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### Abbreviations

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<tr>
<td>ANM</td>
<td>Active Network Management</td>
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<tr>
<td>ANN</td>
<td>Artificial Neural Network</td>
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<tr>
<td>BAU</td>
<td>Business as Usual</td>
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<tr>
<td>BEIS</td>
<td>Department for Business, Energy and Industrial Strategy</td>
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<tr>
<td>BSI</td>
<td>Bigwood Systems Inc.</td>
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<tr>
<td>CA</td>
<td>Contingency Analysis</td>
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<td>CAS</td>
<td>Contingency Analysis System</td>
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<td>CIM</td>
<td>Common Information Model</td>
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<tr>
<td>DNO</td>
<td>Distribution Network Operator</td>
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<tr>
<td>DSO</td>
<td>Distribution System Operator</td>
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<tr>
<td>EHV</td>
<td>Extra High Voltage</td>
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<tr>
<td>ENA</td>
<td>Energy Networks Association</td>
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<td>EPN</td>
<td>Eastern Power Networks plc</td>
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<td>FDG</td>
<td>Flexible Distribution Generation</td>
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<tr>
<td>FM</td>
<td>Forecasting Modules</td>
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<tr>
<td>FTP</td>
<td>File Transfer Protocol</td>
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<tr>
<td>GB</td>
<td>Great Britain</td>
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<td>GE</td>
<td>General Electric</td>
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<td>GEMA</td>
<td>Gas and Electricity Markets Authority</td>
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<td>GSP</td>
<td>Grid Supply Point</td>
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<td>IA</td>
<td>Information Assurance</td>
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<td>ICCP</td>
<td>Inter-Control Centre Communications Protocol</td>
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<td>ICT</td>
<td>Information and Communication Technologies</td>
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<td>IIP</td>
<td>Interactive Innovation Procedure</td>
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<td>IPR</td>
<td>Intellectual Property Rights</td>
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<td>KASM</td>
<td>Kent Active System Management</td>
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<tr>
<td>LA</td>
<td>Look Ahead</td>
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<td>LADD</td>
<td>Logical Architecture Design Document</td>
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<tr>
<td>LCNF</td>
<td>Low Carbon Networks Fund</td>
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<td>LCNI</td>
<td>Low Carbon Networks &amp; Innovation Conference</td>
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<td>LPN</td>
<td>London Power Networks plc</td>
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<td>MDM</td>
<td>Master Data Management</td>
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<td>NG</td>
<td>National Grid</td>
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<td>NGC</td>
<td>National Grid Control</td>
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<td>NIC</td>
<td>Network Innovation Competition</td>
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<td>REST</td>
<td>Representation State Transfer</td>
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<td>RT</td>
<td>Real Time</td>
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<tr>
<td>SCADA</td>
<td>Supervisory Control and Data Acquisition</td>
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<td>SFTP</td>
<td>Secure File Transfer Protocol</td>
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<td>SGT</td>
<td>Super-Grid Transformer</td>
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<td>SICCP</td>
<td>Secure Inter-Control Centre Communications Protocol</td>
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<td>SPEN</td>
<td>Scottish Power Energy Networks</td>
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<td>SPN</td>
<td>South Eastern Power Networks plc</td>
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<tr>
<td>SVM</td>
<td>Supporting Vector Machine</td>
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<tr>
<td>Acronym</td>
<td>Definition</td>
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<tr>
<td>TNO</td>
<td>Transmission Network Operator</td>
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<tr>
<td>TOGAF</td>
<td>The Open Group Architecture Framework</td>
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<tr>
<td>UK</td>
<td>United Kingdom</td>
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<tr>
<td>UKPN</td>
<td>UK Power Networks</td>
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<tr>
<td>WAN</td>
<td>Wide Area Network</td>
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1. Project background

The Kent Active System Management (KASM) project ran from January 2015 to December 2017 and carried out a range of technical innovation trials to demonstrate more advanced operations and planning techniques for the 132kV and 33kV network in East Kent, located in the South Eastern Power Networks (SPN) licence area. The project delivered benefits spanning various areas, including the enablement of low carbon generation, the deferral of capital-intensive reinforcement associated with new generation connections, and improved reliability of the network.

The last few years have seen a number of Grid Supply Points (GSPs) come under pressure from the level of embedded generation exporting power onto the electricity transmission network. In the most extreme form of the electricity network operating in the opposite way to which it was originally designed, whole sections of the network are not only supplying their own demand but are also exporting the surplus onto the transmission system. These conditions on the network can result in significant network constraints which can impact existing generators as well as new generators seeking to connect to the distribution network.

The East Kent area used by the project contains four GSPs (of approximately 350 nationwide), and a fifth is being established. Nevertheless, it currently requires as many as 34 contingency scenarios to be analysed in order to understand the network fully. The significant uptake of wind and solar generation in recent years, due to government incentives, and the presence of interconnectors connected to the transmission system, will only ever increase the number of generation patterns that need to be analysed. There is no longer a simple ‘day of highest winter demand’ and ‘day of lowest summer demand’: there is more variation and hence a greater requirement to monitor all contingencies during real-time operation and future planning of the network.

Contingency Analysis (CA) is a valuable tool to understand more about the network and predict the effect of outages like failures of overhead lines, and to take actions to keep the distribution network secure and reliable. UK Power Networks (UKPN) successfully trialled for the first time the use of CA on Great Britain’s (GB) electricity distribution network. It was also the first trial to utilise a coordinated data exchange with the electricity transmission network.

The KASM project explored and demonstrated the value of the CAS (Contingency Analysis System) in operational and planning timeframes on the network, delivering conservatively estimated net benefits of £0.4m for the project trial area in East Kent. Now proven successful, replication of this method across GB can be considered, and could conservatively provide net benefits of over £62m over the lifetime of the 45-year investment, when compared to business-as-usual (BAU) approaches.

Total funding for the project was £3.9m, with £3.4m secured from Tier 2 funding under the Low Carbon Networks Fund (LCNF). The remaining funding was provided by UKPN (£450k) and its project partners (£50k).
2. Executive summary

In 2015 the KASM project was established to mitigate, through the use of CA and Forecasting Modules (FM), the increasing need for generation curtailment in the distribution network arising from increasing levels of embedded generation.

The use of CA provides grid operators and planners with more realistic operating conditions and scenarios that allow them to move away from using worst-case assumptions, reducing the outage constraints on generators and providing a better understanding of the coincidence of load. This in turn reduces the expected reinforcement required for new connections and/or to operate the network closer to its design limits, thus enabling the integration of more sustainable generation in the current grid.

The project was awarded £3.9m, with £3.4m secured from Tier 2 funding under the Low Carbon Networks Fund (LCNF). The remaining funding was provided by UKPN (£450k) and its project partners (£50k). The project partners were National Grid (NG) and Navigant.

2.1 Scope and objectives

The main objective of the KASM project was to assess the feasibility and value of CA as an operational and planning method that would limit the need for curtailment of (renewable) energy generators on the distribution network and maximise the amount of generation capacity that could be accommodated. To this end, tooling was developed and trialled on the 132kV and 33kV network in East Kent (located in the SPN licence area) for three specific use cases:

- **Reliability Management** – real-time monitoring of the network operation and mitigation of the effects of faults
- **Outage Management** – short-term operating conditions assessment for the network on planned maintenance
- **Network Capacity Management** – network capacity assessment and determination of reinforcement works to ensure reliable operations

2.2 Project outcomes

Three specific capabilities were successfully developed and trialled:

- The sharing of real-time measurement data between the NG and UKPN control rooms via an Inter-Control Centre Communications Protocol (ICCP) link
- FM which uses advanced analytics and machine learning techniques to provide realistic load and generation forecasts for the KASM trial area
- CA which provides state estimation and power flow calculations for contingent scenarios

Additionally, a business design was created that describes the method and conditions under which these capabilities can be scaled up and transferred to BAU.

2.3 Project performance

The project successfully demonstrated the feasibility and value of using CA on the distribution grid, for the first time in the UK. The project satisfied all of the original aims and objectives as listed in the Full Submission bid and all six SDRCs described in the Final Project Direction were delivered successfully. Performance against the aims, objectives and SDRCs is summarised in Section 5.
2.4 Project learning
The learning from the project covered an array of areas dealing with organisational, financial, planning and technical issues.

We recommend a more collaborative but strict vendor-supplier approach for innovation projects, as this will foster a culture of co-innovation and, overall, result in more efficient and effective project delivery, through quick feedback loops on delivered functionality.

To facilitate efficient scaling and cost-effectiveness, innovation projects should design trials and supporting tooling with scaling-up and roll-out to BAU in mind, to ensure the developed capabilities align with the goals of the organisation; although it can be justified to develop tooling that is used only in a trial setting if it facilitates quick development of a lasting capability and fits with the overall enterprise architecture.

Innovation projects with a strong IT component, such as KASM, have a critical dependency on data, often from various disparate sources, and more often than not this data is sourced from multiple sources, both internal and external. The time and effort required to align these data sources and resolve data quality issues should not be underestimated and should be a key consideration when scoping and planning this type of project.

2.5 Method learning
Many of the insights from initial implementation signal a need for master data management, which ensures that consistent data sources are used across an organisation and avoids applications using conflicting data. An important ingredient of this is the CiM for utilities, which defines a common vocabulary and basic ontology for aspects of the electric power industry.

We identified that the two components of the CAS – the CA tool which provides state estimation and power flow calculations for contingency scenarios and the FM which provides generation load profiles – are not used together in all three use cases, allowing for an unbundling of these functionalities. This in turn opens up opportunities to simplify the solution architecture and allow for a more seamless integration with the existing application landscape.

Additionally, a need for various new policies was identified to ensure that the newly developed capabilities benefit customers in a fair and transparent way. The lessons learnt from the method are covered in more detail in Section 8.2.
3. Details of the work carried out

3.1 Project structure and governance

3.1.1 Project structure

Large innovation projects like KASM can only be successfully executed when they are based on a clear project structure and governance model. The KASM project structure is presented in Figure 1. The project was broken down into five delivery workstreams, which are described briefly below.

Figure 1: Structure of the KASM project (for a brief description of the workstreams see the main text)

- **Workstream 1: Information Sharing, Data Integration and Set-up** – this workstream was responsible for reviewing existing business processes for data retrieval and usage
- **Workstream 2: Contingency Analysis Tool Development and Integration** – this workstream was responsible for all activities associated with making the CA tool operational
- **Workstream 3: Load and Generation Forecasting and Network Modelling** – this workstream developed the systems that are used in conjunction with the CA: generator and load modules; forecasting engine; historical generation and load patterns; historical weather patterns; optimisation and normalisation modules
- **Workstream 4: Value Streams and Business Process Impacts** – this workstream explored the objectives, design and methodology to conduct real-world trials with the installed applications. The outcome of these trials will be used going forward to support network management functions across the different time horizons
• **Workstream 5: Knowledge Dissemination and Stakeholder Engagement** – a dedicated workstream was focused solely on the capture and dissemination of knowledge and learning from the project to other DNOs and stakeholders for use in their projects and business activities.

In this section we report mainly on activities carried out in Workstreams 1-4. The activities from Workstream 5 are evidenced in Section 12.

### 3.1.2 Governance model

The governance structure for the project covered three levels and had two different streams: Solution Governance and Project Governance. This model, matched with the project structure presented in Section 3.1.1, facilitated and enabled a robust focus on delivering the solution to the project’s time, cost and quality constraints. The structure is schematically depicted in Figure 2 and the key roles and responsibilities are described below.

- **Steering Group** – ultimately responsible for setting the direction and guiding the KASM project
- **Project Board** – responsible for operational management of the project
- **Workstream meeting** – part of the operational management of the workstream
- **Project Design Authority Board** – reviewed and approved all of the key KASM deliverables
- **Technical Lead meeting** – responsible for the technical development of the project

**Figure 2: KASM project governance structure**

For more information on the project structure, governance model, roles and responsibilities, please see the [KASM Project Handbook](#).
3.2 Installation of ICCP link

The ICCP link is being specified by utility organisations throughout the world to provide data exchange over wide area networks (WANs) between utility control centres, utilities, power pools, regional control centres and non-utility generators. ICCP is also an international standard.

For KASM this communication protocol was the preferred method of connectivity agreed by NG and UKPN. This decision was derived through a number of workshops validating the real-time network data exchange requirements of both parties. The project also conducted a consultative webinar session, inviting other DNOs to contribute any suggestions and lessons learnt for the project team to take on board whilst implementing the ICCP link solution.

In partnership with NGC and General Electric (GE), the project team designed a communications and IT infrastructure solution that satisfied the ICCP objective of reliable, secure and performant data exchange between the UKPN and National Grid control centres. Private dual redundant ops telecom circuits already existed between NG and UKPN and these were leveraged to deliver the WAN circuits over which the ICCP is hosted.

At UKPN the ICCP application is hosted as part of the GE PowerOn SCADA estate. In particular, the ICCP application is dual hosted: on one server at the main Control Centre site and on another at the secondary Control Centre site. These two servers run in a main-standby arrangement where one server is deemed to be the on-line system and the other the backup. At NG the same set-up is in place, where two ICCP applications run from disparate sites in a main-standby arrangement.

After installation of the ICCP link, the NG control engineer can view the status of the distribution network and the UKPN control engineer is able to view the transmission network.

3.3 Solution architecture

The CAS consists of two distinct applications: the CA tool which provides state estimation and power flow calculations for contingency scenarios, and the FM which provides generation load profiles based on historical data and weather forecast data. Both tools consume data from various sources and generate data for applications.

The CAS integration architecture designed by the project covers the aspects of the different architectures aligned to The Open Group Architecture Framework (TOGAF). The Business, Data, Application, Technology and Security architectures are described in detail in our SDRC 9.2 report, which illustrates the overall picture of the CAS. To ensure the architecture designed as part of the KASM solution aligns with the wider UKPN Information Systems strategy, the Logical Architecture Design Documents (LADD) were presented to a review board who approved several key principles of the project architecture.

To manage the complexities of sourcing data from multiple applications, the project developed an enhanced data mapping engine and Data Bridge which facilitates the build of a real-time power flow model. This represents the main innovation in the architecture.

Integration with control room environments required significant design considerations around security and resilience. The project designed an efficient cloud infrastructure rather than using traditional physical hardware. This has resulted in a reduced cost through smart server management, faster speed of deployment and improved reusability, whilst maintaining security of critical systems. This infrastructure allows future projects to easily build on the data available from the KASM project.

The current solution architecture is shown in Figure 3. For a complete overview and discussion of the solution architecture, please see our SDRC 9.2 and 9.3 reports.
Development and integration of CAS

Conventional real-time power flow engines utilise state estimation as an input, which is not commonly available to DNOs due to the limited need to run real-time power flow calculations. In addition, the level of SCADA data available makes state estimation more complex than for transmission network operators (TNOs), whose networks feature more SCADA data sources relative to their network size and granularity. Through an innovative approach, the KASM project has worked with BSI to produce a state estimator for the distribution network.

The CAS uses advanced power flow and smart Homotopy\(^1\) based power flow solvers to study the network for thermal, voltage and steady state violations due to a large set of contingencies. This implementation includes tailored data and

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\(^1\) Current power flow solving software is typically based on the Newton-Raphson method and has several limitations. One key limitation is that a ‘good’ initial point is usually required to obtain a solution. Homotopy based techniques help to mitigate this limitation.
application processing for UKPN's existing online environment, to quickly assess the threat of varying power flows through grid supply points or from generators and to account for the impact of renewable energy.

The output from this assessment can be used to perform real-time CA. The benefit of this can be derived in several use cases, including reliability management, outage management and capacity management. As the level of embedded generation increases, the distribution network power flows become more dynamic; therefore, understanding real-time power flows becomes an important capability to manage the network efficiently and securely.

The CAS that was developed and trialled by the KASM project can be used in three different modes. CA itself has three operational modes which support different use cases:

- **Real Time (RT) mode** – identifies future harmful contingencies in real time
- **Look Ahead (LA) mode** – looks for contingencies at a configurable time in the near future, e.g. 12 hours ahead
- **Study mode** – analyses contingencies based on an archived, offline case

The FM is the module which produces the desired load and generation forecasts. It implements a portfolio of predictive analytic models, including ANNs, SVMs, fuzzy logic, and relevant optimisation techniques and metaheuristic search algorithms. These analytic models and computing techniques are integrated to produce the predictive analytics. An example of the output of the FM is shown in Figure 4.

**Figure 4: FM load data point forecasting.** The blue curve represents the output of the forecaster; the orange curve signifies the measured values. Good agreement can be observed. The difference between the forecast and the observed values increases with the length of the forecasting window.

The CAS was developed by BSI based on requirements gathered by UKPN during the initial phase of the project. It was delivered in two major releases:

- **Release 0 – Core Product (October 2016):** Using this release, the core applications and their capabilities were tested. The key areas of focus were: data import, data accuracy from import and solution quality perspectives, core system interfaces, engine performance, manoeuvrability and system installation
- **Release 1 – Final Product (May 2017):** Using this release, the full CAS application was tested end-to-end. Prioritised modifications and/or fixes identified in Release 0 were incorporated. The application user interface was fully developed with the automated integration of various data interfaces and applications
Following successful integration testing, the CAS was deemed ready for the field trials described in the next section. For more information about the integration testing, please see our SDRC 9.3 and 9.4 reports. For more detail on the field trials, please see our SDRC 9.5 report.

3.5 Execute field trials for real-time, short-term, and long-term use cases

KASM delivered a suite of innovative software solutions which were tested in a set of concurrent field trials, running from May to December 2017. The outcomes of the trials are discussed in Sections 4.2, 4.3 and 4.4.

3.5.1 Network Reliability Management trials

The purpose of the Reliability Management trials was to determine the benefit of using the CAS and the FM in the control room. Control engineers have been trained to use the software and their feedback has been used to tailor the solution to their requirements. During the trial period, five case studies were used to analyse the benefits of the tools.

The CAS operated on a periodic 15-minute cycle, providing control engineers with up-to-date information regarding the current network state, the state of the network under various contingencies and future forecast scenarios (12 hours ahead). The extra high voltage (EHV) control engineers had access to the CAS and used the tool to validate a number of key assumptions. Although during the trial period none of the assumptions that control engineers used from the current processes were proven incorrect, it did provide validation of these high-level calculations.

3.5.2 Outage Management trials

In outage planning, curtailment is a solution that has been used to maintain secure status of the network in the East Kent area. The Outage Management trials compared the current methodology (network status assessment based on offline calculations) for outage planning (a few weeks ahead) with the proposed KASM methodology, which uses forecast data for generation and demand. The case studies described in section 4.3 were focused on avoiding unnecessary curtailment to distributed generators.

When planning the trials, the trial manager and the outage managers defined case studies that most accurately reflected outages on the East Kent network where curtailment could be required. Using conventional assessment methods, the project team successfully identified scenarios where curtailment was necessary and could actually be reduced using the KASM solutions. During the trial period, all of these outages were assessed using the conventional process and compared with the KASM trial process, which uses the FM. The conventional process is based on offline simulation of the network using DigSILENT PowerFactory (UKPN’s EHV power systems modelling tool) and the input data received by NG’s outage planners. The new process uses the forecast output at 24 hours ahead for distributed generation from the FM, rather than the maximum capacity.

3.5.3 Network Capacity Management trials

East Kent is an area where the distribution network is facing capacity constraints due to the high penetration of distributed generation. New firm connections require significant asset reinforcement and several studies have been performed to identify the best solution to this problem. The trials approached this issue by assessing new firm and flexible connections in the area. Specifically, data generated during the trials allowed the development of a demand/generation trends database, which resulted in a model for Network Capacity Management. This database has been embedded in the FM with a data export function for statistical analysis in terms of maximum and minimum recorded power values.

The KASM tools have been trialled by the infrastructure planners for the area, with support from the trials manager. The complete suite (the CAS and the FM) has been developed based on their requirements.

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2 Conventional assessment methods: evaluation of the state of the network based on combinations of worst-case assumptions such as maximum generators, lower electric loads and most onerous contingency scenario.
The existing assessment process for new connections in East Kent is based on offline power flow simulations to determine the required reinforcement of the distribution network. This process is based on several assumptions on demand and generation combinations, as summarised below:

- Daylight Minimum demand (minimum network demand during peak of solar radiation)
- GB Minimum demand
- Primary Maximum Scenario (maximum network demand)
- Renewable resources generators exporting at maximum capacity

The project team analysed the data on demand and generation outputs in East Kent in order to move away from the historical worst-case scenario (set in 2015 and replicated in the studies) to an improved worst case which recognises that maximum generation and minimum demand may not happen at the same time for selected areas – as was previously observed in the Outage Planning trials, described in detail in our SDRC 9.5 report.

Two methodologies were described and applied during the trials period. The first one maintained the 2015 assumptions set at the beginning of the project and aimed to release capacity for new connections by providing additional knowledge of the coincidence of demand and generation on the network. The second method was based on a flexible connection approach that applies this knowledge to assess the expected level of curtailment of the generator, to unlock generation capacity in East Kent.

3.6 Create design for integration into BAU

Introducing new capabilities like CA into an organisation requires changes to existing systems, processes and policies and affects the day-to-day activities of many stakeholders. New roles emerge and existing roles and associated responsibilities change. The last phase of the project created a design for integrating the capabilities developed in the KASM project into BAU. The design describes the modifications to UKPN’s systems, policies and processes that are required to successfully roll out the CAS to BAU.

The design builds on insights from previous BAU implementations at UKPN and lessons learnt from the field trials. It describes the preconditions for a successful BAU roll-out and how the CAS will be used in BAU for its three use cases: real-time monitoring in the control room, outage planning and infrastructure planning. The BAU design contains a list of specific actions for systems, policies and processes and provides indicative timings for each action. Please see Section 11 for more detail.
4. Project outcomes

4.1 ICCP link with NG

The ICCP link that provides real-time measuring data from NG’s control room to UKPN’s SPN control centre went live in December 2015 and has been operating according to its design specification ever since. Figure 5 and Figure 6 show the successful data exchange over the ICCP link.

Figure 5: Successful data exchange over the ICCP link between NG’s control room and UKPN’s SPN control centre
The ICCP link allows NG measurement data to be used in UKPN’s PowerOn system and, subsequently, in the CAS. The ICCP link provides better visibility of the NG network and enables UKPN to act on what is actually happening – a vast improvement on working only on assumptions or on indicative timelines and severities for events communicated ahead of an event.

The ICCP link thus provides tangible benefits to the DNO, by limiting the need for constraints on its distribution network. This additional visibility of the transmission network allows the control engineers to make more informed decisions during operation and management of the distribution network. This would be valid for ICCP links between different DNOs as well.

The ICCP link remains live and in service. It is also being used in the Power Potential project to acquire real-time NG SCADA data. This ongoing innovation project – officially registered as Transmission Distribution Interface (TDI) 2.0 – is a joint Network Innovation Competition (NIC)-funded project between NG and UKPN which aims to address multiple constraints on the transmission network and provide additional network capability for the distribution network. More information about this project can be found here.

4.2 Network Reliability Management trials
The project successfully completed the functional Reliability Management trials with a number of UKPN control engineers. The trials demonstrated data collection from a number of transmission substations, including Grain, Kemsley, Cleve Hill, Canterbury North, Sellindge, Dungeness and Ninfield. In addition, the CAS presented the sensitivity of contingencies on the transmission network to violations on the distribution network – see Figure 7.
During the trials the CAS analysed 13,329 cases. Out of these cases, 89% demonstrated a converging power flow solution, which is considered to be highly successful in a real-time environment, where no manual intervention is applied.

For the 11,870 converging cases, UKPN’s engineers were able to understand the sensitivity of 18 credible contingencies on the transmission and distribution network. This information supports control engineers who manage the network in real time by providing information which allows them to understand network conditions under the next credible fault scenario.

Overall, this first-of-a-kind real-time CA trial in a DNO control room has identified key learnings and highlights the benefits that CA and FM can provide to control room engineers. UKPN believes that these capabilities are fundamental when managing the network more actively, as DNOs transition to DSOs.

### Outage Management trials

Using conventional assessment methods\(^2\), the project team successfully identified scenarios where curtailment was necessary and could be reduced using the KASM solutions. The case studies are described in our SDRC 9.5 report which also provides additional information about the reductions in curtailment.

In all, four case studies were analysed. One of them fell outside the trial period but was analysed retrospectively.

During the trial period, all of these outages were assessed using the conventional process and compared with the KASM trial process which uses the FM.
Table 1: Outage Management trial results

<table>
<thead>
<tr>
<th>Case Study #</th>
<th>Case Study Name</th>
<th>Current Process</th>
<th>KASM Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CANTERBURY – SELLINGDE</td>
<td>Reduction of generator export 49.5MW</td>
<td>No curtailment required</td>
</tr>
<tr>
<td>2</td>
<td>CANTERBURY NORTH – CANTERBURY SOUTH</td>
<td>Reduction of generator export 49.5MW</td>
<td>No curtailment required</td>
</tr>
<tr>
<td>3</td>
<td>HERNE BAY 132/33KV GT1</td>
<td>Reduction of generator export 49.5MW</td>
<td>No curtailment required</td>
</tr>
<tr>
<td>4</td>
<td>CANTERBURY NORTH – KEMSLEY 400KV CIRCUIT</td>
<td>Reduction of generator export 80MW</td>
<td>No curtailment required</td>
</tr>
</tbody>
</table>

Using the FM more informed decisions were made, and by applying the outputs of the forecaster (including a margin of safety), no curtailment was required to the generators. The total distributed generation curtailment reduction was calculated at 3,340MWh. Assuming a conservative value of £80/MWh, this equates to a benefit of £267k for customers during the trial period. During the trial period, outage planners still issued curtailment instructions based on worst-case scenario assumptions, due to the uncertainty of the forecaster. However, as the project has now clearly identified the accuracy of the forecaster, the outage planners will use forecast data for any 2018 outages in the trial area.

4.4 Network Capacity Management trials

Two methodologies were applied during the trials period. The first one maintained the 2015 assumptions set at the beginning of the project and aimed to release capacity for new connections by providing additional knowledge of the coincidence of demand and generation on the network. The second method was based on a flexible connection approach that applies network constraints analysis to assess the expected yearly level of curtailment of the generator and so unlock generation capacity in East Kent.

4.4.1 Firm connections

Firm connections are generators which are allowed to export power to the distribution network without limitation when the network has a secure status. Visibility of demand and generator profiles allows infrastructure planners to optimise their network design according to customers’ needs.

4.4.2 Flexible connections

With a flexible distributed generation connection, the DNO has the ability to control the generator’s output (real power in most instances) to ensure that the network remains within operating limits. UKPN is currently rolling out a Flexible Distribution Generation (FDG) connections approach to its networks and the East Kent area has been opened up for this approach since 26 June 2017.

Prior knowledge of load and generation profiles in the area where new sites are to be connected allows infrastructure planners to propose an estimated yearly generation curtailment based on the point of connection and the capacity of the proposed site. This new approach avoids a significant element of reinforcement work in order to overcome technical issues, such as capacity, voltage or reverse power flow constraints.

4.4.3 Results

The trials highlighted that in order to move away from worst-case planning assumptions, DNOs would need real-time control of these generators. This control could be in the form of active network management schemes or simpler intertrip schemes. When assessing capacity in the East Kent area for flexible generation connections, it was found that capacity for new connections was available depending on the level of flexibility of new generators. The FDG approach is
considered the best long-term solution for the area, with the capability to connect more than 100MW in the coming year and more capacity for the following years, in line with the network development plan.

5. Performance compared to original project aims, objectives and SDRCs
The project successfully satisfied all of its original aims and objectives, as listed in the Full Submission bid. These are summarised in Section 5.1 respectively. All SDRCs in the final Project Direction were delivered on time and on budget, as discussed in Section 5.2.

5.1 Project Aims and Objectives

<table>
<thead>
<tr>
<th>Aim</th>
<th>Objective</th>
<th>Evidence</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real-time monitoring of the network operation and mitigation of the effects of faults</td>
<td>Move from a restorative to a preventive approach by continuously analysing potential contingencies before they occur, alerting control room engineers, and recommending preventative actions.</td>
<td>The CAS performed more than 11,000 real-time power flow calculations from May to November 2017, using data from Kemsley, Canterbury North, Sellindge, Ninfield, Grain, Cleve Hill and Dungeness to demonstrate high reliability and sensitivity to changes on the 400kV network. Please see Section 4 of our SDRC 9.5 report for more details.</td>
<td>✓</td>
</tr>
<tr>
<td>Assessing short-term operating conditions for the network based on planned maintenance and forecasted generation and demand</td>
<td>Move from a manual to an automated approach for analysing of all possible contingencies. Forecasting capability will allow outage planners to use hourly (or sub-hourly) estimates of demand and generation</td>
<td>Published results from functional trials and the achieved benefits in reduced distributed generation curtailment. The trials successfully proved that real-time CA and forecasting techniques provide the fundamental tools to reduce distributed generation curtailment. Please see Section 5 of our SDRC 9.5 report for more details.</td>
<td>✓</td>
</tr>
<tr>
<td>Assessing network capacity, and determining timely reinforcement to ensure reliable operation</td>
<td>Move from using worst-case to realistic operating conditions in assessing network capacity. Archiving capability will enable infrastructure planners to incorporate actual diversity of generation and coincidence with demand.</td>
<td>List of connection offers that have been linked to reinforcement when assessed using conventional processes, and identification of those that have been revised to remove the reinforcement requirement after being assessed using the trialled methodology; quantification of the released network capacity based on the comparison of the above list. The KASM approach has highlighted that developing</td>
<td>✓</td>
</tr>
</tbody>
</table>
5.2 Project Successful Delivery Reward Criteria

The KASM project successfully delivered all SDRC commitments outlined in the Full Submission bid, to a high standard and in a timely manner. SDRCs 9.2 and 9.3 were approved for a change request extension of eight months and also delivered all outputs to a high standard. This additional time was required due to unforeseen complications in extracting and aligning data from our long-term planning system and our control system. Mitigating measures put in place by UKPN as soon as the issue was identified were effective in addressing the problem and ensured delivery of these SDRCs in line with the approved change.

The delivery date of SDRC 9.4 was changed to align with the new delivery programme. The rescheduled delivery of SDRCs 9.2-9.4 did not impact the timeliness of the subsequent SDRCs, nor did it impact the timeliness of the overall project completion.

The table shown in Appendix B – Successful Delivery Reward Criteria) sets out the criteria met for each SDRC and detailed matrices of the evidence can be found in the individual SDRC overview reports.
6. Required modifications to the planned approach during the course of the project

The following modifications were made to the planned approach for KASM.

6.1 Enhanced requirements elicitation and clarification

At the start of the project the team identified a misinterpretation of the intended requirements for the CAS by BSI. This led to an enhanced requirements elicitation and clarification effort, involving end-users and the procurement team, to ensure there was full alignment on the required functionality of CAS so that the solution was fit for purpose and could be delivered on time. Throughout this phase the project team continued to work on the key activities with BSI to ensure there was no slippage and no impact upon key project deliverables.

6.2 Data and model alignment

A key challenge of the project was the data mapping of PowerOn Fusion and PowerFactory model files. The project explored several options for exporting network models from the PowerOn Fusion and Power Factory model. UKPN explored both CIM and PSS/E exports from the Power Factory model and decided that the CIM models provided BSI with the most accurate model of our network. When liaising with GE (the suppliers of PowerOn Fusion), it was decided that the most appropriate export methodology was for GE to create a bespoke XML export. Similarly, DigSILENT produced a set of custom scripts which were executed in PowerFactory before the CIM export and subsequent import into the CAS.

6.3 KASM network boundary

When modelling the NG network, users need to determine the boundary of the KASM project. Outside the boundary, the initial plan was that the NG network would be modelled as equivalent in-feeds at the boundary nodes. The challenge was determining the impact of changing the boundary and how the equivalent points could be updated on both a real-time and longer-term basis. Since equivalents were manually calculated by NG at this stage, it was not possible to obtain real-time updates of NG’s equivalent network power injection at the boundary nodes. A Grid Code change was recommended to Ofgem to waive the restriction on OC2 (Operating Code No. 2) data models, so that these could also be used by the infrastructure planners.

Following a review by Ofgem, the Grid Code change recommended by UKPN was approved by the Gas and Electricity Markets Authority (GEMA) and made effective on 28 July 2016. The change allows DNOs to use the same NG network models for operational and planning purposes, which will be important in improving visibility of NG’s network to DNOs. From a KASM project perspective, it allows the same network models to be used within the CAS, which ensures a more efficient solution architecture.

6.4 Focused field trials

The trial period was adjusted in line with the changed delivery date for SDRC 9.4 (the SDRC was delivered in June 2017, in accordance with the change requests approved by Ofgem). Through continuous engagement, trial participants remained highly engaged with the project during this phase. A strategy was developed to retrospectively analyse available data to ensure that the focused field trials – described in detail in our SDRC 9.5 report – could be augmented to the extent that the project was able to deliver the benefits it set out to deliver.

All the required modifications during the course of the project were successfully managed in order to limit the impact on objectives and deliverables and did not cause any cost or time issues.
7. Significant variance in expected costs
The budget for the project was based on the financial information provided at bid submission in the “Full submission financial spreadsheet”. It was used to inform the budget and create the position of all costs as described in the budget section of the Funding Direction. The table below presents the view of the actual spend against bid budgeted spend to the end of the project (December 2017). Commentary is provided to supplement the budget overview table and explain any variances of +/- 5%.

7.1 Budget Overview

<table>
<thead>
<tr>
<th>Kent Active System Management Financials (£k)</th>
<th>Budget in Project Funding Direction (£)</th>
<th>Actual Expenditure (£)</th>
<th>Variance (£)</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labour Total</td>
<td>1,591,433</td>
<td>1,287,608</td>
<td>-£303,825</td>
<td>-19% underspend</td>
</tr>
<tr>
<td>Equipment Total</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Contractors Total</td>
<td>357,441</td>
<td>346,561</td>
<td>-£10,880</td>
<td>-3% underspend</td>
</tr>
<tr>
<td>IT Total</td>
<td>1,311,114</td>
<td>1,331,005</td>
<td>£19,891</td>
<td>2% overspend</td>
</tr>
<tr>
<td>Travel and Expenses Total</td>
<td>296,091</td>
<td>39,941</td>
<td>-£256,150</td>
<td>-87% underspend</td>
</tr>
<tr>
<td>Contingency Total</td>
<td>296,505</td>
<td>231,466</td>
<td>-£65,039</td>
<td>-22% underspend</td>
</tr>
<tr>
<td>Other Total</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Grand Total</td>
<td>3,852,584</td>
<td>3,236,581</td>
<td>-£616,003</td>
<td>-16% underspend</td>
</tr>
</tbody>
</table>

7.1.1 Labour Costs: Budget Variances
The project underspent on labour costs by 19% compared to the Project Direction. This underspend is due to a change in the number of full time project resources allocated to the project during the design and build phase. These changes were made to ensure efficient and effective delivery of project objectives.

7.1.2 Travel and Expenses: Budget Variances
The project underspent on Travel and Expenses by 87%. In the initial plan, a number of trips to visit the supplier in the United States were envisaged; however, through efficient use of teleconferences and WebEx sessions, this was significantly reduced.
7.1.3 Contingency: Budget Variances

The project utilised some of the contingency but remains 22% underspent in this category. The contingency was allocated for a number of activities associated with consultant support which were not originally captured in our contractor budget. These activities included:

- Design and implementation of IT architecture associated with solution delivery
- Support of technical infrastructure environment
- Support of business design to incorporate CA and forecasting as BAU
- Support for knowledge and dissemination reports

In order to ensure the success of these activities, the project required specific skill sets that were not available within the project team, therefore external support was required.

7.1.4 Overall

Overall, the project has delivered all of the key objectives and outputs whilst underspending by 16%. This underspend can mainly be attributed to reduced labour costs and reduced travel and expenses. The underspend has been achieved by optimising the project team structure and utilising advanced communication technology to liaise with international project suppliers and partners. Where specific skill sets were required which were not available within the project team, the team required consultant support to successfully complete these activities.

8. Update to the business case and lessons learnt from the method

8.1 Update to the business case

The business case for KASM, as presented in the Full Submission bid, identified the following benefits:

- Operation of the network closer to its limit, serving as an alternative to traditional reinforcement
- A reduction in the constraints placed on generators during maintenance and other planned outages
- Improved operational processes to reduce time constraints on outage planners and the overall risk on the network

These benefits and the costs required to realise them were calculated using UKPN’s proposed cost of capital (3.5%), a capitalisation rate of 70% and a depreciation term of 45 years. As such this is fully compliant with both Ofgem’s Cost-Benefit Analysis requirements and typical HM Treasury principles. Overall, the KASM method was estimated to provide a net benefit of £0.4m in present value (2014) terms over the BAU approach. The key contributing benefits identified were:

- **Deferral of a third super-grid transformer (SGT) at Richborough**: Advanced real-time modelling and analysis capabilities will enable the network to be utilised closer to its limit and thus defer the traditional reinforcement and installation of a third SGT at Richborough by two years – reducing the present value of this investment (estimated at £9.7m discounted by £0.7m to £9.0m) in present value (2014) terms
- **Higher utilisation of wind and solar capacity**: Advanced real-time modelling and analysis capabilities, combined with more sophisticated near-term load and generation forecasting, will enable a reduction in the constraints placed on distribution connected wind and solar PV resources during maintenance and other planned outages. This additional production will displace higher carbon emitting resources and reduce lost revenue worth an estimated £2.1m in present value (2014) terms. It is expected that the higher utilisation of wind and solar capacity will also have a positive effect on electricity bills for customers, as zero marginal cost generation will

3 Adjusted in June 2015 compared to the Full Submission bid to reflect updated software OPEX and CAPEX for the project.
displace conventional generation from the grid. This added benefit has not been examined in the context of the KASM business case

- **Maintaining existing outage planning labour**: Automating the forecasting and CA that is normally conducted manually by outage planners will reduce the need to deploy additional resources that would otherwise be required to manage the more sophisticated network in East Kent and the significant works planned around the NEMO project (the interconnector that will connect the UK and Belgium’s electricity systems via subsea cables) – an estimated benefit of £0.2m in present value (2014) terms.

A more detailed description of the method and a breakdown of the costs and benefits are provided in our Full Submission bid – specifically Section 3 and Appendix G, which can be downloaded from the KASM project website. Some additional benefits (such as improved data model, data quality etc) outside the immediate realm of the project were also identified in the Full Submission bid and are reported in Section 5 of our SDRC 9.6 report.

8.1.1 Benefits of a wider roll-out

Analysis conducted on the number of export-constrained GSPs in GB today and under alternate supply and demand scenarios, identifies that there are between five and eight credible sites per year that could benefit from deployment of the KASM method.

Applying the KASM method at these sites is estimated to defer the need for traditional network reinforcement, increase the capabilities of outage planners and reduce the impact of planned outages on existing generation customers. Using a conservative estimate of three sites per year for 10 years, starting in 2018, the estimated net benefit of a wider roll-out across GB is in excess of £62m in present value (2014) terms over the lifetime of the investment.

8.1.2 Carbon benefits

Adopting active system management techniques through the roll-out of the KASM method will translate into environmental benefits through the higher utilisation of wind and solar capacity, avoiding the need to curtail zero-carbon generation.

In the business case calculation it was estimated that there were at least 30 export-constrained GSPs in the UK that could benefit from the deployment of a real-time CA solution by 2030. A linear extrapolation of the benefits estimated for the East Kent region resulted in an estimated carbon emissions saving of approximately 275,000 tonnes of CO₂. This equates to an associated financial saving of £7.6m in present value (2014) terms.

8.1.3 Revisiting assumptions and identified benefits

Throughout the project, the assumptions underpinning the business case and the identified benefits were monitored with respect to their validity, both qualitatively and quantitatively. Any updates informed by the project’s results are discussed below.

- **KASM method costs** – the project was completed on time and within budget
- **First-of-a-kind costs** – the execution of the project and its deliverables did not give rise to the reassessment of these types of costs
- **Avoided lost revenue and carbon emissions** – 95% of the benefits here are realised through avoided outages. The KASM trials demonstrated that the assumed reduced curtailment need of 8,000 MWh/year underpinning this estimate is a realistic and achievable goal. Please see our SDRC 9.5 report for more details
- **Labour costs** – the use of CAS allows for a huge increase in the number of network configurations that can be evaluated by control room, outage planning and infrastructure planning engineers. This increase more than offsets the increased need for this type of calculation that arises from the increasing grid complexity and customer need for transparency. Based on the trial results (please see our SDRC 9.5 report), the initial labour cost savings are achievable, but will be distributed over the three use cases, rather than attributed solely to outage planning

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4 KASM Bid Support Extrapolation Analysis, Smarter Grid Solutions + UK Power Networks, July 2014, Table 7 page 12.
- **Base case cost** – the estimated base case cost has not changed compared to the original assumptions. However, during the life of the project there was a shift in the level of interaction with customers, which was driving, and driven by, a greater (need for) transparency and data-driven insights. This increased interaction with customers could influence how DNOs value traditional reinforcement methods and their alternatives in the future. At this stage it is too early to quantify this trend, but future innovation projects should take this into account.

The overall net costs of replicating the KASM solution are estimated to be £9.3m in present value (2014) terms. This cost is the result of combining the method cost, net of first-of-a-kind costs, with the benefits of the deferred reinforcement and the side benefits of the avoided generation curtailment and labour costs.

The overall business case is therefore still in line with the business case presented in the Full Submission bid, as we have reported in all of our SDRC reports (9.1-9.6).

**Figure 8: A graphical representation of the KASM business case calculation**
8.2 Lessons learnt from the method

8.2.1 Data management

Many of the insights from the initial implementation are related to data management. The implemented solutions that proved to be effective in the context of the initial trial implementation do not necessarily lend themselves to a BAU implementation – typically, as they do not scale well or are insufficiently robust against change and are therefore time-consuming, error-prone and not sustainable.

This is an aspect of development common to every DNO and is therefore not exclusive to the KASM project or to its integration into BAU. For historical reasons, such as the merging of different grids into one DNO, a DNO’s operational technology/information technology (OT/IT) landscape typically features a set of disparate, unconnected subsystems managing selected aspects of the grid and business. These systems have worked well during the KASM project and have been proven reliable. However, they are not connected – resulting in siloed data and no common view on a DNO’s physical and business assets.

In the future, DNOs’ business processes will be increasingly connected and data-driven; the new CAS processes and the existing processes they interact with are typical examples. The quality of the data powering these processes determines their accuracy and effectiveness.

Outcomes of the state estimation that hint at data anomalies are, for example, consistent, non-trivial differences between the state estimation results and measured SCADA data and a large number of contingency violations in the base case. Examples of these are elaborated on in our SDRC 9.5 report.

Master Data Management (MDM) ensures that consistent data sources are used across an organisation and avoids applications using conflicting data. In order to ensure MDM operates effectively, the correct processes, governance, policies, standards and tools need to be embedded within an organisation. Innovation projects such as KASM will highlight the need for MDM by exposing data and model issues in contributing systems and sources (e.g. SCADA/DMS) and external data sources. A noticeable positive side effect of KASM is therefore its contribution to improved model and data quality, both for UKPN and its model and data suppliers (e.g. NG).

Over the past few years, UKPN has implemented a Business Transformation Programme which has delivered a number of efficiencies in reducing the number of overlapping applications and data sources. This project supported the principles of MDM and is currently being embedded within the organisation.

An important ingredient of this is the CIM for utilities, which defines a common vocabulary and basic ontology for aspects of the electric power industry. CIM is rapidly becoming the standard in Europe for describing power networks and markets in an unambiguous way. UKPN is working with GE to develop the capability for PowerOn to periodically, automatically export a complete network model that can be used, among other use cases, by CAS, relieving the need for data mapping of DPF data from PowerFactory. This capability is scheduled to be available by the end of 2018.
8.2.2 Solution architecture

As stated in previous sections, the CAS consists of two distinct applications: the CA tool which provides state estimation and power flow calculations for contingency scenarios, and the FM which provides generation load profiles based on historical data and weather forecast data. In particular, the CAS supports the previously mentioned three use cases – Reliability Management, Outage Management and Network Capacity Management – by providing RT, LA and (offline) Study modes.

Not all tools/components are used in all three use cases and a more modular, highly cohesive yet loosely coupled application architecture would increase maintainability and reduce dependencies and lock-in, as components could be switched out more easily for alternatives as technologies mature and alternative use cases present themselves. Potential simplifications to the solution architecture are discussed in more detail in our SDRC 9.6 report.

8.2.3 Operations and maintenance

Throughout the KASM project there has been good interaction with the application vendor BSI, resulting in short release cycles with tangible, continuous improvements of application. It is expected that the need for new releases will continue for some time to come, as improvements to the workflows, and core functionality of CAS, the Power Flow and State Estimation Solver are made, next to regular bug fix releases. The application is not fully web based but contains a substantial number of components that run on the user’s workstation, most notably the Study mode of the CAS. This makes manual installations and updates unsustainable and support for automatic deployment and updating using UKPN’s standard enterprise solution for application management is therefore strongly desired.

8.2.4 Product Roadmap

During the KASM trial and development of the CAS, a number of potential product improvements and new functionality were identified which though not in the original scope are likely to yield sufficient value to UKPN to warrant future consideration:

- **Forecasting data** – the quality of the forecast is key to the usefulness of the CAS and the FM. Efforts to improve the forecast are likely to have a short payback time
- **Improving state estimation** – together with BSI, UKPN will work to improve state estimation on the distribution network by looking at novel state estimation techniques such as the quasi-gradient smart method (developed by BSI) for networks with insufficient measurement data and the value of using PMU measurement data or tap changers

8.2.5 Security

The security architecture design of KASM has focused on securing the communication channels between UKPN-controlled systems and external systems providing data used by the CAS. Although the data used in the CAS may be of limited (commercial) value, this may not hold for the actionable results of the system. Manipulation of its input data is therefore to be avoided to a level that transcends what would be done based on the value of the data itself.
To improve the level of Information Assurance (IA), a migration to Secure ICCP (SICCP) should be considered and external data sources using (S)FTP or Representation State Transfer (REST) interfaces should be augmented with data payload and sealing, as well as some form of watchdog to monitor availability.

Figure 9: A UKPN control room engineer using the CAS

8.2.6 Processes and Policies

The transition from DNO to DSO, which implies the introduction of Active Network Management (ANM) at scale, is characterised by the introduction of a substantial amount of ICT-driven smart grid solutions, such as the tools developed in the KASM project. The introduction of such new solutions can be impactful for the control room engineers. Their role will be not limited to the use of the tool – they will be part of a more advanced process where data handling, data validation and real-time power flow analysis are key. To facilitate this transition and achieve a swift uptake of this new way of working, UKPN has created a new role in the control room to support the introduction of new smart grid and DSO applications.

This role will act as a ‘product champion’ for the new solutions and accommodate the changing DNO/DSO requirements in the control centre. The responsibility of a product champion is primarily to own, develop and realise the product vision.
Additionally, this transition and the use of its enabling tooling require the creation and/or augmentation of several policies:

- **Curtailment policy** – increasing transparency on the network and emerging ANM options mandate a fair and adequate policy detailing how to determine the amount of required curtailment and which generators will be curtailed under which circumstances
- **Data retention policy** – in an increasingly data-driven organisation where (access to) data is of strategic value, it is important to specify a data retention policy that ensures important data is kept, organised and accessible to the right resources
- **Forecaster frequency policy** – for outages exceeding the forecasting window, the forecaster should be rerun either at the end of the original forecast period or periodically using a sliding-window type of approach. A policy should be in place that includes the rationale for a chosen approach in relation to required safety margins to the FM results and resourcing implications, as well as guidelines for the periodic evaluation of these
- **Application development process** – moving from a more traditional waterfall based approach to an Agile software development method facilitates fast and cost-effective development of new features and ensures these remain closely aligned with the requirements of users and business process owners
9. Lessons learnt for future innovation projects

UKPN recognises the importance of continuous structured innovation as it transitions from a traditional DNO into a DSO role. To ensure innovations are successful, disseminated throughout the organisation and provide measurable value, UKPN has developed an Interactive Innovation Procedure (IIP) which describes the end-to-end innovation journey, from idea generation to the idea becoming a reality and making UKPN’s service more reliable. The five-step procedure provides innovators with the tools and knowledge to help them contribute to UKPN’s vision of being the “Most Innovative DNO”.

UKPN’s tried and tested project management and governance approach has been a vital ingredient for the KASM project’s delivery on time and within budget.

In this section we present three lessons learnt that will contribute to future innovation projects’ effectiveness and impact.

9.1 Collaborative approach

A more collaborative approach is preferred over a strict vendor-supplier approach for innovation projects, as exact requirements are not always known at the start of the project. Such an approach facilitates timely requirements elicitation and refinement and provides quick feedback loops on delivered functionality. It fosters a culture of co-innovation and, overall, results in more efficient and effective project delivery.

9.2 Design for BAU, develop for trial

In innovation projects a distinction should be made between developing new capabilities and developing tooling to leverage those capabilities in an operational setting. The capabilities need to live and grow beyond the trial, whereas this is not necessarily the case for the tooling.

Any project should design trials and supporting tooling with scaling-up and roll-out to BAU in mind, to ensure the developed capabilities are a good fit with goals, needs and, at a more practical level, the enterprise architecture of the organisation. However, to prevent lengthy implementation times and high costs for innovations that have not proven successful, it can be justified to develop tooling that is used only in a trial setting if it facilitates quick development of a lasting capability.

9.3 Dependencies on data sources and their quality

Innovation projects with a strong IT component – like KASM – have a critical dependency on data, often from various disparate sources, and more often than not the data is sourced from multiple sources, both internal and external.

The availability and quality of this data is not always under the DNO’s control. Technical and process safeguards should be implemented to detect and remedy data issues, which requires strong data management competencies and strong internal and external stakeholder and vendor management.

It is evident that DNO operation will become more data-driven in the near future. Demonstration projects like KASM thus serve as an early warning system for data dependencies and data quality issues.
10. Project replication

KASM was designed and developed to demonstrate feasibility and value of the capabilities associated with using CA on the East Kent 132kV and 33kV networks. The tooling required for this was developed to deal with the specifics of these networks, which for a substantial part relate to MDM – specifically, data quality and systems integration.

The digitalisation of the energy system, the development of new DNO capabilities like CA and the transition of a DNO into a DSO are all factors that contribute to an increasing use of, and dependency on, software solutions and highlight data management and software solution interoperability issues. For more information, please see our SDRC 9.6 report.

Innovation projects such as KASM highlight the need for MDM by exposing data and model issues in contributing systems and sources (e.g. SCADA/DMS) and external data sources. A noticeable positive side effect of KASM is therefore its contribution to improved model and data quality, both for UKPN and its model and data suppliers (e.g. NG).

For DNOs looking to replicate this project, or a similar type of project, we would recommend a managed soft launch, per deployed CAS component, per area for the reasons stated below:

1. To incorporate region-specific data
2. To address the most prominent data management challenges
3. To gain buy-in from the user groups

Each licensed grid area is likely to have area-specific data that requires changes to how components of the CAS are used. These types of specifics tend to manifest themselves only upon incorporation of the tool into BAU. In addition, the FM needs to be trained for each site specifically, using relevant historical data; this may not always be available to the same extent for each licensed area.

Successfully integrating new tooling into a workflow requires the target user group to trust the results the tool provides and to see the value that it brings to their jobs. To achieve this, the tool and its benefits should be presented to all users at the start of the soft-launch process, leveraging the results from the KASM trial. Enthusiastic users from each group can subsequently be selected as CAS volunteers, ironing out the kinks in the initial deployment and facilitating adoption of the tool by their peer groups, as schematically represented in Figure 10.

Further information to help guide replication efforts can be found on the project’s website. Here, the newly generated intellectual property from the project has been documented in the Intellectual Property Rights (IPR) section of each of our six-month progress reports.
11. Planned implementation

The KASM project team studied three use cases corresponding to the different business areas affected by the introduction of CA: Reliability Management, Outage Management and Infrastructure Planning.

The initial implementation and operation of the CAS demonstrated its usefulness for these three use cases and yielded some useful insights – in some cases, beyond the scope of the original project. These insights – acquired by reviewing the trial results presented in our SDRC 9.5 report and by interviewing internal stakeholders who held a key role on the project – helped us identify a number of steps that need to be taken for a successful integration into BAU. In this section we group these actions, connect them to the three main use cases and provide a tentative timeline for implementation.

This high-level planning is informed by a few guiding principles:

- Innovation projects serve to demonstrate feasibility and value of the capability. Although the aim is to maximise the return on investment for any software development done in the KASM trial, this does not necessarily mean all tooling developed in the trial context will move into BAU in its current form.
- UKPN aims to achieve as much value for as many users as possible, as quickly as possible. Since not all user groups require the same capabilities developed in KASM, and not all components of the CAS have the same level of maturity, a staggered release of the various capabilities is the most prudent approach.
- UKPN acknowledges the value of the experience and expertise that different user groups have with their existing tools. Implementing new functionality on platforms already in use by key user groups is therefore preferred.

As highlighted in Section 5 of our SDRC 9.5 report, the most direct and quantifiable value of all capabilities developed in the KASM project is provided by the FM for outage planning. The BAU roll-out will therefore start with the roll-out to all of SPN, followed by EPN and LPN.

There is no immediate need to roll out CA SPN-wide or to other licensed areas (although the need for CA is expected to increase as more renewable generation is connected to the grid). To roll out CA now to all of SPN and/or other licensed areas would require a substantial data mapping effort. The time and effort required for this cannot be justified with regard to the upcoming automated CIM export capabilities and the possibilities for a more consistent and automated workflow that provides. The roll-out of CA into BAU is therefore scheduled to happen after the roll-out of full CIM capabilities for GE PowerOn in UKPN, in Q4 2018.

More information on the transition to BAU can be found in our SDRC 9.6 report.
12. Learning dissemination

The KASM project incorporated the use of software, hardware and soft measures that produced various streams of knowledge and lessons learnt. It is expected that the project’s conclusions will have the most impact with DNOs, TNOs and distributed generation developers. Other parties that would potentially benefit from the knowledge generated by KASM are academic institutions, the Department for Energy and Industrial Strategy (BEIS), Ofgem, the Energy Networks Association (ENA) and various smart-grid stakeholders and groups.

Stakeholder engagement is a vital way of communicating project activities to interested parties; the information transfer process was therefore bi-directional so that information fed back to the UKPN project team. The high-level knowledge dissemination plan for the project is shown in Figure 11.

![Figure 11: KASM high-level plan providing an overview of the project knowledge dissemination](image)

<table>
<thead>
<tr>
<th>Year</th>
<th>Q1</th>
<th>Q2</th>
<th>Q3</th>
<th>Q4</th>
<th>Q1</th>
<th>Q2</th>
<th>Q3</th>
<th>Q4</th>
<th>Q1</th>
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</tbody>
</table>

The specific mechanisms and activities are discussed below.

12.1 Leveraged existing learning

Where possible, the project leveraged learning from other related projects. Specifically, the project gathered and built upon lessons learnt from previous implementations of ICCP links. This involved engaging with Electricity North West to understand their approach to implementing an ICCP and the key learning generated.
12.2 Learning dissemination mechanisms

Learning was disseminated throughout the project lifecycle via various mechanisms, as listed in Table 3. For each mechanism the number of instances/occurrences is provided. Specific dissemination activities and documents are discussed in Section 12.3.

Figure 12: UKPN’s KASM Project Lead and BSI’s Founder and President presenting at LCNI 2017

<table>
<thead>
<tr>
<th>Mechanism</th>
<th>Number of instances/occurrences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project website</td>
<td>1</td>
</tr>
<tr>
<td>Progress reports</td>
<td>6</td>
</tr>
<tr>
<td>SDRC reports</td>
<td>6</td>
</tr>
<tr>
<td>Webinars</td>
<td>2</td>
</tr>
<tr>
<td>Conferences, workshops, fora and panels</td>
<td>16</td>
</tr>
<tr>
<td>Press releases and social media</td>
<td>2</td>
</tr>
</tbody>
</table>
12.3 Specific dissemination activities and documents

In this section we highlight some specific key dissemination activities and documents.

12.3.1 Conference presentations, posters and papers

Throughout the KASM project the team actively sought to participate in international conferences, gathering feedback from and sharing knowledge with stakeholders in the public and private sector, ranging from fellow DNOs and TNOs to academics, consultants, vendors and suppliers. Key papers, posters and talks presented at these conferences are listed in Table 4.

<table>
<thead>
<tr>
<th>Conference</th>
<th>Contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIRED 2016 Conference</td>
<td>Poster: “Challenges in Model and Data Merging for the implementation of a Distribution Network Contingency Analysis Tool”</td>
</tr>
<tr>
<td>LCNI 2016 Conference</td>
<td>Presentation: “Kent Active System Management”</td>
</tr>
<tr>
<td>CIRED 2017 Conference</td>
<td>Paper and poster: “Challenges in Model and Data Merging for the implementation of a Distribution Network Contingency Analysis Tool”</td>
</tr>
<tr>
<td>LCNI 2017 Conference</td>
<td>Presentation: “Kent Active System Management”</td>
</tr>
</tbody>
</table>
12.3.2 Industry awards
The project was shortlisted for three industry leading awards, as shown in Table 5. This industry recognition is testament to the quality and contributions the KASM project has delivered over the past three years.

Table 5: Awards for which KASM was shortlisted

<table>
<thead>
<tr>
<th>Award</th>
<th>Category</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>UK IT Industry Award 2016</td>
<td>Infrastructure Innovation</td>
<td>Shortlisted</td>
</tr>
<tr>
<td>Energy Institute Awards 2017</td>
<td>Technology</td>
<td>Shortlisted</td>
</tr>
<tr>
<td>IET Innovation Awards 2017</td>
<td>Power</td>
<td>Highly Commended</td>
</tr>
</tbody>
</table>

12.4 Learning and dissemination workshop – April 2017
The project held a learning and dissemination workshop with internal and external stakeholders at the IET in London on 12 April 2017. All DNOs were invited to the event and all bar one attended. The attendees represented a broad range of roles within each DNO, allowing varying points of view to be captured.

The workshop consisted of four presentations with time allowed in between for interactive questions and discussion. The following four topics and messages were disseminated:

- Learning from installation of a contingency analysis tool
- Our ICCP link
- The benefits and challenges associated with short-term load and generation forecasting
- An introduction to Power Potential (TDI 2.0)

Approximately 20 people attended and the post-event feedback was extremely positive with attendees rating the event as either ‘Excellent’ or ‘Very Good’.

Figure 13 shows a photo taken of a KASM team member presenting at the learning and dissemination event hosted at the IET.
12.5 **Project close-down event – March 2018**

The project team hosted an interactive close-down event at Altitude in London on 22 March 2018 where a range of stakeholders, including other DNOs, were invited to discuss the learnings from the entire project.

This dissemination event was a valuable opportunity for other DNOs who are planning to implement similar tools to understand key risks and lessons learnt during the three years of the project. In addition, it highlighted the benefits that the KASM solutions can deliver to DNOs and their customers. KASM has highlighted a number of opportunities where DNOs can deliver smart savings.

Over 35 people attended the event which was rated by participants as either ‘Excellent’ or ‘Very Good’. A total of 10 interactive presentations were given which were rated with an average score of 4.5 out of 5.

Figure 14 shows a photo taken at the event where UKPN's Head of Innovation stressed the importance of innovation for UKPN.
12.6 **Peer review of Close-Down Report**

This report was peer reviewed by SP Energy Networks (SPEN) who has confirmed that UKPN has successfully demonstrated the feasibility and viability of CA in distribution networks. The letter from SPEN containing its feedback can be found in Appendix A – Peer Review Supporting Letter).
13. Key project learning documents

Key KASM learning documents and project progress reports are tabulated below. More project documents can be found on the KASM project website.

13.1 SDRC reports

<table>
<thead>
<tr>
<th>Document Title</th>
<th>Publication Date</th>
<th>Document Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDRC 9.1</td>
<td>December 2015</td>
<td>Strategy for Inter-Control Centre Communication Protocol (ICCP)</td>
</tr>
<tr>
<td>SDRC 9.2</td>
<td>November 2016</td>
<td>Contingency Analysis System Integration</td>
</tr>
<tr>
<td>SDRC 9.3</td>
<td>November 2016</td>
<td>Installation of forecasting modules</td>
</tr>
<tr>
<td>SDRC 9.4</td>
<td>June 2017</td>
<td>Demonstration of use of real-time contingency analysis in the control room</td>
</tr>
<tr>
<td>SDRC 9.5</td>
<td>December 2017</td>
<td>Completion of Trials and Implementation of Reliability Management, Outage Management and Network Capacity Management</td>
</tr>
<tr>
<td>SDRC 9.6</td>
<td>December 2017</td>
<td>Development of Business Design to incorporate Contingency Analysis as Business as Usual</td>
</tr>
</tbody>
</table>

13.2 Project progress reports

During the project, progress reports were submitted to Ofgem every six months. These reports tracked progress against plan for the individual workstreams and the project as a whole, discussed deliverables, learning and dissemination activities, and listed identified risks and mitigation measures. Table 7 lists these reports and their location on UKPN’s innovation website.

<table>
<thead>
<tr>
<th>Document Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>KASM Project Progress Report June 2015</td>
</tr>
<tr>
<td>KASM Project Progress Report December 2015</td>
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<tr>
<td>KASM Project Progress Report June 2016</td>
</tr>
<tr>
<td>KASM Project Progress Report December 2016</td>
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<tr>
<td>KASM Project Progress Report June 2017</td>
</tr>
<tr>
<td>KASM Project Progress Report December 2017</td>
</tr>
</tbody>
</table>

13.3 Miscellaneous additional reports

Various other documents were published during the project that contain key learnings and insights, notably conference papers and posters (please see Section 12.3.1).
14. Contact details
Details of the project and its learnings can be found on the KASM website.

For further details, please contact:

Alex Jakeman and Luca Grella
innovation@ukpowernetworks.co.uk
Kent Active System Management
UK Power Networks
237 Southwark Bridge Road
London
SE1 6NP
Appendix A – Peer Review Supporting Letter

Alex Jakeman
Project Lead – KASM
UK Power Networks
Newington House
237 Southwark Bridge Road
London
SE1 6NP

Dear Alex,

Kent Active System Management (KASM) Close-Down Report – DNO Peer Review

Further to your request for SP Energy Networks to review and comment on the Close-Down Report produced in respect of UK Power Networks Kent Active System Management (KASM), NIC funded project, I can confirm that we have undertaken the review and consider that the objectives and deliverables as agreed in the Project Direction have been satisfied by UK Power Networks.

In addition, subject to the requirements of the NIC funding governance arrangements, we can confirm that we consider that the Close-Down Report as reviewed by SP Energy Networks is clear and understandable and contains sufficient detail and information to enable a DNO, not closely involved with the project, to make use of the learning generated to implement their own network solution and which would enable improved wider network visibility and interface directly with the GB Transmission System Operator, National Grid as part of a Business As Usual offering.

Should you wish to discuss anything further or have any additional requirements that you need to address in respect of the KASM project, please do not hesitate to contact me.

Yours sincerely,

Ewen Campbell Norris
Senior Project Manager
Network Technical Service

SP House, 320 St Vincent Street, Glasgow, G2 5AD
Telephone: 0141 014 0038
www.senergynetworks.co.uk
## Appendix B – Successful Delivery Reward Criteria

<table>
<thead>
<tr>
<th>SDRC</th>
<th>Description of SDRC</th>
<th>Deadline</th>
<th>Result &amp; Evidence</th>
</tr>
</thead>
</table>
| 9.1  | *Development of the strategy for inter-control room communication protocol for the purposes of KASM*  
- Published report on key technical and commercial challenges relevant to inter-control room link and the KASM project, whether proposed by the KASM team or raised by stakeholders, including other DNOs;  
- Implementation guidelines for the inter-control room communication link in consultation with National Grid for use by the project. | 31 December 2015 | Completed on time  
- The SDRC 9.1 report “Strategy for Inter-Control Centre Communication Protocol (ICCP)” was submitted to Ofgem on 29 December 2015.  
- The SDRC 9.1 report is published on UKPN’s [KASM website](https://kasm.ukpn.co.uk). |
| 9.2  | *Completion of the system integration of Contingency Analysis (CA) software into UK Power Networks systems, excluding a real-time link to National Grid*  
- Sign-off on set up of CA software;  
- Sign-off on successful demonstration and testing of CA software; and  
- Published report on CA software integration that includes the control room IT architecture, lessons learned, engagement with other DNOs, and identified risks. | 31 March 2016  
Revised: 30 November 2016 | Completed on time as per approved change request  
- Due to unforeseen complications in data extraction, the project team submitted a change request to extend the SDRC 9.2 deadline by eight months. This change request was approved by Ofgem.  
- The SDRC 9.2 report “Contingency Analysis System Integration” fulfilled all the SDRC 9.2 criteria. Supporting evidence can be found in Table 1 of the SDRC 9.2 report (page 7).  
- The SDRC 9.2 report and its six appendices were submitted to Ofgem on 30 November 2016. The SDRC 9.2 report is published on UKPN’s [KASM website](https://kasm.ukpn.co.uk). |
<table>
<thead>
<tr>
<th>SDRC</th>
<th>Description of SDRC</th>
<th>Deadline</th>
<th>Result &amp; Evidence</th>
</tr>
</thead>
</table>
| 9.3  | **Completion of installation of forecasting modules that will link the DNO control room with other data sources** | 31 March 2016 | **Completed on time as per approved change request**  
- Due to unforeseen complications in data extraction, the project team submitted a change request to extend the SDRC 9.2 deadline by eight months. This change request was approved by Ofgem.  
- The SDRC 9.3 report “Installation of forecasting modules” fulfilled all the SDRC 9.3 criteria. Supporting evidence can be found in Table 1 of the SDRC 9.3 report (page 7).  
- The SDRC 9.3 report was submitted to Ofgem on 30 November 2016.  
- The SDRC 9.3 report is published on UKPN’s KASM website.  |
|      | - Sign-off on installation of forecasting modules;  
- Forecast data, benchmarked for accuracy against historical data;  
- Published report demonstrating forecasts including each of solar, on-shore wind and off-shore wind;  
- Forecast error curves plotted at primary substation, 132kV circuit, and GSP levels;  
- Description of integration architecture with the overall solution;  
- Published report on data aggregating forecasting modules that includes lessons learned and identified risks. | Revised: 30 November 2016 |  |
| 9.4  | **Demonstration of use of real-time contingency analysis in the control room** | 31 December 2016 | **Completed on time as per approved change request**  
- Due to a knock-on effect of the delayed delivery of SDRCs 9.2 and 9.3, the project team submitted a change request to extend the SDRC 9.4 deadline by six months. This change request was approved by Ofgem.  
- The SDRC 9.4 report “Demonstration of use of real-time contingency analysis in the control room”, including one appendix, fulfilled all the SDRC 9.4 criteria. Supporting evidence can be found in Table 1 of the SDRC 9.4 report (page 6).  
- The SDRC 9.4 report and its appendix were submitted to Ofgem on 14 June 2017 in line with the new timelines agreed.  
- The SDRC 9.4 report and its Appendix – Survey template are published on UKPN’s KASM website. | Revised: 15 June 2017 |  |
|      | - Demonstration of contingency results from live SCADA readings, supplied within 15 minutes of them being collected;  
- Completion of user survey identifying the most critical forecast time periods perceived by control room users (e.g. next 15 mins; tomorrow; next shift);  
- Published report with description of the solution, the user interface, and the capabilities. |  |  |
<table>
<thead>
<tr>
<th>SDRC</th>
<th>Description of SDRC</th>
<th>Deadline</th>
<th>Result &amp; Evidence</th>
</tr>
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<tbody>
<tr>
<td>9.5</td>
<td><strong>Completion of trials and implementation of reliability management, outage management and network capacity management</strong>&lt;br&gt;• Published results from functional trials and the achieved benefits in reduced distributed generation curtailment;&lt;br&gt;• Published report demonstrating data collection from Grain, Kemsley, Cleve Hill, Canterbury North, Sellindge, Dungeness and Ninfield 400kV network and sensitivity of the contingency analysis results to this data;&lt;br&gt;• List of connection offers that have been linked to reinforcement when assessed using conventional processes, and identification of those that have been revised to remove the reinforcement requirement after being assessed using the trialled methodology; quantification of the released network capacity based on the comparison of the above list;&lt;br&gt;• Published report on considerations for selecting, designing and installing CA software for each use case.</td>
<td>31 December 2017</td>
<td><strong>Completed one week early</strong>&lt;br&gt;• The SDRC 9.5 report “Completion of Trials and Implementation of Reliability Management, Outage Management and Network Capacity Management” and its associated four appendices fulfilled all the SDRC 9.5 criteria. Supporting evidence can be found in Sections 4, 5 and 6 of the SDRC 9.5 report (pages 12-34).&lt;br&gt;• The SDRC 9.5 report and its four appendices were submitted to Ofgem on 22 December 2017. The SDRC 9.5 report and all appendices are published on UKPN’s <a href="#">KASM website</a>.</td>
</tr>
<tr>
<td>9.6</td>
<td><strong>Development of business design to incorporate contingency analysis as business-as-usual</strong>&lt;br&gt;• Identification of business areas impacted by the introduction of contingency analysis in a Distribution Network Operator&lt;br&gt;• Outline of proposed changes to systems, policies and processes required in the DNO operating model in order to incorporate contingency analysis as part the business as usual operation</td>
<td>31 December 2017</td>
<td><strong>Completed one week early</strong>&lt;br&gt;• The SDRC 9.6 report “Development of Business Design to incorporate Contingency Analysis as Business as Usual” and its associated appendix fulfilled all the SDRC 9.6 criteria. Supporting evidence can be found in Table 1 of the SDRC 9.6 report (page 12).&lt;br&gt;• The SDRC 9.6 report and its appendix were submitted to Ofgem on 22 December 2017. The SDRC 9.6 report and its appendix are published on UKPN’s <a href="#">KASM website</a>.</td>
</tr>
</tbody>
</table>