DISTRIBUTION RESTORATION ZONE CONTROL SYSTEM (DRZCS) STANDARD

Issue 1.0

June 2024

Version Control

Version	Date	Author	Rationale
Issue 1	June 2024	The Company	Base Document

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)**.

Parts 1, 2 and 3 of 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.

Whilst parts 1, 2 and 3 of this document are provided for guidance, part 4 is mandatory where a **Network Operator** installs a **DRZCS**.

All terms in this document which are bold are defined Grid Code terms.

1. Table of Contents

2. DRZCS Requirements

2.1 DRZCS Generic Requirements

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

In addition to the generic functional and non-functional requirements set out below, the **DRZCS** should be capable of receiving information from the **Restoration Contractor** required for the successful operation of a **DRZ**. The requirement to provide such information should be included in the **Distribution Restoration Contract** and the detail of the information will be discussed during the development of the **DRZP**.

2.1.1 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**.
- 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 ability to manually operate their **Plant** where there is a risk to the safety of **Apparatus, Plant** and /or personnel.
- 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 Contractor's Plant** and **Apparatus** to facilitate 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 stable operation of the **Power Island** to detect in real time any disturbances which cannot be managed by the **Restoration Contractors**'

Plant and **Apparatus**. The **DRZCS** is to execute a fast-acting control action to avoid the instability or where the instability cannot be prevented, the **DRZCS** shall be capable of raising an alarm.

- 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 **Restoration Contractor's Plant** and **Apparatus** 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 identified during the DRZ design process). 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** / **The Company 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' Plant** and **Apparatus** based on a priority e.g., pre-determined feeder priority, pro-rata, speed of response, technical best, proximity etc. The priority will be determined by the **Network Operator** for each **DRZ** during the development of the **Distribution Restoration Zone Plan (DRZP)**.

- The **DRZCS** shall be capable of instructing various **Restoration Contractors** to increase or decrease the **Active Power** output / input from their **Plant** and **Apparatus** to create more head room/foot room**.**

Block loading

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

- The **DRZCS** shall be capable of establishing (in real time) whether each load block is within the appropriate or aggregate **Restoration Contractor's Plant** or **Apparatus 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** available from the **Restoration Contractors Plant** and **Apparatus** and therefore increase the effective **Block Loading Capability** of the **DRZ**.

Distribution Network Energisation

- Once the **Anchor Generator** has energised part of the **Distribution Restoration Zone**, 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 synchronise **Top-Up Restoration Contractors'** sites and ii) when to request a **Restoration Contractor** to synchronise their **Plant** and /or **Apparatus** to the **Network Operator's System** 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) controlling circuit breakers associated with **Restoration Contractor's Plant** and/or **Apparatus** and those circuit breakers in the **Network Operator's System**, required to impose block loads, where required by the **DRZP**.

2.1.2 Overall Power Island Control and Monitoring

- Where a **Network Operator** installs a **DRZCS** for each of its **Distribution Restoration Zones**, a central controller shall also be required where there is a need to co-ordinate the operation of each **DRZCS**.
- While maintaining stability and observing all operational limits with the **DRZ**, the **DRZCS** shall manage **Active Power** and **Reactive Power** from the **Restoration Contractors**' **Plant** and **Apparatus** within its controlled area.
- The **DRZCS** shall calculate available **Active Power** and available **Reactive Power** volumes in real time.
- The **DRZCS** shall be capable of controlling the provision of both **Active Power** and **Reactive Power** simultaneously and independently.
- The **DRZCS** shall be capable of issuing set points and other control parameters to **Restoration Contractors**' **Plant** and/or **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**) where required by the **DRZP**, 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**, where required by the **DRZP**, the **DRZCS** shall report to the **Network Operator** the overall **Active Power** and **Reactive Power** resources available for control within the **DRZ**.

2.1.3 Communications Monitoring and Fail-Safes

The following features are typical of an autonomous control system deployed on **GB** distribution **Systems** (e.g., active network management (ANM) system), and should be considered as part of the design of the **DRZCS**.

- The **DRZCS** shall have two modes of operation:
    - An active mode that is operational during a **System Restoration** event, where the **DRZCS** is controlling **Restoration Contractor's Plant** and **Apparatus**; and
    - A supervisory mode that is operational at all other times, to monitor the health of the communications, key data sources, to identify any issues that may prevent the **DRZCS** operation in its active mode, but without controlling **Restoration Contractor's Plant** and **Apparatus**.

- The **DRZCS** shall monitor the health of the system (e.g., communication channels, SCADA data) at all times, and not only when activated as part of **System Restoration**. The **DRZCS** should raise an alert to the **Control Centre** when the system is in an unhealthy state.

- The **DRZCS** shall have the functionality to monitor the health of the communication channels between the centralised and decentralised hardware components (if any) of the **DRZCS** and take appropriate fail-safe actions upon a failure or loss of communications between components. The predesignated actions may range from tripping the **Restoration Contractors**' site, or individual **Plant** or **Apparatus**, through to application of a holding position of the output and / or input of the **Restoration Contractors**' **Plant** or **Apparatus**.

- The **DRZCS** shall monitor the health of the communication channels up to the **Network Operator's** interface point with the **Restoration Contractor's Plant** and/or **Apparatus**. In the event of a loss of communication channel, the **DRZCS** shall implement a predesignated fail-safe action.

- The **DRZCS** shall be required to monitor the health of communication channels to all relevant measurement devices. 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 take a mitigating action where an instruction is not carried out for example disconnecting a **Restoration Contractor's** site or individual **Plant** or **Apparatus**.

- The **DRZCS** shall have the functionality to re-connect a **Top-Up Restoration Contractor's Plant** or **Apparatus** to the **Network Operator's System** where it has been disconnected in response following a tripping instruction issued by the **DRZCS** (e.g., tripped due to non-compliance or as an emergency balancing measure) and where is operationally possible to do so.

2.1.4 **DRZCS** 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. Where this functionality is not available, any full shutdown of the **DRZCS** for maintenance / engineering activities shall be agreed by all relevant parties.

    - The **DRZCS** shall allow for the maximum and minimum rated controllable **Active Power** and **Reactive power** from a **Restoration Contractor's Plant** or **Apparatus** to be configurable.

    - When operating in supervisory mode, the **DRZCS** shall have the functionality to add or remove additional **Restoration Contractor** into the **DRZCS** without any requirement for full shutdown of the **DRZCS**.

    - The **DRZCS** shall allow the **Block Loading Capability** of the **Restoration Contractor's Plant** and **Apparatus** to be user defined.

- The **DRZCS** shall provide warning to the **Network Operator** when the **Block Loading Capability** of the **Restoration Contractor's Plant** within the **Power Island** is insufficient to energise **Demand** blocks in accordance with the requirements of the **Distribution Restoration Zone Plan**.

- Any **DRZCS** component should support local and remote access to diagnostic information. It should be possible to see the operational state of all components. This should include:

    - Current status of all input / output signals from the **DRZCS**;

    - Communications status;

- Software modules and versions;
- Hardware module status; and
- Real-time **Event** log.

- All **DRZCS** components should have diagnostics to send the state of the health of the **DRZCS** to **Network Operators**. If the **DRZCS** has a battery, the battery status should be sent to **Network Operators**.

2.1.5 Wider Network Synchronisation

Before, during and after the process of synchronising to the wider network, until the **DRZP** is terminated, the **DRZCS** is required to contribute to the stability of the **Power Island**. It is expected that the **Restoration Contractor's Plant** and **Apparatus** site will be provided, by the **Network Operator** or **Relevant Transmission Licensee** as appropriate, with a remote measurement at the point of interface, and the **Restoration Contractor's Plant** and **Apparatus** will ramp the **Plant** output up/down (and any other actions necessary as instructed by the **DRZCS**) to synchronise the **Power Island** with the wider network. Once **Frequency** and voltage are in synchronism, a synchronising check relay at the point of synchronisation 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., Voltage Control Mode, Power Factor Control Mode or Reactive Power Control Mode) 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).

2.1.6 Wider System Energisation

When the **DRZCS** attempts to energise a part of the system as defined in the **DRZP**, there are expected to be significant voltage fluctuations associated with energising various assets on the distribution and **Transmission Systems** (e.g., GSP transformers). The system to be energised, as defined in the **DRZP**, could consist of an adjoining interconnected distribution system, however in most cases the **DRZCS** will instruct operation of the circuit breaker to 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 the wider **System** as defined in the **DRZP**:

- 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 select voltage control mode or **Reactive Power** mode) to **Restoration Contractors**' **Plant** and/or **Apparatus** to prepare the **DRZ** to energise a part of the system as defined in the **DRZP**.
- The **DRZCS** is required to report to the **Control Centre**, the availability and output of **Restoration Contractors Plant** within the **Power Island** such as **Active Power** (generation and load) and **Reactive Power** (absorbing and exporting) in advance of any switching actions taken to energise a part of the system as defined in the **DRZP** i.e., operate the **Power Island** as a virtual power **Plant** before, during and after the energisation process.

2.1.7 Visualisation

The requirements listed below should not be considered 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**, **The Company** and the **Relevant Transmission Licensee**.

- A graphical user interface shall be provided for the part of the **System** within the scope of the **DRZCS** and designed in agreement with **The Company**. The interface will provide **Network Operators**, **The Company** and **Restoration Contractors** using the **DRZCS** access to agreed functionality and provide visibility of the whole system performance. Real time **DRZCS** status information shall be displayed for each **DRZ** along with a list of alarms and data measurement requiring **Network Operator** action. In normal operation, it shall be possible to see the latest data available to the **DRZCS** 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 **Active Power** output of **Restoration Contractor's Plant** within the **Power Island**;
    - estimated magnitude of **Load** blocks;
    - generation/**Load** within the **DRZ** in reserve for fast balancing; and
    - setpoints of all dispatched **Restoration Contractors' Plant** and **Apparatus**.
- Operational 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; and
    - viewer – read only, see current system status and historical operation.
- The centralised component of the **DRZCS** shall provide a secure Web Server HMI (Human Machine Interface) that can be accessed locally or remotely. The displays should include **Restoration Contractor's** output 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 Contractor's** site to permit local **Operation** / testing. This should support the following information indications:
    - Measurement – Voltage at **Restoration Contractor's User System Entry Point**;
    - Measurement – **Active Power** (MW) at **Restoration Contractor's User System Entry Point**
    - Measurement – **Reactive Power** (MVAr) at **Restoration Contractor's User System Entry Point**;
    - Measurement – **Frequency** at **Restoration Contractor's User System Entry Point**;
    - Control/Indication – Trip and close of any associated circuit breaker;

- Control/Indication – MW set point issued to **Restoration Contractor**;
- Control/Indication – MVAr set point issued to **Restoration Contractor**;
- Control/Indication – Voltage set point issued to **Restoration Contractor**;
- Control/Indication – **Frequency** set point to **Restoration Contractor**;
- Indication – **Restoration Contractor's** restoration availability status; and
- Indication – Status of the communication between the **DRZCS** and the **Restoration Contractor's** site.

2.1.8 General Requirements

- The **DRZCS** shall co-ordinate with other **Network Operator's** automation functions to obviate any interference with the energisation or stability of a **DRZ**.
- The **DRZCS** may integrate with the **Network Operator's** DMS (Distribution Management System) and be capable of using available network SCADA data.
- The **DRZCS** shall support role based access control to determine the functionality available to each **Network Operator**, e.g. viewing, administration and control.
- The **DRZCS** shall provide a data historian capability to record events in the **DRZ** such as:
  - all control actions issued by the **DRZCS**;
  - **Restoration Contractors** compliance to **DRZCS** control instructions;
  - critical warnings regarding stability of the **DRZ**; and
  - monitor the availability of the energy resource used by the **Restoration Contractor's Plant**.

The requirements listed below are recommendations included in the reports which are listed in Table 1.

- The **DRZCS** system is required to dispatch alternative **Protection** settings to **Network Operator** / the **Relevant Transmission Licensees**'s **Protection** relays as required and as appropriate for each stage of restoration to the extent permitted in the **DRZP**.
- The **DRZCS** system is required to perform a network switching schedule to enable interconnection of individual **Power Islands** to the extent permitted in the **DRZP**. The execution of the energisation shall be co-ordinated with the **DRZCS**.
- **The Network Operator's** DMS is required to provide the **DRZCS** with real-time network measurements e.g. **Active Power** and **Reactive Power** associated with each load block.

Table 1 includes links to initial **DRZCS** designs from original equipment manufacturers (OEMs). These links are provided for information purposes only i.e. they don't set out any additional requirements.

GE digital	Microsoft Word - GE-D_ReStart-DRZC_FunctionalDesignSpec_v2_redacted.docx (nationalgrideso.com)
SEL Engineering Services	Microsoft 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)

2.1.9 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 **Network Operators** will have their own policy relevant to most non-functional requirements.

Resilience

- The **DRZCS,** including the associated communications channels, shall be capable of hot standby in a dual redundant configuration 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 operate in supervisory mode 24/7, 365 days per annum and have a minimum in-service availability of 99.99% per annum. The **DRZCS** shall be available to operate in active mode 24/7, 365 days per annum. The architecture of the **DRZCS** including the associated communications channels shall be such that a failure of a single item shall not cause the **DRZCS** to fail.

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.
- 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

- The **Network Operator** shall undertake maintenance at appropriate intervals to ensure the successful completion of testing and data submission in accordance with requirements of Grid Code OC5.7.4.

3. Functional Specifications for Operational Telecommunications of DRZCS

3.1 Functional Requirements

This section provides guidance for the telecommunications functional requirements for **DRZCS**.

- Technical requirements;
- Configuration, environmental and other requirements;
- Bandwidth requirements;
- Power resilience requirements;

- Supported protocols; and
- Cyber security considerations.

3.1.1 Technical Requirements

Table 2 lists the technical requirements for telecommunications infrastructure to support data 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.
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.

Requirements	Description	Values
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)

Table 2: Technical requirements

3.1.2 Configuration, Environmental and Other Requirements

The non-technical requirements 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,	Circuits should be segregated such that localised disaster **Events** (storm damage,

Requirements	Description	Values
	flooding etc, not to cause degradation of service.	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.
Electromagnetic Compatibility (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	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

Requirements	Description	Values
Disaster Recovery		day, 7 days a week, within 15 minutes of being instructed to do so.

Table 3: Configuration, environmental and other requirements

3.1.3 Power Resilience Requirements

According to ENA EREC 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 **Total Shutdown** or **Partial Shutdown**. 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

3.1.4 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.

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

- Type of interface;
- Number of interfaces;
- Protocol; and
- 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; and
- 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

3.1.5 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	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

3.2 Cyber Security Standards and NIS regulations

The cyber security standards listed in table 8 and NIS regulations have been identified as essential in the setup of a **DRZCS**.

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

3.3 Technology Suitability Summary Based on Functional Specifications

The table below lists the different technologies for the 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.

4. Distribution Restoration Zone Control System Tests

Whilst parts 1 2 and 3 of this document are provided for guidance, this section is mandatory where a **Network Operator** installs a **DRZCS**.

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 capabilities shall be tested or otherwise demonstrated:

- 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** where it is required to have this functionality, 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 synchronising equipment on which the **DRZP** relies.
- The operational measurements, status indications and sequence of operation of the **DRZCS** including the output and status of **Restoration Contractors**' **Plant** and **Apparatus** shall be demonstrated where agreed in the **DRZP**.

5. Appendix 1: Abbreviations

ABBREVIATION	DEFINITION
ANM	Active Network Management
DMS	Distribution Management System
DRZP	Distribution Restoration Zone Plan
DRZCS	Distribution Restoration Zone Control System
DRZ	Distribution Restoration Zone
GSP	Grid Supply Point
IACSs	Industrial Automation and Control Systems
IEMS	Integrated Energy Management System
LDAP	Lightweight Directory Access Protocol
NIS	Network and Information System Regulations
RTU	Remote Terminal Units
SCADA	Supervisory Control and Data Acquisition