DISTRIBUTION RESTORATION ZONE CONTROL System (DRZCS)

FUNCTIONAL AND NON-FUNCTIONAL REQUIREMENTS

1. Table of Contents

PURPOSE AND SCOPE

The purpose of this document is to define functional and non-functional requirements for a **Distribution Restoration Zone Control System (DRZCS)** for use where a **Network Operator** chooses to deploy a **DRZCS** to operate and manage a **Distribution Restoration Zone (DRZ)**. This document defines the required functional and non-functional requirements of a **DRZCS** but does not dictate or recommend any aspect of how a **DRZCS** should be implemented. As such the standard should be taken as guidance for the design and procurement of the **DRZCS** rather than a fully detailed specification.

This document applies to a **Network Operator** where they choose to deploy a **DRZCS** to operate and manage a **DRZ**.

1. DRZCS requirements

1.1 DRZCS generic requirements

The sections below list the generic functional and non-functional requirements for the **DRZCS**. The requirements are grouped into several sections.

1.1.1 Power Island control

General

- The **DRZCS** shall be able to balance **Demand** and generation to maintain stability of the **DRZ.**
- The **DRZCS** shall be capable of maintaining voltage stability within defined limits via **Restoration Contractors**' **Plant** or **Apparatus**.
- The **DRZCS** shall be capable of maintaining **Frequency** stability within defined limits via **Restoration Contractors**' **Plant** or **Apparatus**.
- The **DRZCS** shall be capable of simultaneously managing multiple **Restoration Contractors**' **Plant** and **Apparatus** which may comprise different technologies.
- The **DRZCS** shall be capable of managing **Restoration Contractors**' **Plant** and **Apparatus** which may have the capability to operate in a variety of different operating modes (e.g., PV, PQ, **Frequency** sensitive mode).
- The **DRZCS** shall be capable of issuing set points and other control parameters to **Restoration Contractors**' **Plant** and **Apparatus**.
- The **DRZCS** shall be capable of simultaneous control of **Active Power** and **Reactive Power** to/from **Restoration Contractors**' **Plant** and **Apparatus** or devices installed within the **DRZ.**
- The **DRZCS** shall be capable of supporting manual intervention by the **Network Operator**, and the **Restoration Contractor** to the **Network Operator's** instruction, in combination with automatic control, although, all parties should have the abilities to manually operate **Plant** where there is a risk to the safety or personal or damage.
- The **DRZCS** shall accommodate different **Network Operators** and **Restoration Contractors**' **Plant** and **Apparatus** configurations.

Fast Balancing

- The **DRZCS** shall be capable of issuing instructions to **Restoration Contractors' Plant** and **Apparatus** to ensure that there is sufficient fast balancing response (both pickup and drop-off)

available to maintain the generation/load balance of the **Power Island** when subject to credible disturbances.

- The **DRZCS** shall be capable of continually monitoring the stability of the **Power Island** to detect any disturbances which cannot be managed by the **Restoration Contractors**' **Plant** and **Apparatus**. The **DRZCS** is to execute a fast-acting mitigating control action or raise an alarm when there is a disturbance.
- If the **DRZCS** is unable to restore the **Frequency** of the **Power Island** to within pre-defined limits (e.g., either a fast **Frequency** resource didn't deliver the service as expected, or there wasn't sufficient fast **Frequency** resource at the time of the **Event**) the **DRZCS** should take all actions necessary to ensure that the **Anchor Generator** remains energised and connected to the **Network Operator**'**s System** where possible.
- The **DRZCS** shall be capable of determining if there is insufficient fast response resource to respond to credible disturbance **Events** (e.g. block load, energisation steps, generation trips and feeder trips). An alarm shall be raised immediately when the deficit is identified and not as a result of a post-**Event** disturbance.
- The **DRZCS** shall be capable of restoring the **Frequency** of the **DRZ** within agreed limits under credible conditions of **Demand** variability. The credible conditions will be determined by the **Network Operator** / ESO for each **DRZ** during the development of the **Distribution Restoration Zone Plan (DRZP)** which will establish the required fast **Frequency** response resource reserves.

Slow **Balancing**

- The **DRZCS** shall be capable of distributing **Active Power** changes required to maintain the **Target Frequency** among the various **Restoration Contractors** based on a priority e.g., pre-determined feeder priority, pro-rata, speed of response, technical best, proximity etc.

- The **DRZCS** shall be capable of instructing various **Restoration Contractors** to indirectly increase or decrease the **Active Power** output to create more **Headroom**/footroom**.**

Block loading

- The **DRZCS** shall be capable of calculating the volume of **Block Loading Capability** (pickup/acceptance and reduction/drop-off/rejection capability) within the **DRZ.**

- The **DRZCS** shall be capable of establishing whether each load block is within the appropriate or aggregate **Restoration Contractors**' **Plant's** or **Apparatus's Block Loading Capability**. The **DRZCS** shall inhibit automatic block loading action that exceeds the established capacity.

- The **DRZCS** shall only allow a block loading action that exceeds the capacity identified above where a manual instruction, to implement the block loading or over-ride an inhibited block loading action, has been issued.

- The **DRZCS** must use other **Restoration Contractors**' **Plant** and/or **Apparatus** to complement the volume of **Block Loading Capability** required of the **Restoration Contractors** and therefore increase and decrease the effective **Block Loading Capability** of the **DRZ.**

Distribution **N**etwork Energisation

- Once the **Anchor Generator** has energised part of the **Network Operator's System,** the **DRZCS** must determine i) when the **Start-Up** has been completed successfully (using measurements and any other relevant signals from the **Anchor Generator**) and ii) when the system is stable to begin energising parts of the wider **Network Operator's System.**

- The **DRZCS** must be capable of determining i) when to energise the sites of **Restoration Contractors** who provide Top-up services and ii) when to request a **Restoration Contractor** to synchronise to and subsequently begin exporting or consuming **Active Power** and/or **Reactive Power**.
- The **DRZCS** shall be capable of directly (e.g. direct communication with a remote terminal unit (RTU) or circuit breaker (CB) trip circuitry) or indirectly (e.g., via SCADA/DMS) controlling circuit breakers associated with **Restoration Contractors Plant** and **Apparatus** and those circuit breakers in the **Network Operator's System,** required to impose block loads, where required by the **DRZP**.

1.1.2 Overall Power Island Control and Monitoring (OPICM)

- Where a **Network Operator** installs **DRZCS** for each of its **Distribution Restoration Zones**, a central controller shall also be required to co-ordinate the operation of each **Distribution Restoration Zone Controller**.
- While maintaining stability and observing all operational limits with the **DRZ**, the **DRZCS** shall aggregate P and Q services from the **Restoration Contractors**' **Plant** and **Apparatus** within its controlled area to the **Interface Point**(**s**) with the wider network.
- The **DRZCS** shall calculate available **Active Power** (P) and available **Reactive Power** (Q) volumes in real time.
- The **DRZCS** shall be capable of providing both services (P and Q) simultaneously and independently. Therefore, separate service requests can be sent for P and Q.
- The **DRZCS** shall be capable of dispatching set points to control **Restoration Contractors**' **Plant** and **Apparatus** to produce or absorb **Active** and **Reactive Power** output in real time.
- The **DRZCS** shall be capable of executing a pre-determined set of actions to prepare for energisation of the **Transmission Network** (or other wider sections of the **Network Operator's System**), such as instructing that all **Restoration Contractors**' **Plant** to be placed in voltage control mode or instructing the **Anchor Generator** to operate to a specific **Power Factor** or **Reactive Power** output (to lessen the voltage step change on energisation).
- When synchronising two **Power Islands** or operating while **Synchronised** to the wider network outside the bounds of the **DRZ**, the **DRZCS** is required to report the overall **Active** and **Reactive Power** resources available for control within the **DRZ.**

1.1.3 Communications Monitoring and Fail-Safes

The following requirements are typical of an autonomous control system deployed to **GB** distribution **Systems** (e.g., active network management (ANM) system). As a basis it can be assumed that these requirements also apply to a **DRZCS**.

- The **DRZCS** shall monitor the health of the system (e.g., communication channels, measurements) at all times, and not only when activated as part of a **System Restoration Event**. The **DRZCS** should raise an alert to the **Control Centre** when errors are detected.
- The **DRZCS** shall have the functionality to monitor the health of the communication channels between the centralised and decentralised hardware (if any) components of the **DRZCS** solution and take appropriate fail-safe actions upon a failure or loss of the communications between the components. The agreed actions will range from tripping the **Restoration Contractors**' site, or

individual **Plant** or **Apparatus**, through to a holding position of the output of the **Restoration Contractors**' **Plant** or **Apparatus**.

- The **DRZCS** shall be required to monitor the health of the communication channel between each **Restoration Contractor's** control **System** and the interfaced **DRZCS** device (e.g., a **Restoration Contractor's Plant** controller). In the event of a loss of communication channel, undertake an action that implements an agreed fail-safe action.
- The **DRZCS** shall be required to monitor the health of the communication channel to all measurement devices and validate the health/quality of all critical measurements. If appropriate, the **DRZCS** should implement an appropriate mitigating action, such as using a different measurement source, or implementing a fail-safe action.
- The **DRZCS** shall have the functionality to detect and respond by taking a mitigating action in disconnecting a **Restoration Contractor's** site or individual **Plant** or **Apparatus**, for a failure to respond to or non-compliance with an instruction issued by the **DRZCS**.
- The **DRZCS** shall have the functionality to re-connect **Restoration Contractor's Plant** or **Apparatus** to the distribution system of the relevant DNO following a tripping instruction issued by the **DRZCS** only (e.g., tripped due to non-compliance or as an emergency balancing measure). Also, it shall have the ability to differentiate when a tripping instruction has not been initiated by the **DRZCS** (e.g., tripped by a protection system) in the course of its normal and agreed operation. Therefore, to execute a corresponding action to not re-energise the relevant **Restoration Contractor's** site (or **Plant** or equipment) until further instruction is received from the relevant **Network Operator**'**s** operational **Control Centre** that the **Restoration Contractor** can be reconnected to the network.

1.1.4 System Maintenance/Engineering

- The **DRZCS** shall allow for all configurable parameters of the **DRZCS** to be modified without a **Restoration Contractor's Plant** or **Apparatus** needing an outage.
    - The **DRZCS** shall allow for the maximum and minimum rated controllable power from a **Restoration Contractor's Plant** or **Apparatus** to be configurable.
    - The **DRZCS** shall have the functionality to add or remove additional Distributed energy resource (DER) from the **Network Operator's System** without any requirement for full **Shutdown** of the **DRZCS** or adverse interruption to the normal day-to-day **Operation** of existing DER connected and managed by the **DRZCS**.
    - The **System** shall allow the useable **Block Loading Capability** of the **Anchor Generator** to be **User** defined.
- The **DRZCS** shall provide warning to the supervising **Operator** when the remaining **Block Loading Capability** of the **Power Island** is insufficient to energise any further **Demand** blocks.
- Any **DRZCS** component which is co-located with each controlled DER (DER Controller) should support local and remote access to diagnostic information. It should be possible to see the operational state of all elements. This should include (based on access rights):
    - Current status of all I/O signals
    - Communications status
    - Sequence of event logs
    - Syslog
    - Software modules and versions
    - Battery status
    - Hardware module status
    - Real-time **Event** log

1.1.5 Wider Network Synchronisation

Before, during and after the process of synchronising to the wider network, the **DRZCS** is required to contribute to the stability of the **Power Island**. It is expected that the **Anchor Generator** site will be provided with a remote measurement at the point of interface, and the **Anchor Generator** will ramp the **Plant** output up/down (and any other actions necessary as determined by the **Anchor Generator**) to align the **Power Island** with the wider network. Once **Frequency** and voltage are in synchronism, a synchro check relay operating at the interface will allow the associated circuit breaker to be closed.

The following requirements are relevant to the **DRZCS** during synchronisation:

- The **DRZCS** is required to dispatch pre-determined set points (e.g., voltage or **Frequency** set points) or control modes (e.g., request enter voltage control mode if not already) to **Restoration Contractors' Plant** to prepare the **DRZ** for synchronisation with the wider system.
- Once **Synchronised** to the wider system, the **DRZCS** is required to report dispatchable **Active** and **Reactive Power** to the supervising **Control Centre**, i.e., operate the **Power Island** as a virtual power **Plant** (associated requirements are listed in section 1.1.2).

1.1.6 Wider Network Energisation

When the **DRZ** is requested to energise a part of the wider system, there are expected to be significant voltage fluctuations associated with energising various assets on the distribution and **Transmission Systems** (e.g., GSP transformers). The wider system to be energised could consist of an adjoining interconnected distribution system, however in most cases the **DRZ** will energise sections of the **Transmission Network** (132kV in Scotland and 275kV or 400kV in England and Wales and Scotland).

The following requirements are relevant to the **DRZCS** during energisation of a wider network:

- The **DRZCS** is required to dispatch pre-determined set points (e.g., voltage or **Reactive Power** set point) or control modes (e.g., ability to enter voltage control mode or **Reactive Power** mode) to **Restoration Contractors**' **Plant** to prepare the **DRZ** for the wider network energisation
- The **DRZCS** is required to report to the **Control Centre**, available resources of the **Power Island** as **Active Power** range (generation and load) and **Reactive Power** range (absorbing and exporting) in advance of any switching actions taken to energise the wider network, i.e., operate the **Power Island** as a virtual power **Plant** before, during and after the energisation process.

1.1.7 Visualisation

The requirements listed below should not be considered firm or essential; they are provided as example requirements that may be appropriate. Individual **Network Operators** will have their own preference on how they wish the **DRZCS** application to be made visible to their control centre and other **Users**.

- A graphical user interface shall be provided for the **System** and designed in agreement with DNO and EEMUA 191. EEMUA 191 is the basis of Health and Safety Executive Guidance for **Operator** displays. The interface will provide **Users** access to important functions and provide visibility of the whole system performance. Real time **System** status information shall be displayed for each **DRZ** along with a list of alarms and points requiring **User** action. In normal

Operation, it shall be possible to see the latest data received and access trends for a relevant time period. The following information shall be visible on the main **User** interface available to the **Control Centre** operator:

- real-time **Block Loading Capability** of **Power Island**
- estimated magnitude of **Load blocks**
- generation/**Load** in reserve for fast balancing
- setpoints of all dispatched **Restoration Contractors' Plant** and **Apparatus**.

- Access to the **DRZCS** shall be limited to personnel with dedicated usernames and passwords. Each **User** shall be assigned an access level and rights for the **DRZCS** depending on their role. Examples of authorisation levels are provided below:
  - admin – full control, allowed to initiate changes to configurations etc.
  - controller – manage/operate system, unable to change settings/configurations.
  - viewer – read only, see current system status and historical **Operation**.
- The centralised component of the **DRZCS** shall provide a secure Web Server HMI that can be accessed locally or remotely. The displays should include **Restoration Contractor's** monitoring data including voltage, MW and MVAr measurements at the **Point of Connection** and current set points and connection breaker status.
- The **DRZCS** shall include an interface at the **Restoration Contractors'** site to permit local **Operation** / testing. This should support the following indications:
  - Measurement – Voltage at **Restoration Contractor**
  - Measurement – **Active Power** (MW) at **Restoration Contractor**
  - Measurement – **Reactive Power** (MVAr) at **Restoration Contractor**
  - Measurement – **Frequency** at **Restoration Contractor**
  - Control/Indication – Trip and close of any associated breaker
  - Control/Indication – MW set point to **Restoration Contractor**
  - Control/Indication – MVAr set point to **Restoration Contractor**
  - Control/Indication – Voltage set point to **Restoration Contractor**
  - Control/Indication – **Frequency** set point to **Restoration Contractor**
  - Indication – **Restoration Contractor's** restoration availability status
  - Indication – Communications status.

1.1.8 General Requirements

- The **DRZCS** shall co-ordinate with other DNO automation functions to obviate any interference with the energisation or stability of a **DRZ.**
- The **DRZCS** may integrate with the DNO DMS and be capable of using available network SCADA data.
- The **DRZCS** shall support role based access control to determine the functionality available to each **User**, e.g. viewing, administration and control.
- The **DRZCS** shall provide a data historian capability to record **Significan**t **Events** such as:
  - all control actions issued by the **DRZCS**
  - **Restoration Contractors** compliance to **DRZCS** control instructions
  - critical warnings regarding stability of the DRZ
  - monitor **Restoration Contractors** resource availability.

1.1.9 EMS/DMS requirements

The requirements listed below are recommendations which represent the majority opinion from the **DRZCS** companies' design outputs which are listed in Table 1. These recommendations are subject to change following laboratory environment testing of the solution.

- The EMS/DMS system is required to dispatch alternative **Protection** settings to DNOs/TOs **Protection** relays as required and as appropriate for each stage of restoration.
- The EMS/DMS system is required to perform a network switching schedule to enable interconnection of individual **Power Islands**. The execution of the energisation shall be co-ordinated with the **DRZCS**.
- The EMS/DMS system shall confirm that the network configuration is suitable to begin **System Restoration** before informing the **DRZCS**.
- The EMS/DMS system is required to provide the DRZCS with live network measurements associated with each block load.

Table 1 shows examples of initial **DRZCS** designs from original equipment manufacturers (OEMs).

GE digital	soft Word - GE-D_ReStart-DRZC_FunctionalDesignSpec_v2_redacted.docx (nationalgrideso.com)
SEL Engineering Services	soft Word - 021416.000.00_Rep_NationalGrid_DistributedRestart_20200902_Redact.docx (nationalgrideso.com)
Smarter Grid Solutions	download (nationalgrideso.com)
ZIV	download (nationalgrideso.com)

Table 1. **DRZCS** designs from original equipment manufacturers (OEMs).3

1.1.10 Non-Functional Requirements

The requirements listed below should not be considered firm or essential, they are provided as an initial proposal of requirements that may be appropriate. Individual DNOs will have their own policy relevant to most non-functional requirements.

Resilience

- The **Control Centre** level **DRZCS** shall be capable of hot standby in a dual redundant configuration with automatic swap-over in the event of any failure.
- The **GSP** level **DRZCS** shall be dual redundant and operate in hot-standby mode with automatic swap-over in the event of any failure.

- The **DRZCS** shall support resilient communications to the appropriate **Control Centre**(**s**) for managing and overseeing the restoration sequence.
- All field equipment shall have a proven track record of reliability in substation environments and should be deployed in BAU for similar applications.

Cybersecurity

- The **DRZCS** shall be penetration tested by an independent third-party company and a report made available with the system.
- The **DRZCS** software shall be scanned on a regular basis for vulnerabilities using a vulnerability scanning software tool and patches / security updates applied to mitigate these vulnerabilities.
- The **DRZCS** shall be protected against unauthorised access.
- The **DRZCS** shall support centralised authentication using secure Lightweight Directory Access Protocol (LDAP).
- The **DRZCS** shall support a configurable password policy which covers length, complexity, expiry, no use list, and no repeating of passwords.
- The **DRZCS** shall support authentication which is based on a role-based mechanism with each role offering a different level of access.
- The **DRZCS** shall support account lockout with a configurable timeout.
- The **DRZCS** shall record all authorised and unauthorised logins in the logs.
- The **DRZCS** shall retain logs which can be controlled to restrict them from unauthorised access.
- The **DRZCS** shall be capable of transferring all data in a secure and encrypted manner, including the transmittal of passwords, i.e., they are not transmitted in plain text.
- The **DRZCS** should support system hardening by removing unused applications and closing unused ports.

Availability

- The **DRZCS** shall utilise a real time operating system and is required to function 24/7, 365 days per annum and have a minimum in-service availability of 99.99% per annum. The architecture of the **DRZCS** shall be such that a failure of a single server does not cause the **DRZCS** to fail or detrimentally affect the performance of connected **Restoration Contractors** had the failure not occurred.

Timestamp

- The **DRZCS** shall conform to an agreed timestamp mechanism, once the overall clocking arrangement has been designed. It will synchronise with relevant network field devices and/or **Restoration Contractor's** interface equipment that forms part of the **System** that in turn will be sourced from the existing DMS relevant to the distribution system area.
- The purpose of the timestamp will be to assign a sequence order for any action or instruction undertaken or issued by the **DRZCS** and which can be used for post-**Event** auditing and/or settlement of **Ancillary Services.**
- Measured values used by the **DRZCS** must have a consistent timestamp that should be **Synchronised** across all critical **DRZCS** components including **Restoration Contractor's** controller equipment and where a timestamp is distributed to the control system of the managed **Restoration Contractor**.

Maintainability

- It is a requirement that all **DRZCS** shall require no routine or planned maintenance. The **DRZCS** shall have no fans or moving parts. The **DRZCS** shall have no memory backup batteries.
- The **DRZCS** must be able to restart unaided from power on, communication failure and a hard or soft restart.
- All **DRZCS** will be supported by module or unit repair only for a minimum period of 10 years. All **DRZCS** supplied will be supported by module replacement for a minimum period of 20 years

2. Functional Specifications for Operational Telecommunications of DRZCS

2.1 Functional Requirements

This document provides the telecommunications functional requirements for **DRZCS**

- Technical requirements
- Configuration, environmental and other requirements
- Bandwidth requirements
- Power resilience requirements
- Supported protocols
- Cyber security considerations.

2.1.1 Technical Requirements

Table 2 lists the technical requirements for telecommunications infrastructure to support data and voice communication for both the manual and automated control modes of restoration process.

The technical requirements to support the telecommunications networks are described in terms of various considerations including interfaces, protocols, bandwidth, latency, environmental, configurations and power requirements. The technology type and network configuration play a crucial role in determining whether the technical requirements are met, the critical parameters being data rates, latency, bandwidth and independent power resilience of the end-to-end solution.

Requirements	Description	Values

End-to-End Delay	This defines the maximum allowable communication channel 'end-to-end' delay.	The maximum allowable communication channel 'end-to end' delay for the different categories should not exceed the specifications for teleprotection systems (ENA 48-6-7). Category 1 – 6 milliseconds Category 2 – 10 milliseconds Category 3 – 30 milliseconds SCADA services – 100 milliseconds The Central Model which incorporates a **DRZ** will require the following: Fast balancing action/Phasor measurements – 30 milliseconds Slow balancing action – 90 milliseconds No time critical data – 100–200 milliseconds
Differential Delay	The requirements for differential delay under steady state conditions.	The maximum admissible differential delay for the different categories should be as specified. (ENA 48-6-7). Category 1 – 400 microseconds Category 2 – 10 milliseconds Category 3 – 30 milliseconds
Jitter	This defines the maximum permissible jitter.	The maximum permissible jitter shall be according to ITU-T G.823 (2048kbit/s) specifications for a digital service, ITU-T G.824 (1544kbit/s), ITU-T G.825 (SDH) as appropriate.
Manual Switching	This will define the capability for manual and automatic switching.	It shall have the ability to disable automatic switching for specific services, e.g. SCADA and protection services.
Specifications for Communications Protocol Requirements	The requirements to specify the communication protocol that needs to be supported.	It should support protocols required for SCADA, protection and voice services such as DNP3.0, 6870-5-110, **IEC** 608705 – 101, ICCP (60870-6), 61850 Secure File Transfer Protocol (SFTP) SNMP v3 (for device management) TCP/IP, MPLS,61850, 61870-104, Modbus, C37.94. x21, RS232/485, audio. The protocol requirement for an automated restoration is listed in protocol table (table 7)
Telephone **User** Requirements	This defines the **Control Centre** and substation telephone **User** requirements.	The operational telephony system shall be designed to meet the **Control Centre** and substation **User** requirements. (See section 2.3).

Table 2: Technical requirements

2.1.2 Configuration, Environmental and Other Requirements

The non-technical requirements apply to all manual and automated restoration processes. These include environmental factors, segregation, power resilience and other factors.

Requirements	Description	Values

End-to-end Service Availability	End-to-end availability for a single service A minimum of 2 separately services shall be provided	1. This shall be minimum of 99.94% over a rolling 12-month period.
Physical Separation Design	Requirements for physical separation between specified separately routed telecommunication services along the entire route for cabled services. This requirement shall not apply where the AC Power circuit is not duplicated.	1. Minimum of five metres physical separation between specified separately routed telecommunication services along the entire route. ENA 48-6-7 Issue 2. This shall be risk assessed if the above is not achievable. This applies to wired services.
Failure **Isolation** Procedures	The compliance with the principle of no knock-on failures and have proactive automatic **Shutdown** procedures in place to prevent a failure of network equipment triggering maloperation of other non-directly interconnected network equipment or systems within the application layer.	Compliance with principle of no knock-on failures as in the description. ENA 48-6-7 Issue 2.
Restoration of Service	Priority to restoration of service.	Priority to restoration of service in accordance with ENA 48-6-7 Issue 2.
Segregation of Circuits	Requirements for segregation of network for localised disaster **Events**, such as storm damage, flooding etc, not to cause degradation of service.	Circuits should be segregated such that localised disaster **Events** (storm damage, flooding etc) would not result in degradation of service. This applies to wired services.
Location of Equipment	Requirements for **Location** of equipment securely and away from areas liable to flooding.	Required as in the description.
Change of Routes	Requirements for continued service operation where service route has changed, e.g. due to network failure or planned infrastructure change.	Required as in the description. ENA 48-6-7 Issue 2.
Power Source	Requirements for type of power source, redundancy and specifications.	The telecommunications equipment shall be designed to operate from a 24V/48V/110V DC power source. The equipment shall be capable of being powered from two separate supplies. ENA 48-6-7 Issue 2.
High Voltage Sites	Requirements for installations and safety at hot sites.	All fibre inlet cables and cross-site links must not contain any metallic elements e.g. foils or strength members. If copper is used at hot

		sites (e.g. for PSTN, ISDN, SCADA, **Operational Data** or telephony services) then the metallic conductors shall be isolated from earth by an approved **Isolation** barrier. No joints are permitted in the hot zone. Only hot site trained personnel are permitted to install or work on copper delivered infrastructure.
Environmental Performance	Requirements for environmental and test performance of equipment at **HV** electrical substations.	Equipment located in substations and power stations shall be immune to electrical interference. All proposed equipment shall comply with BS EN 61850-3.
Equipment Design	Requirements for equipment to work without error or degradation for the environmental conditions specified for these **Locations.**	It shall be designed to work without error or degradation for the environmental conditions specified for these **Locations.**
Operation in Extended Temperature Ranges	Requirements for equipment to work at certain temperatures	Where mounted within an enclosure, it shall be capable of normal **Operation** at a temperature 15°C higher than the upper temperature limit of the environmental class. When operating in extended temperature ranges the equipment should use passive cooling to minimise power requirements and to avoid reliance on any active components such as fans.
Earthing in Substation Telecommunications Room	Requirements for **Earthing** in substations.	The **Earthing** policy adopted should be such that the performance of existing substation equipment will not be impaired. See also ENA 48-6-7 Issue 2.
EMC Requirements	EMC requirements so it does not impair the performance of any other equipment in the substation by compromising the existing **Earthing** arrangements	All equipment installed in substations meets the EMC requirements stated and does not impair the performance of any other equipment in the substation by compromising the existing **Earthing** arrangements.
Safety and Site Access	Requirements for safe access to site and safety of equipment.	There is a requirement for the equipment to be in a secured **Location** and safe access for personnel.
Business Continuity and Disaster Recovery	Requirement for Business Continuity and Disaster Recovery procedures.	DR procedures should be capable of switching or re-routing of operational telecommunications services 24 hours per day, 7 days a week, within 15 minutes of being instructed to do so.

Table 3: Configuration, environmental and other requirements

2.1.3 Power Resilience Requirements

According to Engineering Recommendation ENA G91, the baseline requirement is for the core **Transmission** and distribution substations to be designed so that they are resilient for a minimum period of 72 hours. This means that the substation **Protection**, control and SCADA functions should be available such that the site can be safely energised within 72 hours of the inception of a **System Restoration Event**. In view of this standard and the recommendation the functional specification specifies the following:

Mains Independence	Requirements for mains independent electricity supplies to telecoms rooms at substations and **Control Centres**	In the event of a mains failure, there shall be no loss or disruption of communications services for at least 72 hours. This provision will not require manual intervention to achieve. Mains independence shall be maintained during outage and planned maintenance conditions. To achieve this, all the active devices (any device that requires power to operate) in the end to end telecommunication path for **Restoration Contractors** services shall be independent power resilient lasting up to 72 hours at least

Table 4: Power Resilience requirements

2.1.4 Bandwidth Requirements

The introduction of a **DRZCS** within the existing telecommunications network would impact the bandwidth requirements. This section articulates the bandwidth requirements for an automated restoration process. The bandwidth requirements for a manual process are the same as the normal **Operations** of the power **System** in providing data and voice communication.

There are various considerations that determine or impact the bandwidth requirements. These include:

- Type of interface
- Number of interfaces
- Protocol
- Configurations such as encryption

Interfaces can be split into 4 categories:

- Digital Only – fast balancing requirements
- Analogue and Digital – fast balancing requirements
- Analogue and Digital – slow balancing requirements
- SCADA

Communication/Interface Type	Estimated Bandwidth
Fast balancing communication link	For **IEC** 61850-9-2LE up to 5.760 Mbps per analogue measurement may be expected.
Slow balancing communication link	This is expected to be low due to the relatively slow polling rate of the protocols used (expected to be 1–2 seconds). Using DNP3.0 protocol, the bandwidth requirement is about 20 kbit/s.

Table 5: Bandwidth requirements

The table below gives an indication of the bandwidth requirements for the fast balancing communication channel using 2 different protocols (with encryption).

Location	Bandwidth Required (kbps)	
	IEC 61850 R-GOOSE	EC 60870-5-104
Central Control Site (2 fast resources)	11600	2700
Control Centre	1940	1940
Outstations (fast) (each)	6600	1800
Outstations (slow) (each)	1800	1800
Measurement only locations	1700	1700

Table 6: Bandwidth requirements per communication protocol

This is based on bandwidth calculated (x2 showing that there are two resources and R indicates a redundant system (e.g. twice the bandwidth required with a single communications link) shown in figure below.

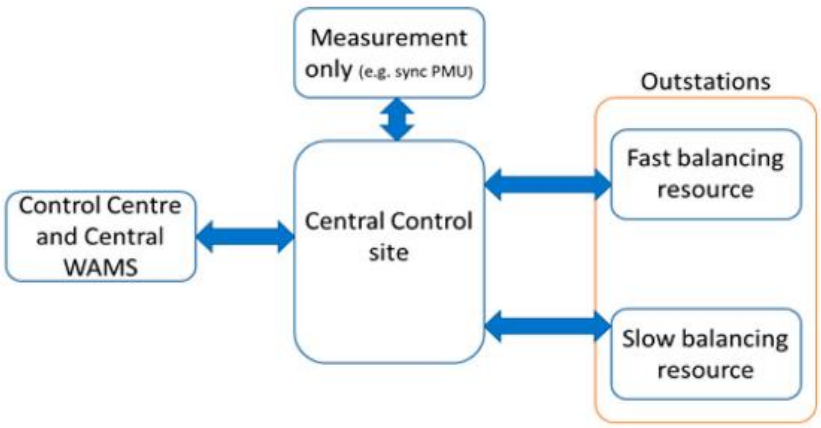

Figure 1: Schematic of architecture on which bandwidth of table 1 was calculated

2.1.5 Protocol Requirements

The Distributed ReStart project undertook design work for **DRZCS** with vendors and identified the following protocols that may be required. The protocols used could in turn influence the configuration and functional requirements. These protocols are applicable to the automated restoration process and hence the preferred Central Model.

Protocol	Purpose	Type

IEEE C37.118	Synchrophasor format for Frequency and phasor data.	Periodic with 50 Hz data rate
IEEE 1588 PTP	Time synchronisation protocol for PMUs and PhCs.	Periodic
IEC 61850 GOOSE	Fast control/protect protocol for local control actions (within substation).	Event based
IEC 61850 R-GOOSE	Fast control/protect protocol for wide-area control actions, potential use for fast balancing.	Event based
EC 60870-5-104	Non-encrypted data stream to get data/commands from legacy equipment such as resources/DMS.	Poll based but can be polled periodically.
IEC 60870-5-104 (with TLS)	Authenticated and encrypted data stream to get data/ commands across the wide-area network securely. Used for general commands/data, possible for fast balancing with development.	Poll based, but can be polled periodically, typically slower than GOOSE.
IEC 61850 MMS	Used for monitoring of the scheme, reports from devices, management of test modes and settings changes for the scheme.	Reports can be period, or **User** based for settings/control.
NTP	Network Time protocol for WAMS server.	Periodic.
DNP 3.0	Distributed network protocol used in process automation systems such as data acquisition and control systems.	Poll based, solicited and unsolicited.
SSH	Secure Shell is a cryptographic network protocol for operating network services securely over an unsecured network.	various authentication methods.

Table 7: Protocol requirements

2.2 Cyber Security Standards

The cyber security standards listed have been identified as essential in the setup of a **DRZCS** and hence are required in the automated restoration options including the Central Model.

Name	Description
IEC62351 (Components)	Standards for Securing Power system Communications.
IEC62443 (Processes and Functions)	Flexible framework to address and mitigate current and future security vulnerabilities in industrial automation and control systems (IACSs).

Table 8: Cyber security standards

2.3 Technology Suitability Summary Based on Functional Specifications

The table below lists the different technologies for the preferred Central Model and automated restoration process. The table analysed these technologies in terms of the latency, data rates and cost. The suitability of the technology for use in restoration process is largely dependent on meeting the latency requirements. The cost of deploying the technology could vary depending on several factors, including if it is a new technology deployment or extension of technology already in use at a particular site.

	Data Rate	Voice	Latency	VPN	Range	Relative Cost	Age	Restrictions
VHF/UHF	35 Kb/s	N	<50 ms	Y	Wide Area	Moderate	Dated	Low Data rates
TETRA	80 Kb/s	Y	<50 ms	Y	Wide Area + inbuilding	Very High	Dated	Low Data rates
LTE 4G/5G	10 Mb/s	Y	variable up to 500 ms	Y	Wide Area	Low	Evolving	Latency/Power Resilience/ Emergency availability
Private LTE	*	Y	*	Y	Wide Area + inbuilding	High**	Evolving	Subject to spectrum availability
Microwave	up to 1000 Mb/s	Y	<50 ms	Y	LoS	Low/ Moderate	Evolving	LoS Antenna Mounting/ Alignment

Fibre	up to 1000 Mb/s	Y	<50 ms	Y	Variable	Low to Very High***	Evolving	Accessibility/ Availability
Copper Line	100 Mb/s	Y	<50 ms	Y	Variable	Low to High	Dated	End of Life
Satellite	Kb/s	Y	125ms – 500ms	Y	UK Wide	Low/ Moderate	Evolving	Latency

Table 10: Technology evaluation against functional specification

* Private LTE performance is dependent upon design and guaranteed service.

** Initial network cost would be high as it would require the capital investment for network roll-out but with ongoing costs relatively low. This represents one use case of the many that would be supported by a Private LTE network designed for energy **Network Operators**.

*** If fibre is already present then cost will be modest, if it's not then the potential cost of deployment can be very high.

3. Distribution Restoration Zone Control System Tests

Where a **Network Operator** uses a **DRZCS** as part of the implementation of a DRZP, the **Network Operator** shall undertake tests or otherwise demonstrate the correct functioning of the **DRZCS**.

Once every three years, the following tests shall be run:

- That communications systems maintain correct **Operation** for at least 72 hours following a **Total Shutdown** or a **Partial Shutdown**.
- That the **DRZCS** where it is required to have this functionality is able to reconfigure the **Network Operator's System** and where required as part of a DRZP, **Transmission Licensee**'s **Plant** and **Apparatus** in response to the appropriate test or simulated signals etc. This functionality shall be demonstrated as being available for at least 72 hours following a **Total Shutdown** or a **Partial Shutdown**.
- That the **DRZCS** is able to instruct **Restoration Contractors**' **Plant** and **Apparatus** at the relevant **Connection Point** in response to the appropriate test or simulated signals etc. This functionality shall be demonstrated as being available for at least 72 hours following a **Total Shutdown** or a **Partial Shutdown**.
- That the **DRZCS**, in a suitable test configuration, is capable of synchronizing its **Power Island** to the wider system in response to the appropriate test or simulated signals etc, and that the appropriate signals are generated. The testing should include the separate testing of any passive synchronizing equipment on which the **DRZP** relies.

- The operational metering signals, status indications and sequence of operation of the **DRZCS** including the output and status of **Restoration Contractors**' **Plant** and **Apparatus** to **System Test Technical Specification** shall be demonstrated where agreed in the **DRZP**.

Where the relevant **Network Operator** has installed a **DRZCS**, the **Network Operator** shall conduct the above tests at least once every three years.

4. Appendix 1: Abbreviations

ABBREVIATION	DEFINITION
DER	Distributed Energy Resource
DMS	Distribution Management System
DNO	Distribution Network Operator
DRZP	Distribution Restoration Zone Plan
DRZCS	Distribution Restoration Zone Control System
DRZ	Distribution Restoration Zone
VLP	Virtual Lead Party
ESO	Electricity System Operator
ANM	Active Network Management
RTU	Remote Terminal Units
TO	Transmission Owner
SCADA	Supervisory Control and Data Acquisition
DSO	Distribution System Operator
WASM	Wide Area Measurement Systems
GSP	Grid Supply Point
EMS	Energy Management System
ROCOF	Rate of Change of Frequency
CBA	Cost Benefit Analysis
LDAP	Lightweight Directory Access Protocol
PLL	Phase Locked Loops
UFLS	Under Frequency Load Shedding
OFGS	Over Frequency Generation Shedding
IACSs	industrial automation and control systems