WPD INNOVATION
Transforming the electricity network

Network Event and Alarm Transparency (NEAT) Design

Prepared by Harmonic Analytics Ltd.

WESTERN POWER DISTRIBUTION
Serving the Midlands, South West and Wales

Version Control

Issue	Date
1	30 March 2021
2	4 May 2021
3	12 May 2021
3.1	13 May 2021

Publication Control

Name	Role
Lee Begg, Janice Chin, Ploi Yibmantasiri – Harmonic Analytics	Author
John Taylor - PSC	Reviewer
Jenny Woodruff – WPD	Approver

Contact Details

Email

wpdinnovation@westernpower.co.uk

Postal

Innovation Team
Western Power Distribution
Pegasus Business Park
Herald Way
Castle Donnington
Derbyshire DE74 2TU

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Contents

1. Document Purpose

This document provides a detailed description and the modelling methodology of the NEAT system and processes to support the functional requirements specified in the Specification document [1]. This design document is the second stage of the development of the NEAT system which will be followed by a Build phase which will include setting up data interfaces, refining models and creating dashboards. Following the completion of the Build phase a period of Trials and Analysis will be undertaken with findings disseminated to the relevant stakeholders.

2. Introduction

2.1. Background

The Network Event and Alarm Transparency (NEAT) project aims to use analytical methods on alarms and events to discover the root causes of alarms on the Active Network Management (ANM) and System Voltage Optimisation (SVO) systems when they are not operating optimally. Understanding the root causes of alarms will overall help reduce the frequency of system problems, reduce alarm and event volumes and ensure ANM and SVO are operating optimally.

Western Power Distribution (WPD) is transitioning from being a Distribution Network Operator (DNO) to a Distribution System Operator (DSO). As this transition occurs, WPD is investing in new systems for real time dynamic network management and optimisation schemes, particularly ANM and SVO. These new systems are anticipated to support new DSO functions which are likely to have the same impact as ANM and SVO: not only increasing the volume of alarms and events but also introducing new types of alarms and events that differ to those traditionally managed in the control room.

The complexity of these new systems requires thorough analysis to be able to resolve the root causes of the alarms. This analysis is time consuming, which could result in lengthy delays before systems are restored to full operation, but also involves high support costs due to the length of time spent on alarm and event investigation. WPD would like this project to improve their understanding of these events and alarms with a view to ensuring that the ANM, SVO and future DSO related systems can be supported effectively.

The NEAT tool will combine data from several WPD systems to be used in complex analytics and modelling, for instance correlating ANM/SVO alarms and events with information from the asset register and control room. The models developed will then be used to identify patterns in data provided during a trial period to speed up root cause identification and problem resolution.

2.2. Methods

The project is split into two core components:

- Analytical modelling methods such as Bayesian Analysis, Machine Learning and other statistical techniques to develop clustering, predictive and inferential models. These methods will seek to describe the correlations and causation between events, data inputs, and resulting alarms, so they can be understood and resolved.
- A dashboard visualization for the analysis, processing, and presentation of alarms to the control engineers and more detailed investigation teams.

2.3. Analytical Modelling

Harmonic's data science team utilised Exploratory Data Analysis (EDA) as well as Alarm Flood analysis, Clustering and association rule analysis to identify the relationship between alarm events and possible root causes of alarm events (e.g., fault in a particular alarm, change in alias, switching events etc.). The details of the methods and data used can be found in a separate Data Quality Analysis (DQA) /EDA NEAT report [2].

2.4. Dashboard Visualisation

The dashboard is a website utilising various libraries for the analysis, processing and presentation of alarms. Visualisations in the dashboard include various graphs and tables.

The website will be written in Python using the Django framework, and using Celery for task management and scheduling. Bootstrap 4 will be used for styling the website and several JavaScript libraries will be included to display visualisations. Components included on the website are:

- A core data model and views
- Data importers for loading data from WPD systems into the data model

- A Postgres database for storing processed data.

2.5. Trial and BAU Requirements

To reduce the impact of suboptimal operation of these systems, the NEAT tool needs frequent updates from the data sources and high levels of availability. However, during the trial, the system will only need to be available between 7am - 7pm but will likely easily exceed this. While the trial requirements will be less onerous, the system will be designed to ensure that a system suitable for BAU rollout can be supported.

2.6. Systems

The key systems NEAT will interact with are the SCADA control system and the DSO Support systems. The DSO support systems currently used by WPD are SVO and ANM.

2.6.1. PowerOn Fusion and Advantage

PowerOn is the SCADA control system used by WPD and is currently being upgraded from Fusion to Advantage. The system communicates with Remote Terminal Units (RTUs) at substations to control and record the state of the network. PowerOn also communicates with other systems, such as the SVO and ANM systems, for additional functionality and applications.

2.6.2. SVO

The System Voltage Optimisation (SVO) system assists in integrating additional distributed generation within the electricity network more efficiently by more precisely managing the voltage across large zones. SVO calculates target voltages every 5 minutes, and the set points for the tap changers to try to achieve those targets are communicated back to PowerOn to send to the devices.

2.6.3. ANM

Active Network Management (ANM) can limit generators to avoid exceeding the power flow constraints in the network. This allows the generators to export power to the network without needing to pay for the reinforcement to avoid constraints that prevent them from generating without active management. Every 30 seconds the ANM system checks the live data from PowerOn and decides if a constraint is being reached. If there is one, it will start restricting (“curtailing”) one or more generators to remain safely under the constraint. ZIV and SGS are two different vendors of ANM used within WPD’s network.

3. Architecture

The NEAT solution user interface is a Web application, with a PostgreSQL database data storage and background worker processes. The interface is built on top of the Django web application framework and is internally broken down into “apps”. Each app typically contains views and templates that are presented to the user, and tasks that happen in the background worker processes.

A common visual style is provided to all apps to make the application look seamless - the user should not notice moving between the apps. The design of the views is shown in Chapter 7. Wireframes.

The tasks from the various apps are executed by the Celery task framework in the background worker processes, triggered either by the view for a user interaction or on a schedule by Celery Beat. These tasks implement the import and processing of the dataflow, detailed in Chapter 4. Data Pipeline.

The NEAT solution will be functional in Chrome, Edge, and IE11.

3.1. Framework

The NEAT web application will be built on the Django framework, as it provides many security features and other useful functionality.

In addition, we will be using the Django Rest Framework which extends Django to provide REST APIs in a similar construction to normal views in Django and provides numerous features around the APIs.

We will also be using the Celery task management framework. This greatly simplifies the interactions between parts of the system and abstracts away many of the issues in building such systems. Celery also provides a service called “beat” which triggers tasks based on a schedule, similar to Cron or Task Manager.

3.2. Apps

Apps in Django allow for the separation of concerns and provide clear interfaces between (internal) components. An app can have database models, views and templates, background or scheduled tasks, REST APIs, and tests of these parts for the app.

NEAT apps:

- **neat_linkage** - linking the other apps together
- **poweron** - models, importers, and views of the data from PowerOn
- **electricity_cim** - INM model importer and models (existing Harmonic Analytics Component)
- **issue_tracking** - the app providing the key issue tracking views, models, and processes
- **risk_forecast** - Risk dashboard app

For more details on the data models for these apps, see Chapter 5. Data Model.

4. Data Pipeline

There are some known causes for issues within the SVO and ANM systems which are reflected in the datasets that have been selected.

For example, the state estimation system within SVO will not function correctly if it does not have correct measurement data from SCADA or if the network model being used for state estimation is incorrect. Lack of good measurement data may be the result of a telecomms failure (which are indicated in the PowerOn alarms) or where the monitoring equipment has been configured incorrectly (which may be the result of work on site as indicated by CROWN records of maintenance or inspection work, or from PowerOn system patches being created at a location where work is due to take place).

An incorrect network model could be due to an alteration of the physical network by addition or removal of cables, lines or equipment which would normally be expected to be reflected in PowerOn by the creation and application of a network patch. While the change to the network would ultimately be reflected in the INM, this update would rely on the updated network model being provided from PowerOn and/or GIS rather than being updated by the network patch process and therefore could happen much later than the change to PowerOn network model. Therefore, network patches from PowerOn are expected to be a useful indicator for identifying issues relating to network model updates.

The network model used for state estimation could also fail to reflect the real-world configuration if the process to reflect switching operations from PowerOn has not been applied correctly. For this reason, switching operations are likely to be a useful input to identify this type of error.

4.1. Data Sources/Mapping

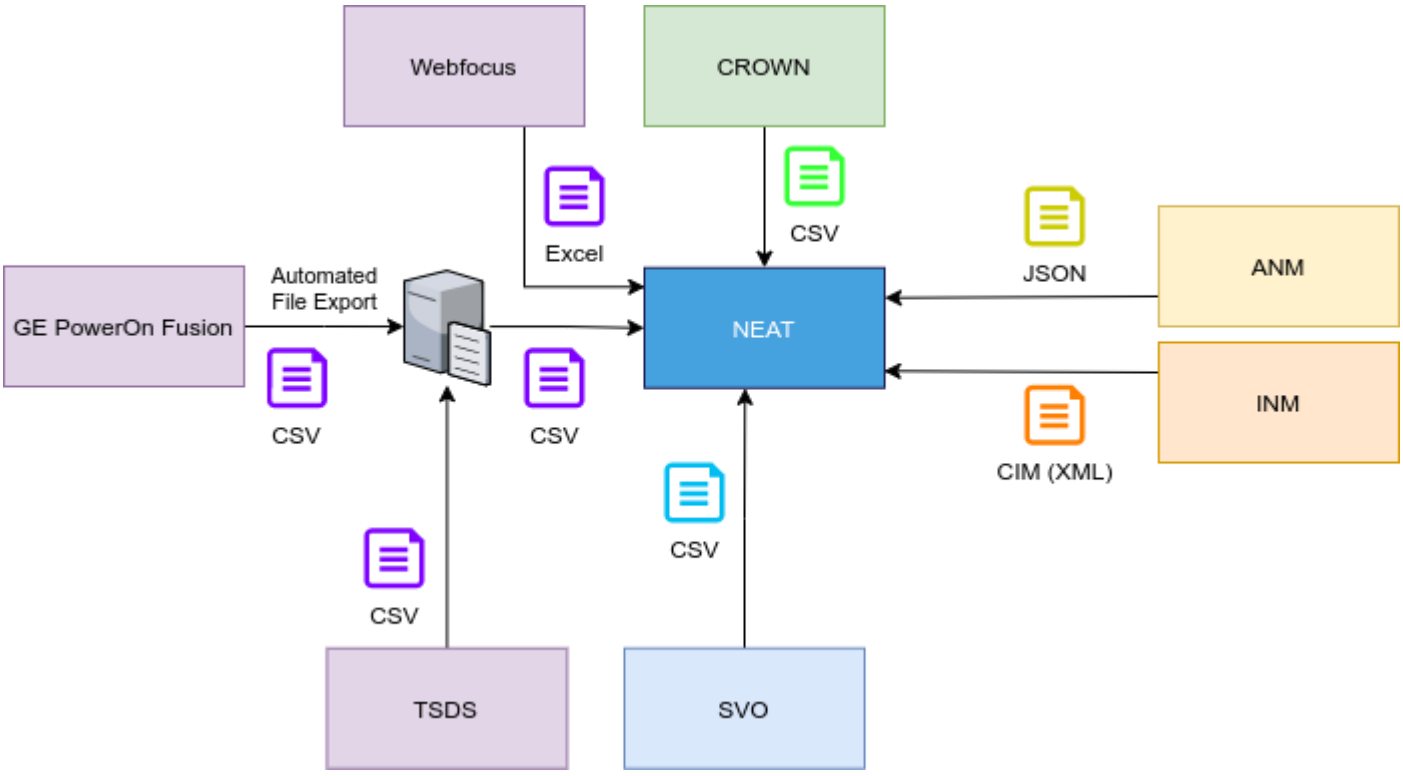

Figure 1 How data from WPD systems is imported into NEAT.

The Integration of other systems for data ingestion into NEAT will be finalised at the next stage. Please see the Addendum for details about the integration approaches.

4.1.1. GE PowerOn Fusion/Advantage

An automated one-way file export will be made at incremental periods (ideally as frequently as possible, at a minimum of 3 times a day) from the PowerOn database to a repository. NEAT will access the repository to download the exported CSV files. PowerOn will be the source of alarm data but also will provide information on network patches that have recently been applied or will be applied soon. This gives an indication of potential changes to the network model. PowerOn will also be the source of any updates to the ICCP bilateral tables for the SVO or ANM systems, though exports of these files do not need to be made as often and daily export would be sufficient to identify any changes in devices.

4.1.2. Webfocus

Webfocus is a standardised interface for presenting reports. It is linked to PowerOn and provides a switching report for planned outages as an Excel file.

4.1.3. SVO

SVO data is stored in a history database that is accessed within a virtual machine. Currently, CSV files are manually exported from the history database, transferred to the user's local machine and stored in a shared folder. It is expected that this process could be automated with help from GHD and the assistance of WPD IR.

4.1.4. INM

The INM data is updated monthly and uploaded to https://www.westernpower.co.uk/our-network/energy-data-hub/common-information-model. NEAT will download the monthly XML file.

4.1.5. CROWN

The CROWN data is stored in a database and contains maintenance reports and asset information. The asset role data is exported weekly and the event occurrence which contains when planned maintenance occurs is exported daily. The reference item table is also exported to understand the type of planned maintenance. This data is exported as CSV files.

4.1.6. ANM

The ANM system from ZIV contains an ANM module which is executed every 30 seconds to determine the setpoints and curtailment of generators. A CIM database contains an overview of the network based on an ISPA model. This is updated manually every 6 months. The CIM database also contains log files and outputs after every run of the ANM module. The log files will be sent to NEAT in the JSON format via HTTP requests.

4.2. Data Files

The required data files from each system are described in Table 1.

Table 1 Data files from WPD systems used in NEAT.

Source	Frequency	Data	Description
PowerOn	As frequently as possible	Event Log	Core table. Related to the Component Header table
	As frequently as possible	Command Log	Contains information about changes to discrete/mode points.
	Daily	Component Header	Core table specifies the network model of the system.
	As updated or quarterly	Component Class Defn	Lookup table for COMPONENT_CLASS and COMPONENT_SUBSTATION_CLASS columns in the Component Header

	Weekly	Component Attribute	Attributes to include: • Voltage • is commissioned • Any attribute ending with No (e.g. Pole No) • Manufacturer • Make / Type
	As updated or quarterly	Alarm Type	Lookup table for the ALARM_TYPE column in the Event Log data
	As updated or quarterly	Alarm Priority	Lookup table for the ALARM_PRIORITY column in the Event Log data
	As updated or quarterly	Control Zone	Lookup table for the ALARM_ZONE_ID column in the Event Log data
	Daily	Future Patch Applications	Information about changes to the components in the system
	Daily	SVO ICCP Bilateral Table	Link SVO items to PowerOn components via the component's alias
	Daily	ANM ICCP Bilateral Table	Link ANM items to PowerOn components via the component's alias
Webfocus	Daily	Switching Items	Determine when planned work occurred on components
TSDS	Daily	Tap Position	Analogue value on analogues. Can be used for diagnosing SVO. Can link to a component in PowerOn via the component alias?
	Daily	Voltage	Analogue value on analogues. Can be used for diagnosing SVO. Can link to a component in PowerOn via the component alias?
	Daily	Amps	Analogue value on analogues. Can be used for diagnosing SVO. Can link to a component in PowerOn via the component alias?
	Daily	MW	Analogue value on analogues. Can be used for diagnosing ANM. Can link to a component in PowerOn via the component alias?
	Daily	MVar	Analogue value on analogues. Can be used for diagnosing ANM. Can link to a component in PowerOn via the component alias?
SVO	Daily (last 36 hours of data)	Red Alarms	Alarms in SVO that may not be passed to PowerOn
	As updated or quarterly	Alarm Configuration	Defines the alarms (Red Alarms) in SVO
ANM	Every 5 minutes	Run Log	Log results from one run of the ANM system
CROWN	Weekly	Asset Role	Asset that was worked on. Substation number on this table can be linked to a substation on PowerOn (PowerOn component)
	Daily (last 48 hours of data)	Event Occurrence	Past work on assets in the network, contains the date when it was worked on.
	As updated or quarterly	Reference Item	Mapping table for the Event Occurrence table. Defines the type of work conducted.

INM	Monthly	Equipment Node-breaker model	Common Interchange Model (CIM) of the WPD Electricity network including substations, transformers, circuit breakers, lines, and bus bars

An overview of the relationships between the data is shown in Figure 2.

System	Colour
PowerOn	Purple
CROWN	Green
INM	Orange
SVO	Blue
ANM	Yellow

Note	Line Color
Cross over boundaries	Red |
Discrete connected to one of the objects in the box	Pink |
Terminal connected to one of the objects in the box	Blue |

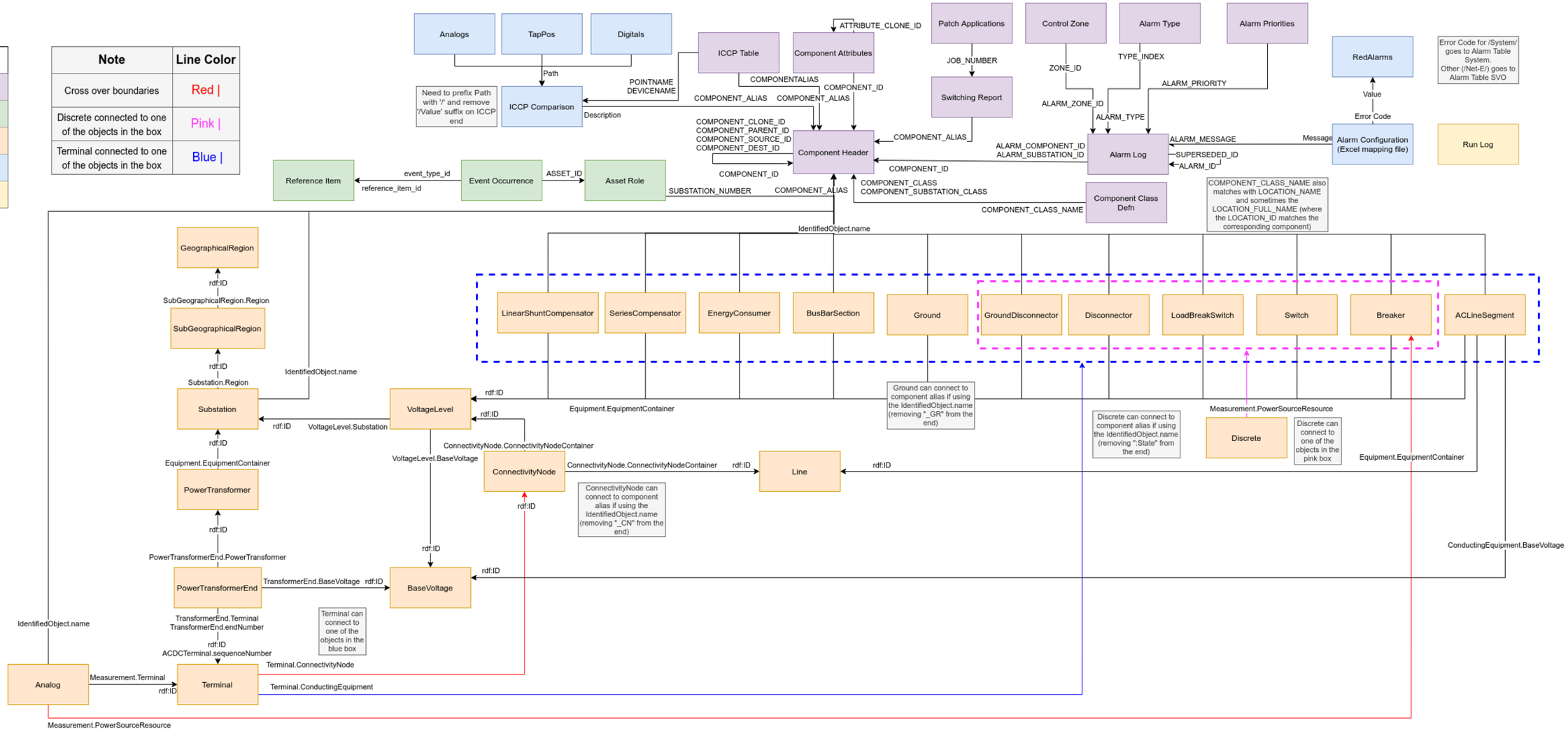

Figure 2 Relationship between data files in WPD systems

4.3. Data Formats

Table 2 Data file examples from WPD systems

Source	Format	Example
INM	XML (using CIM)	<cim:Terminal rdf:ID="_INM_ID_F8EBE02A-E309-4142-91BD-01A8BE772A7E_T2"> <cim:IdentifiedObject.name>ALIAS-22089-V_T2</cim:IdentifiedObject.name> <cim:Terminal.ConductingEquipment rdf:resource="#_F8EBE02A-E309-4142-91BD-01A8BE772A7E"/> <cim:ACDCTerminal.sequenceNumber>2</cim:ACDCTerminal.sequenceNumber> <cim:Terminal.ConnectivityNode rdf:resource="#_INM_ID_F8EBE02A-E309-4142-91BD-01A8BE772A7E_CN"/> </cim:Terminal> <cim:MeasurementValueSource rdf:ID="_2E6A4644-E539-48BA-8B76-06E26AA16180"> <cim:IdentifiedObject.name>Forecasted</cim:IdentifiedObject.name>
ANM	JSON	16-Apr-21 07:15:31 [Cornwall - ANM] (20): Gen not available for MW control: Ventonteague WF status flags are "ANM Not Enabled" 16-Apr-21 07:15:31 [Cornwall - ANM] (20): Gen not available for MW control: Denbrook WF status flags are "ANM Not Enabled" 16-Apr-21 07:15:31 [Cornwall - ANM] (20): Gen added to MW stack: Future PD Food Serv status flags are "ANM on" 16-Apr-21 07:15:31 [Cornwall - ANM] (20): Gen not available for MW control: West Carclaze status flags are "ANM Not Enabled" 16-Apr-21 07:15:31 [Cornwall - ANM] (20): Gen not available for MW control: Batsworthy WF status flags are "ANM Not Enabled" 16-Apr-21 07:15:31 [Cornwall - ANM] (20): Created stack containing 5 generators 16-Apr-21 07:15:31 [Cornwall - ANM] (20): Gen not available for MW control: Ventonteague WF status flags are "ANM Not Enabled" 16-Apr-21 07:15:31 [Cornwall - ANM] (20): Gen not available for MW control: Denbrook WF status flags are "ANM Not Enabled" 16-Apr-21 07:15:31 [Cornwall - ANM] (20): Gen added to MW stack: Future PD Food Serv status flags are "ANM on" 16-Apr-21 07:15:31 [Cornwall - ANM] (20): Gen not available for MW control: West Carclaze status flags are "ANM Not Enabled" 16-Apr-21 07:15:31 [Cornwall - ANM] (20): Gen not available for MW control: Batsworthy WF status flags are "ANM Not Enabled" 16-Apr-21 07:15:31 [Cornwall - ANM] (20): Base case load flow solved 16-Apr-21 07:15:31 [Cornwall - ANM] (20): Failed to run sensitivity study for generator Future PD Food Serv. Test MW values are identical, check MW ratings 16-Apr-21 07:15:32 [Cornwall - ANM] (20): Resolving constraints at 11.0kV 16-Apr-21 07:15:32 [Cornwall - ANM] (20): Maintaining curtailment for Future PD Food Serv, position 2, at -0.00MW , originally 0.00MW 16-Apr-21 07:15:32 [Cornwall - ANM] (20): Resolving constraints at 33.0kV 16-Apr-21 07:15:32 [Cornwall - ANM] (20): Maintaining curtailment for Future PD Food Serv, position 2, at -0.00MW , originally 0.00MW 16-Apr-21 07:15:32 [Cornwall - ANM] (20): Resolving constraints at 132.0kV 16-Apr-21 07:15:32 [Cornwall - ANM] (20): Maintaining curtailment for Future PD Food Serv, position 2, at -0.00MW , originally 0.00MW 16-Apr-21 07:15:32 [Cornwall - ANM] (20): Rechecking constraints at all voltages 16-Apr-21 07:15:32 [Cornwall - ANM] (20): Maintaining curtailment for Future PD Food Serv, position 2, at -0.00MW , originally 0.00MW 16-Apr-21 07:15:32 [Cornwall - ANM] (20): Setting final generator output for Future PD Food Serv to 0MW and 0.0MVAr 16-Apr-21 07:15:32 [Cornwall - ANM] (20): Constrained generators at stack position 2 and above. 16-Apr-21 07:15:32 [Cornwall - ANM] (20): 16-Apr-21 07:15:32 [Cornwall - ANM] (20): Load Flow metrics: 16-Apr-21 07:15:32 [Cornwall - ANM] (20): Number of load flows = 7 16-Apr-21 07:15:32 [Cornwall - ANM] (20): Time per load flow = 0.138secs 16-Apr-21 07:15:32 [Cornwall - ANM] (20): 16-Apr-21 07:15:32 [Cornwall - ANM] (20): Base case overloads: 16-Apr-21 07:15:32 [Cornwall - ANM] (20): No normal overloads found 16-Apr-21 07:15:32 [Cornwall - ANM] (20): 16-Apr-21 07:15:32 [Cornwall - ANM] (20): Final overloads: 16-Apr-21 07:15:32 [Cornwall - ANM] (20): No normal overloads found
SVO	CSV	Timestamp, Path, Value, QualityTextUser, Alarm 12/06/20 00:00, /Net-E/.InjectionSources/WaterLake/InjSrcBB_T2/SVO1_Errorcode, 999, HIS - Not collected, Green 12/06/20 00:00, /Net-E/.InjectionSources/Radstock/Alarms/SVO1_Errorcode, 999, Telemetered - Valid, Green 12/06/20 00:00, /Net-E/.InjectionSources/NetherStowey/Alarms/SVO1_Errorcode, 999, Telemetered - Valid, Green 12/06/20 00:00, /Net-E/.InjectionSources/MarshGreen/InjSrcBB_T2/SVO1_Errorcode, 999, HIS - Not collected, Green 12/06/20 00:00, /Net-E/.InjectionSources/BowhaysCross/Alarms/SVO1_Errorcode, 999, Telemetered - Valid, Green
PowerOn	Excel/CSV	ALARM_ID, ALARM_REFERENCE, ALARM_VALUE, ALARM_INITIAL_TIME B017c0f1fALRM, 101, 2, 01/11/2020 20:00:38.000000 +00:00 B017c0f20ALRM, -62, 18, 01/11/2020 19:55:39.607425 +00:00 B017c0f25ALRM, 50, 55, 01/11/2020 20:00:59.284000 +00:00 B017c0f27ALRM, 101, 1, 01/11/2020 19:53:04.000000 +00:00 B017c0f29ALRM, 101, 2, 01/11/2020 20:01:40.000000 +00:00
TSDS	CSV	Analogue, Time, Value, Units, Quality TIVERTON BSP,33kv,Busbar A,CB 2L5,Current Analogue.Current (A), 01/11/20 00:00, 41.052872, A, Good TIVERTON BSP,33kv,Busbar A,CB 2L5,Current Analogue.Current (A), 01/11/20 00:30, 43.799496, A, Good TIVERTON BSP,33kv,Busbar A,CB 2L5,Current Analogue.Current (A), 01/11/20 01:00, 42.151524, A, Good TIVERTON BSP,33kv,Busbar A,CB 2L5,Current Analogue.Current (A), 01/11/20 01:30, 42.151524, A, Good

4.4. Data Assumptions/Processing

- Any sensitive information from PowerOn has not been used and is not stored within NEAT. To make data extraction simpler, datasets have been extracted from PowerOn with sensitive data which has subsequently been processed to remove / redact the data. This process as partially documented in [3] will be incorporated into the NEAT data processing.
- INM is updated monthly from PowerOn, CROWN (Asset Management), and Electric Office (GIS)
- Only the operational status of SVO (stopped or running) is tracked as an alarm in PowerOn.
- SVO components are tracked in PowerOn with their analogue and discrete values recorded in TSDS. This assumption is similarly implied for the ANM system.
- PowerOn contains ICCP Bilateral tables which will be used to get the components related to the ANM and SVO systems.
- In PowerOn, if there is more than one event at the same millisecond, these events should be treated as a communication issue and be excluded from modelling. The communication issue can occur on Panacea manufactured devices on the DNP 3.0 link due to interference on the radio channel (such as mobile traffic systems). Consequently, the host RTU is acknowledging an alarm but the device (e.g. PMAR) does not receive acknowledgement from the RTU. Therefore, the device resends the same message with the same timestamp until it is reset or receives an acknowledgement.
- The newer devices using DNP3.0 set the timestamp within the automation base station and not the device. The DNP3.0 protocol is only applied between the base station and the host RTU – not over the air direct to the device. This means that the ack is always received by the base station and the device buffer is successfully reset.
- Information about changes to the mode in ANM and SVO is recorded in the PowerOn event logs.
- The equipment node breaker model in INM contains the relationships to map to the PowerOn components and CROWN assets (specifically the Name and NameType table).
- PowerOn contains a command log about the discrete/mode changes

5. Data Model

The data model as shown in Figure 3 shows the database tables and fields created within the system and how they relate to each other. The data models from further systems (such as ANM) can be added later.

Data from various systems as specified in Section 4.2, Data Files are imported and used in the data models. Figure 4 shows the relationship between the NEAT system database tables and these data files. Additional database tables can be added to support other systems.

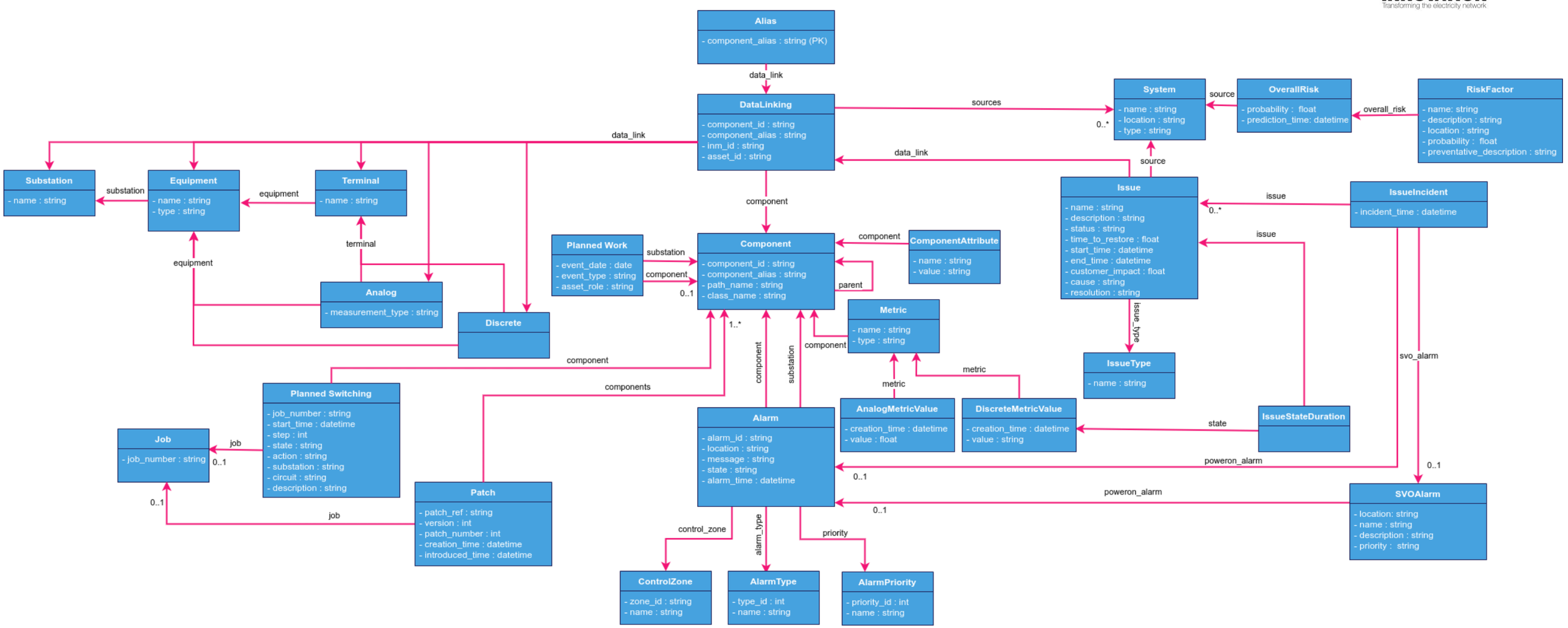

Figure 3 NEAT Database Model

Note	Line Color
Cross over boundaries	Red |
Discrete connected to one of the objects in the box	Pink |
Terminal connected to one of the objects in the box	Blue |
WPD External System Connection to NEAT	Purple |

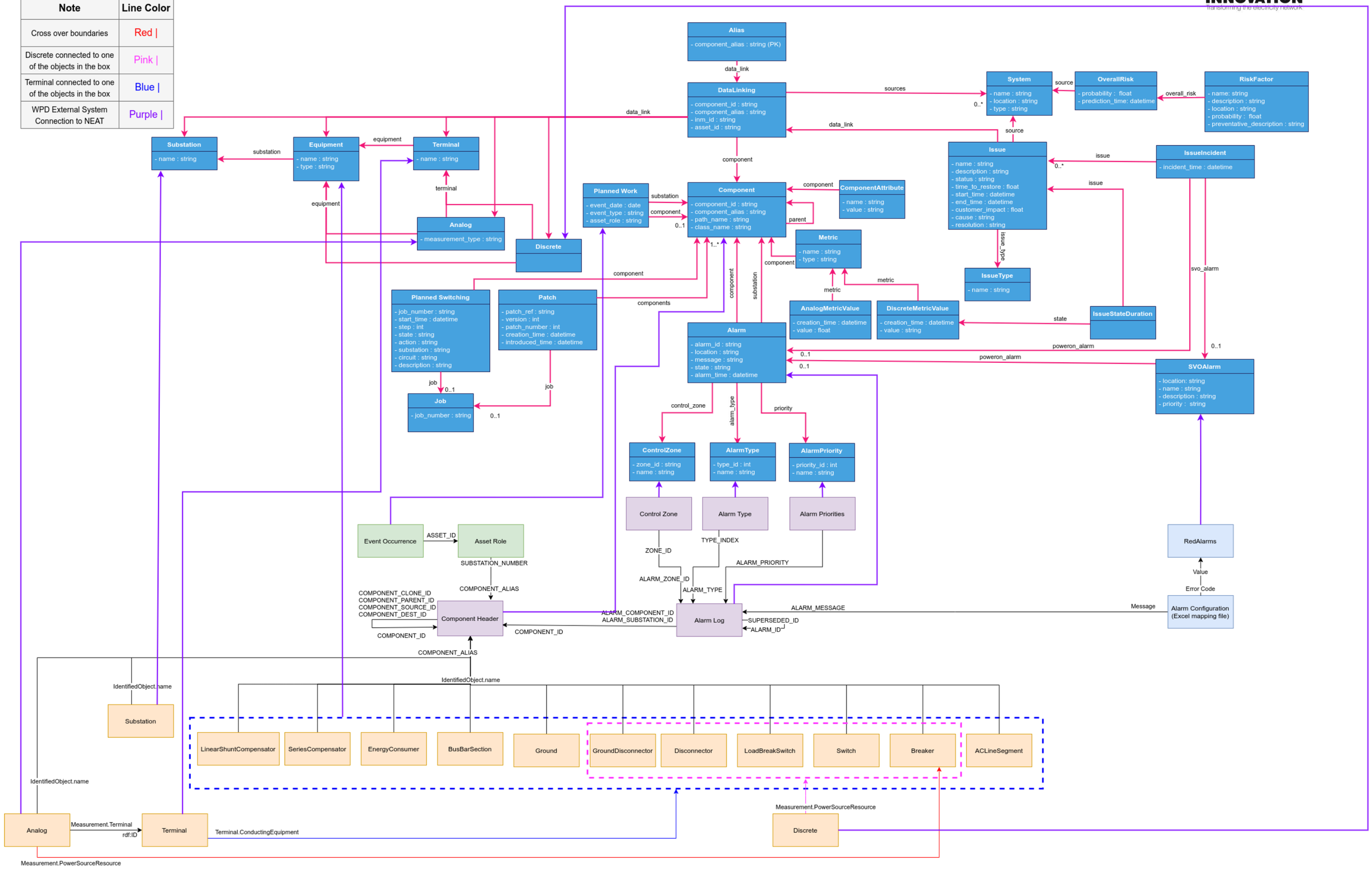

Figure 4 Relationships between WPD data files and NEAT database model

6. User Interaction

Users will be using the NEAT system to ensure that the SVO and ANM systems are operating optimally, therefore they will want to be able to:

1. Easily see an overview of any current issues ordered by priority.
2. Be able to drill down into the details of individual issues and determine the most likely cause so that they can initiate remedial action. (e.g., manually update the network model, confirm a suspected telecoms fault has been identified within PowerOn and is being managed, report a server failure to WPD IR etc.)
3. Easily see an overview of the current risk assessment for future incidents with an indication of risk confidence and potential impact
4. Be able to drill down into the details of the individual risks to determine if any pre-emptive remedial action is required.
5. Monitor the long-term trends in operation of the ANM and SVO systems with reports that show the number and impact of incidents e.g., MWh of generation constrained while the systems were not operating optimally but also give a better understanding of activity when the systems are healthy.
6. Monitor the long-term trends in the accuracy of risk identification and the likely benefits from pre-emptive action. A drop off in these may indicate that a change in WPD operations or systems has occurred which may require the predictive models to be revisited.
7. As a system admin task, set or update the weightings to be used to prioritise current issues or future risks.

6.1. Navigation

The sitemap in Figure 5 shows the web pages in NEAT and how pages are accessed from other pages. For example, the user can access the Risk List page from the Risk Dashboard page. At the top of every page, is a navigation bar (Figure 6) to allow users to navigate between the different entry pages easily.

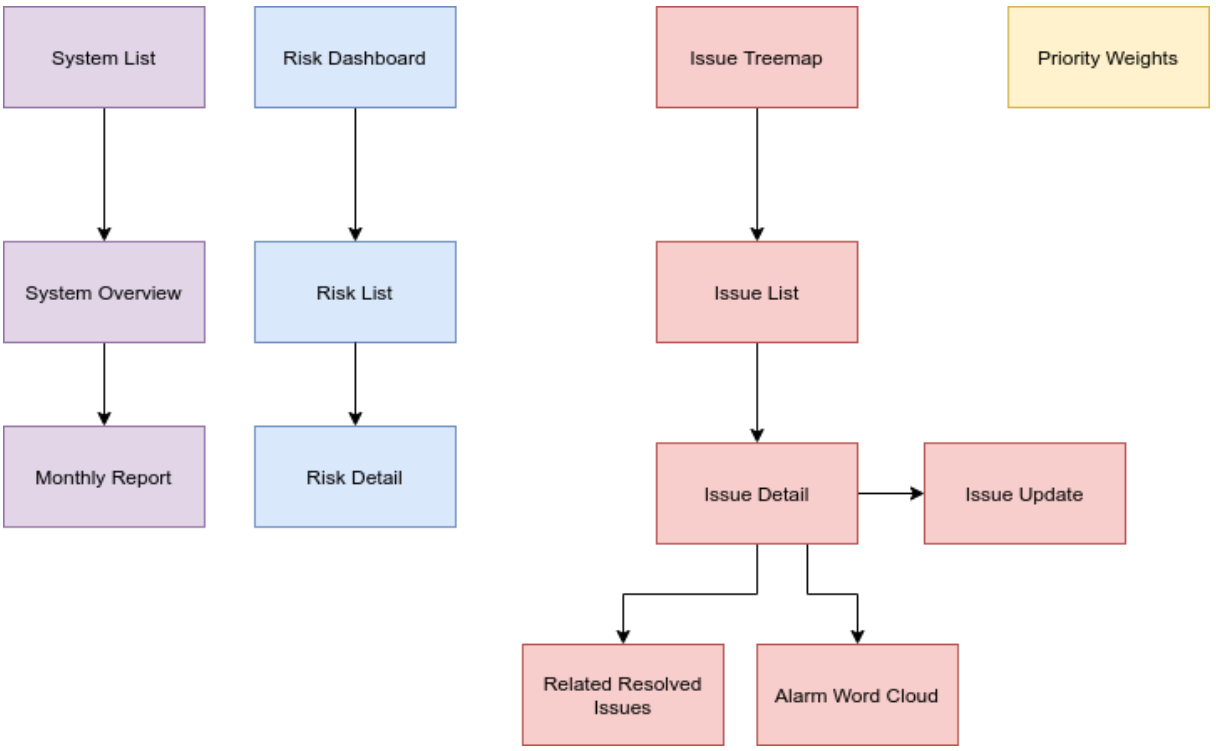

Figure 5 Sitemap

System List

Figure 6 Navigation Bar

Within some pages, a breadcrumb will also be shown below the navigation bar (Figure 7) so users can navigate back up pages.

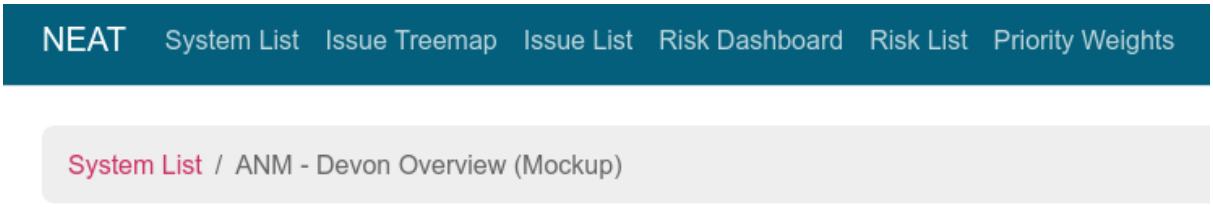

Figure 7 Breadcrumb

6.2. Common Functionality

Graphs are exportable to images. The data contained in the graph can also be exported into a CSV file.

7. Wireframes

The wireframes specify the contents of pages in NEAT with their connections specified in Section 6.1, Navigation.

An issue is defined as a problem occurring in a DSO Support system (SVO, ANM). An issue can be due to a combination of factors from different systems. Usually has groups of alarms and components related to it.

A risk is the likelihood of the system experiencing an issue in the future.

7.1. Issue Treemap

Fulfils requirements: FR101, FR102, FR201, FR202, FR203, FR204, FR205

This page would be a first step for users to have a high-level look at issues over a certain timeframe to understand what are the most concerning issues.

The issues treemap allows users to look at the total number of issues summarised by various factors such as the type of the issue (as shown in Figure 8), and the system source. The size of the block of the treemap indicates the number of issues related to it; the larger the block, the more issues are related to it. The colour shows the relative average priority between the categories.

Hovering over a block as shown in Figure 9 will show a tooltip of the number of issues, average priority and percentage of issues based on the previous factors drilled through as filters.

Clicking on a block in the treemap allows the user to drilldown into the issues using the specific factors as filters. The filters used would then appear next to the dropdown. The dropdown in the top right of the treemap allows the user to change which categorisation is being used, and includes:

- Issue Type
- System Type
- System Location
- Status (Open or Resolved)

From the filtered issues shown in the treemap, the user can view the issues in the Issue List page using the “List View” button.

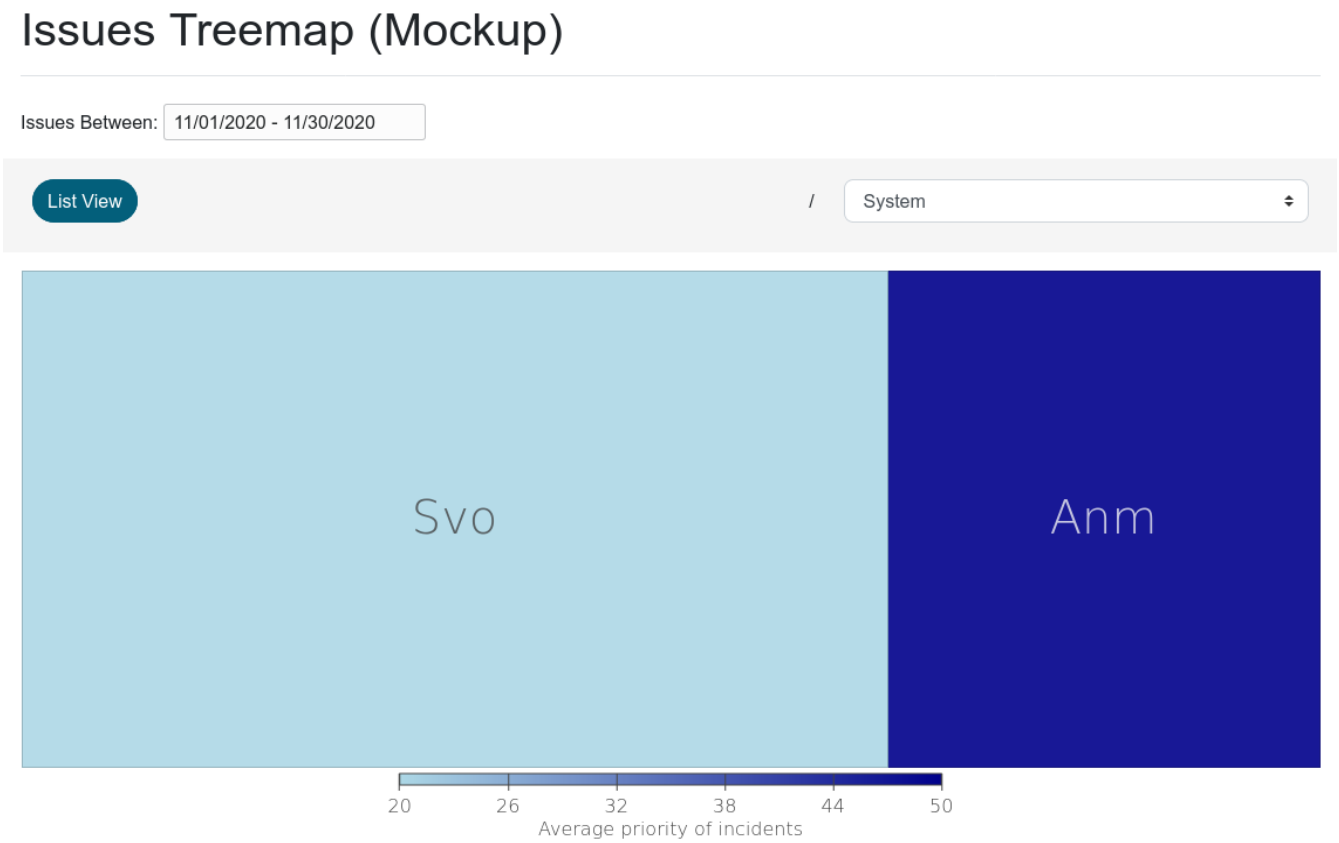

Figure 8 Wireframe of Issue Treemap page

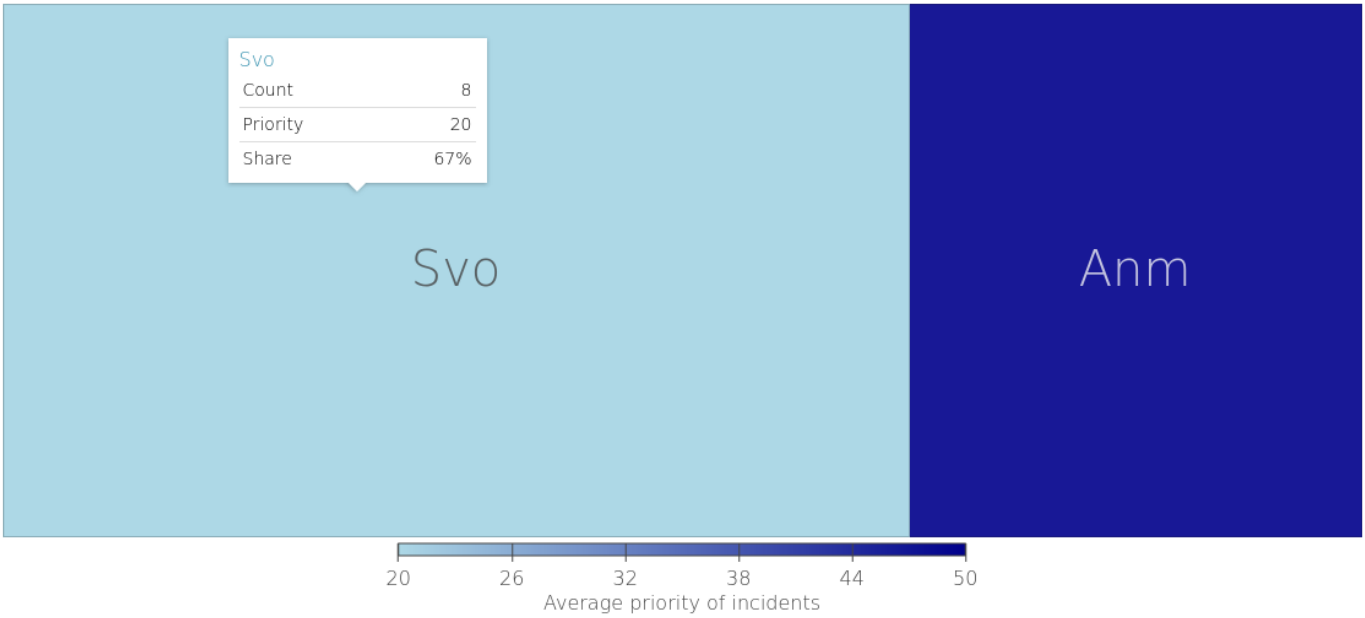

Figure 9 Hovering over SVO block on Issue Treemap

7.2. Issue List

Fulfils requirements: FR101, FR102, FR201, FR202, FR203, FR204, FR205

The issues list shows a table of all issues, detailing various aspects of the issue including the system source, issue type, name of the issue and component related to the issue. The table allows the user to sort each column and filter the table using the search bar.

Clicking a row in the table, will allow the user to view more details of the issue (Issue Detail page).

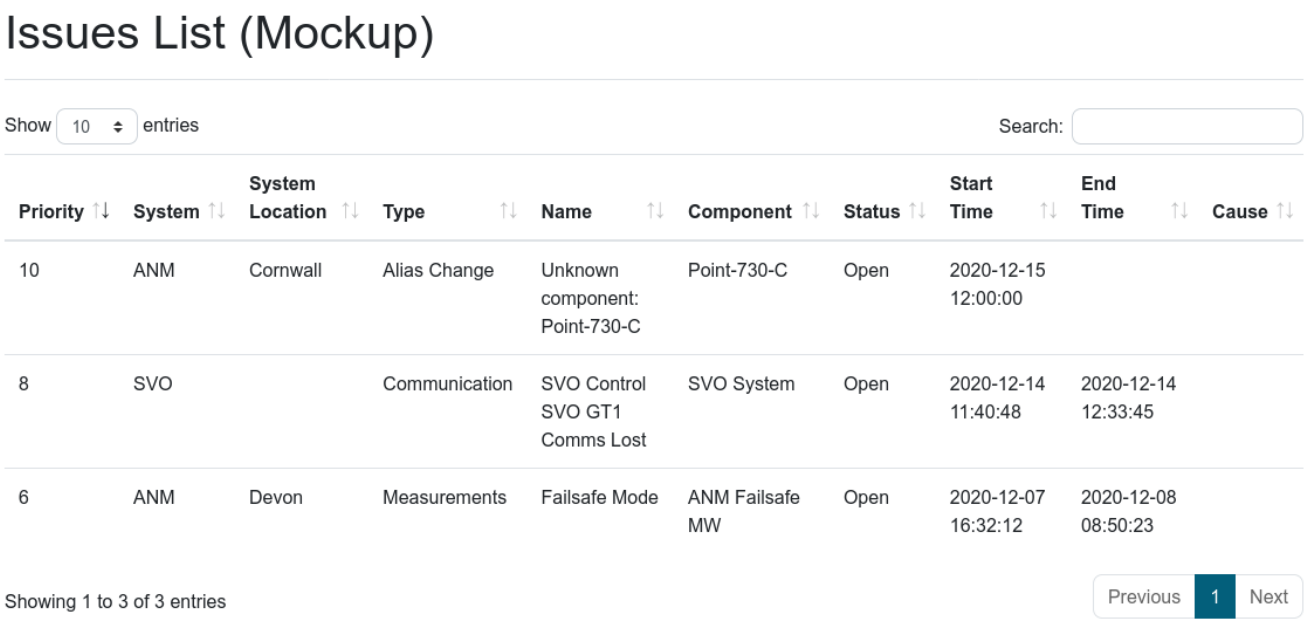

Figure 10 Wireframe of Issue List page

7.3. Issue Detail

Fulfils requirements: FR104, FR301, FR302

We can look at more specific details of the issue on this page. This includes the root cause of the issue and resolution (if filled in) as well as a table of alarms that were affected or related to the issue.

A user can update the cause and resolution for the issue (the specific implementation is adaptable, whether it be updating it on a new page or updating it via a modal). We can also go to other pages related to this issue.

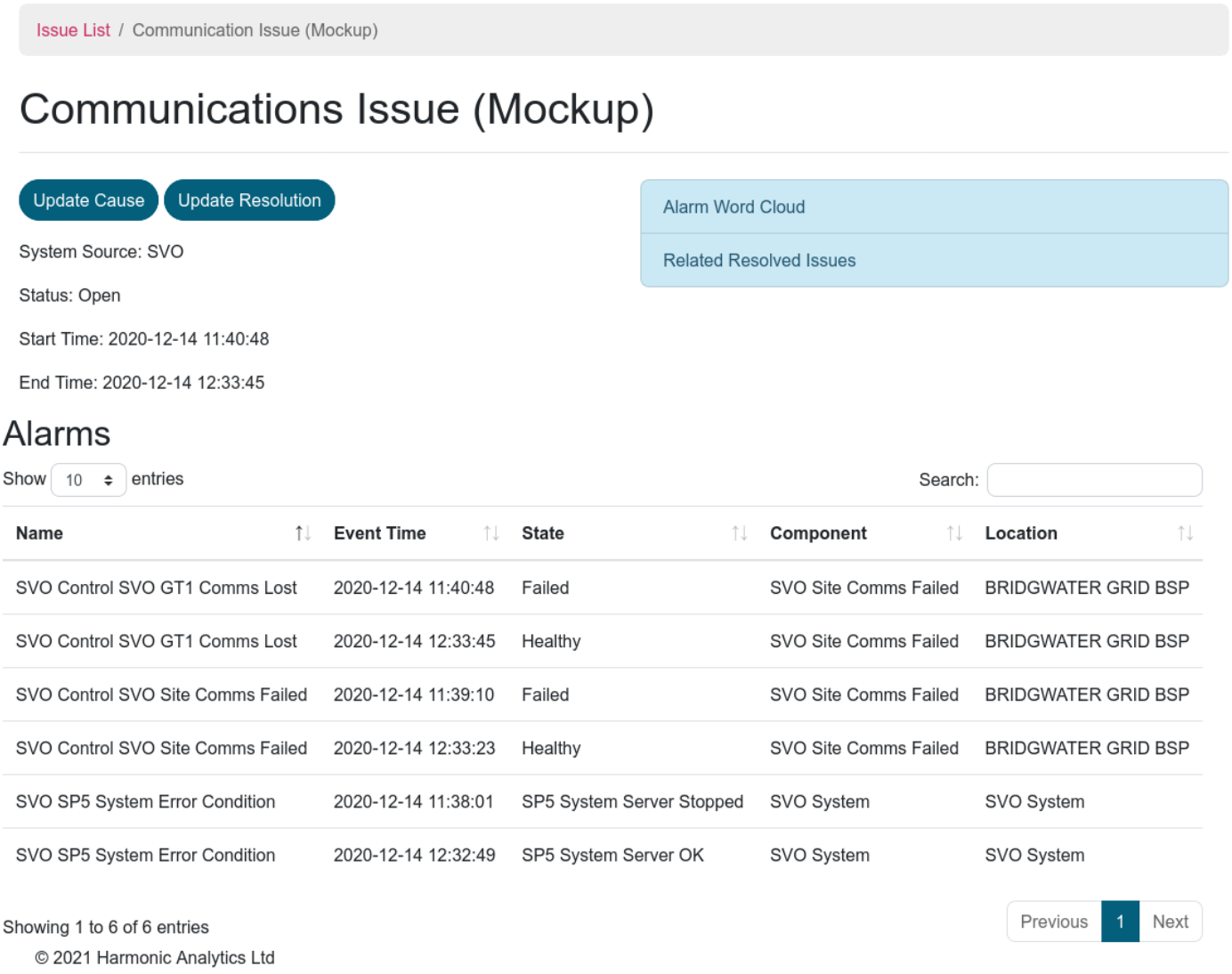

Figure 11 Wireframe of Issue Detail page

7.4. Related Resolved Issues

This page shows the causes of older resolved issues for the same type of issue within the same system. This helps users diagnose the current issue by seeing if it could have had a similar cause or substation to a previously occurring issue.

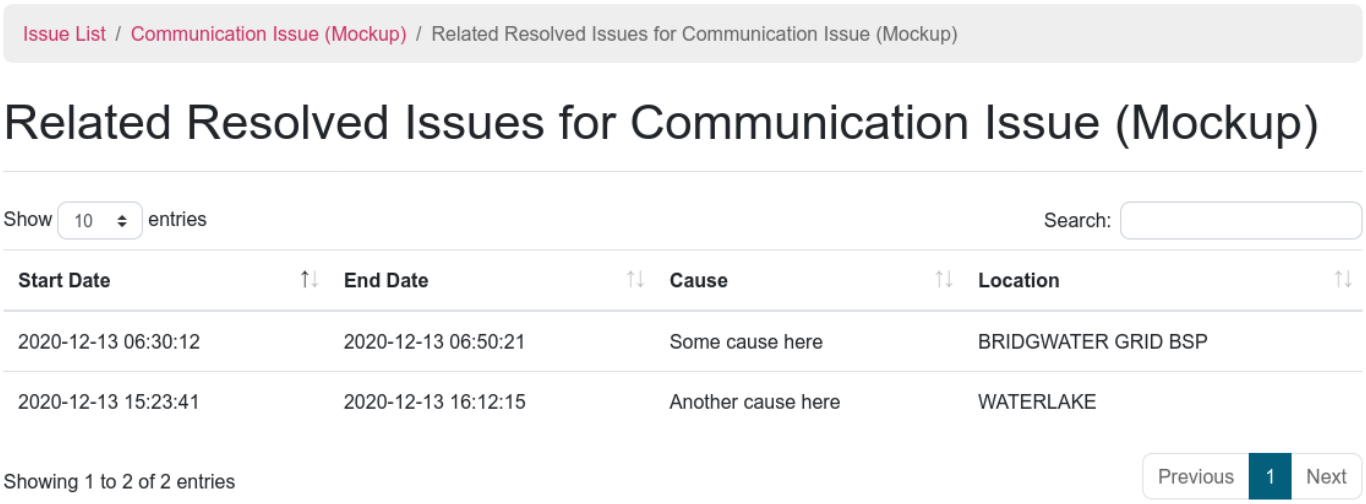

Figure 12 Wireframe of Related Resolved Issues page

7.5. Alarm Word Cloud

Shows alarms with their messages that were grouped for this issue. Hovering over a message will show a tooltip detailing the number of occurrences for the alarm, and the number of occurrences it was in different states.

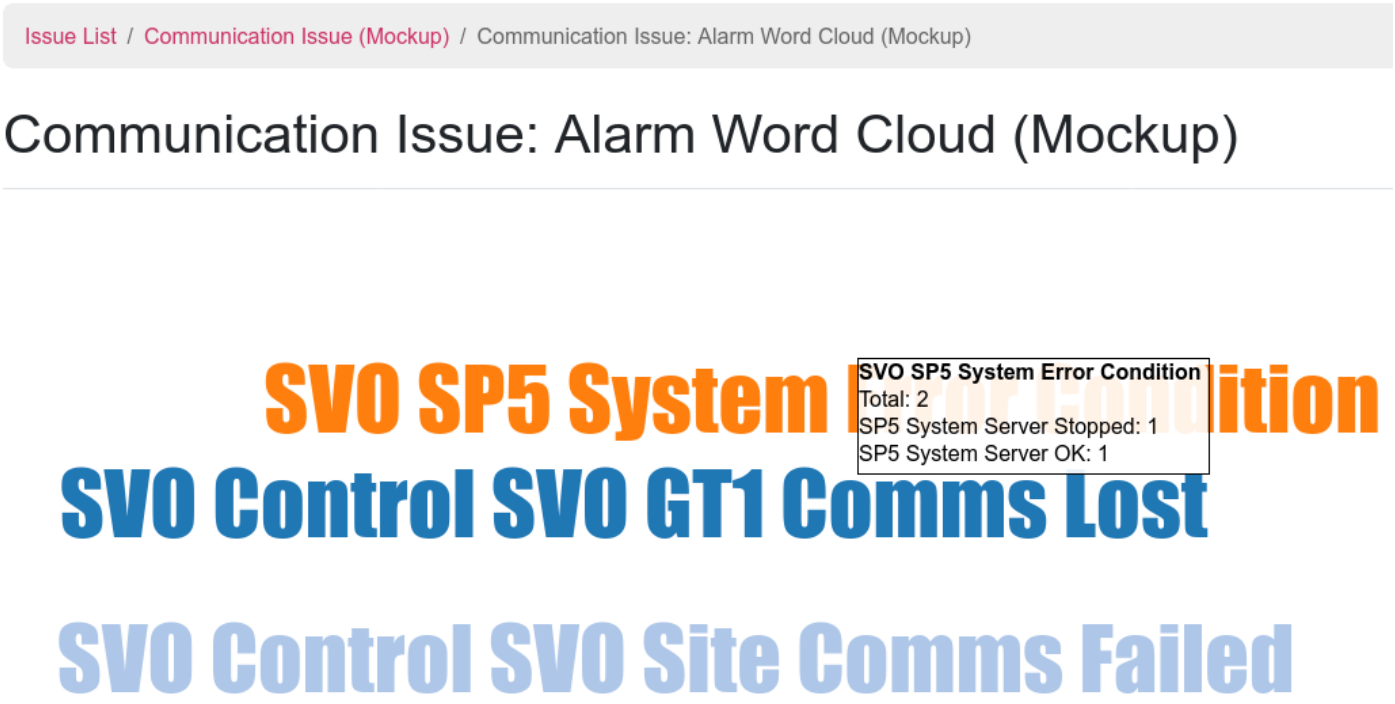

Figure 13 Wireframe of Alarm Word Cloud page

7.6. Risk Dashboard

Fulfils requirements: FR503.

The Risk dashboard shows the overall risk for each individual system. Risk is colour-coded using a traffic light system: red indicating high risk, yellow indicating medium risk and green indicating low risk. Risks are identified when alarms or events occur in patterns that are recognised as often preceding issues.

Clicking on a block will direct the user to view the risk factors relating to the system on the Risk List page.

A map of the counties and unitary authorities in the United Kingdom are also shown. The user can toggle between SVO and ANM to see the level of risk the systems pose.

The word cloud (Figure 15) shows the risk of components, a larger word indicating a higher risk. Hovering over a component will show the percentage risk for the component.

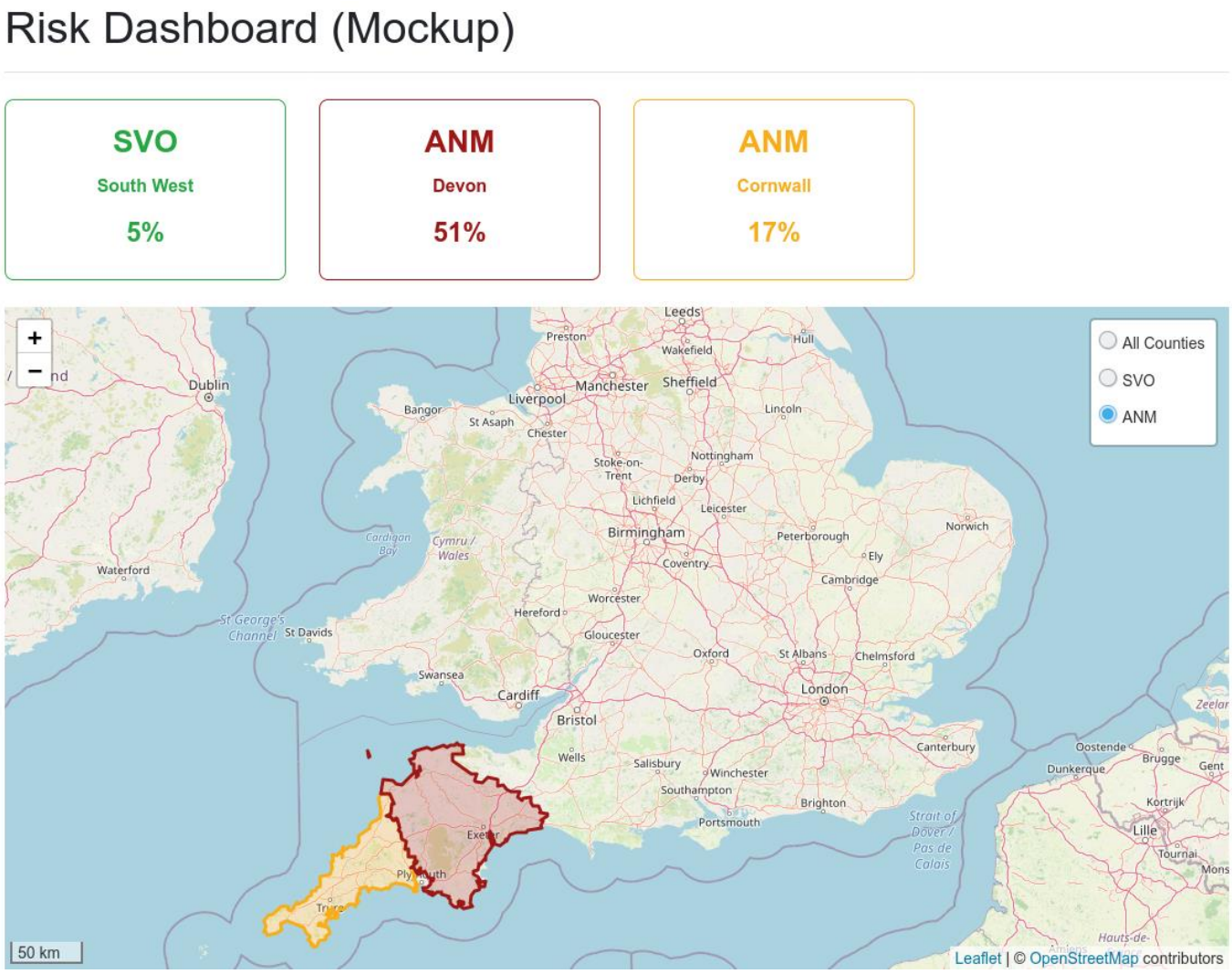

Figure 14 Wireframe of Risk Dashboard page (top half)

Component Risk Word Cloud

Figure 15 Wireframe of Risk Dashboard page (bottom half)

7.7. Risk List

Fulfils requirements: FR501, FR502, FR504

The risk list shows a table of risk factors detailing various aspects of the risk factor including the system source, location, name of the issue and likelihood of occurrence. The table allows the user to sort each column and filter the table.

Clicking a row in the table, will allow the user to view more details of the risk factor (Risk Detail page).

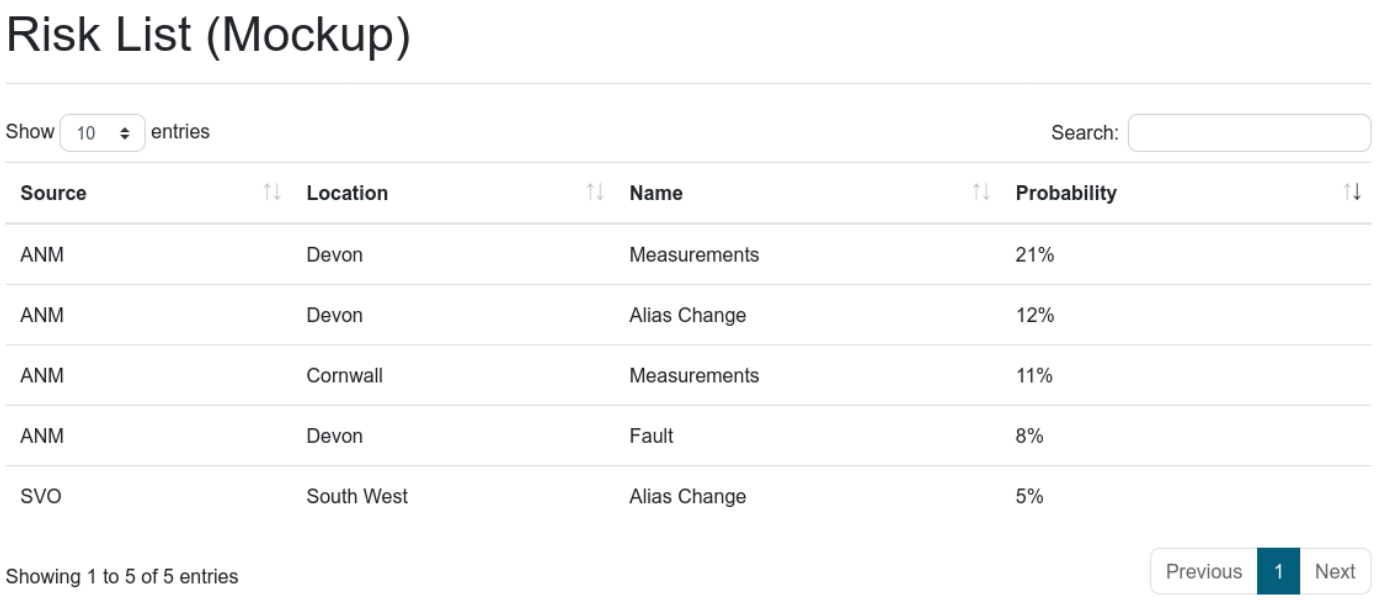

Figure 16 Wireframe of Risk List page

7.8. Risk Detail

Fulfils requirements: FR501, FR502, FR504

Various details of the risk factor are displayed on this page as well as a table of components that could be affected by the risk factor occurring.

The affected components are PowerOn components that could cause alarms related to this risk occurring.

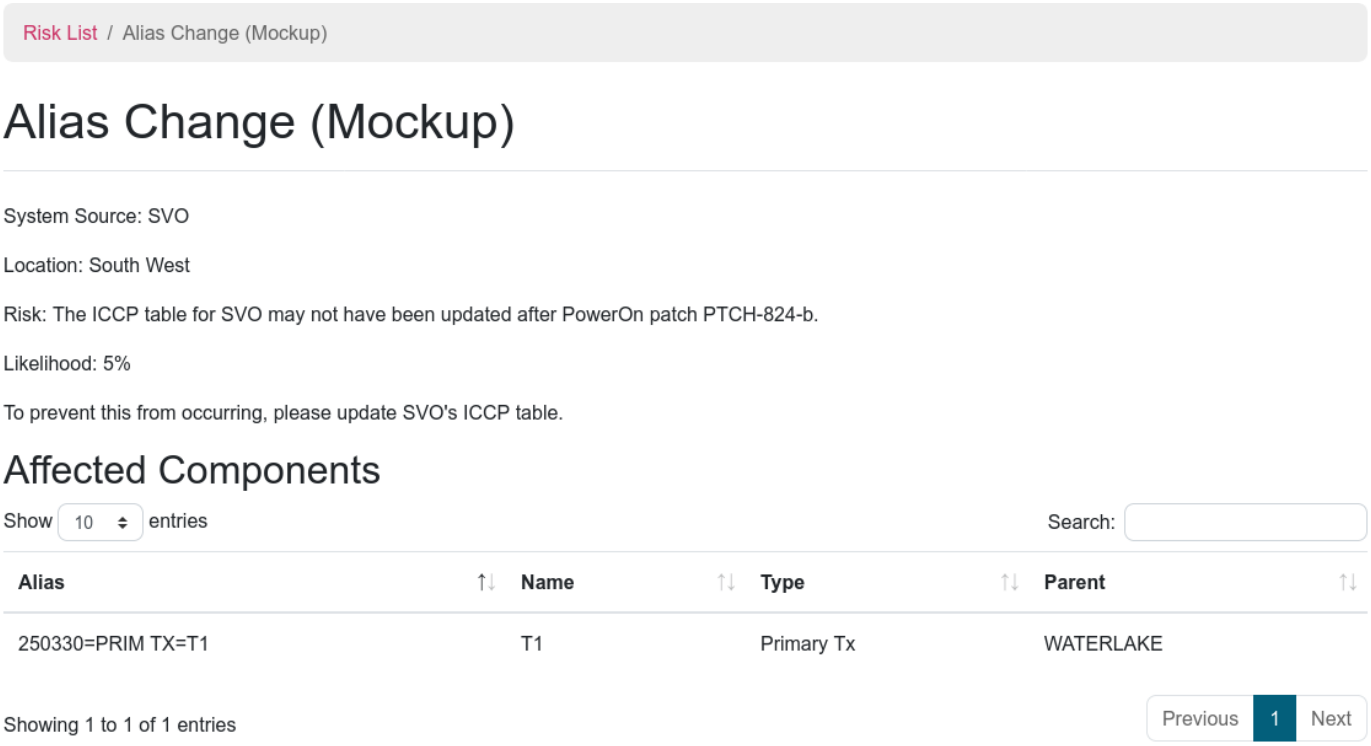

Figure 17 Wireframe of Risk Detail page

7.9. System List

This page shows the systems that NEAT keeps track of.

Clicking on a system will direct the user to the System Overview page for the system.

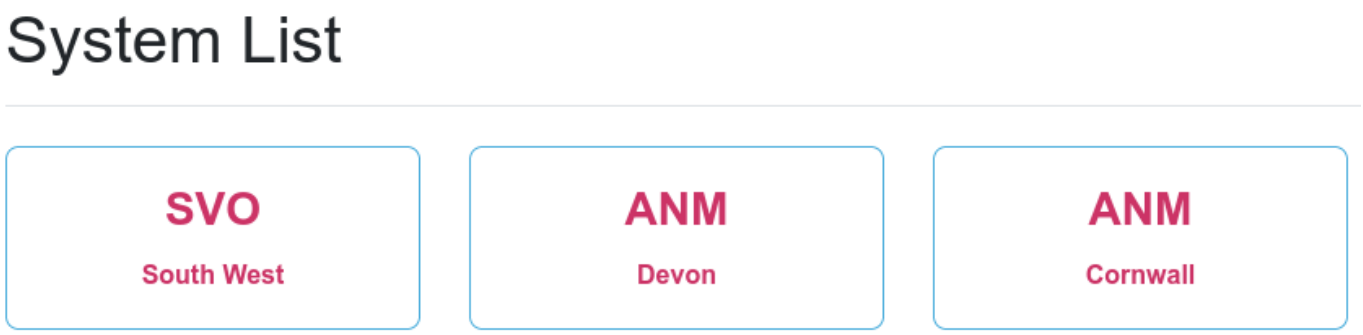

Figure 18 Wireframe of System List page

7.10. System Overview

The System overview page shows information about a system. Two line graphs are shown below: the top graph shows the daily likelihood of different risk factors; the bottom graph shows the daily number of issues related to the system against the system's availability.

This page will allow the user to track the system's health and performance over time.

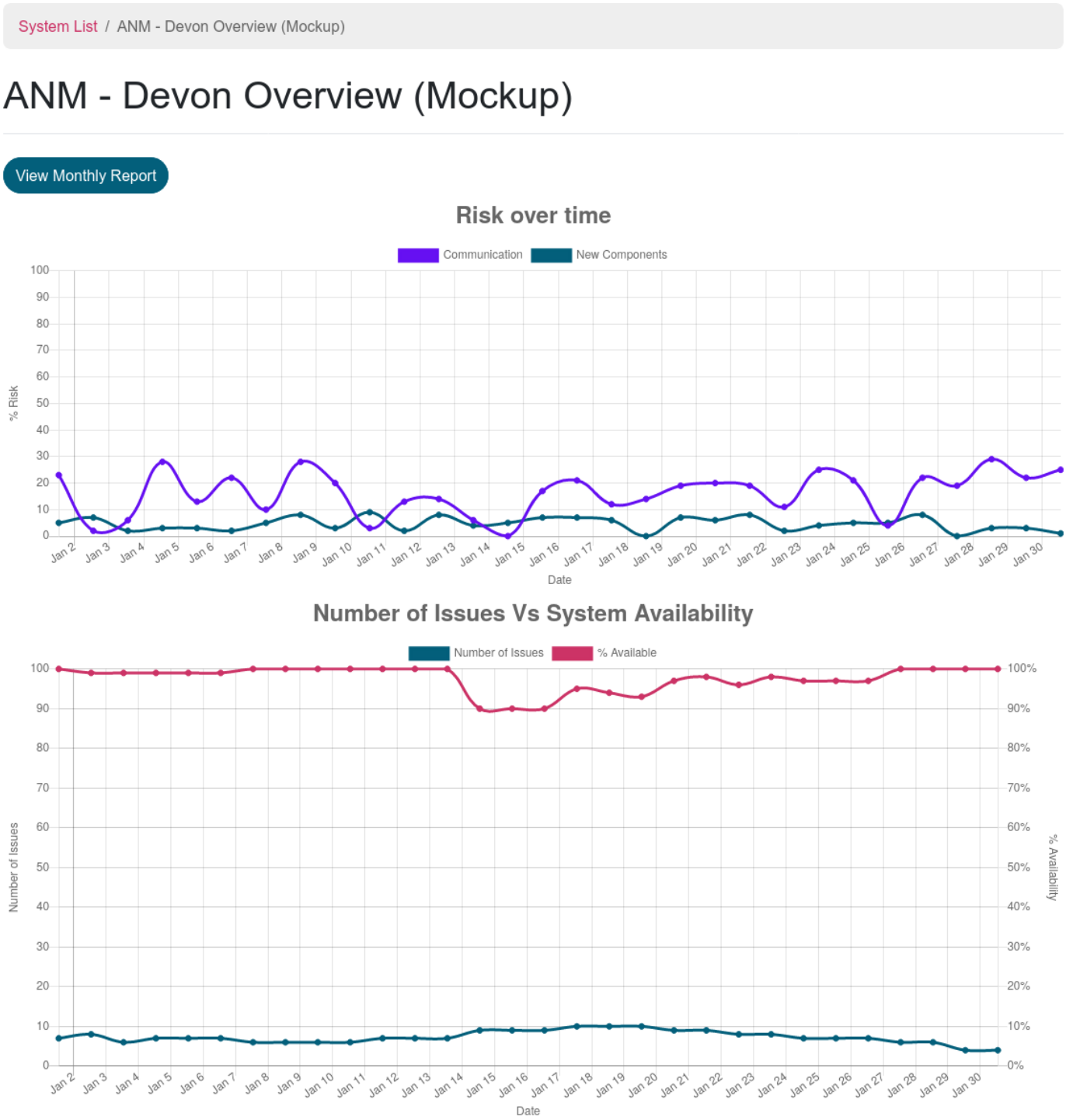

Figure 19 Wireframe of System Overview page

7.11. Monthly Report

Fulfils requirements: FR603, FR701.

The monthly report shows information about the ANM system for a particular month.

The first graph shows the mode the ANM system is in at any given point in time. The second graph shows the proportion of time the ANM system is in a particular mode for a day.

The table shows a summary of the types of alarms that occurred within the month such as the percentage of alarms for a particular type.

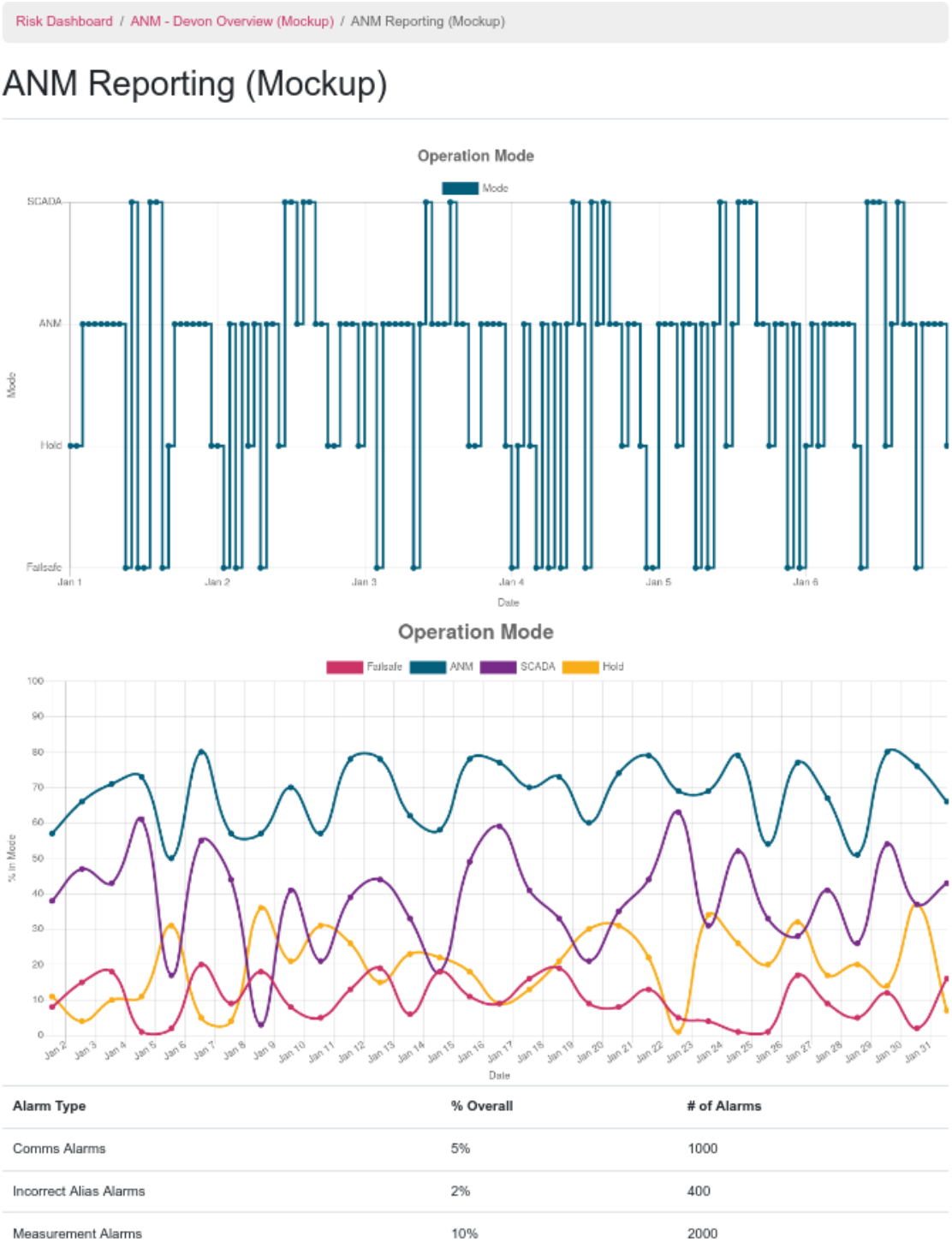

Figure 20 Wireframe of Monthly Report page

7.12. Priority Weights

NEAT automatically determines the priority of issues it identifies. This page allows users to scale the priority of issues; a higher weighting means the issue will have a higher priority.

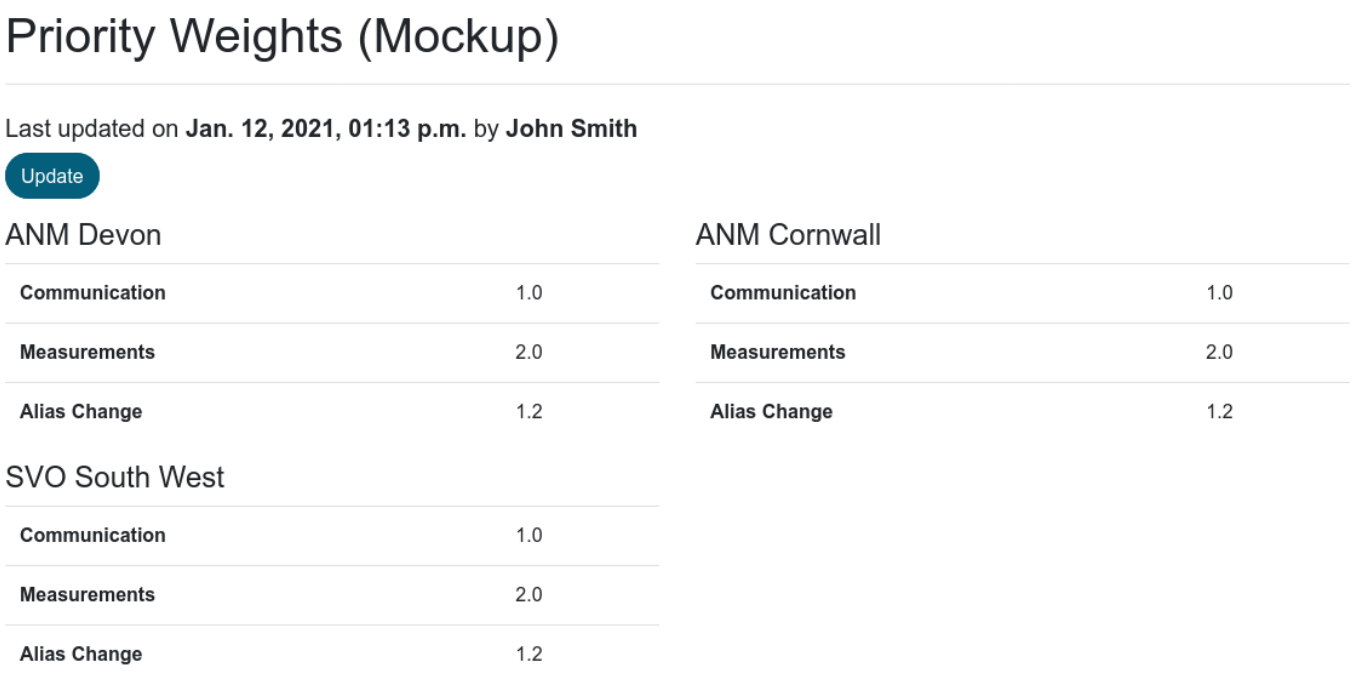

Figure 21 Wireframe of Priority Weights page

8. Testing

8.1. Automated Testing

The NEAT application contains automated tests to ensure the core functionality of the system is operating as intended throughout development. There are two techniques used for testing: Django unit testing and Selenium. The automated tests are executed every time a commit is added to the version control system.

The Django unit tests can be created for checking data importing, processing and handling; static webpage content and HTTP requests across web pages; as well as other functionalities executed on the server.

Selenium is used to create automated browser tests. This performs scripted user actions against a web browser allowing for changes to be checked. For example, a user could click a button which adds a new graph to the page. With Selenium, we can check that clicking the button causes the graph to appear. We can also check the newly added graph's contents and functionality. Selenium can also be run across multiple browsers.

8.2. Manual Pre-release Testing

A User Acceptance (UAT) test book will be created which WPD will use to review the system. Several testers will use this test book to check the system is working as intended. It will also help show if content on the page is easily understandable and discoverable by the tester.

The UAT test book will contain cases for different scenarios when interacting with the system. Each case will contain a set of step-by-step instructions detailing how the user interacts with the page such as what they should click on the screen.

9. User Acceptance

Testers will use the UAT test book to check the system is working. Issues discovered during testing are logged for fixing. After the issues are fixed, the test case is re-tested.

10. Deployment

10.1. Architecture

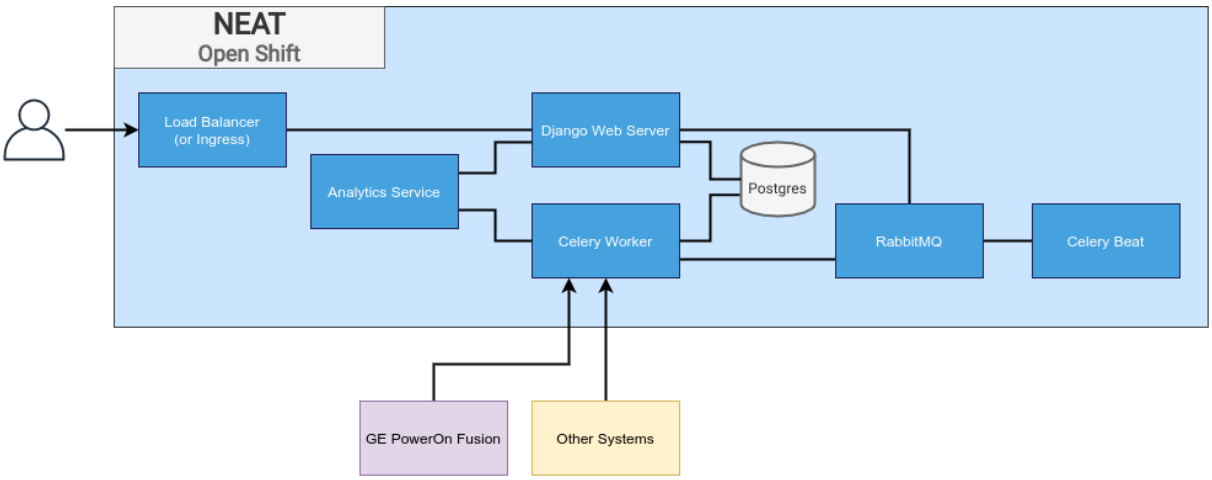

Figure 22 Overview of NEAT Architecture

The NEAT solution will be deployed as a set of components on WPD's OpenShift cluster.

The first Deployment object is the web interface. The number of instances can be scaled to suit the number of users accessing the system. A Service collects the web instances together, and an Ingress or Load Balancer provides external (to the cluster) access to the web application. The web interface may also be used by internal components to fetch or record information stored in the database.

The second Deployment is the workers. These can be scaled to suit the number of queued tasks. The running of tasks is managed by the Celery framework, and fetches tasks from the RabbitMQ server. Importing data is one of the tasks performed by the workers.

A single Scheduler pod (managed either as a deployment or statefulset) running Celery Beat is run to trigger periodic tasks by pushing them into the RabbitMQ queue for the Celery workers to receive and process.

These first three deployments all run the same container image with the main code developed for the NEAT solution.

If required, an analytics service deployment can be used to run R code written for this project to perform some of the analysis and modelling. This too can be scaled to suit the workload. It would be triggered by a Celery worker task and might retrieve data and upload results to the web site via an internal API or return the results to the Celery task.

The NEAT solution uses a database, and the preferred software is PostgreSQL. This can be running as a StatefulSet (or deployment) in the OpenShift cluster, using a PersistentVolumeClaim to store the data long term.

A message queue system is used by Celery to communicate tasks between the triggering systems (web, beat, worker) and the workers. The preferred product for this is RabbitMQ which can be run as a deployment or stateful set on OpenShift.

Files, such as the CSS and JS files for the web application and uploaded data files are stored in a Django-Storages compatible file storage service. Options include AWS S3 buckets (or compatible); Azure Storage; FTP or SFTP hosts running a webserver. If there is no preferred optional, we can run the S3-compatible minIO service as a StatefulSet set on OpenShift with a PersistentVolumeClaim to store the data. Data is pushed to the file storage service on some web requests, and at deployment time (either a separate pod or an init pod for the main deployment). Data can be fetched by http request (most likely https secured) by users (when authorised) or by http(s) or upload protocol (i.e., ftp or sftp) by worker and analytics service pods.

10.1.1. Alternatives

The solution can be deployed on Kubernetes with no changes.

The set of components can be deployed on a Linux server running Docker using the Docker Compose orchestrator or split across multiple servers.

The database, message queue system, and/or file storage services could be hosted externally from the other components.

10.2. Hardware Requirements

The following hardware requirements are per instance (one production instance, and likely a staging or testing instance).

10.2.1. CPU

The minimum number of (v)CPU threads available to the NEAT application is 8.

10.2.2. Memory/RAM

16GB RAM total is the minimum required for the NEAT solution.

10.2.3. Disk Space

The actively used container images total about 4 GB.

The worker and analytics service processes should have at least 8GB of (ephemeral) scratch space for temporary files.

The database needs to have at least 100GB of space. Approximately 10GB will be used with the initial data loading, and usage will increase by 1-2 GB per month.

The file storage system requires about 100GB of storage. About 500MB will be used for the static files, and the rest will be consumed at about 15GB per year for source data storage. This could be configured to only store a limited duration of source data.

10.3. Process

The process for deployment will be organised with WPD IR.

The steps to deploy include:

- Creating container image(s)
- Updating supporting components (database, message queue, file storage) deployments
- Refreshing static (CSS/JS) files
- Migrating the database if needed
- Updating the deployments of the web, worker, beat, and analytics service.
- Validate all components are working properly

If done correctly, updating the deployment should have zero downtime and not impact long-running tasks.

Glossary

Abbreviation	Term
ANM	Active Network Management
API	Application Programming Interface
AVC	Automatic Voltage Control
CCP	Connection Control Panel
CIM	Common Information Model
CSS	Cascading Style Sheet
CT	Current Transformer
DMS	Distribution Management System
DNO	Distribution Network Operator
DSO	Distribution System Operator
DSO Support Systems	Systems that support the DSO function of WPD, such as ANM and SVO systems
DQA	Data Quality Assessment
ESO	Electricity System Operator
FEP	Front End Processor
HV	High Voltage
ICCP	Inter-Control Centre Communications Protocol
INM	Integrated Network Model
IR	Information Resources
JS	JavaScript
kV	Kilovolt
LIFO	Last In First Out
LV	Low Voltage
MVA	Mega Volt Amps
MVAr	Mega Volt Amps (reactive)
MW	Megawatts
NEAT	Network Event and Alarm Transparency
NMS	Network Management System
OLTC	On Load Tap Changer
OMS	Outage Management System
OTS	Operator Training Simulator
PMAR	Pole mounted auto-reclose circuit breakers
PoF, PoA	GE PowerOn Fusion, PowerOn Advantage
RTU	Remote Terminal Unit
SCADA	Supervisory Control and Data Acquisition
SGS	Smarter Grid Solution
SVO	System Voltage Optimisation
TSDS	Time Series Data Store

VT	Voltage Transformer

References

[1] Harmonic Analytics Ltd., “Network Event and Alarm Transparency (NEAT) Specification of Solution Requirements,” 2021.

[2] Harmonic Analytics Ltd., “Network Event and Alarm Transparency (NEAT) Data Quality Assessment Summary,” 2021.

[3] J. Woodruff, “20210322 - Revised Data Redaction for new format PowerOn alarms data,” 2021.

WPD INNOVATION

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Western Power Distribution (East Midlands) plc, No2366923

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Western Power Distribution (South West) plc, No2366894

Western Power Distribution (South Wales) plc, No2366985

Registered in England and Wales

Registered Office: Avonbank, Feeder Road, Bristol BS2 0TB

wpdinnovation@westernpower.co.uk

www.westernpower.co.uk/innovation

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