CReDo+ AND DAFNI

Slides by Stephane Fernandez-Garcia (CPC) and Jens Jensen (DAFNI)

27 March 2024

DRAMATIS PERSONAE

Who is behind CReDo? (today)

Connected Places Catapult – project lead	Anglian Water – asset owner
CMCL Innovations – software, models	BT – asset owner
STFC Hartree – data science, models	UK Power Networks – asset owner
STFC DAFNI – trusted infrastructure, software	DNV - assurance and risk

1. CReDo+ OVERVIEW AND BENEFITS

INFRASTRUCTURE INTERDEPENDENCIES

DAFNI
Data & Analytics Facility for National Infrastructure

CReDo IS A CLIMATE CHANGE ADAPTATION DIGITAL TWIN

DAFNI
Data & Analytics Facility for National Infrastructure

Bringing together data across energy, water, and telecoms networks

- Anglian Water: water and sewerage assets,
- BT and Openreach: communication assets,
- UK Power Networks: electricity distribution assets.

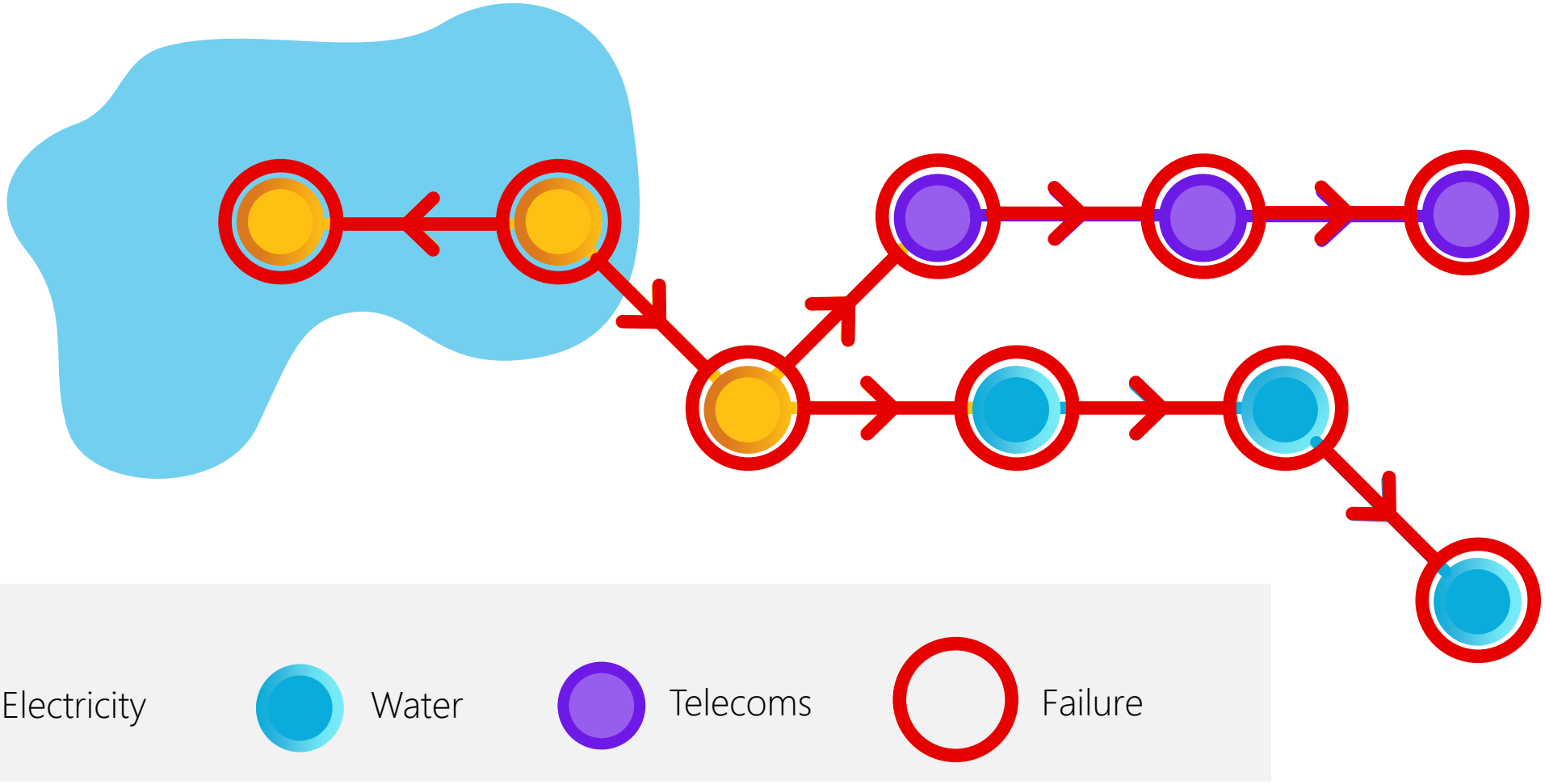
With weather and infrastructure data

- Infrastructure interdependencies
- Asset failure and system impact
- What can we do to prepare or respond?

HOW DO WE INCREASE SYSTEM RESILIENCE AND ADAPT?

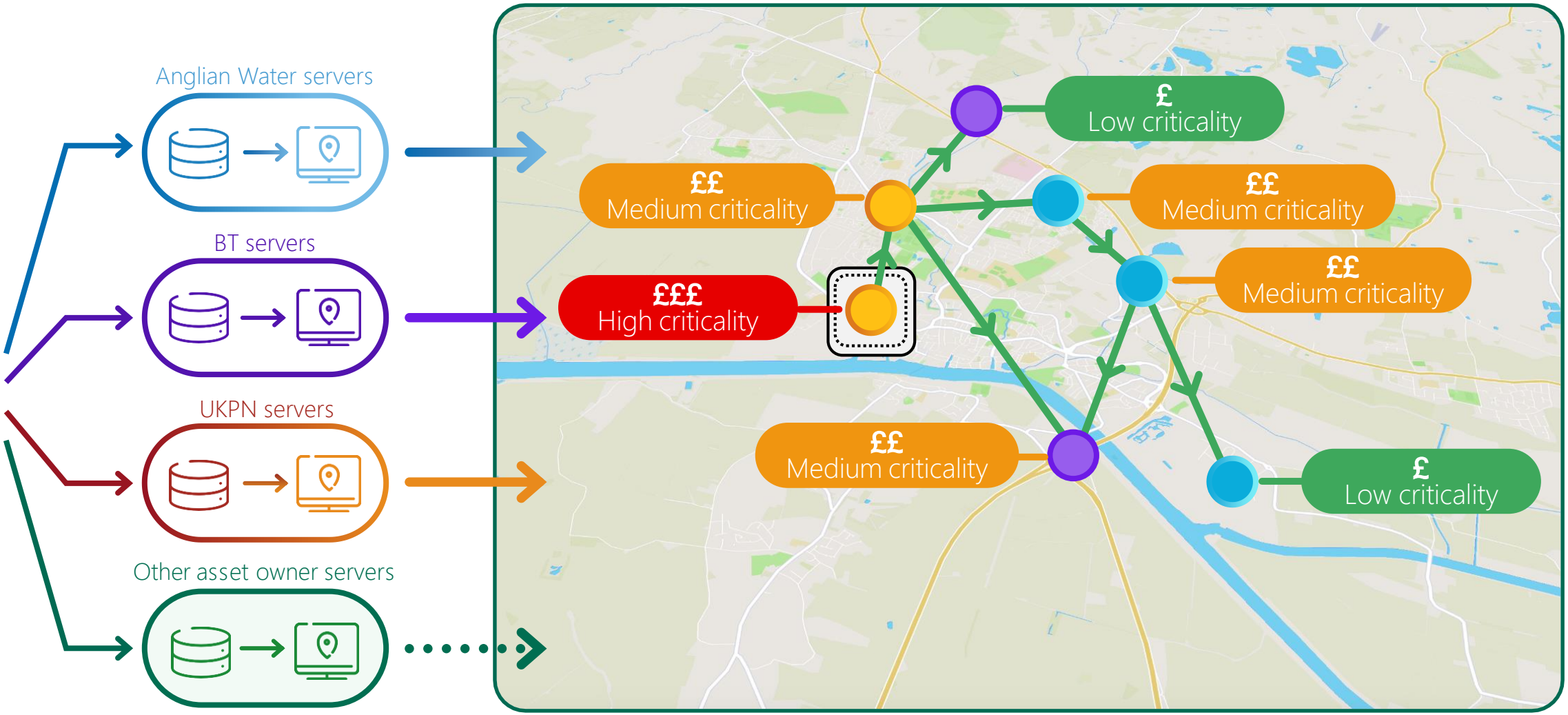
A CONNECTED UNDERSTANDING TO CASCADING RISK

DAFNI
Data & Analytics Facility for National Infrastructure



...FOR COORDINATED RESILIENCE PLANNING

DAFNI
Data & Analytics Facility for National Infrastructure



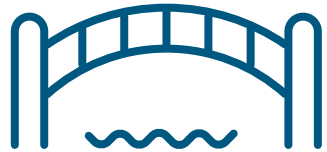
CReDo MISSION & USP

DAFNI
Data & Analytics Facility for National Infrastructure

Climate Resilience Demonstrator → Climate Resilience Decision Optimiser

MISSION

Enable coordinated decision making and efficient investment by understanding interdependencies and cascading risk across critical national infrastructure, so that together we can increase resilience to extreme weather and adapt to climate change.

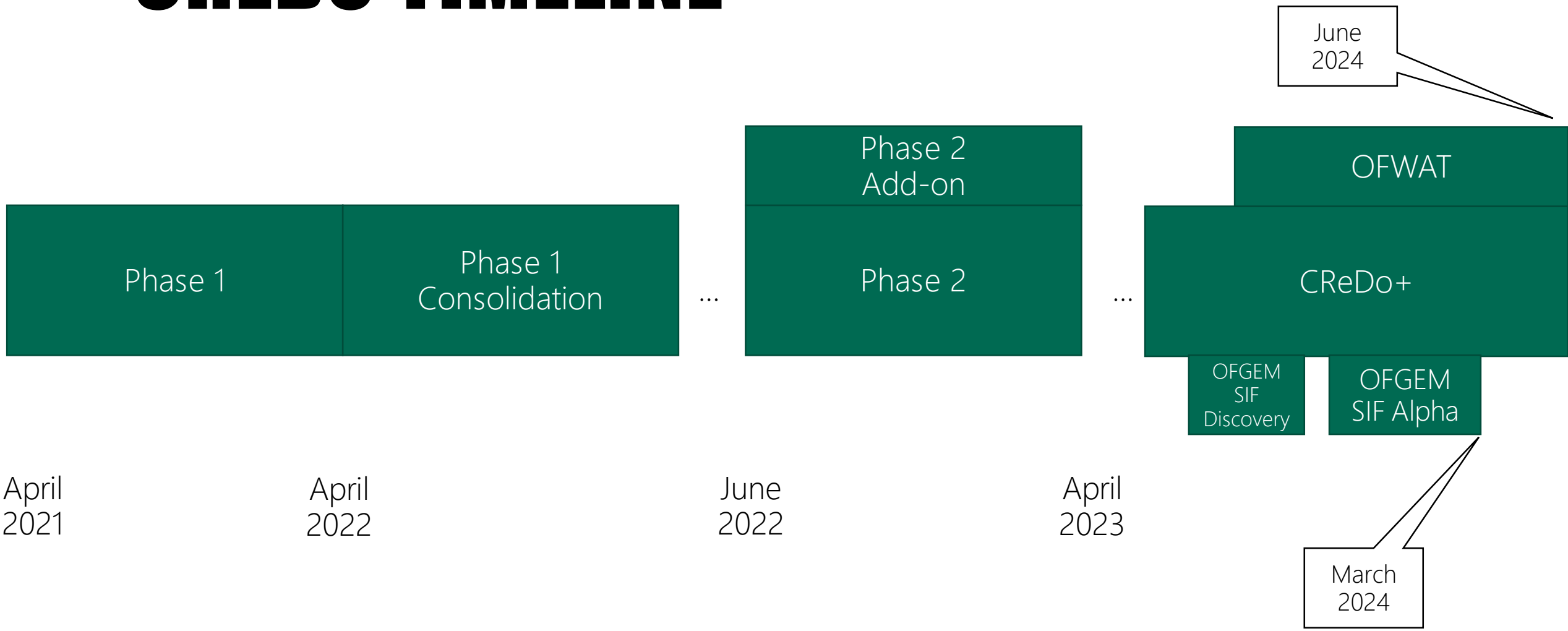


USP

CReDo connects data across siloed organisational boundaries, enabling a whole system approach to modelling infrastructure interdependencies. This allows users to see who they are dependent on and cascading climate risk from extreme weather, supporting better decision making and reporting.

CREDO TIMELINE

data sharing agreement
extended to March 2025



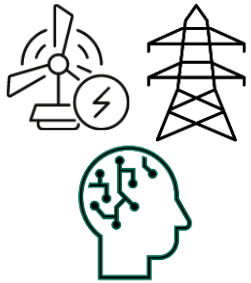
CReDo+ ALPHA PHASE

DAFNI
a & Analytics Facility
National Infrastructure

Prototype a scalable pipeline for cascading risk modelling, test for extreme heat, and integrate with CReDo

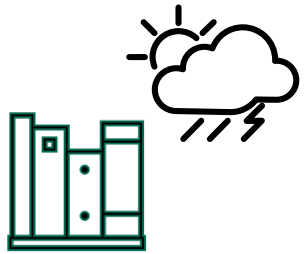
User friendly Digital Elicitation Tool

Create a working prototype to test scalable approach to risk modelling



Bayesian asset risk models

Run elicitations with UKPN subject matter experts and engineers to encode tacit knowledge into Bayesian risk models



Library of models for all weather

Link asset data to create the library of Bayesian risk models for extreme heat

CReDo

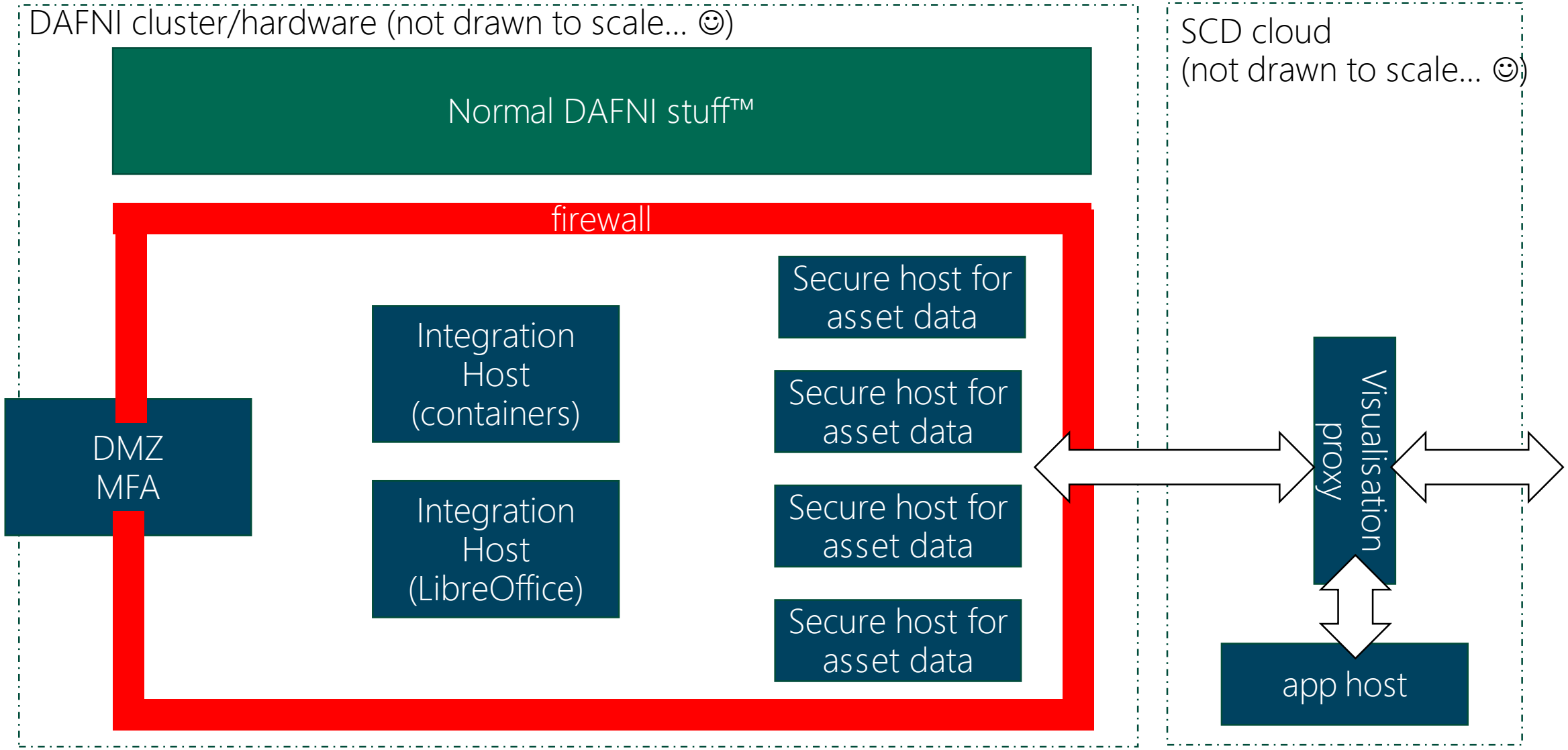
Digital twins and other technologies

Integrate into CReDo stack with new visualisation, and connect asset risk models to understand future heat failure cascades

2. CREDO ON DAFNI

In DAFNI? Near DAFNI?

DAFNI SERVICES – CREDO+



UX

DAFNI
Data & Analytics Facility for National Infrastructure

Supporting different kinds of users

DAFNI user	Technical skill	Main tool	Support	Todo
Build models	☠	Docker	training	Builder
Workflows	☺	DAFNI	⚑	Debugging
Explore visualisations	😎	Jupyter, data explorer	⚑	
Find data	⚑	NID		Non-NID

CReDo user	Technical skill	Main tool	Support	Todo
Build models	☠☠	podman		
Workflows	N/A	N/A	N/A	??
Explore visualisations	😎	custom	CReDo	
Explore data	☹	libreoffice calc, VS code		More data, more formats

CREDO ON DAFNI

DAFNI
Data & Analytics Facility for National Infrastructure

Some parts of CReDo are on Normal-DAFNI

- Flood modelling based on HiPIMS
- CReDo group on Normal-DAFNI has synthetic infrastructure data
  - Designed to mimic interesting features in real data
  - Utility models, eg uncompressing data
  - Visualisation built with support from Rose

3. ASSET MODELLING

ELECTRICITY DISTRIBUTION

FAILURE MODELS FOR ELECTRICITY NETWORKS

CReDo – Expert elicitation

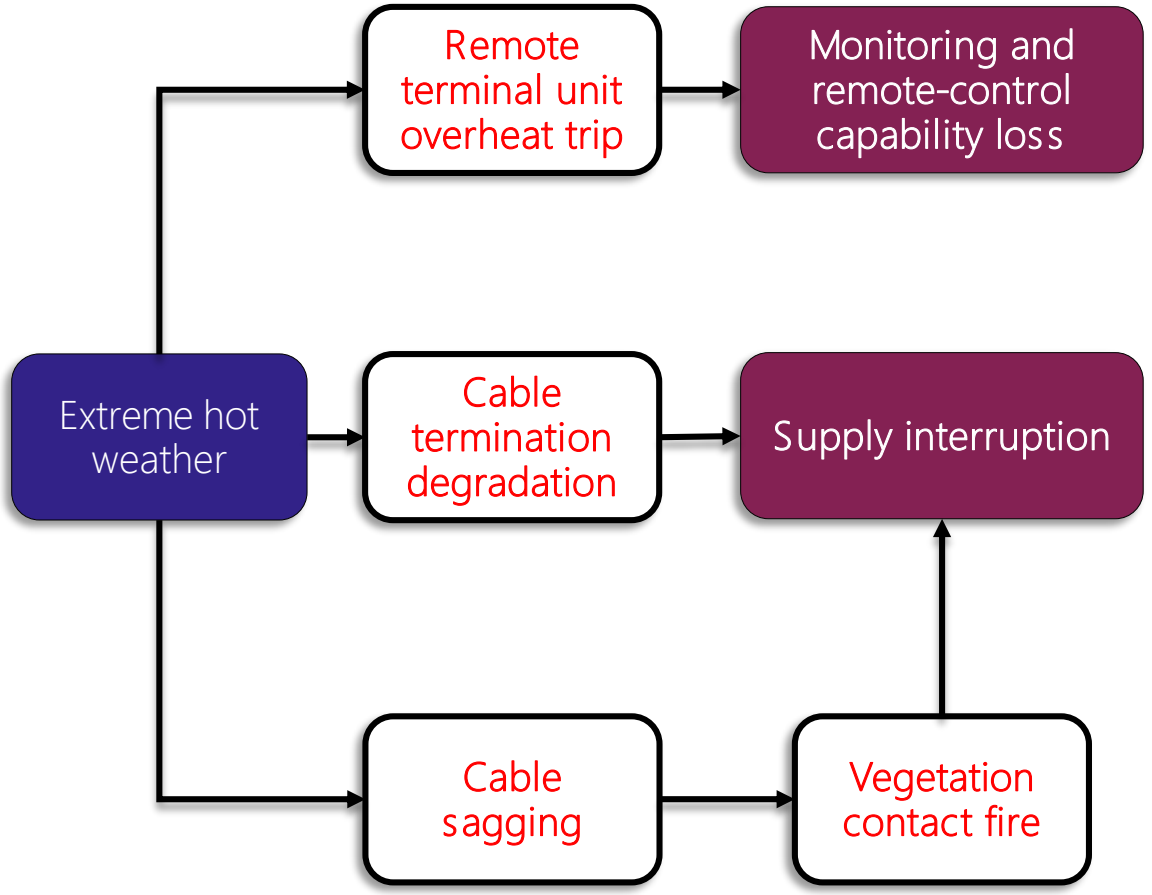
DAFNI
Data & Analytics Facility for National Infrastructure

A method to formalise and document tacit knowledge from your expert staff into readily usable mathematical

How does it work?

In-person structural elicitation sessions → Model structures

Captures key variables describing the behaviour of **vulnerable** assets and the **chain of events leading to impacts**, such as supply interruptions.



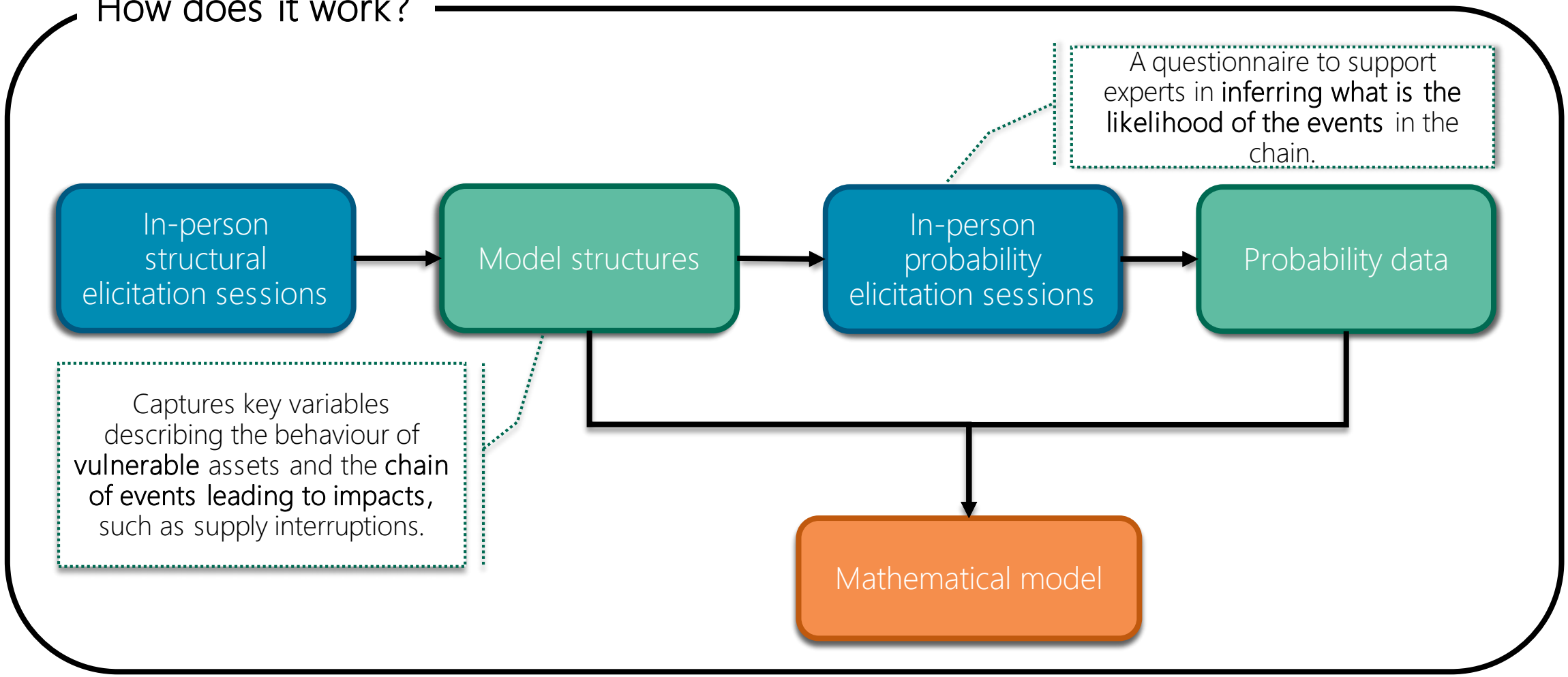
Example model structure

CReDo – Expert elicitation

DAFNI
Data & Analytics Facility for National Infrastructure

A method to formalise and document tacit knowledge from your expert staff into readily usable mathematical models

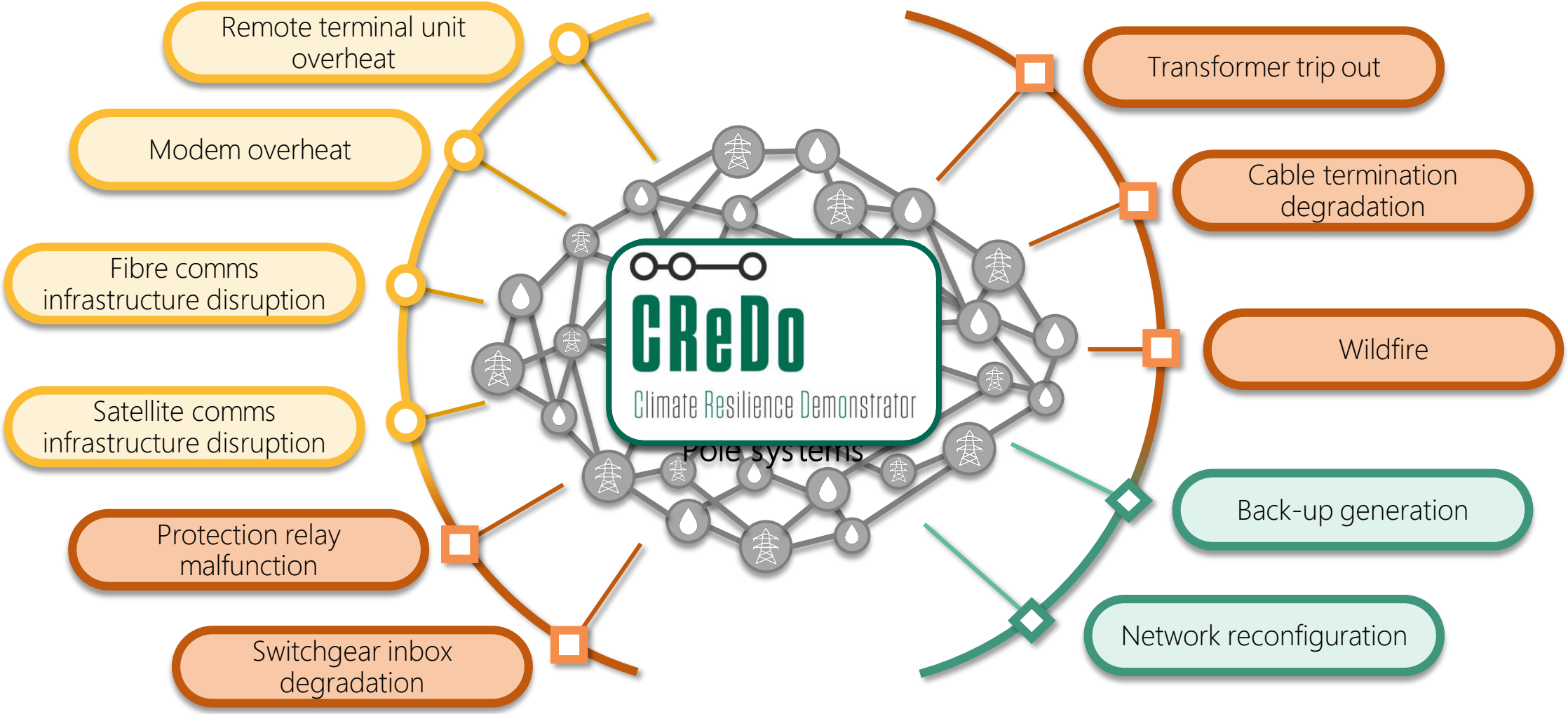
How does it work?



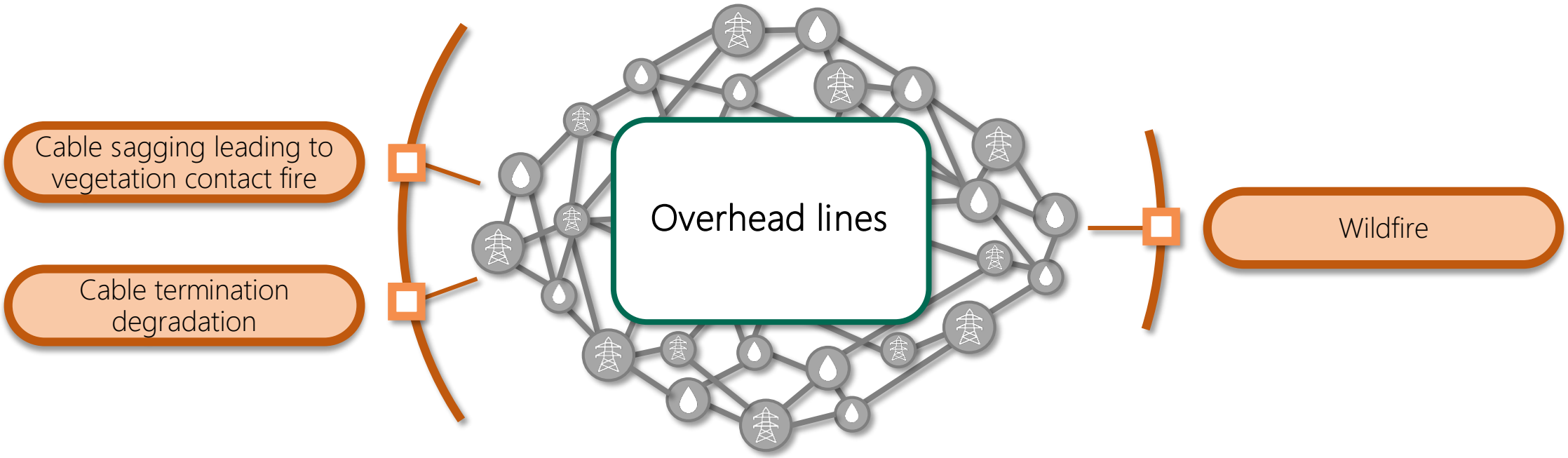
ASSET MODELLING

A SUMMARY OF ELICITATION OUTPUTS

OUTPUTS OF ELICITATION VULNERABILITIES & MITIGATIONS



OUTPUTS OF ELICITATION VULNERABILITIES & MITIGATION (2)



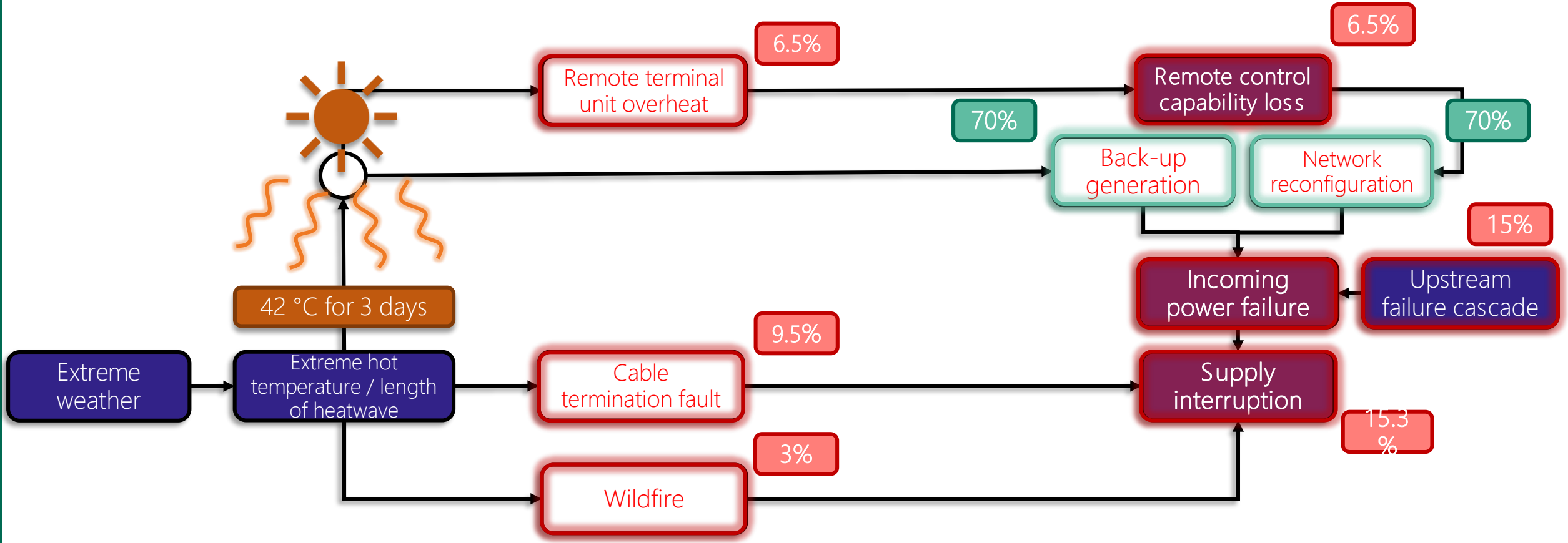
Supply interruption faults

ASSET MODELLING

OBTAINING OUTPUTS WITH THE NEW MODELS

RUNNING MODELS FOR EACH SITE TO EVALUATE RISK

DAFNI
Data & Analytics Facility for National Infrastructure



What is the chance that each individual event takes place?

What is the likelihood of a supply interruption?

What is the probability of losing telecom services?

What is the chance of being impacted by other sites?

Now, it is possible to run the models to understand what could happen.

ASSET MODELLING

EXPERT ELICITATION - ADVANTAGES AND CHALLENGES

ADVANTAGES AND CHALLENGES IN EXPERT ELICITATION

DAFNI
Data & Analytics Facility for National Infrastructure

Advantages

Flexible

It is possible to model many different types of events.

Little data

You do not need vast amounts of processed data, mainly expertise

Tailored complexity

You can make simple or very complex models, depending on what your objective is.

Challenges

In-person

Requires a mathematical expert leading the process and lengthy interviews to obtain the information.

Mathematical nuance

The process seems simple, but there is a lot of mathematical detail to consider to ensure robustness.

Generalisation

The interviews need to be specific, so how do you generalise the results of one site to many?

4. DIGITAL ELICITATION TOOL

DIGITAL ELICITATION TOOL

DAFNI
Data & Analytics Facility for National Infrastructure

Building an elicitation tool prototype

The goal is to extract information from people's heads…

- Structural elicitation – which factors can cause failure or degradation
- Probabilistic elicitation – how likely is each factor to affect the asset

The importance of sharing failure models

- Several people contribute
- Continuing work on models to build more sophisticated models

Deploy failure models into the CReDo Digital Twin

- Real assets, real scenarios, simulated failures

Digital Elicitation Tool: Challenges

DAFNI
Data & Analytics Facility for National Infrastructure

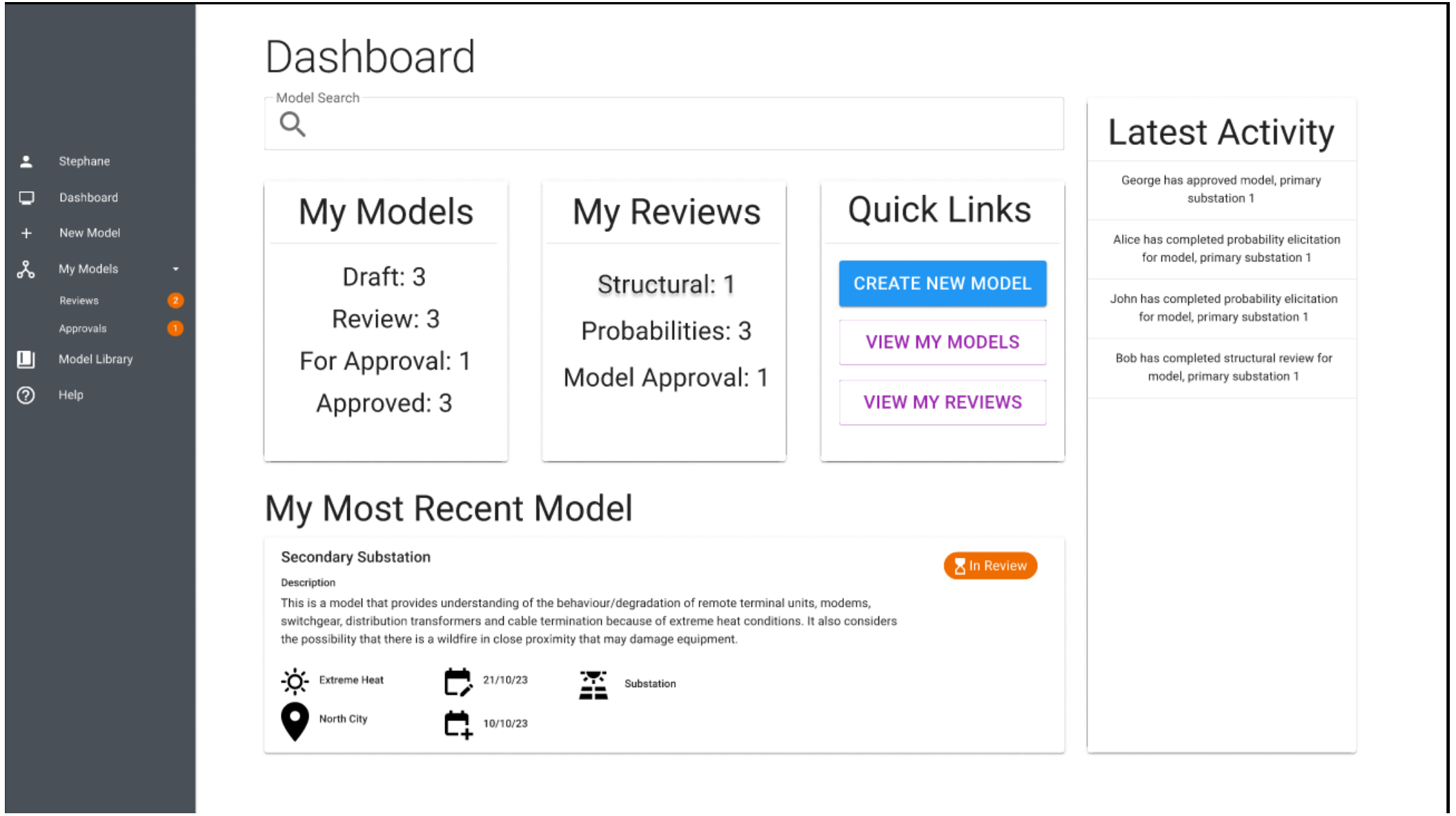
What are the challenges we are aiming to solve through the to

1. Scalability
   - Lots of substations – all similar to each other, yet all are different from each other
   - Deployment of models into real world scenarios

2. The need for contributions from different experts for a single failure model
   - Capturing asset-specific structural and probabilistic failures
   - Underlying mathematical models (e.g Bayesian models, probability distributions)
   - Continuous improvement of models by adding details
   - QA and correctness of models

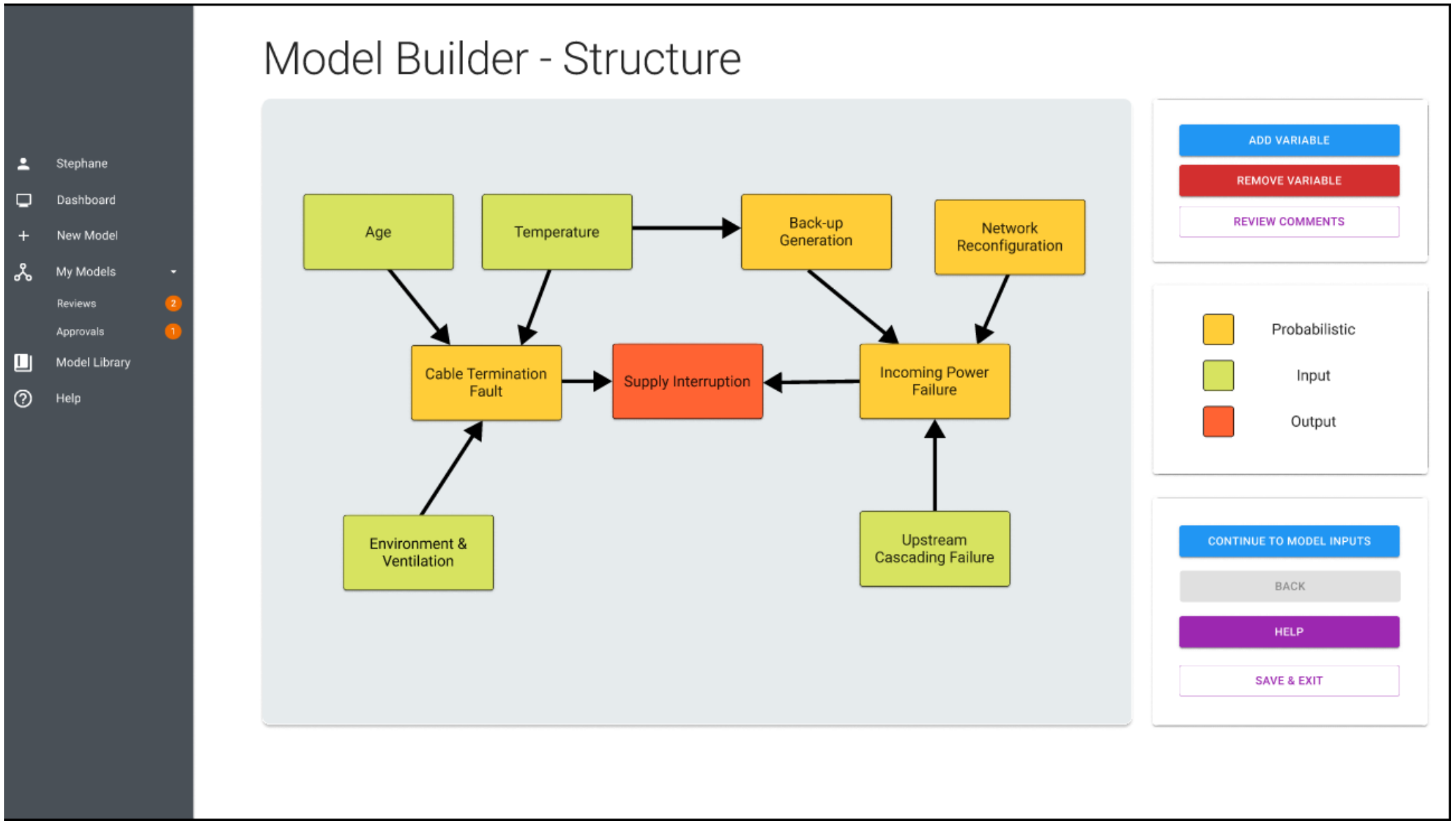
MODELS LIBRARY

DAFNI
Data & Analytics Facility for National Infrastructure



STRUCTURAL ELICITATION

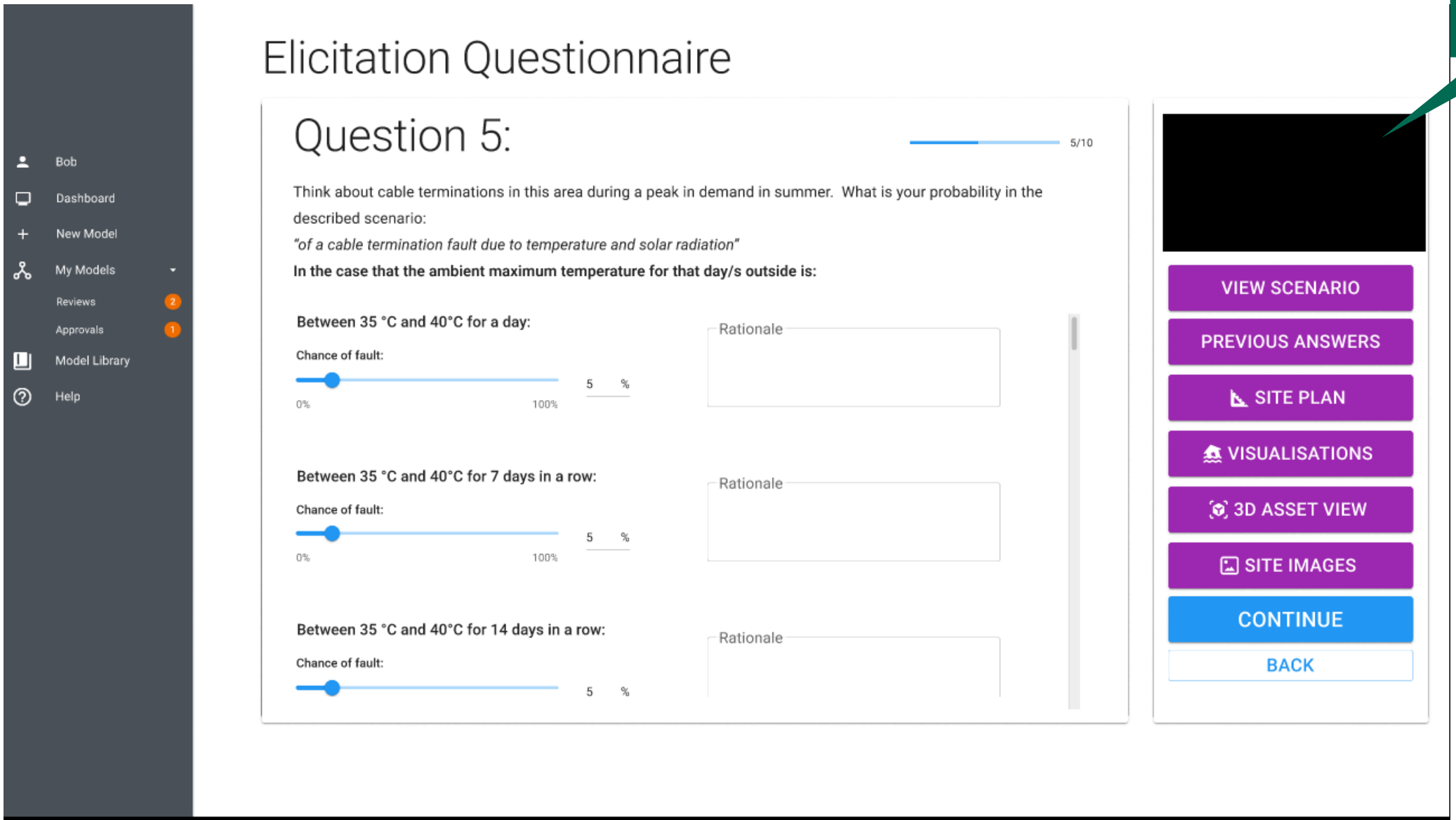
DAFNI
Data & Analytics Facility for National Infrastructure



PROBABILISTIC ELICITATION

DAFNI
Data & Analytics Facility for National Infrastructure

map is here



CReDo+
DIGITAL ELICITATION TOOL

DAFNI
Data & Analytics Facility for National Infrastructure

What next for the elicitation tool?

Using DET in BSRW...

1. Take out power network specific things; adapt embedding of failure model into non-CReDo DT

2. Can we combine with e.g. USARIS failure models?

3. Make available to all DAFNI users and feed back into CReDo

$. Demonstrate at the September conference

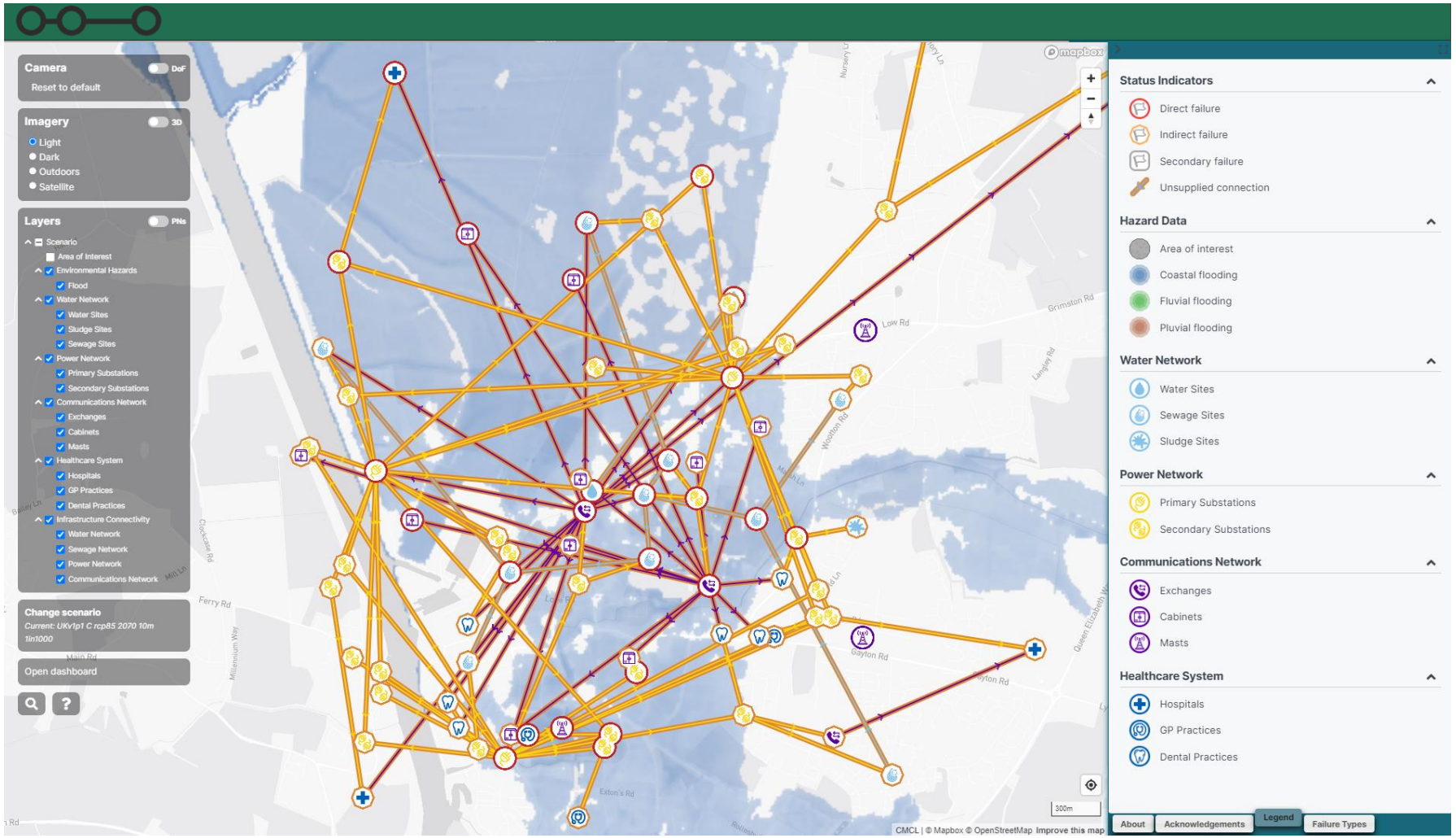
5. DIGITAL TWINNING

CREDO PLATFORM

DAFNI
Data & Analytics Facility for National Infrastructure

Integration of asset and weather event data for different climate scenari

Effect of flooding on combined energy, water and telecoms network

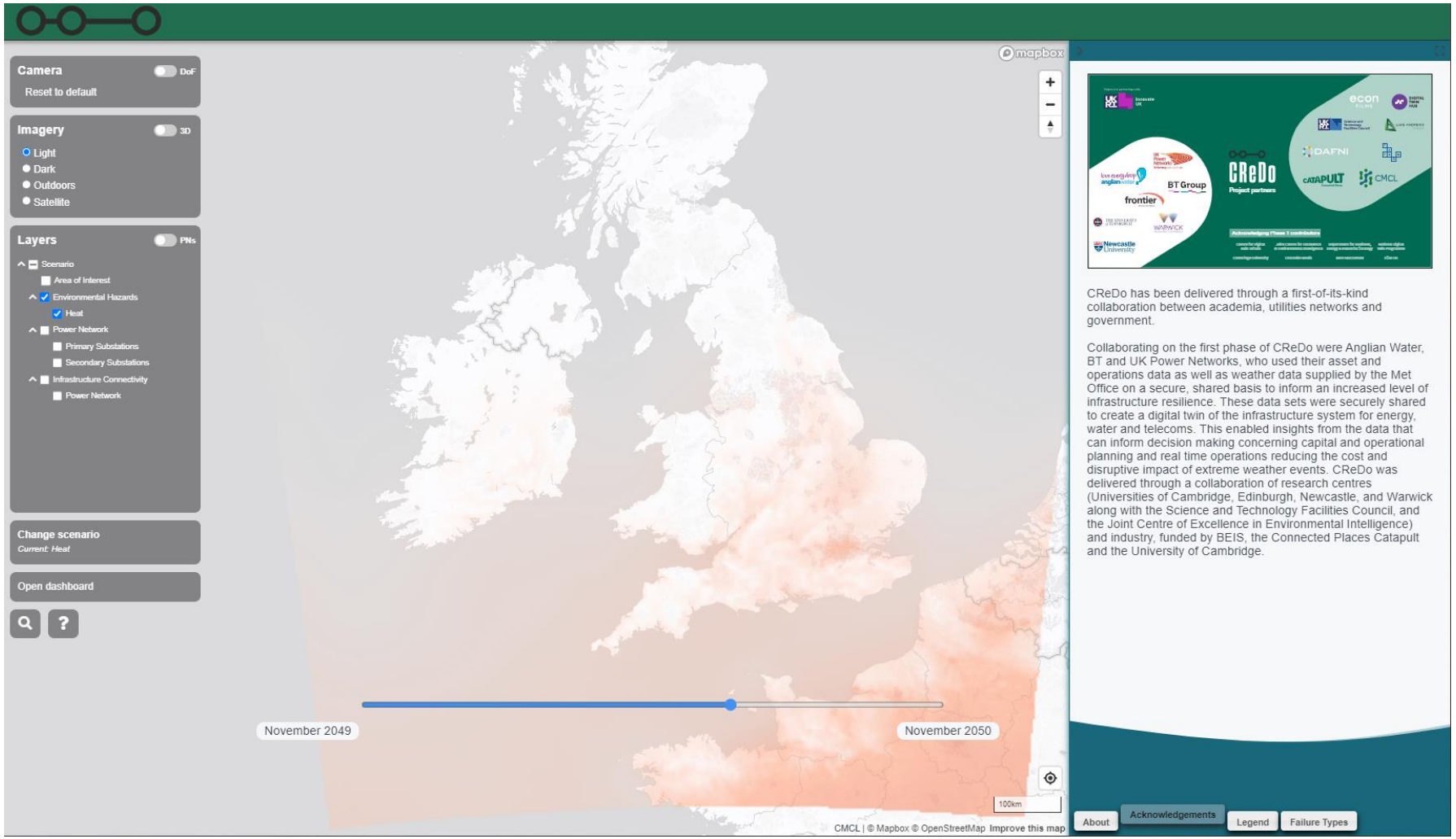


CREDO PLATFORM

DAFNI
Data & Analytics Facility for National Infrastructure

Integration of asset and weather event data for different climate scenari

Extreme heat weather events

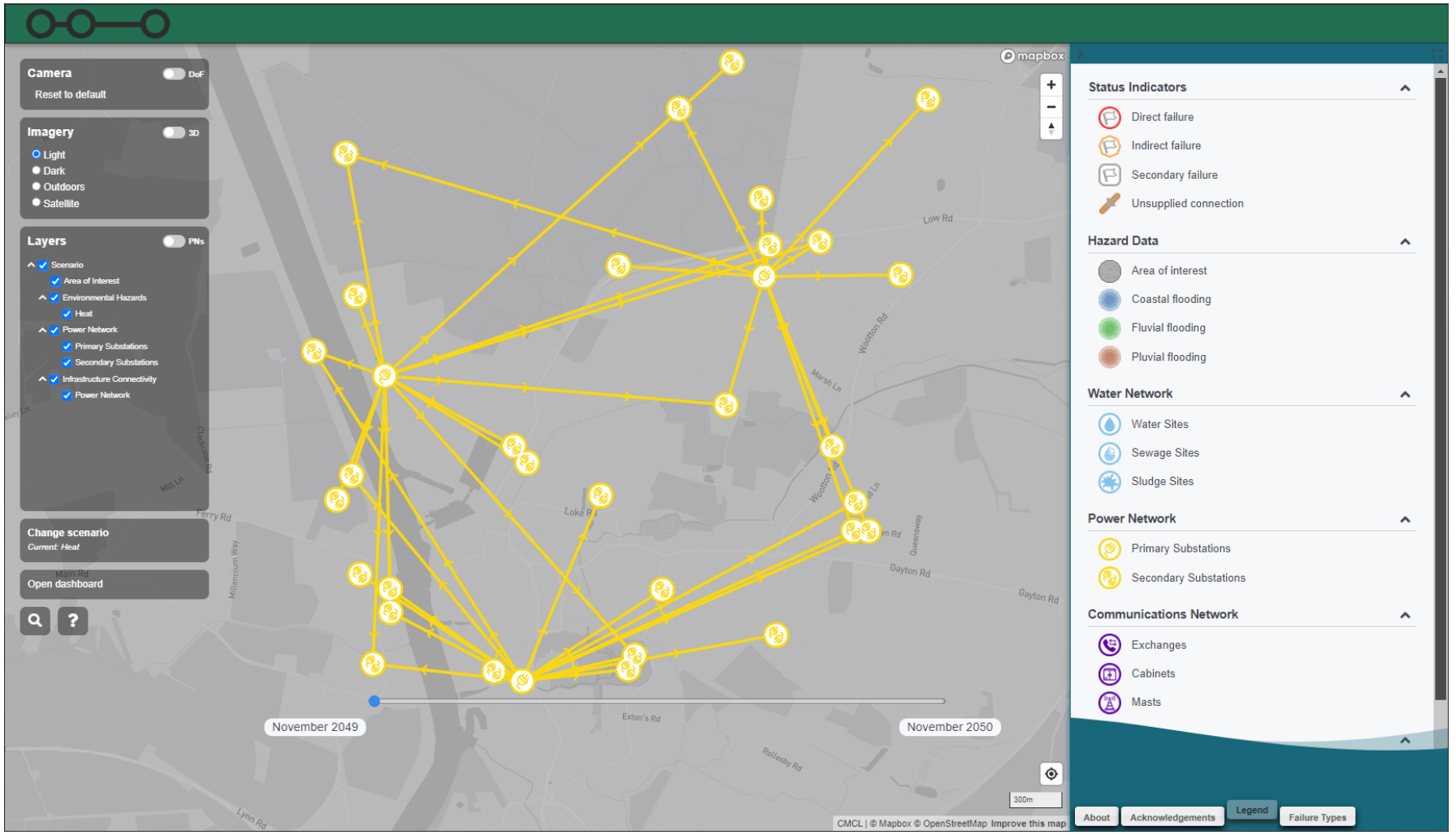


CREDO PLATFORM

DAFNI
Data & Analytics Facility for National Infrastructure

Integration of asset and weather event data for different climate scenari

Asset networks

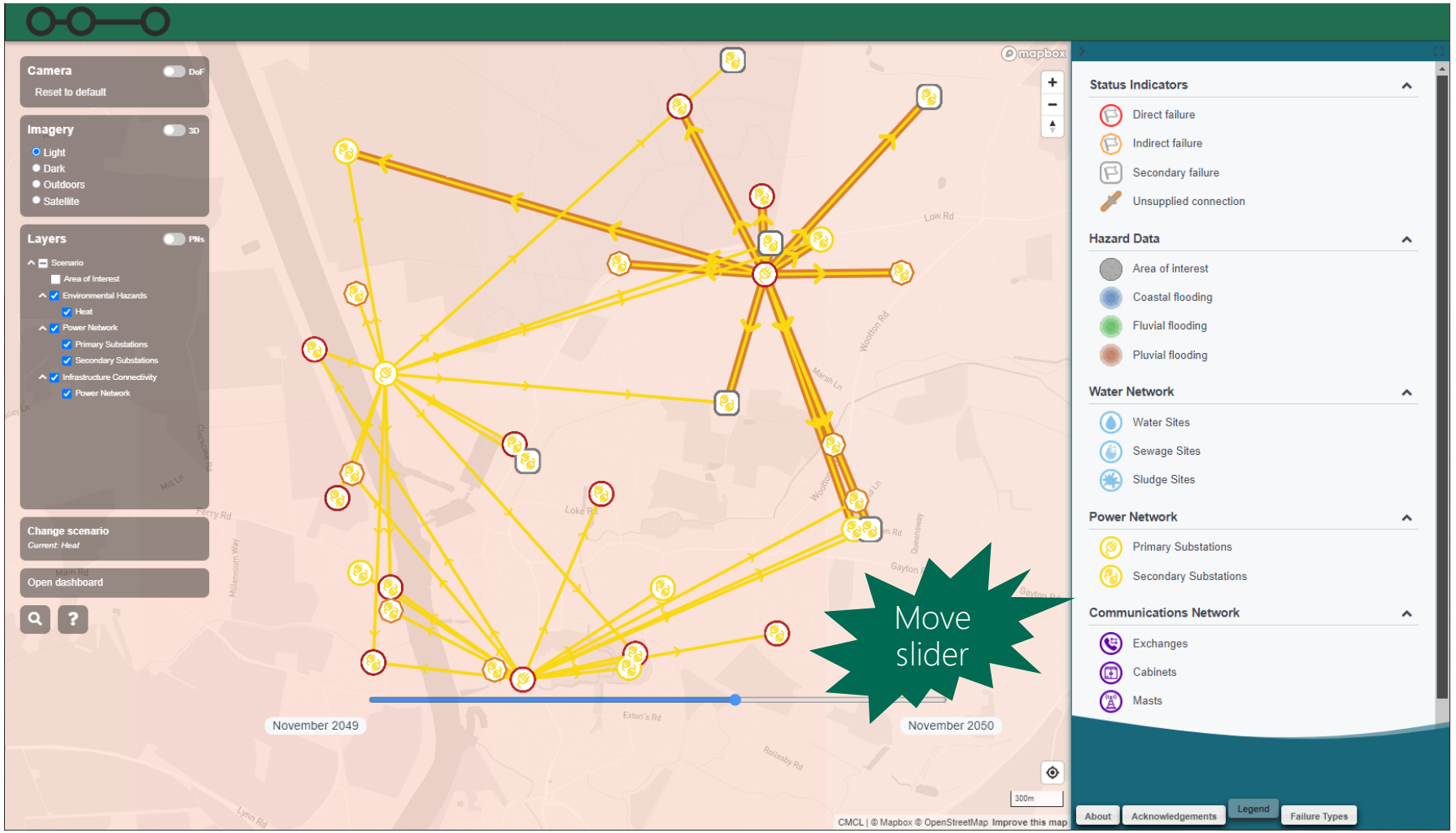


CREDO PLATFORM

DAFNI
Data & Analytics Facility for National Infrastructure

Integration of asset and weather event data for different climate scenari

Failure model connected to each asset

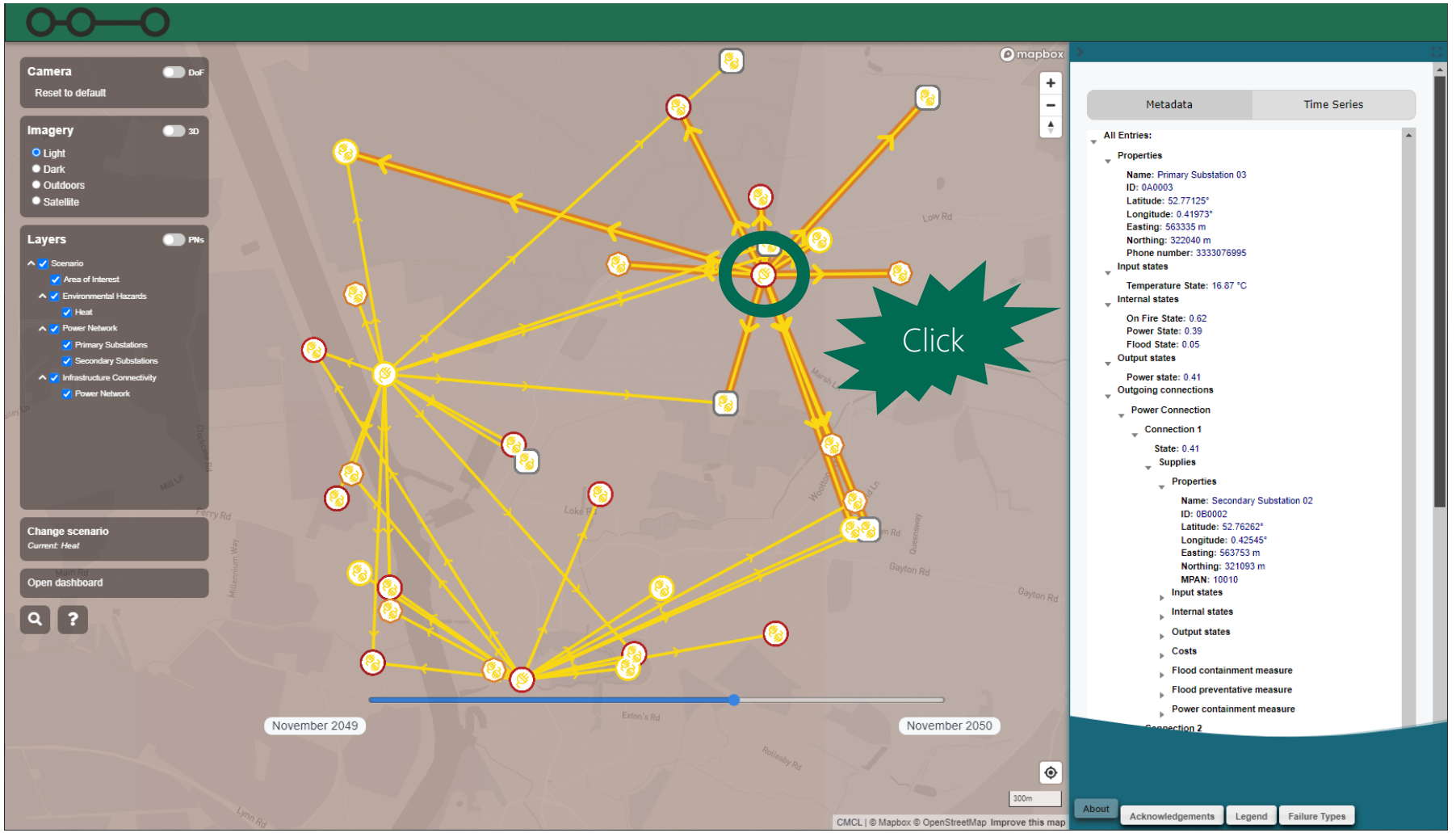


CREDO PLATFORM

DAFNI
Data & Analytics Facility for National Infrastructure

Integration of asset and weather event data for different climate scenari

Asset data



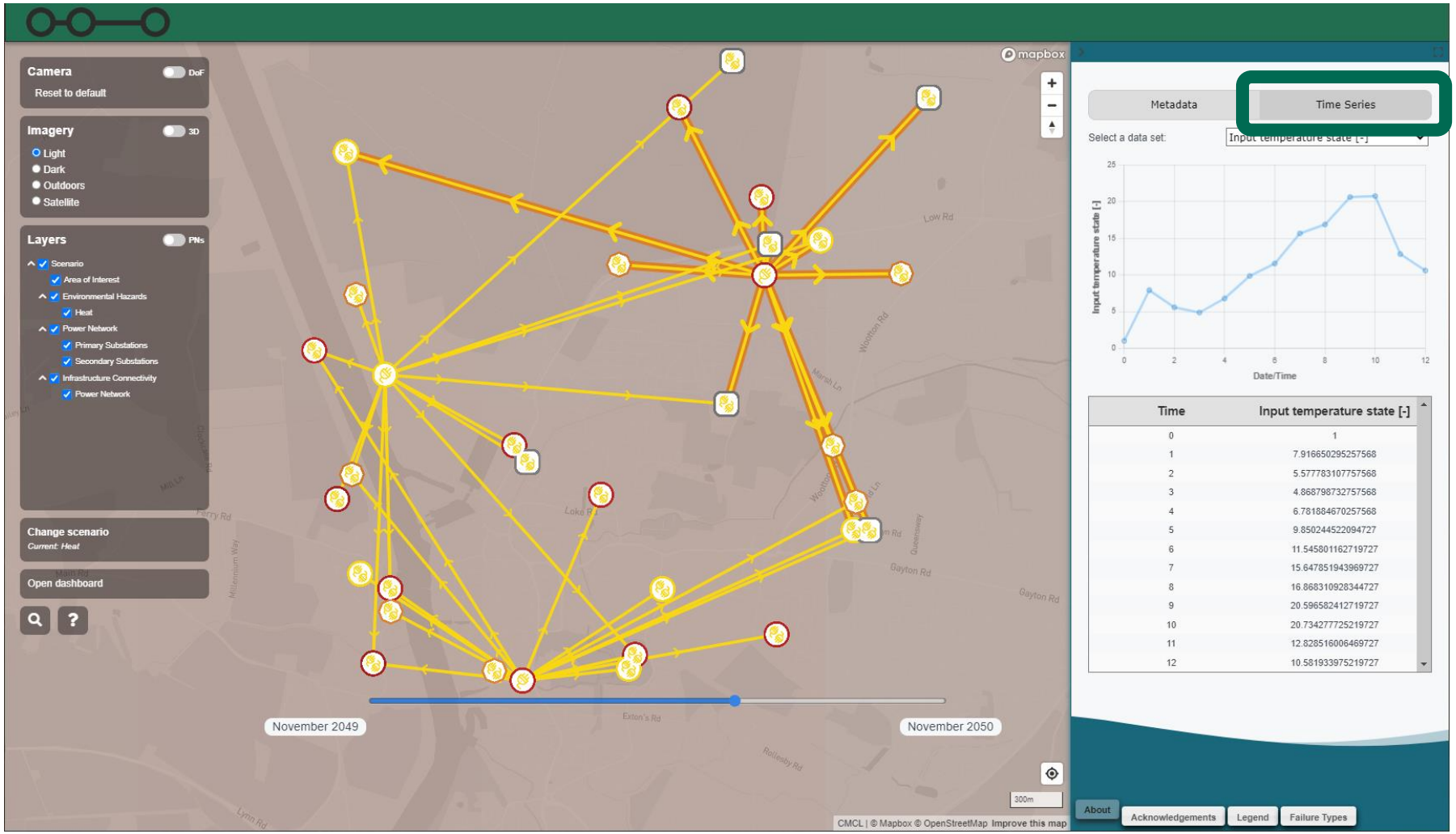
CREDO PLATFORM

DAFNI
Data & Analytics Facility for National Infrastructure

Integration of asset and weather event data for different climate scenari

Click

Time history

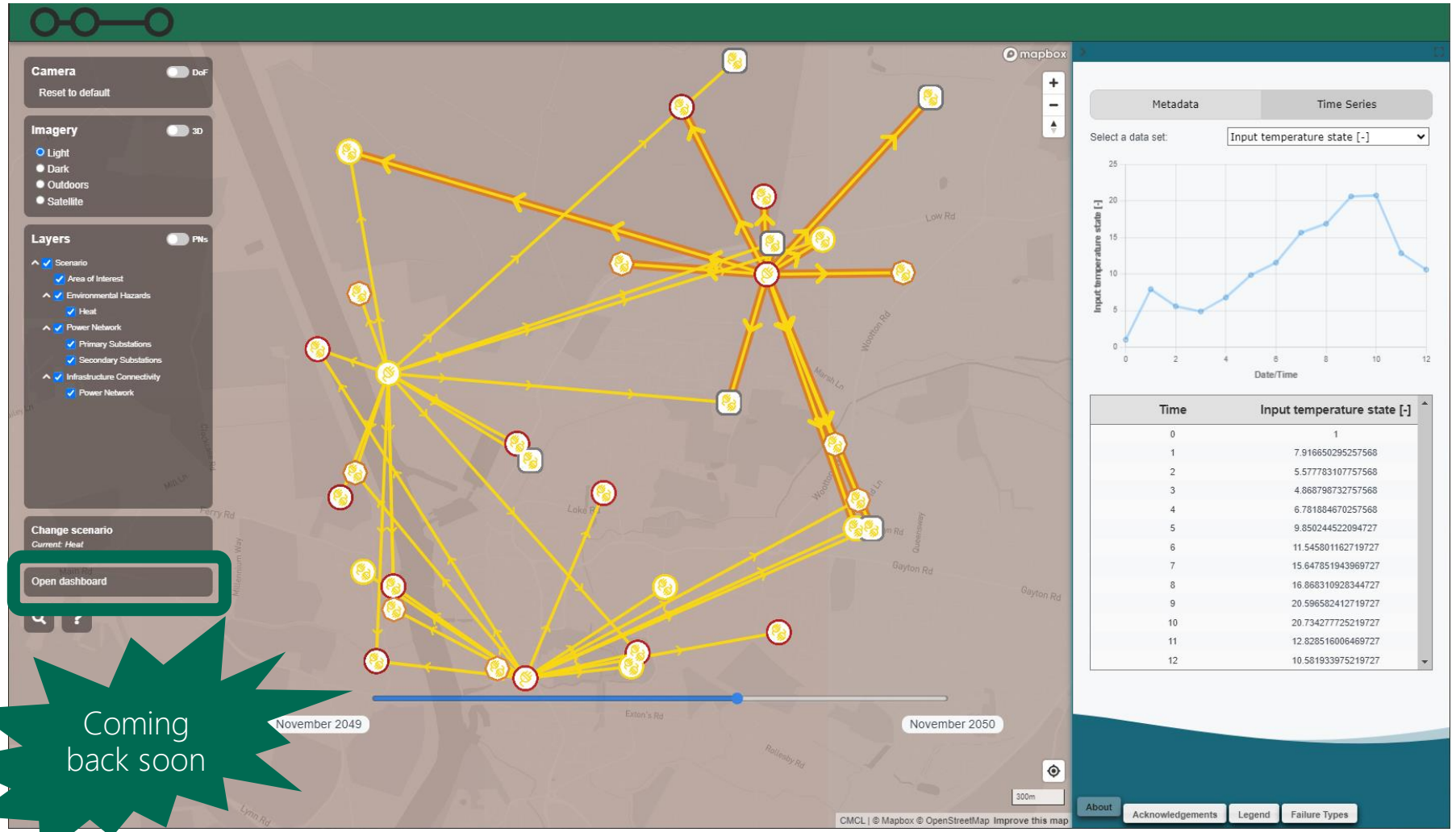


CREDO PLATFORM

DAFNI
Data & Analytics Facility for National Infrastructure

Integration of asset and weather event data for different climate scenari

Summary information across scenarios

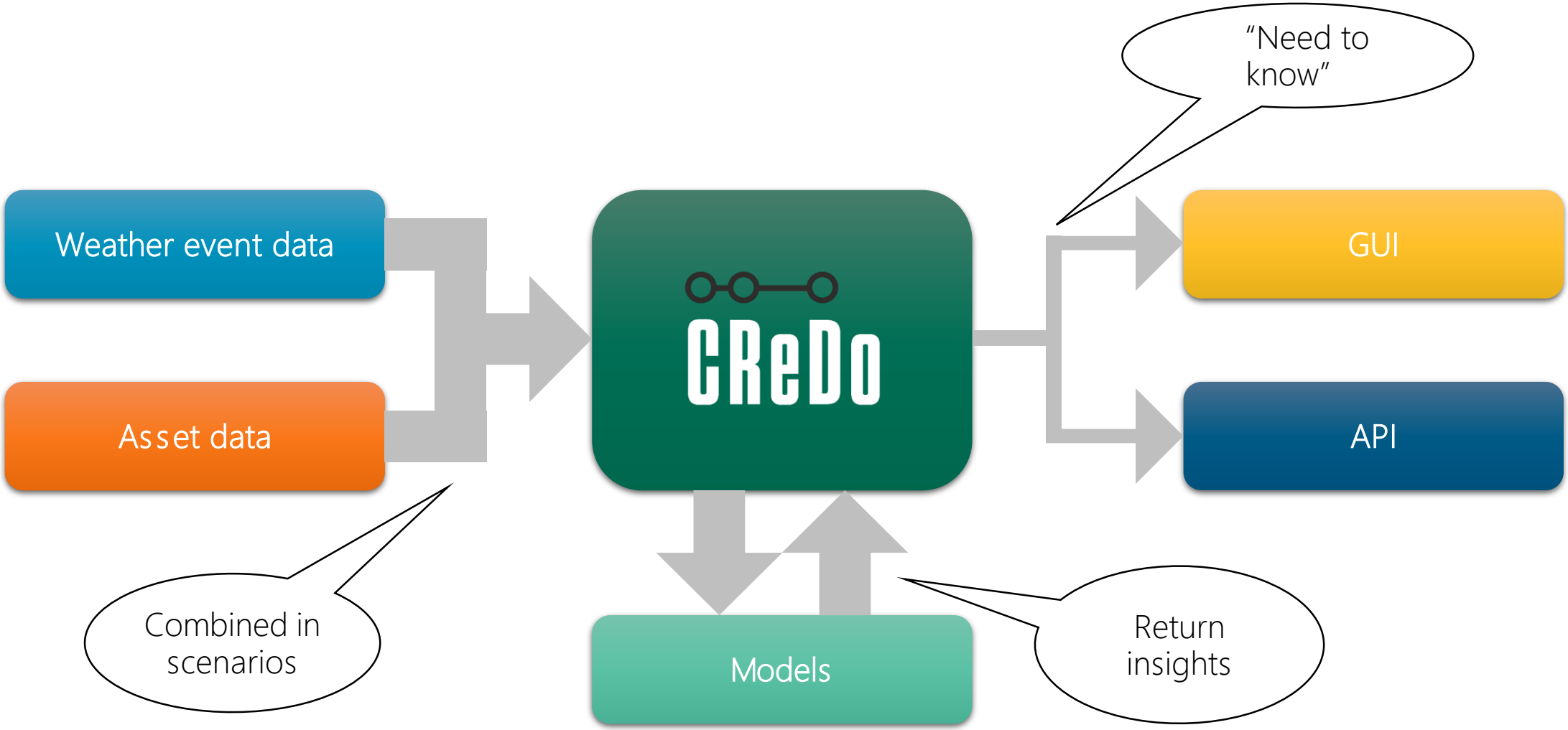


Coming back soon

CREDO DATA FLOW

DAFNI
Data & Analytics Facility for National Infrastructure

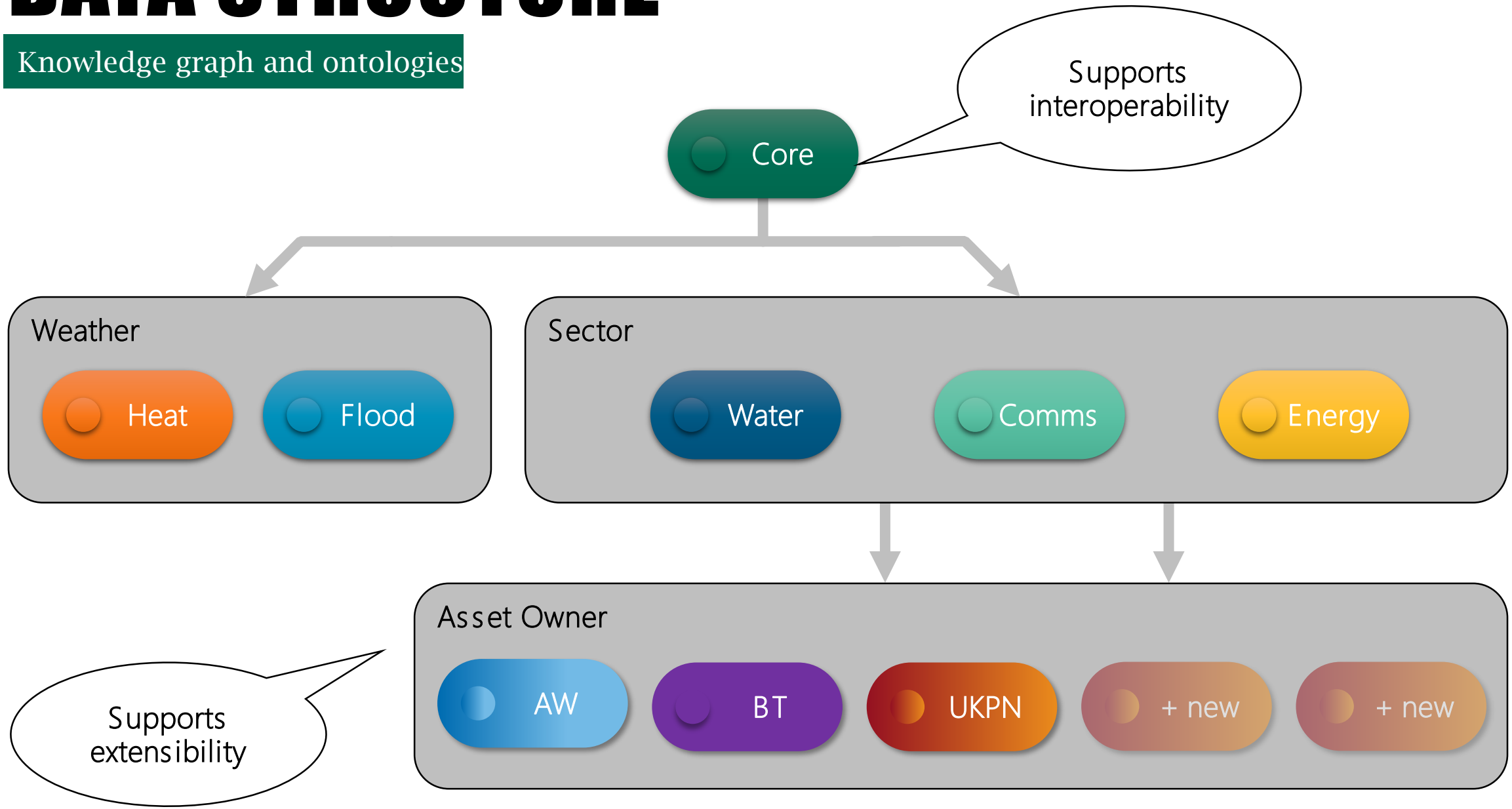
Integration of asset and weather event data for different climate scenari



DATA STRUCTURE

Knowledge graph and ontologies

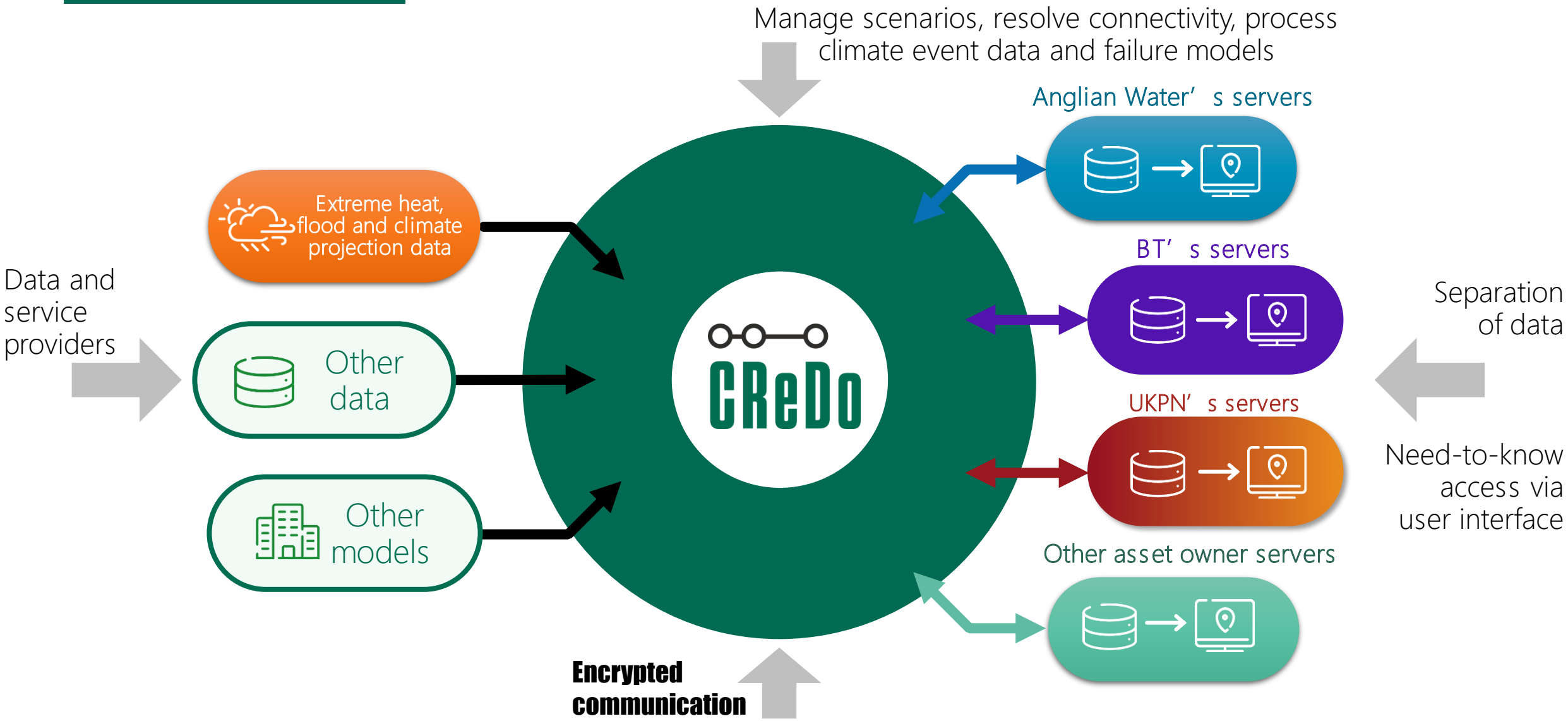
DAFNI
Data & Analytics Facility for National Infrastructure



DATA SHARING INFRASTRUCTURE

DAFNI
Data & Analytics Facility for National Infrastructure

Distributed Architecture



6. FUTURE

CATAPULT
Connected Places

CREDO AND DAFNI

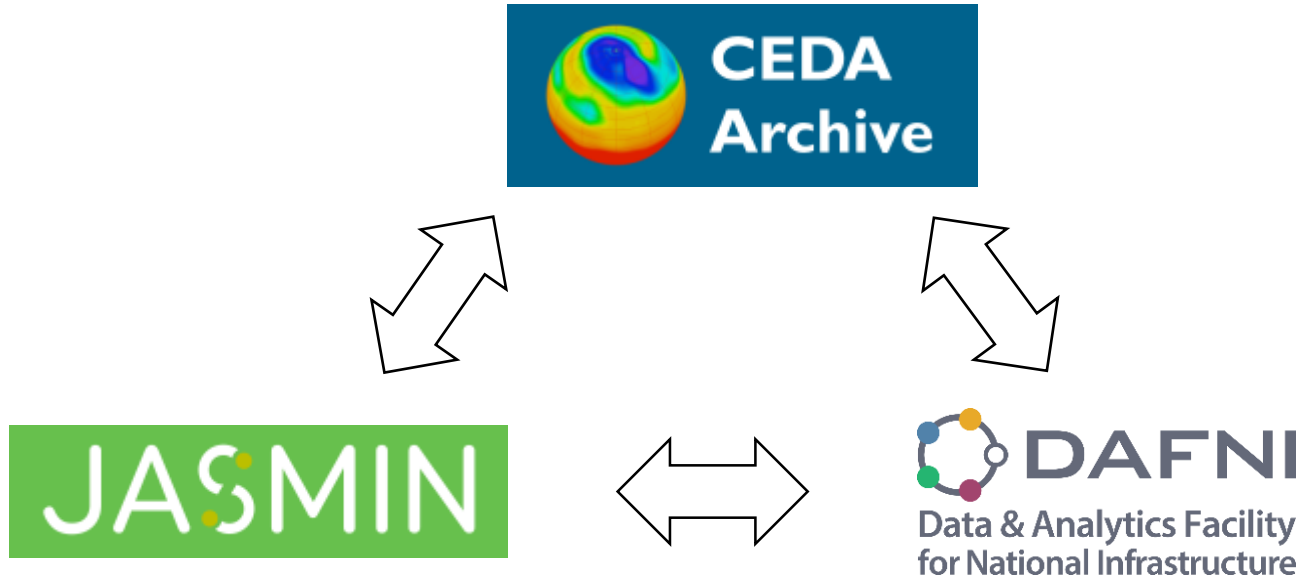
Ask not what you can do for CReDo

SUPPORTING CLIMATE PROJECTS

DAFNI
Data & Analytics Facility for National Infrastructure

DAFNI already has loads of NERC-funded stuff

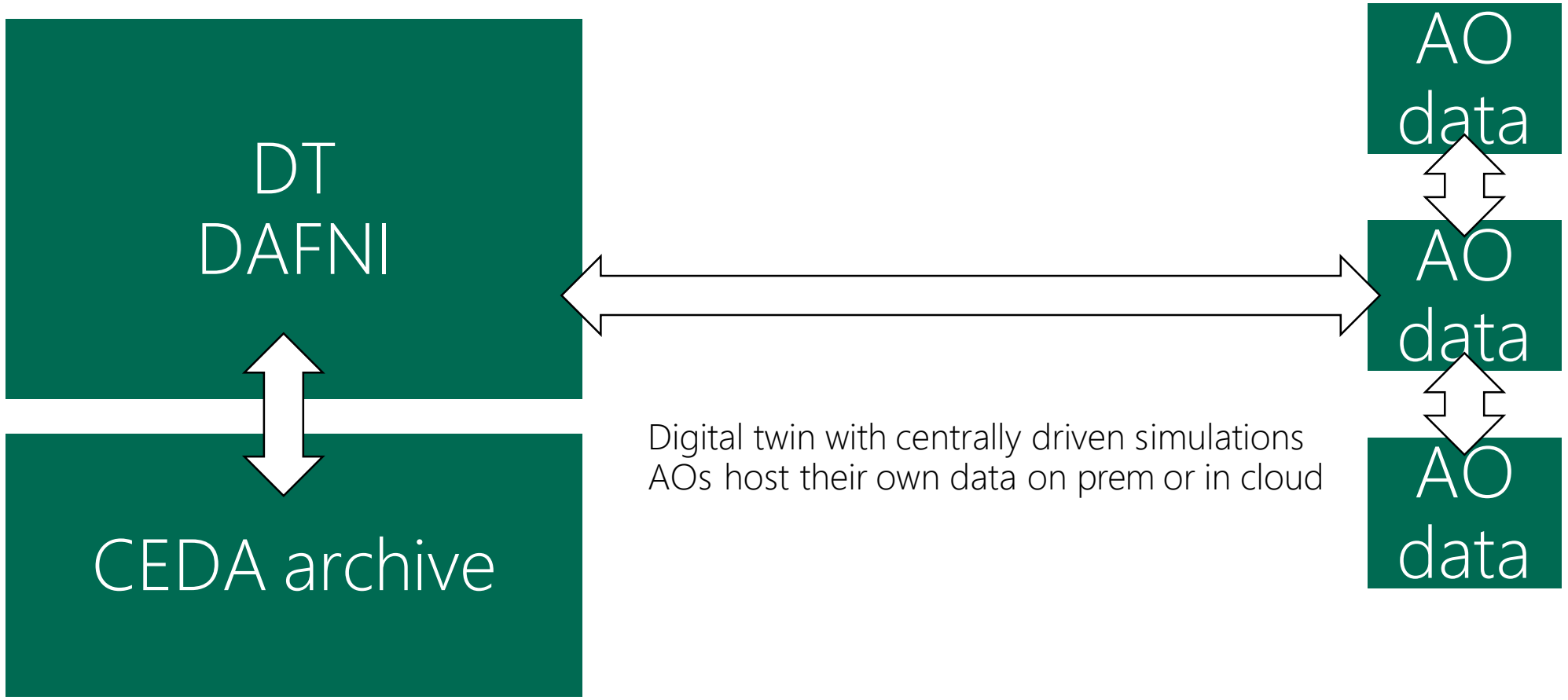
- Closer integration between JASMIN, DAFNI and the CEDA Archive
- OpenCLIM and CGFI are examples of NERC funded projects on DAFNI
- Like CReDo, DAFNI projects have flooded many locations, such as Newcastle ☺
- More climate resilience in BSRW



TOWARDS HYBRID INFRASTRUCTURE

DAFNI
Data & Analytics Facility for National Infrastructure

Asset owners running their own data hosts



HANDLING CONFIDENTIAL DATA

DAFNI
Data & Analytics Facility for National Infrastructure

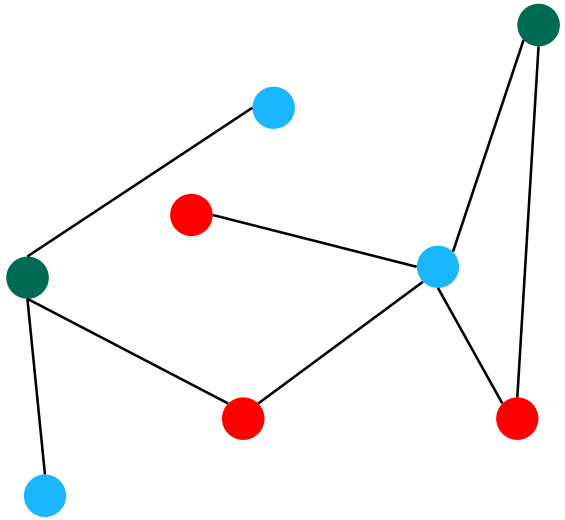
… towards a trusted research environment?

- JASMIN and DAFNI use cases for TRE
  - Though neither of us has healthcare data (nor do we want it thank you very much)
  - We have contacts with the DARE UK projects and the Manchester group(s)
- CReDo needs a higher LoA than normal-DAFNI can provide
- Normal-DAFNI uses old school username/password to ensure the LoA

HIDING SENSITIVE DATA

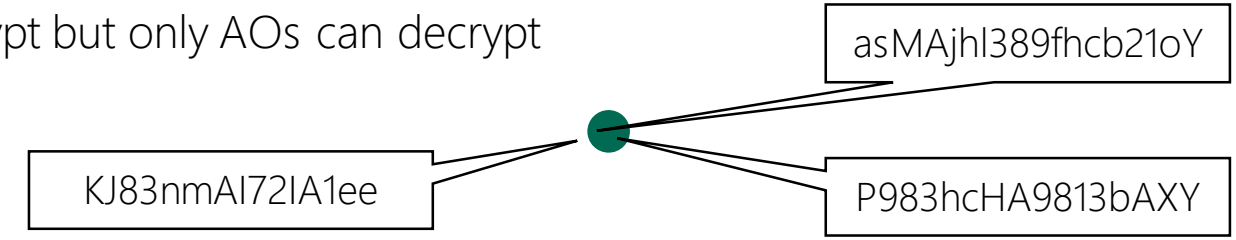
DAFNI
Data & Analytics Facility for National Infrastructure

Using computational complexitiy and more advanced crypto



- For cascade effects, the *graph* is important
  - But locations are not
  - Finding isomorphisms between graphs is NP-complete (I think)

- For environment effects, the *location* is important
  - Hide location with a one way trap door function
  - Encoded nonce prevents replay and ensures each location has multiple encodings
  - The central DT can encrypt but only AOs can decrypt



6. CREDO IN UNAM TERRAM

Building a Secure and Resilient World

UKRI BUILDING A SECURE AND RESILIENT WORLD (2023-29)

DAFNI
Data & Analytics Facility for National Infrastructure

https://www.ukri.org/what-we-do/browse-our-areas-of-investment-and-support/building-a-secure-and-resilient-world/

The aim is to:

- strengthen social and economic resilience
- enhance national security across virtual and physical spaces
- ensure the UK can absorb adversity, deal with change, and respond to emerging threats and opportunities

Potential target areas include:

- the UK energy supply grid
- resilient supply chains, including food and critical materials
- UK response to global risks
- adaptation to change and robust decision making

DAFNI CERIA

Centre of Excellemce for Resilient Infrastructure Analysis

https://www.dafni.ac.uk/the-centre-of-excellence-for-resilient-infrastructure-analysis/

- Can we combine the work from CReDo and DAFNI BSRW?
  - Strengthen asset resilience modelling tools for non-electricity assets
  - Feed back into future CReDo activities
- Improve user support on DAFNI domain experts with less technical patience
- More sharing Useful Stuff™ across digital twins on DAFNI
  - CReDo stuff in credo group

THANK YOU

For more information, please contact:

credo@cp.catapult.org.uk