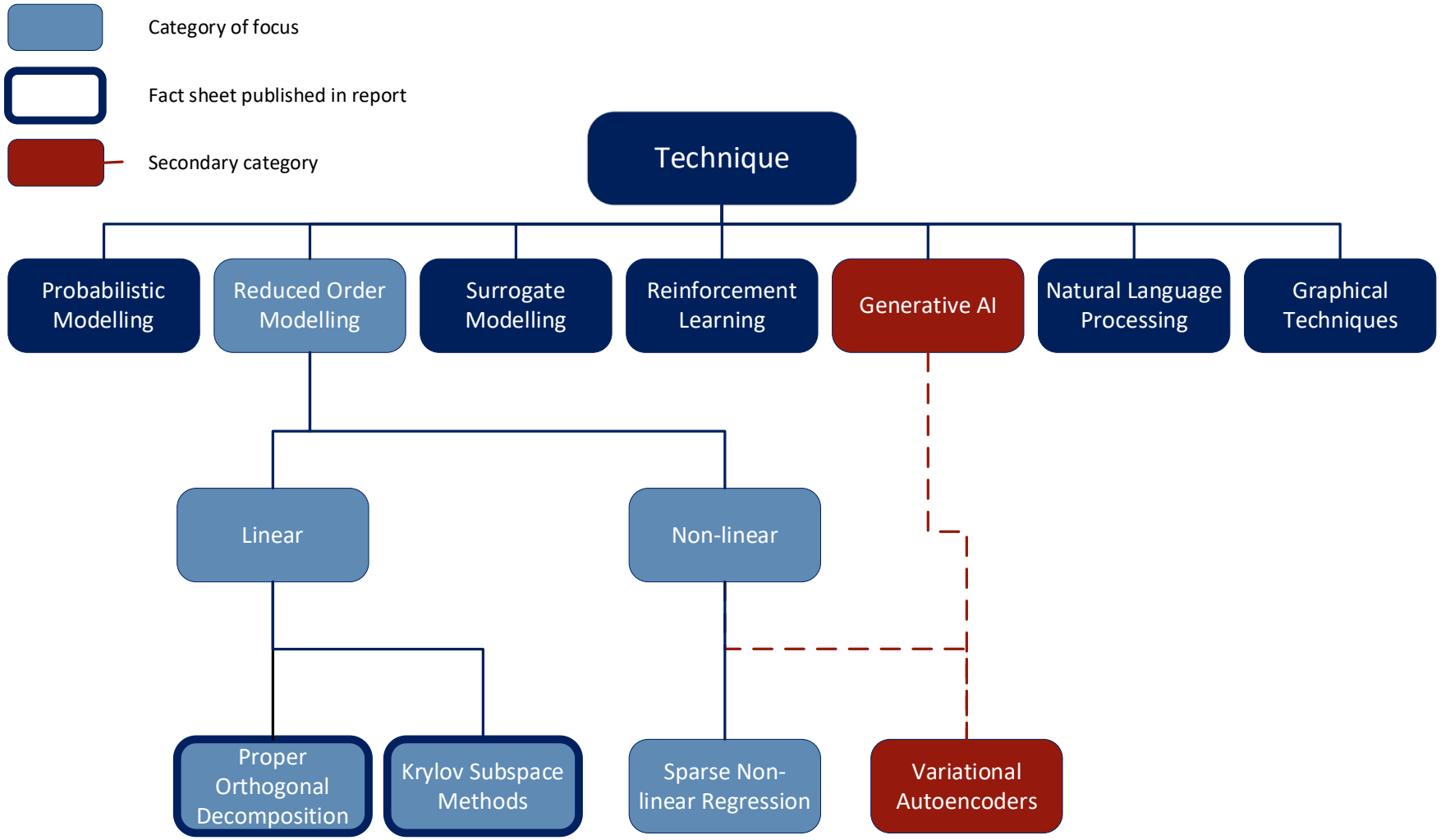
TECHNIQUES

Provide an update on the modelling techniques that have been explored.

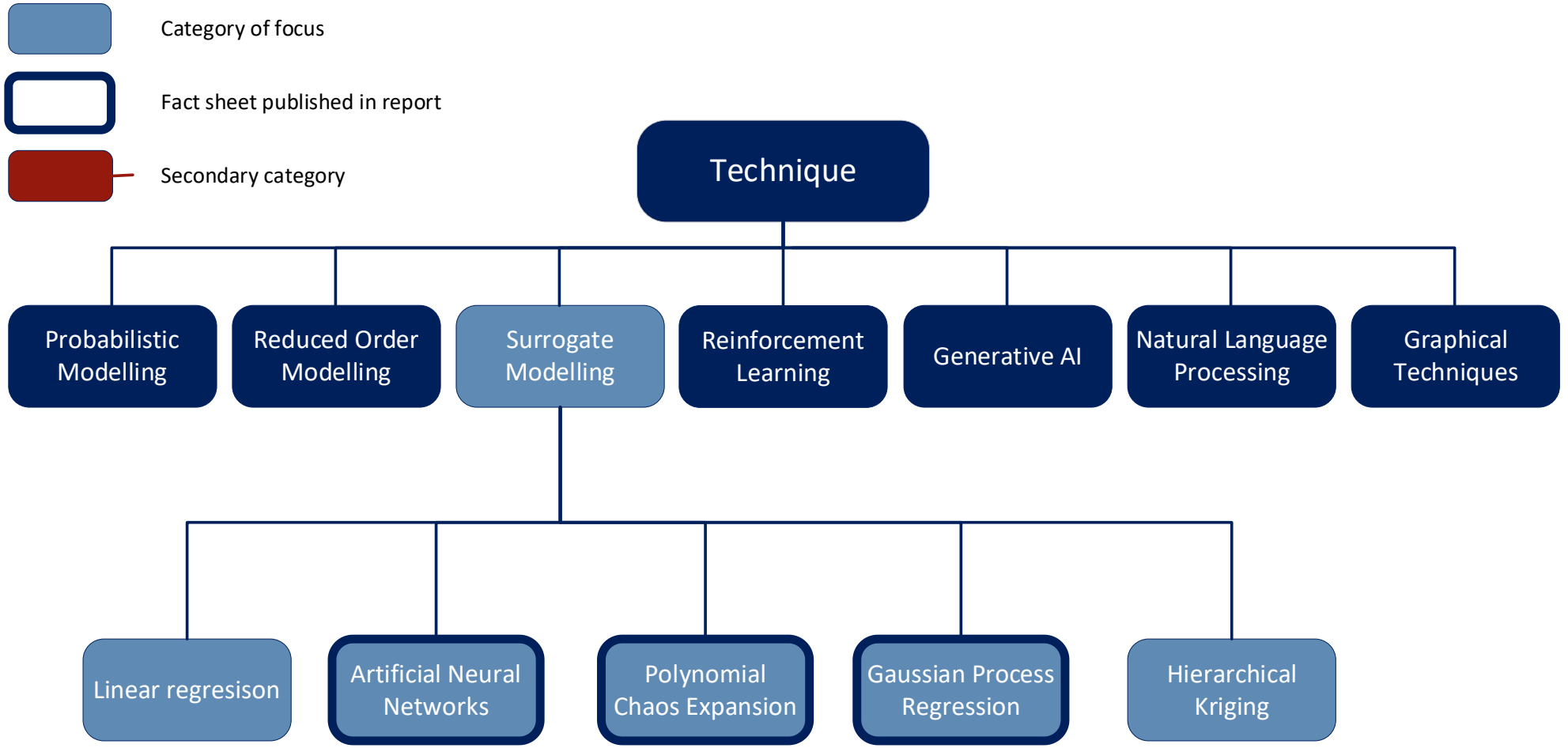
Techniques


Category of focus
Fact sheet published in report
Secondary category
Technique
Probabilistic Modelling
Reduced Order Modelling
Surrogate Modelling
Reinforcement Learning
Generative AI
Natural Language Processing
Graphical Techniques
Conventional statistical modelling
Bayesian Networks
Forward Propagation
Inverse Methods
Sensitivity Analysis
Monte Carlo
Markov Chain Monte Carlo
Nested Sampling
Importance Sampling
OAT Analysis
Sobol Analysis
Morris Analysis

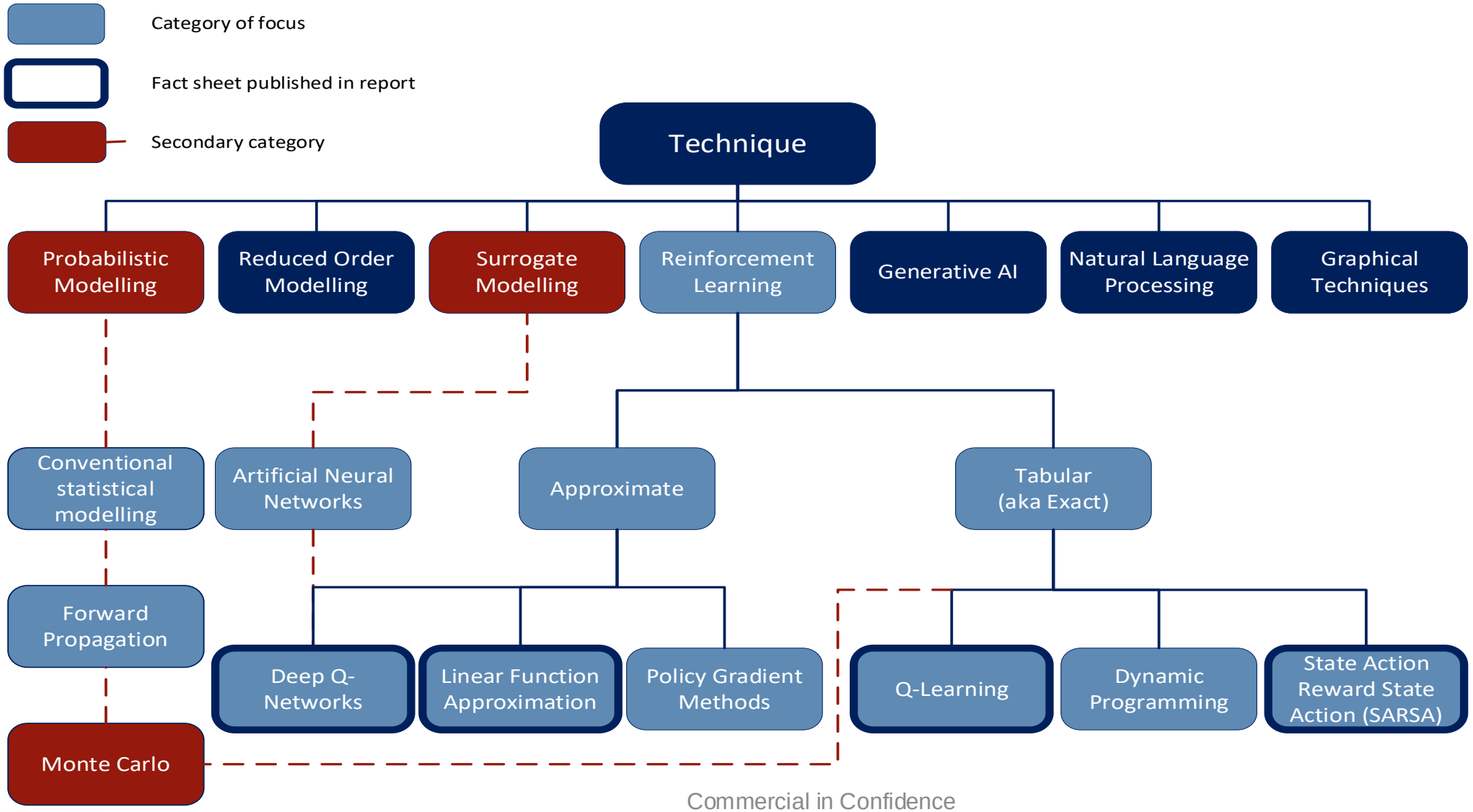
Techniques


Category of focus
Fact sheet published in report
Secondary category
Technique
Probabilistic Modelling
Reduced Order Modelling
Surrogate Modelling
Reinforcement Learning
Generative AI
Natural Language Processing
Graphical Techniques
Linear
Non-linear
Proper Orthogonal Decomposition
Krylov Subspace Methods
Sparse Non-linear Regression
Variational Autoencoders

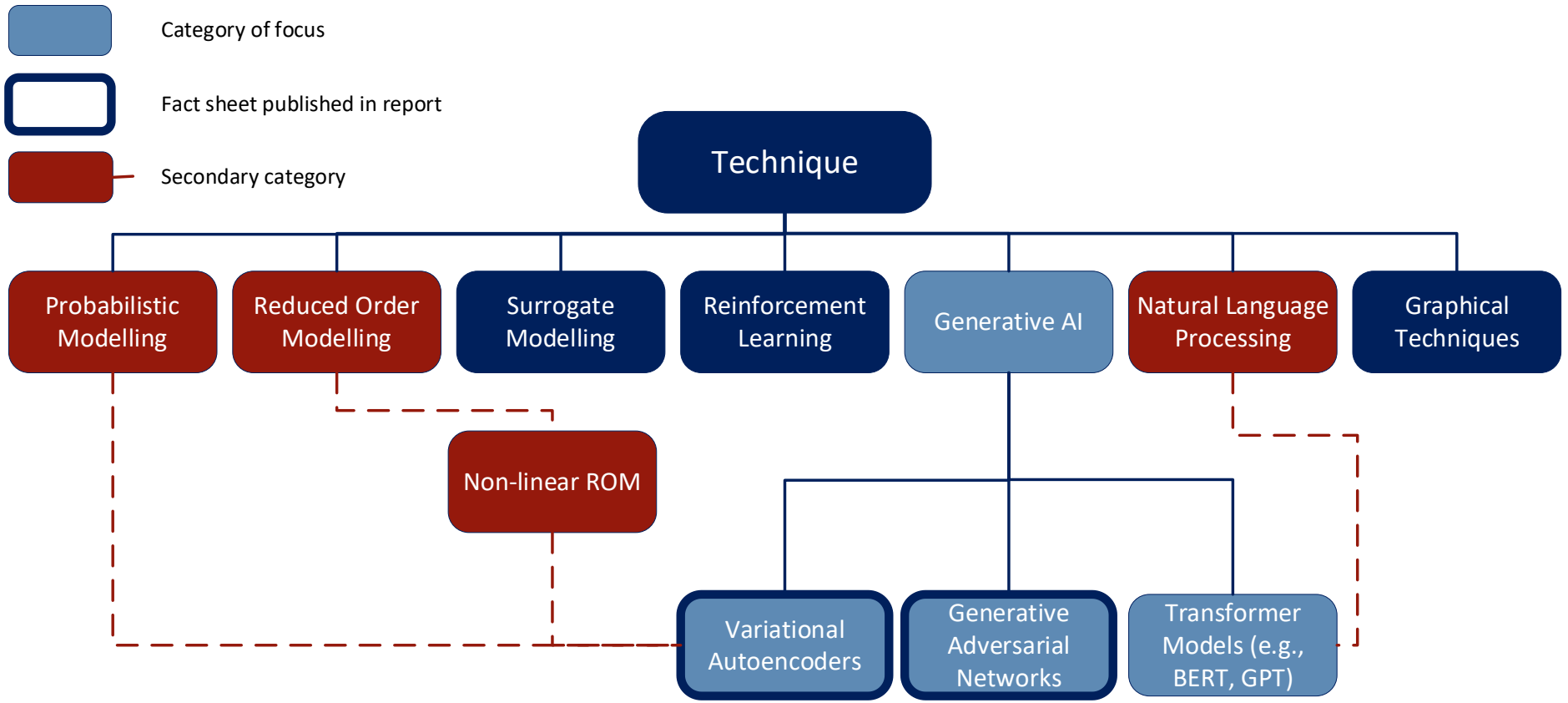
Techniques


Category of focus
Fact sheet published in report
Secondary category
Technique
Probabilistic Modelling
Reduced Order Modelling
Surrogate Modelling
Reinforcement Learning
Generative AI
Natural Language Processing
Graphical Techniques
Linear regresison
Artificial Neural Networks
Polynomial Chaos Expansion
Gaussian Process Regression
Hierarchical Kriging

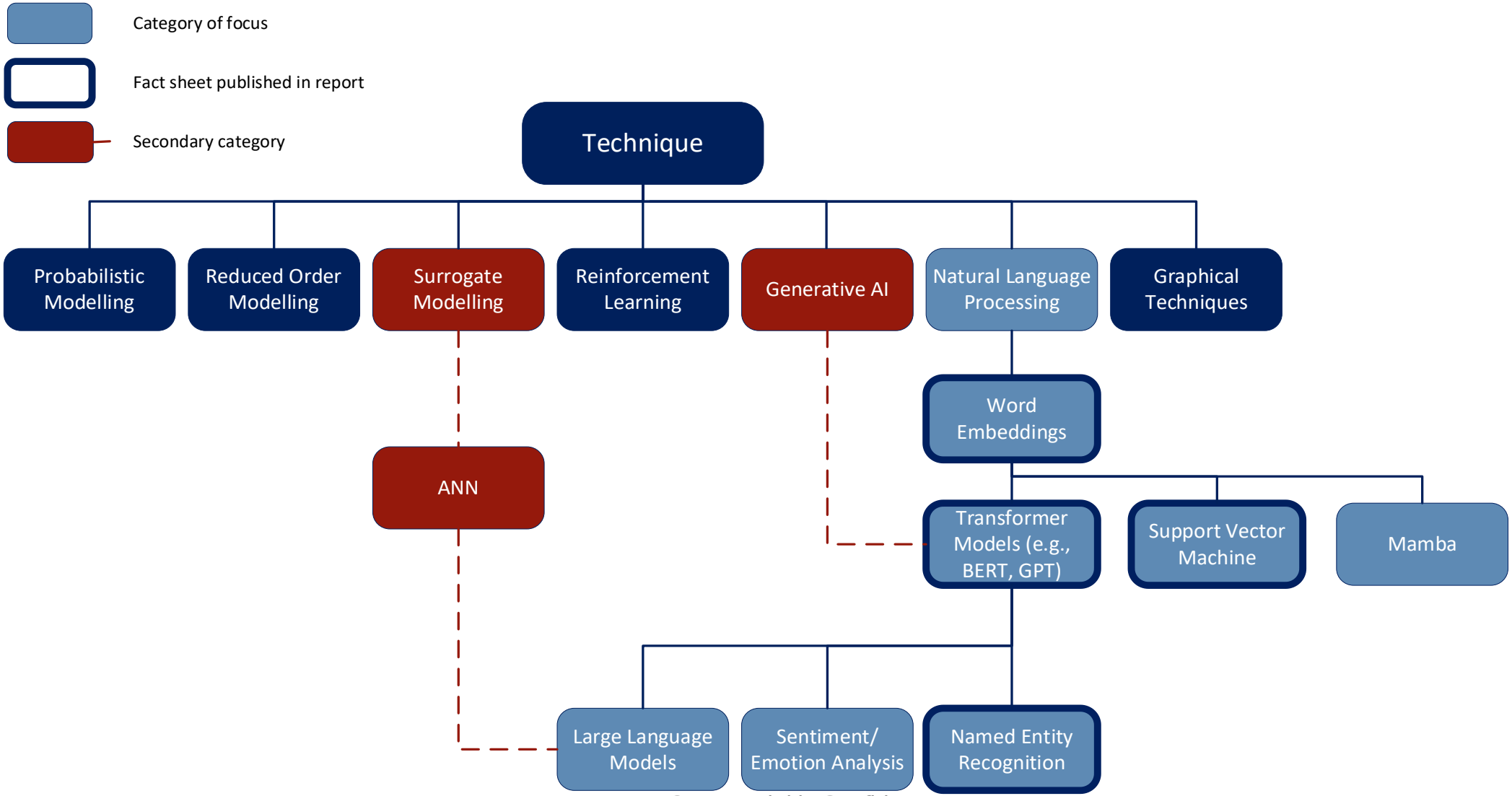
Techniques


Category of focus
Fact sheet published in report
Secondary category
Technique
Probabilistic Modelling
Reduced Order Modelling
Surrogate Modelling
Reinforcement Learning
Generative AI
Natural Language Processing
Graphical Techniques
Conventional statistical modelling
Artificial Neural Networks
Approximate
Tabular (aka Exact)
Forward Propagation
Deep Q-Networks
Linear Function Approximation
Policy Gradient Methods
Q-Learning
Dynamic Programming
State Action Reward State Action (SARSA)
Monte Carlo

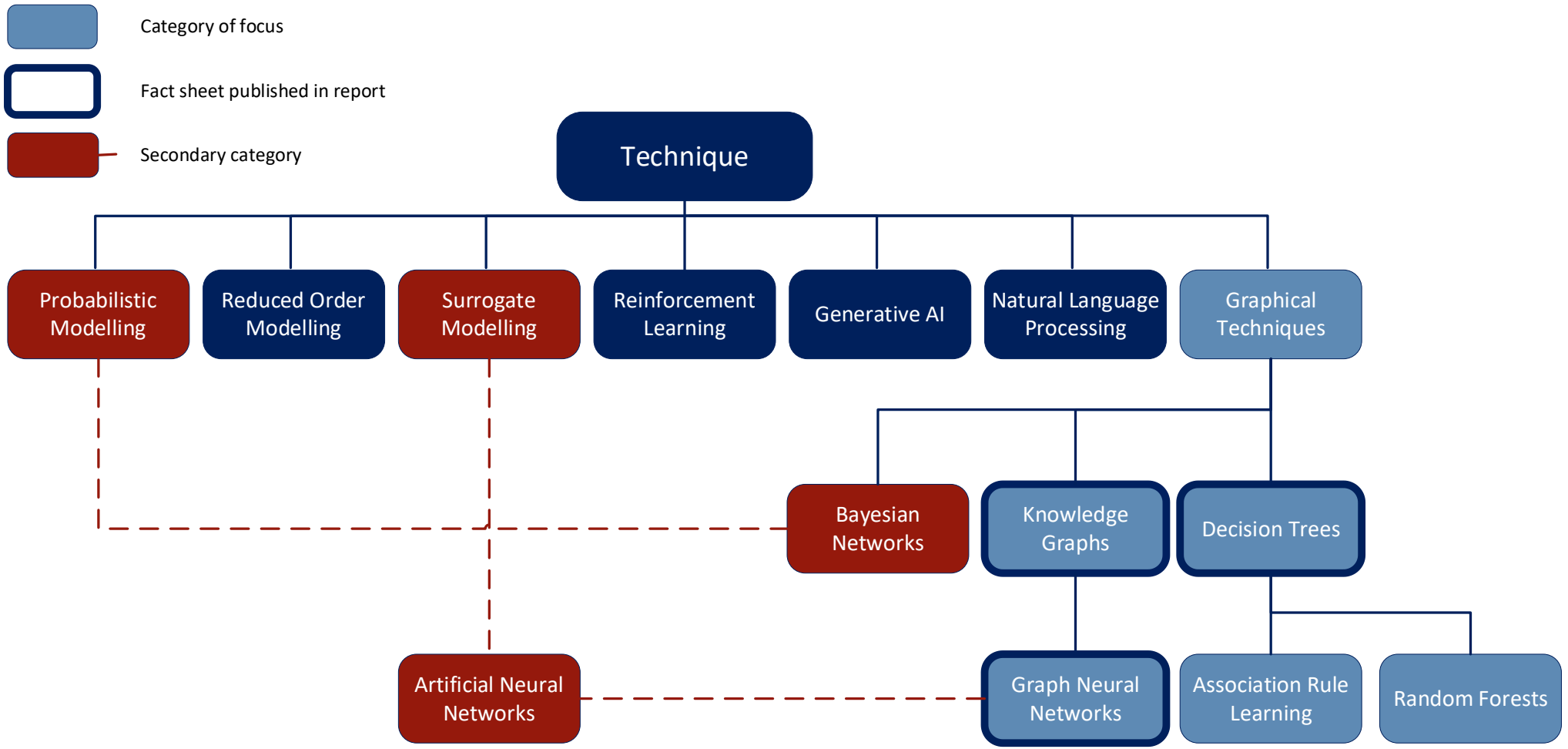
Techniques


Category of focus
Fact sheet published in report
Secondary category
Technique
Probabilistic Modelling
Reduced Order Modelling
Surrogate Modelling
Reinforcement Learning
Generative AI
Natural Language Processing
Graphical Techniques
Non-linear ROM
Variational Autoencoders
Generative Adversarial Networks
Transformer Models (e.g., BERT, GPT)

Techniques


Category of focus
Fact sheet published in report
Secondary category
Technique
Probabilistic Modelling
Reduced Order Modelling
Surrogate Modelling
Reinforcement Learning
Generative AI
Natural Language Processing
Graphical Techniques
ANN
Word Embeddings
Transformer Models (e.g., BERT, GPT)
Support Vector Machine
Mamba
Large Language Models
Sentiment/ Emotion Analysis
Named Entity Recognition

Techniques


Category of focus
Fact sheet published in report
Secondary category
Technique
Probabilistic Modelling
Reduced Order Modelling
Surrogate Modelling
Reinforcement Learning
Generative AI
Natural Language Processing
Graphical Techniques
Bayesian Networks
Knowledge Graphs
Decision Trees
Artificial Neural Networks
Graph Neural Networks
Association Rule Learning
Random Forests

OPTIONEERING

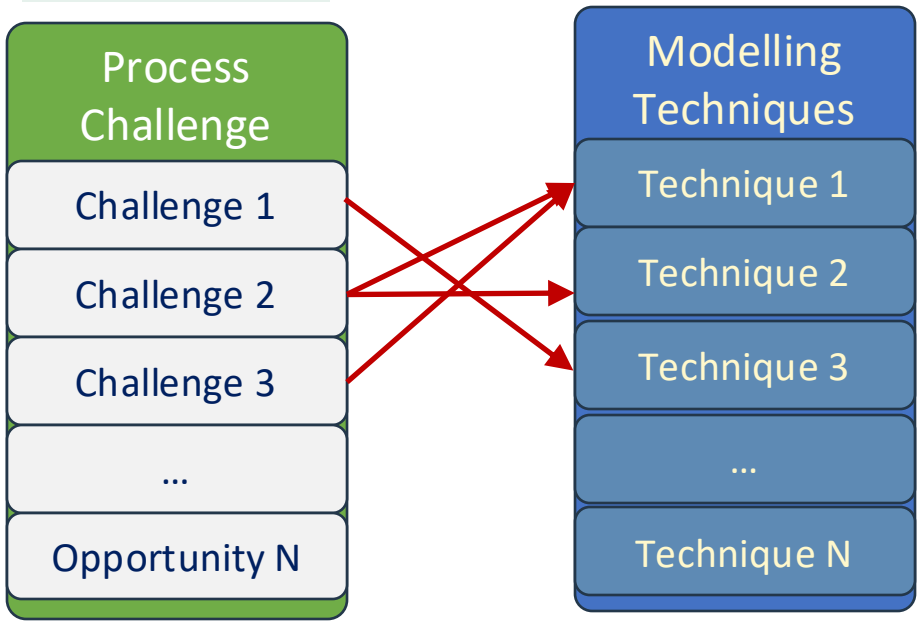
Downselect the most appropriate innovation idea for progression to Alpha Phase.

Multicriteria Decision Analysis

MCDA used to rank the different innovation ideas based on their suitability for SIF Alpha Phase

Opportunities identified during WP2

Reviewed techniques



Map techniques to appropriate challenge

Enhancement criteria:

- *Accuracy*
- *Insight*
- *Speed*
- *Explainability*
- *Trustworthiness*
- *Traceability*

Difficulty criteria:

- *Time to implement*
- *Resource needs*
- *Data requirement*
- *Model training*

Multicriteria Decision Analysis

Innovation ID	Enhancement (1-10)	Difficulty (1-5)	Impact Score (15)
CH1_T1			
CH2_T1			
CH3_T2			
CH4_T3			
N			

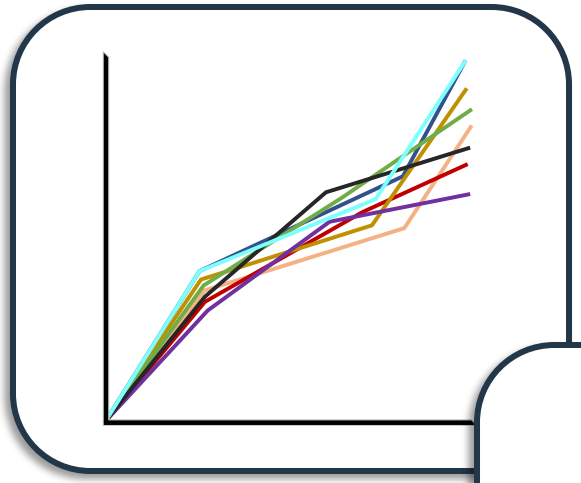
Multicriteria Decision Analysis

UID	Process Ref	Challenge	Proposed Technique	Innovation Description	Enhancement (10)	Difficulty (5)	Score (15)
CH1	Supply & Demand	Changing landscape	Probabilistic with surrogate model	Markov Chain Monte Carlo (MCMC) for generating demand profiles with a spatio-temporal Graph Convolutional Neural Network to predict dispatch outcomes in less time	8	5	**13**
CH2	Supply & Demand	Increasing scenarios					
CH3	Supply & Demand	Optimisation	Reinforcement Learning	Reinforcement learning agent to learn recommended optimal policies	8	4	**10**
CH4	Supply & Demand	Input bias and uncertainty	Probabilistic sensitivity analysis	Sobol variance-based sensitivity analysis to highlight the contribution of inputs to uncertainty	8	2	**10**
CH5	Supply & Demand	Data acquisition	Generative AI	Model to generate synthetic data where data is late/missing	2	4	**6**
CH6	Supply & Demand	Data preparation	Natural Language Processing	Named Entity Recognition to semi-automate the data processing, pre-analysis	6	3	**9**

Multicriteria Decision Analysis

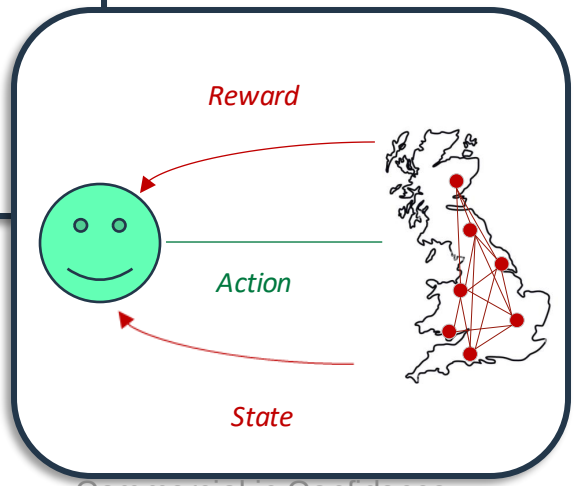
UID	Process Ref	Challenge	Proposed Technique	Innovation Description	Enhancement (10)	Difficulty (5)	Score (15)
CH7	Supply & Demand	Deterministic analysis	Probabilistic model	MCMC for generating demand profiles [*see CH1*] or Bayesian Network	8	3	**11**
CH8	Demand	Model transparency	Reduced order model	Reduce dimensions to present the greatest contributory factors with bespoke visualisation	6	3	**9**
CH9	Demand	DER capacity	Surrogate model	Train model, such as hierarchical kriging, with DNO models to quickly determine likely DER generation	6	4	**10**
CH10	Supply	Plexos time constraints	Surrogate model	GCNN predicts what PLEXOS dispatch will suggest for a given demand / capacity and run much faster than a full dispatch optimisation	8	4	**12**
CH11	ETYS	Deterministic ETYS inputs	Probabilistic model	Link to MCMC approach but would need alignment with Pouya development	4	3	**7**
CH12	ETYS	PowerFactory time constraints	Surrogate model	Trained on PowerFactory for quick approximate runs	4	4	**8**
CH13	NOA	Deterministic CBA	Probabilistic model	Bayesian network cost benefit analysis	4	3	**7**

SIF Scope Recommendation



Markov Chain Monte Carlo Model

Spatio-temporal Graph Convolutional Neural Network



Reinforcement Learning Agent

ALPHA

- Generate MCMC framework for a single module, as proof of concept.
- Prototype GCNN for a small region of network, trained on Plexos data.
- Develop requirements for Reinforcement Learning agent.

BETA

- Develop MCMC capability for demand and supply capacity.
- Generate whole energy system GCNN.
- Integrate Reinforcement Learning optimiser for SSEP decision making enhancement.

Optioneering

- Confirm approval of proposed Alpha Phase project and define scope during the workshop on 17th May.
- Frazer-Nash to provide first draft by of submission by 7th June.
- ESO to submit final version by 19th June.