SIF - Scenarios for Extreme Events

Basis of design - Workshop outputs

Date:	December 2023
Classification:	UNCLASSIFIED

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Issue No.:	01	**Approved By:**	David Maclennan

1 Purpose

This document summarises key discussion and outputs from the Basis of Design workshop for the SIF Scenarios for Extreme Events Alpha Phase project. This was held on 19th October 2023 and was attended by representatives from all consortium partners:

- **National Grid ESO:** Neil Adams, Katerina Foke Sandoval, Carol Carlin, John Zammit-Haber.
- **Met Office:** Phil Hodge and Paula Gonzalez, Joe Osborne.
- **University of Strathclyde:** Magnus Jamieson, Keith Bell, Panagiotis Papadopoulos.
- **Frazer-Nash Consultancy:** David Maclennan, Megan Pearce, Chris Williams, Luke Edelston, Daniel O'Brien.

2 Workshop Outputs

This section contains workshop outputs that have been elicited and subsequently refined from information gathered at the workshop.

2.1 Vision Statement

Develop a model framework that describes vulnerabilities to the GB energy network, using weather and non-weather ***stress event scenarios*** *and key system interfaces (including but not limited to telecoms and water), to inform* ***risk*** *assessment and resilience planning by:*

- *Defining* ***resilience metrics*** *and time horizons that quantify potential network vulnerabilities.*
- *Defining a conceptual* ***risk framework*** *for combining* ***risk estimates*** *to calculate the* ***total risk*** *to infrastructure.*
- *Creating a proof-of-concept prototype model that inputs one or more* ***stress event scenarios*** *to map network vulnerabilities.*

Core definitions highlighted in **bold** are included in Annex A.

2.2 Model Scope

The purpose of the prototype model is to demonstrate a methodology and what is possible. Further model developments may build on the prototype model or be of a different architecture depending on feedback and future needs. The use of historic GB events to validate resilience metrics and model outputs will be explored.

2.3 Stakeholder Map

This diagram identifies key stakeholders for the project which will be used in use case development. It describes an "onion model" of stakeholders, increasing in level of abstraction from the model itself through its supporting organisations and into the wider environment.

Figure 1: Stakeholder Map for the Alpha Phase Model

2.4 Model Use Cases

The diagrams overleaf are illustrations of proposed core capabilities of the model in a standardised format known as a Use Case Diagram. They describe the capabilities of the model and which stakeholders perform each function.

Figure 2 shows the use cases of the Alpha Prototype Model, which is a subset of the use cases for the End State Operational Model illustrated in Figure 3. These are a refinement of the use cases elicited in the workshop, which are listed in Annex B.

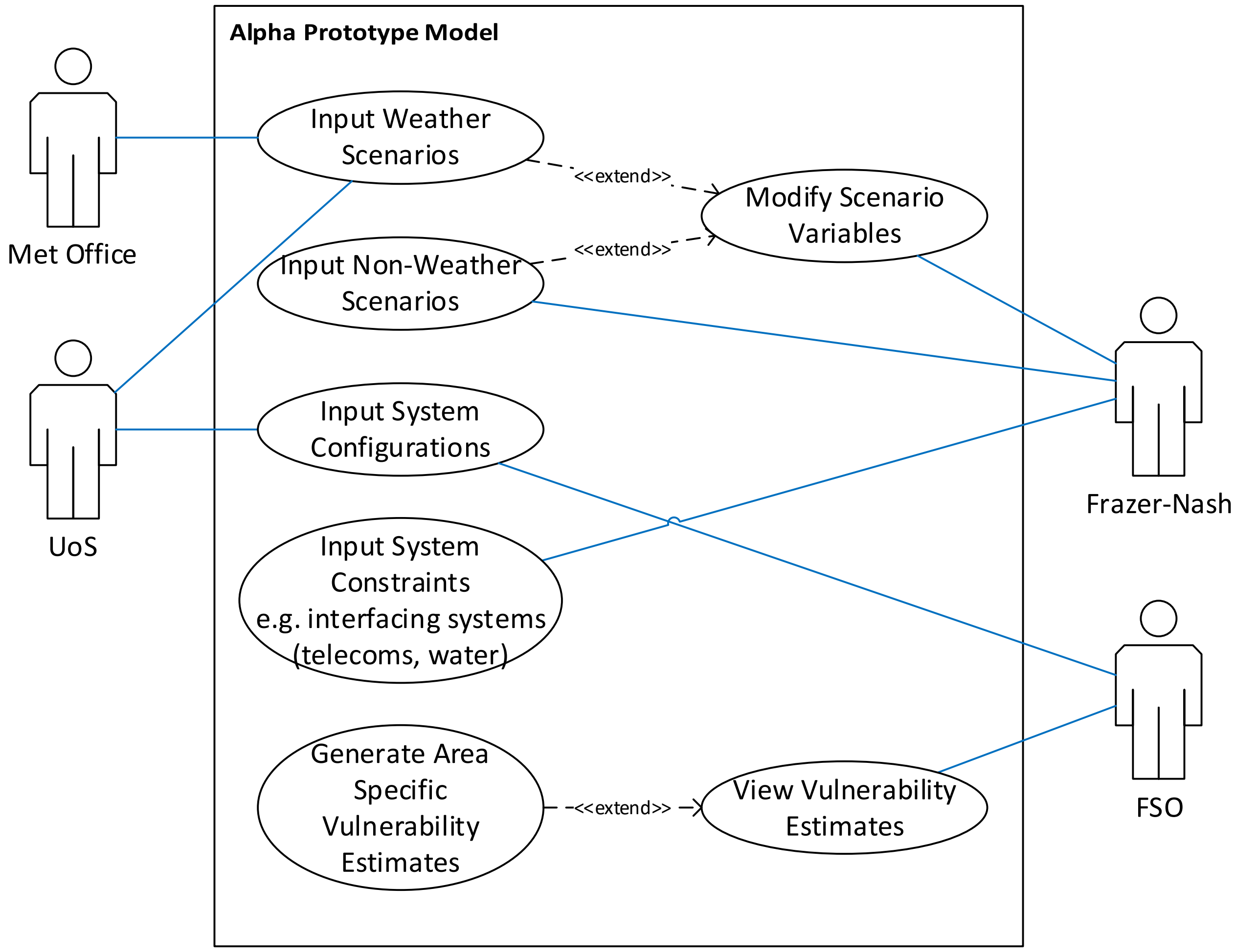

Figure 2: Uses Cases for the Alpha Prototype Model

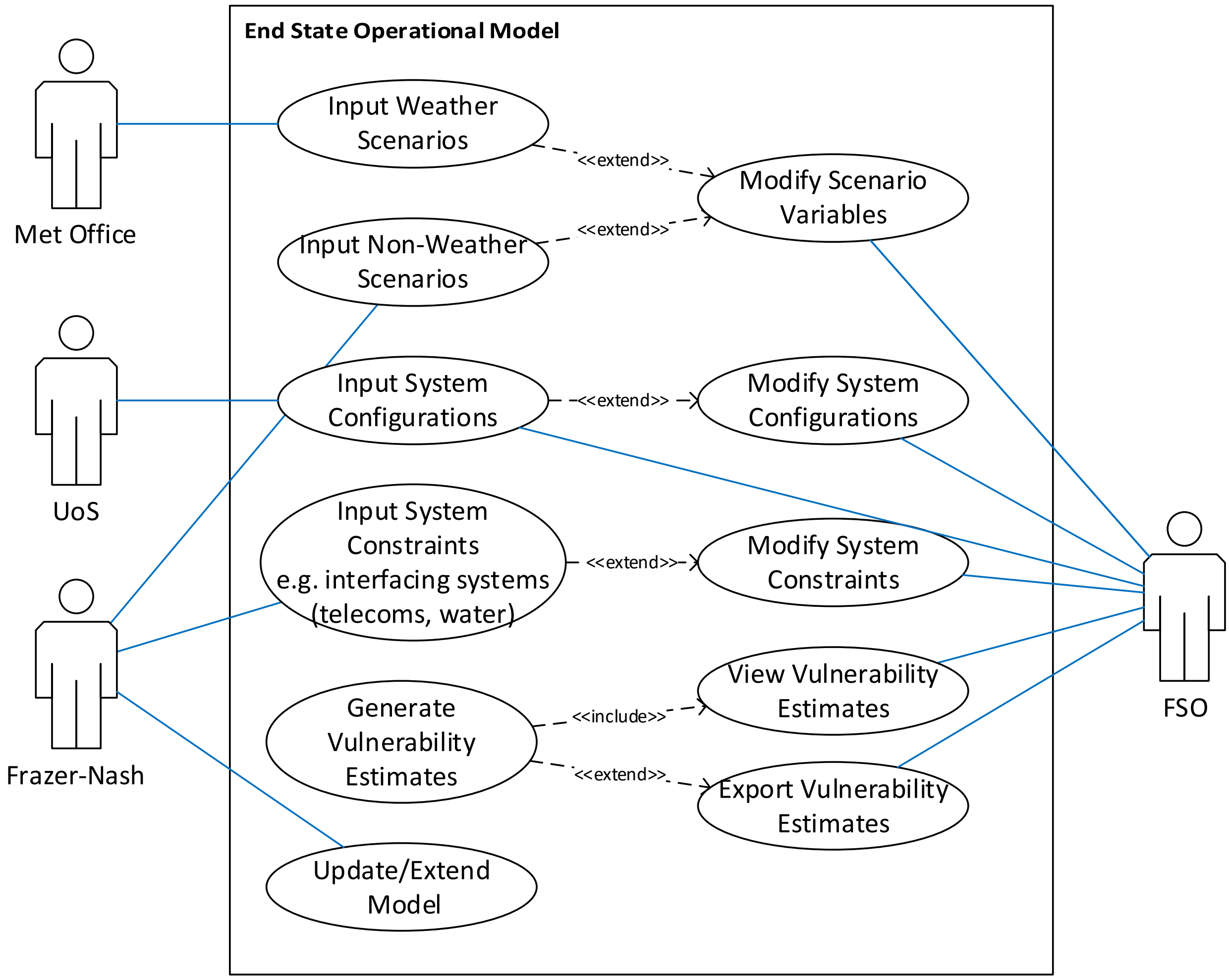

Figure 3: Uses Cases for the End State Operational Model

Annex A – Definitions

Table 1: Definitions

Term	Definition
Risk	Risk is generally defined as the combination of the likelihood of an event and the impact it has: $$Risk = Likelihood\ x\ Impact$$ Risk to infrastructure also depends on time horizon (i.e., the next week, month, year etc) and location.
Risk Estimates	A model uses one or more Stress Event Scenarios to generate an estimate of risk for an asset type / region etc (TBD). Similarly, Subject Matter Experts may be used to make judgements to estimate risk.
Risk Framework	The methodology to combine Risk Estimates to calculate the Total Risk to the Energy Network.
Resilience Metrics	Impacts to the Energy Network (e.g. Customer Average Interruption Duration Index is greater than value X), associated with Impact Scores (e.g. Low, Medium, High).
Stress Event Scenarios	Descriptions (textual and/or numerical) of archetypal events that often strain the GB energy network and lead to negative operational impacts.
Total Risk	Total Risk is defined as the combined risk to Infrastructure, in a specific location (x), over a defined time period (T): $$Risk = \sum_{x,T}^{n} Likelihood * Impact\ (x, T)$$

Annex B – Use cases

Proposed use cases for the model were elicited from the group via a collaborative exercise, with each attendee asked to write ideas on post-it notes which were later categorized based on perceived value and feasibility. The below list is the content of these post-its, with some wording edited for clarity:

- Advise critical energy users on backup fuel stock.
- Advise on emergency response.
- Analyse GB's international network interdependencies.
- Analyse specific fault cases in-depth.
- Anticipate outages on the system.
- Apply operational actions such as line switching, dispatch, and load shedding.
- Calculate the cost of lost customers due to outages.
- Combine expert opinions with quantitative modelling.
- Define the current inter-network resilience state.
- Decide on future interconnections.
- Detect unknown vulnerabilities through stress testing and scenarios.
- Model system behaviour over time.
- Evaluate the cost of events to identify the most extreme cases.
- Feed model results into risk awareness reports.
- Identify critical areas of the network.
- Identify major network interdependencies.
- Identify overhead line sections for hardening.
- Identify regions or components where redundancy is justified.
- Improve response efficiency, including spatial information.
- Inform energy development plans.
- Inform energy policy decisions.
- Inform investment decisions to enhance resilience to specific hazards.
- Inform operational practices during emergencies.
- Inform regional resilience strategies.
- Inform the design of recovery mechanisms following emergencies.
- Inform the development of processes across different organizations.
- Inform investment decisions to enhance resilience to specific hazards.
- Inform regional resilience strategies.
- Input medium and long-term scenarios.
- Input short-term scenarios for impact assessment.
- Plan investment, especially for the Regulatory Period (RIIO).
- Know which aspects of infrastructure need better protection.
- Know which events should be secured against.
- Plan local and regional response.
- Locate spare parts and repair teams.
- Manage outages effectively.
- Model impacts on a scale of days/weeks.
- Model impacts on the system and understand risks.
- Monitor energy framework and license changes.
- Monitor energy market shifts, particularly gas security.
- Plan network reinforcement and response.
- Plan for spare parts and outages.
- Plan network reinforcement for improved resilience.
- Predict financial impacts of investments.
- Predict long-term impacts of events.
- Predict/validate the impact of known previous events.
- Prioritize mitigation areas and advise on emergency response.
- Report on vulnerability risks to inform investment decisions and regulatory compliance.
- Respond to global events affecting the energy system.
- Run what-if scenarios for impact assessment.
- Schedule power generation during emergency scenarios.
- Set standards for system resilience.
- Share model results with concerned parties to identify dependencies and vulnerabilities.
- Test different system configurations.
- Test the effectiveness of emergency procedures.
- Understand the cost/benefit of different scenarios.
- Update network design standards and regulations.
- Use the model for climate change scenario planning.
- Visualize vulnerable parts of energy, water, and telecom networks.

Annex C – Workshop Discussion

This section contains summarised notes of significant discussions that took place during the workshop.

- General appetite to understand high impact risks to the GB energy system and to be able to quantify them using resilience metrics, e.g.:
    - Volume of affected "customers".
    - Duration of disruption.
    - Scope of disruption, such as
        - Geographical
        - Type of asset
    - Cost of disruption (to operators and consumers)

- 1st July 2024 – NG ESO becomes the Future System Operator (FSO)
    - Part of FSO remit is to create a report by 2025 on national risk to energy network, which includes a risk register and recommended mitigations. Ideally, this project would inform this report.
    - With their new powers they will be able to request data from other organisations.

- Definitions:
    - Extreme events are often referred to as "Stress Events".
    - ESO would like to have an agreed set of terms.

- What do we want a GB energy model to do?
    - Compare different kind of events / scenarios (Inputs)
    - Represent energy system configurations (Model)
        - Past
        - Present
        - Future(s)
    - Predict impacts of different scenarios and system configurations (Outputs)
        - Find areas of low resilience.
        - Inform investment.
        - Inform standards and regulations.

- Desired Project Outcomes
    - Inform FSO risk register (and therefore inform ministers).
    - Improve decision making in one or more of:
        - Prevention
        - Response (containment)
        - Recovery (restoration)
    - Understand interdependencies between networks.

- High impact scenarios
    - Storms and lightning strikes have biggest impact according to Met Office.
    - We should choose scenario types that are easier to model (lightning is unpredictable, wind is easier).

- Input data into scenarios and model need to be decided.

- Power systems are modelled on scale of milliseconds to weeks.
    - ESO notes that we are interested in impacts on the scale of weeks to years.
    - Some modelling has been based on expert quantitative judgement (aligns with Work Package 1 report from discovery phase which says that a model in our project could include both expert judgement and modelling).

- Telecoms are affected by electricity outages.
    - Copper network is being turned off; this had a 7-day power backup.
    - New (fibre) system is less resilient to power outages.

- There is a confidential list of critical infrastructure which needs to be supplied with energy.

- There was some agreement on wanting to model a previous event, such as storm Arwen, to validate the model framework to model future events.
    - Model outputs would be validated against what occurred in real life.
    - The model can be further refined based on this.
    - The model should then be applied to future forecasts to see how well it works.
    - The model could be constrained in various ways, to make its development achievable, by:
        - The type of model it implements (e.g., Bayesian).
        - The region / geography it models.
        - The system abstraction level.
        - Time period it models.

- Group thinks that a future operational model would probably be implemented using multiple models.
    - Development of a model architecture would facilitate multiple models and defining of interfaces.