	Functional Design Specification	Technology
CONCO Energy Solutions		

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1. INTRODUCTION

This document presents CONCO Energy Solutions' Functional Design Specification (FDS) for networking devices to be used in substation automation applications within Eskom's Transmission Group. The FDS reflects the supplier's functional design for equipment offered on contract 4600060000 for the Development of Transmission Protection, Telecontrol and Substation Automation Solution.

The document is structured such that it corresponds directly with Eskom's original specification for this commodity viz., *Goods Information for: Standard Networking Devices for the Substation Environment Standard, Unique Identifier 240-68111223, Rev 1*. The intention for replicating the structure is to facilitate the direct comparison of the functional requirements against the offered functional specification. As such, sections or clauses that appear in the original specification document that have no direct correlation in the FDS are indicated as being Not Applicable (N/A).

2. SUPPORTING CLAUSES

2.1 SCOPE

2.1.1 Purpose

The purpose of this document is to provide the functional design specification in response to Eskom's requirements for substation switches and routers. This document details the specifications of the offered substation networking equipment (switches and routers) in the context of the hardware, software and protocol supported.

2.1.2 Applicability

This FDS shall apply throughout Eskom's Transmission substations for new switch and router installations and the upgrading of existing systems.

2.2 NORMATIVE/INFORMATIVE REFERENCES

Parties using this document shall apply the most recent edition of the documents listed in the following paragraphs.

2.2.1 Normative

The following referenced documents provide the necessary detail to supplement this FDS. In cases of conflict however, this document takes precedence.

EPL 240-68111223   Goods Information for: Standard Networking Devices for the Substation Environment Standard

EPL 240-61268959   Substation Automation – Network Architecture Standard for Transmission Substations

TESGL0020   Transmission Secondary Plant Technology Development

TTE41-1077   Substation Automation Network Architecture Standard

ISO 9001:2000   Quality Management Systems

EPL 240-55410927   Cyber Security Standard for operational technology

Standard NERC CIP–001–1 — Sabotage Reporting

Standard NERC CIP–002–3 — Cyber Security — Critical Cyber Asset Identification

Standard NERC CIP–003–3 — Cyber Security — Security Management Controls

Standard NERC CIP–004–3 — Cyber Security — Personnel and Training

Standard NERC CIP–005–3 — Cyber Security — Electronic Security Perimeter(s)

Standard NERC CIP-006-3c — Cyber Security — Physical Security

Standard NERC CIP–007–3 — Cyber Security — Systems Security Management

Standard NERC CIP–008–3 — Cyber Security — Incident Reporting and Response Planning

Standard NERC CIP–009–3 — Cyber Security — Recovery Plans For Critical Cyber Assets

IEC 61850 Ed 1, Parts 1-14, Standard for Communication networks and systems in substations

IEC 60870-2-1:1995, Telecontrol equipment and systems Part 2: Operating conditions - Section 1: Power supply and electromagnetic compatibility

IEC 60870-2-2:1996, Telecontrol equipment and systems Part 2: Operating conditions - Section 2: Environmental conditions (climatic, mechanical and other non-electrical influences)

IEC TS 61000-6-5:2001, Electromagnetic compatibility (EMC) Part 6-5: Generic standards. Immunity for power station and substation environments

IEEE 1613-2009, IEEE Standard for environmental and testing requirements for communications networking devices installed in electric power substations.

IEEE 802-2001, IEEE Standard for Local and Metropolitan Area Networks: Overview and Architecture

IEEE 802.1AX-2008, IEEE Standard for Local and Metropolitan Area Networks – Link Aggregation

IEEE 802.1D-2004, IEEE Standard for Local and Metropolitan Area Networks: Media Access Control (MAC) Bridges

IEEE 802.1Q-2011, IEEE Standard for Local and Metropolitan Area Networks: Media Access Control (MAC) Bridges and Virtual Bridged Local Area Networks

IEEE 802.1X-2010, IEEE Standard for Local and Metropolitan Area Networks: Port-based Network Access Control

IEEE 802.3-2008, IEEE Standard for Information Technology – Telecommunication and Information Exchange between Systems - Local and Metropolitan Area Networks

IEEE C37.238-2011, IEEE Standard Profile for Use of IEEE 1588 Precision Time Protocol in Power System Applications

IEC 60050, International Electrotechnical Vocabulary – Details for IEV number 112-01-27: "binary prefix"

ISO/IEC 80000-13:2008, Quantities and units -- Part 13: Information science and technology

2.2.2 Informative

Not Applicable.

2.3 DEFINITIONS

Term	Definition
Substation Automation	A system for managing, controlling and protecting a power system using real-time system data, local and remote control and advanced electrical protection. Core components are local intelligence, data communication and supervisory control and monitoring.

Term	Definition
Network Topology	The arrangement of systems on a computer network that defines how the computers, or nodes, within the network are arranged and connected to each other. Some common network topologies include star, ring, line, bus, and tree configurations.
Bay Level	A bay is a part of a substation containing switchgear and control devices designed for an electrical supply line, transformer, etc. connected to busbar of the substation. These parts of a substation may be managed by devices with the generic name "bay controller" and have protection systems called "bay protection". The bay level represents an additional control level below the overall station level.
Station Level	The station level aggregates the control systems and protection systems that are contained at bay level and includes those systems that are not attributable to a bay.
Gateway	A device that converts one protocol or format to another. In the substation context, a gateway is defined as an application gateway that converts commands and/or data from one format to another.
Head-of-Line (HOL) blocking	HOL blocking occurs when the packet at the head of a queue cannot be transmitted to an output due to a contending packet from another input. At the same time, a packet further back in the queue is blocked although its destination port is free to receive the packet.
RMON	Remote Network Monitoring is a standard monitoring specification that supports monitoring and protocol analysis. It enables various network monitors and console systems to exchange network-monitoring data.
CoS	Class of Service is a 3-bit field that is present in an Ethernet frame header when 802.1Q VLAN tagging is present. The field specifies a priority value between 0 and 7, which can be used by quality of service tools to differentiate, prioritise and shape network traffic. CoS operates only at the data link layer.
GOOSE	Generic Object Oriented Substation Events is a control mechanism for sending event data over a network.
Serial Port Server	A network device containing RS-232 and RS485 ports with the ability to encapsulate serial data into an Ethernet connection. Each serial port typically has a single IP socket mapped to a serial port.

2.3.1 Classification

Controlled Disclosure: Controlled Disclosure to external parties (either enforced by law, or discretionary).

2.4 ABBREVIATIONS

Abbreviation	Description
3DES	Triple Data Encryption Algorithm
AAA	Authentication, Authorization and Accounting
AC or ac	Alternating Current
ASCII	American Standard Code for Information Interchange
AES	Advanced Encryption Standard
BCU	Bay Controller *or* Bay Control Unit
BGP	Border Gateway Protocol

Abbreviation	Description
BME	Bandwidth Management Equipment
BPDU	Bridge Protocol Data Unit
Cat5e	Category 5E UTP or STP cable
Cat6	Category 6 UTP or STP cable
CHAP	Challenge Handshake Authentication Protocol
CLI	Command Line Interface
CoS	Class of Service
DC or dc	Direct Current
DCE	Data Circuit-terminating Equipment
DCRA	Dual Control Room Architecture
DHCP	Dynamic Host Configuration Protocol
DSCP	Differentiated Services Code Point
DTE	Data Terminal Equipment
DTP	Dynamic Trunking Protocol
EMI	Electro Magnetic Interference
eRSTP	Enhanced Rapid Spanning Tree Protocol
FAT	Factory Acceptance Test
FLD	Fast Link Detection
FOBOT	Fibre Optic Break-Out Tray
GARP	Generic Attribute Registration Protocol
GBIC	GigaBit Interface Converter
GMRP	GARP Multicast Registration Protocol
GOOSE	Generic Object Oriented Substation Event
GPS	Global Positioning System
GVRP	GARP Virtual Local Area Network Registration Protocol
HDLC	High-level Data Link Control
HMI	Human Machine Interface
HOL	Head-of-Line blocking
HTTP	HyperText Transfer Protocol
I/O	Input Output
IDS / IPS	Intrusion Detection and Prevention System
IEC	International Electrotechnical Commission
IED	Intelligent Electronic Device
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IGMP	Internet Group Management Protocol

Abbreviation	Description
IP	Internet Protocol
IPAM	IP Address Management
IPsec	Internet Protocol Security
IRB	Integrated Routing and Bridging
ISDN	Integrated Services Digital Network
IS-IS	Intermediate System to Intermediate System
LAN	Local Area Network
LC	Lucent Connector
LFI	Link Fault Indication
LLDP	Link Layer Discovery Protocol
MAC	Media Access Control Address
MMRP	Multiple MAC Registration Protocol
MSTP	Multiple Spanning Tree Protocol
MTBF	Mean Time Between Failure
MVRP	Multiple VLAN Registration Protocol
NAT	Network Address Translation
NERC CIP	North American Electric Reliability Corporation - Critical Infrastructure Protection
NTP	Network Time Protocol
OSPF	Open Shortest Path First
PAP	Password Authentication Protocol
PoE	Power over Ethernet
PSTN	Public Switched Telephone Network
PPP	Point-to-Point Protocol
QoS	Quality of Service
RADIUS	Remote Authentication Dial In User Service
RFC	Request For Comments
RIP	Routing Information Protocol
RMON	Remote Network Monitoring
RSTP	Rapid Spanning Tree Protocol
SAT	Site Acceptance Test
SC	Subscriber Connector *or* Standard Connector *or* Siemon Connector
SCRA	Single Control Room Architecture
SFP	Small Form-factor Gigabit Interface Converter
SMS	Short Message Service
SNMP	Simple Network Management Protocol
SNTP	Simple Network Time Protocol

Abbreviation	Description
SOE	Standard Operating Environment / Sequence of Events
SSH	Secure Shell
SSL	Secure Socket Layer
ST	Straight Tip / Bayonet Fibre Optic Connector
STP	Shielded Twisted Pair / Spanning Tree Protocol
TOS	Type of Service
UID	Document Unique Identifier
UPS	Uninterruptible Power Supply
UTP	Unshielded Twisted Pair
VLAN	Virtual Local Area Network
VoIP	Voice over IP
VPN	Virtual Private Network
VRRP	Virtual Router Redundancy Protocol
WAN	Wide Area Network

2.5 ROLES AND RESPONSIBILITIES

Not Applicable.

2.6 PROCESS FOR MONITORING

Not Applicable.

2.7 RELATED/SUPPORTING DOCUMENTS

Not Applicable.

3. PROJECT PROGRAMME

Not applicable to this document.

4. ARCHITECTURE OVERVIEW

Eskom's original substation automation network architecture was based in essence on a two-tier design. The top tier consists of high capacity; high speed backbone Ethernet switches which provide the physical connectivity to the lower tier switches. The lower tier switches provide physical connectivity to the bay IEDs, the Gateway(s), HMI(s), router and other equipment. In order to meet high system availability criteria, each lower tier switch connects redundantly to two backbone switches, as shown in Figure 1.

The new network design philosophy for dual main protection lends itself to the concept of a segregated control room for each main protection. As such, new substation designs are structured around a two control room design approach and this design is catered for in the network architecture as indicated in Figure 2.

Key	Description
——	1 Gbps connections
——	10/ 100Mbps connections
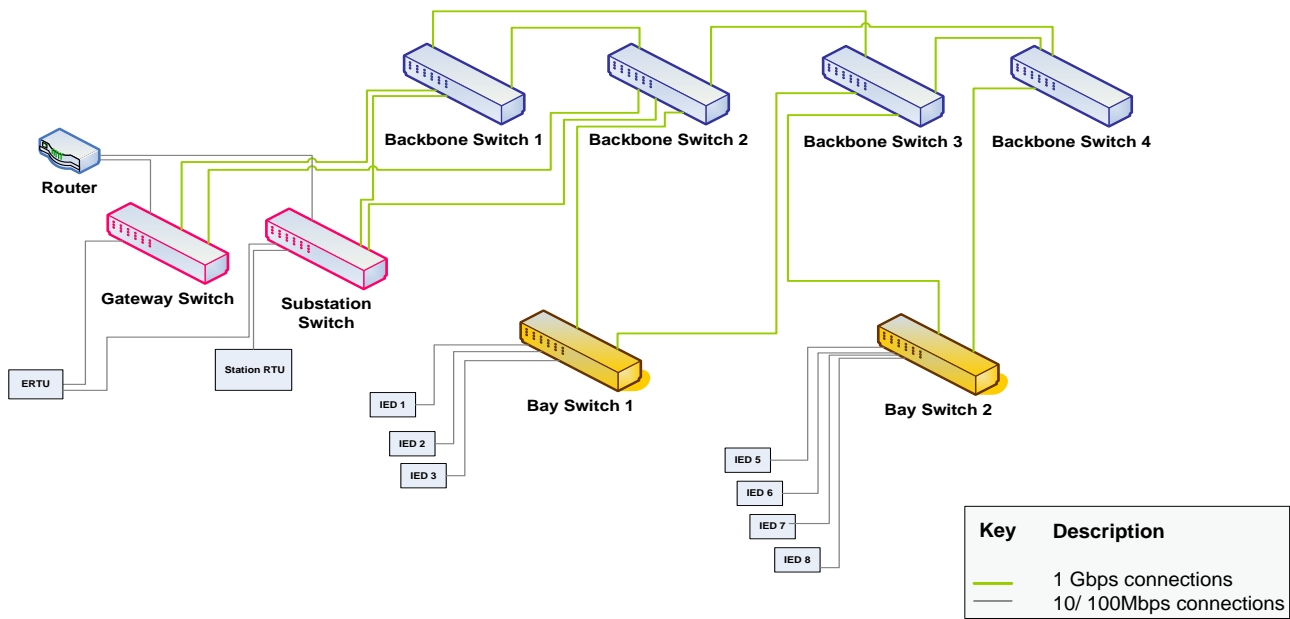
Figure 1 : Illustration of the Network Topology
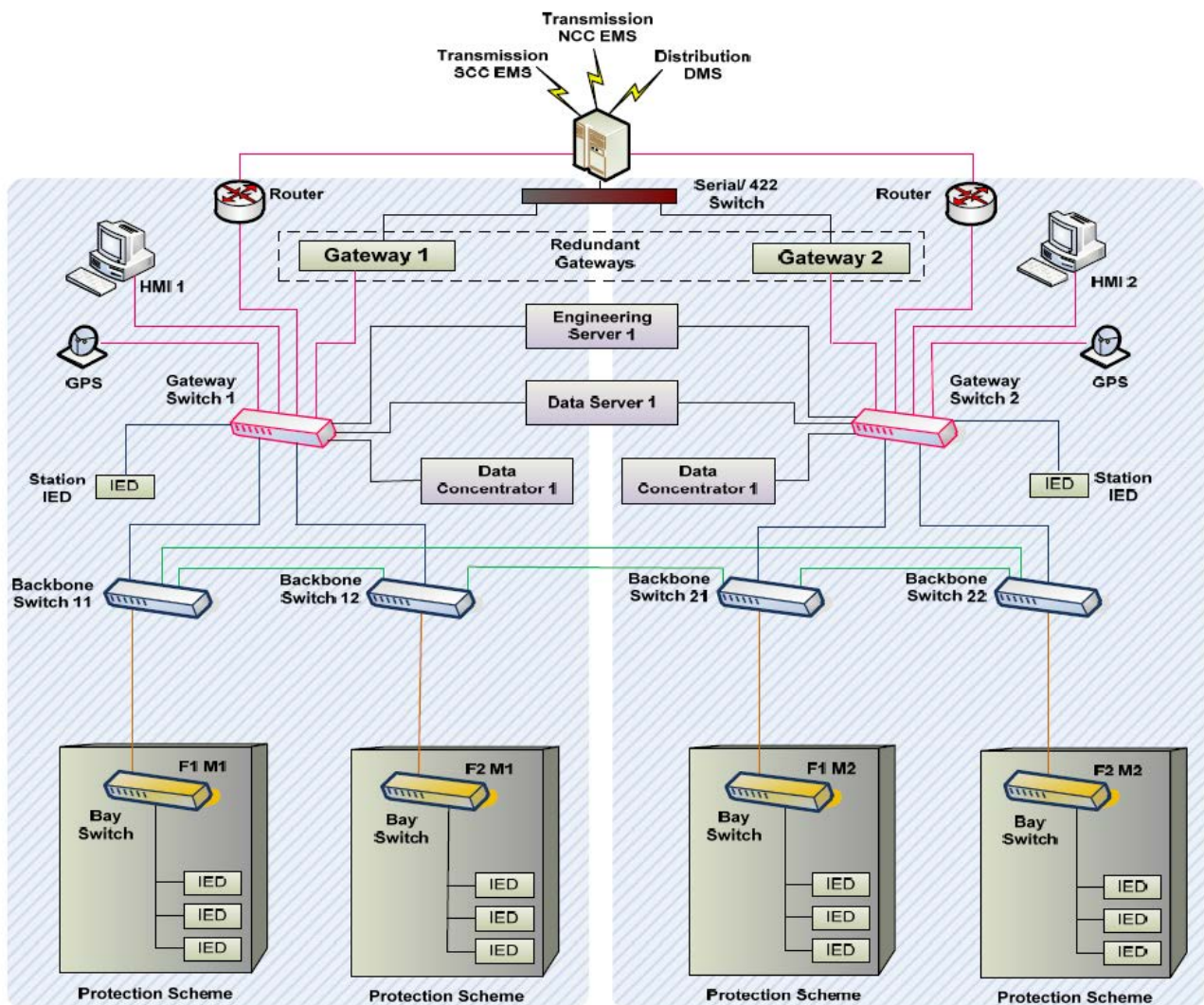
Figure 2: Network topology and redundancy for dual main protection

The two standard architectures mentioned above will be referred to as follows within this document in order to correctly identify the applications applicable to each topology correctly. Furthermore, the definition of both topologies is intended to eliminate potential issues related to interpretation.

- The single control room architecture as depicted in Figure 1 shall be referenced by the acronym SCRA;
- The dual control room architecture as depicted in Figure 2 shall be referenced by the acronym DCRA.

Based on the aforementioned architectures, the design aspects shall be noted:

- The document focuses on the dual control room architecture.
- No provision or details have been provided regarding common equipment requirements.
- Only a single station IED will exist in a DCRA.
- Engineering Workstation is included in Main 1 and Main 2 schemes in a DCRA.
- Data Concentrator and Localised engineering server (where applicable and used) will be used as shown in Figure 2 in a DCRA.

5. PHILOSOPHY

The design philosophy for equipment offered is such that no special developments are required to meet Eskom's requirements. Furthermore, essential features of the offered devices are interoperable with other vendor devices where interoperability is measured against international standards.

The offered products allow for scalability with respect to network topologies, modularity with respect to hardware design and firmware upgradeability to cater for evolving power system requirements.

6. DESIGN REQUIREMENTS

The equipment offered has been split into the following system components:
- Gigabit switch;
- Layer 2 switch;
- Substation router;
- Layer 3 switch;
- Serial Port Server; and
- General requirements.

The sections which follow contain details of each of these system components.

7. GIGABIT SWITCH REQUIREMENTS

The purpose of the Gigabit Switch is to perform the function of a backbone switch. The gateway switch and each bay switch will only have a single link to its backbone switch in its half of the segregated system in the DCRA. There is no redundant cabling between the backbone switches and the lower tier (bay) switches due to the redundancy requirement being catered for by the duplication of the equipment (separate protection schemes, etc.) in this design. The only exception to this requirement is the station switch which will have dual links to backbone switches from Main 1 system and Main 2 system for common equipment. The network resilience to port, power, cable or switch failure is catered for by the redundant autonomous main protection scheme in the separate control room.

The product offered is the Siemens Ruggedcom RSG2488 (hereafter referred to as RSG2488).

7.1 ENVIRONMENTAL, ELECTRICAL AND MECHANICAL REQUIREMENTS

The RSG2488 is substation hardened and ruggedized to be able to withstand the following, without the performance being out of limits, reliability being compromised or the life cycle being shortened.

7.1.1 Environmental

The RSG2488 will be:

7.1.1.1 Compliant with Class C3, as per IEC 60870-2 part 1, Table 1;

7.1.1.2 Capable of operating within a temperature range of -40°C to 85°C, with passive cooling.

7.1.2 Altitude

The device will operate within an altitude range between 0 – 2500m. The RSG2488 has been fully tested up to 2000m, but will operate up to 2500m, however other environmental specifications may be affected (e.g. lower max temperature).

7.1.3 EMI Immunity

The RSG2488 will provide error-free operation when exposed to EMI stress and electrical surges, as per Class 2 requirements of IEEE 1613.

7.1.4 Electrical

The RSG2488:

7.1.4.1 will operate within an electrical interference environment, where equipment is situated within high voltage switching compounds (132 kV or above) such that it is subject to high levels of radiated electrical interference, due to its physical placement or its direct connection to electrical plant.

7.1.4.2 will not be affected by other device frequencies.

7.1.4.3 will not generate any interference, which could hinder its own performance or the performance of the other equipment in its vicinity.

7.1.5 Power Supply

7.1.5.1 The power supply voltages are selectable at time of order placement. Please refer to Table 36 in Appendix A for details of offered products and items.

7.1.5.2 The voltage options are: 48 Vdc, 110 Vdc and 220 Vdc.

7.1.5.3 The voltage tolerances are as per Table 1.

Table 1: Siemens Ruggedcom DC supply tolerances

Nominal supply voltage	48 Vdc	110 Vdc	220 Vdc
Normal supply voltage	52,8 Vdc	117 Vdc	234 Vdc
Equipment terminal voltage limits	43 Vdc to 55 Vdc	88 Vdc to 132 Vdc	176 Vdc to 264 Vdc
Connection to earth	Note 1	Note 1	Note 1
NOTE 1: Fully floating supply symmetrically balanced about earth with earth fault detection set to detect 10 mA current from either pole to earth. For the 48 Vdc telecommunications supply, the positive is earthed.			

7.1.5.4 Dual, redundant power supplies will be provided (when ordered in this configuration) with separate inputs per power supply to be able to draw from separate power sources. Please refer to Table 36 in Appendix A for details of offered products and items).

7.1.5.5 The power supplies will be hot swappable.

7.1.5.6   The power supply connectors will be screw-type terminal block.

7.1.6   Mechanical Shock and Vibration

The device will comply with Class Bm, as per IEC 60870-2 part 1, section 4.2.2.

7.2   HARDWARE

7.2.1   Switching Fabric

7.2.1.1   The switching fabric bandwidth will be at least twice the total capacity of connecting modules. The capacity will be 63 Gbit/s.

7.2.1.2   The RSG2488 switch will not allow head of line blocking.

7.2.1.3   The RSG2488 switch will utilise the store-and-forward method for switching.

7.2.1.4   The switching latency on the RSG2488 unit will be 5 µs.

7.2.2   Fibre Ports

The gigabit fibre ports (please refer to Table 36 in Appendix A for details of the offered products and items):

7.2.2.1   will support multimode communication (1000Base-SX) with a wavelength of 850 nm.
For module slots 1 to 6, the following options exist:

Table 2: Siemens Ruggedcom RSG2488 1000Base-SX Gigabit fibre modules (Slots 1-6)

Module Code	Description
A05	4 x 1000SX - Multimode, 850nm, LC, 500m
A09	4 x 1000SX - Multimode, 850nm, LC, 500m

For module slots 7 to 8, the following option exists:

Table 3: Siemens Ruggedcom RSG2488 1000Base-SX Gigabit fibre modules (Slots 7-8)

Module Code	Description
G67	2 x 1000SX SFP - Multimode, 850nm, LC, 500m

7.2.2.2   will support single mode communication (1000Base-LX) with a wavelength of 1310 nm.

For module slots 1 to 6, the following options exist:

Table 4: Siemens Ruggedcom RSG2488 1000Base-LX Gigabit fibre modules (Slots 1-6)

Module Code	Description
A07	4 x 1000LX - Singlemode, 1310nm, LC , 10km
A10	4 x 1000LX SFP - Singlemode, 1310nm, LC, 10km

For module slots 7 to 8, the following option exists:

Table 5: Siemens Ruggedcom RSG2488 1000Base-LX Gigabit fibre modules (Slots 7-8)

Module Code	Description
G68	2 x 1000LX SFP - Singlemode, 1310nm, LC, 10km

7.2.2.3   will support LC connectors (as indicated).

7.2.2.4   will be modular to allow for future expansion or repairs.

7.2.2.5   will support a minimum of 8 Ethernet gigabit ports with two modules populated in slots 1 to 6.

7.2.3   General

7.2.3.1   The device will be made of aluminium rather than heavy duty steel, but is supplied with the option to mount on a standard 19" rack panel. Options do exist for DIN rail mounting as well. Please refer to Table 36 in Appendix A for details of offered products and items.

7.2.3.2   The RSG2488 will have terminal blocks for power and I/O connections that are rated for industrial applications. Please refer to Table 36 in Appendix A for details of offered products and items.

7.2.3.3   There will be an order option to add a protective coating on the circuit board, to protect against dust and moisture. Please refer to Table 36 in Appendix A for details of offered products and items.

7.2.3.4   There will be a dedicated RS232 DCE console port on a DB9 connector for switch management.

7.2.3.5   There will be a number of module ordering options allowing the use of appropriate, utility grade Small Form-factor Pluggable (SFP) modules, if and when required. Note that the SFP modules must be approved by Siemens to ensure overall conformance of the unit to published specifications. Please refer to Table 36 in Appendix A for details of offered products and items.

7.3   REQUIRED FUNCTIONALITY

7.3.1   Virtual Local Area Networks (VLANs)

The RSG2488:

7.3.1.1   will support up to 255 configured VLANs in the identification number range 1 to 4094.

7.3.1.2   will comply with IEEE 802.1Q-2005.

7.3.1.3   will support the double-tagging of an Ethernet frame/QinQ functionality [refer to IEEE 802.1ad-2005 rather than IEEE 802.1D-2004].

7.3.1.4   will not support the Multiple VLAN Registration Protocol (MVRP) for automatically propagating VLAN information across a network. Only GVRP will be supported.

7.3.1.5   will support VLAN assignment per port, for untagged traffic.

7.3.2   Spanning Tree Protocol

The RSG2488:

7.3.2.1   will be able to "heal" the network with a speed of less than 5 ms per hop.

7.3.2.2   will support mesh topologies of up to 160 devices.

7.3.2.3   will support the Rapid Spanning Tree Protocol (RSTP) [refer to IEEE 802.1D-2004].

7.3.2.4   will support the Multiple Spanning Tree Protocol (MSTP) [refer to IEEE 802.1Q-2005].

7.3.3   Link Aggregation

The RSG2488:

7.3.3.1   will allow for the linking of Ethernet ports into one logical trunk for higher bandwidths.

7.3.3.2   will not comply with IEEE 802.1AX-2008 as only static link aggregation will be supported.

7.3.4   Traffic Prioritisation

The RSG2488:

7.3.4.1   will allow for the classification of priorities based on MAC address, port, tags and IP Type of Service (TOS).

7.3.4.2   will allow time critical data to be classified as higher priority.

7.3.4.3   will support numerous priority queues for TOS.

7.3.4.4   will comply with the QoS Prioritisation schemes in the IEEE 802.1Q-2005.

7.3.5   Port Configuration

The RSG2488:

7.3.5.1   will allow for automatic configuration of ports.

7.3.5.2   will allow for automatic crossover detection.

7.3.5.3   will allow for manual configuration of media type state, speed and duplex state.

7.3.5.4   will have the capability to disable ports that are not being used.

7.3.5.5   will allow a port to be configured to a specific VLAN.

7.3.5.6   will be capable of limiting which VLANs are accessible through a trunk port.

7.3.5.7   will allow the limiting of the number of MAC addresses admissible per port.

7.3.5.8   will allow the limiting of the number of VLANs per port. This is only applicable to trunk ports as edge ports can only be assigned to a single VLAN.

7.3.6   Port Rate Limiting

The RSG2488:

7.3.6.1   will have the ability to limit traffic on a per-port basis.

7.3.6.2   will allow the traffic limiting selection to be either Broadcast; Multicast; or Unicast, which is essential for managing network traffic.

7.3.7   Port Based Access Control

The RSG2488:

7.3.7.1   will provide a means for authenticating and authorising devices attached to the Ethernet ports.

7.3.7.2   will comply with IEEE 802.1X-2010.

7.3.8   Port Mirroring

The RSG2488 will support port mirroring that is essential for network monitoring and troubleshooting on live networks.

7.3.9   Time Synchronization

7.3.9.1   The RSG2488 will support the Simple Network Time Protocol (SNTP) that is used to synchronise the internal system clocks of itself and other devices allowing for correct correlation of time stamped events for troubleshooting.

7.3.9.2   The RSG2488 will provide an SNTP client for time synchronization.

7.3.9.3   The RSG2488 device will support IEEE 1588 version 2 and IEEE C37.238-2011.

7.3.9.4   The RSG2488 will be able to function as a SNTP server and client.

7.3.10 Other Requirements

The RSG2488:

7.3.10.1 will provide a Link Fault Indication (LFI) under all failure conditions, to allow devices at the far end of a fibre connection to detect a link failure.

7.3.10.2 will allow for Fast Link Detections (FLD) for quicker discovery of new devices or links in the network.

7.3.10.3 will allow FLD to be automatically turned off, as a failsafe, in the case of a large number of link state changes propagating across the network.

7.3.10.4 will be unable to auto-sense the IP version as it is a layer 2 device.

7.3.10.5 will support the Link Layer Discovery Protocol (LLDP) [refer IEEE 802.1AB-2005 rather than IEEE 802.1AB-2009].

7.3.10.6 will support the Internet Group Management Protocol (IGMP) version 3 [refer to RFC 4604] that is used in managing the membership of multicast groups.

7.3.10.7 will be able to perform IGMP snooping.

7.3.10.8 will not support the Multiple MAC Registration Protocol (MMRP) that allows multicast traffic in bridged LANs to be confined to areas of the network where it is required. [refer to IEEE 802.1Q-2005]

7.3.10.9 will be able to filter broadcast frames, within user defined thresholds, to prevent broadcast storms.

7.3.10.10 will support multi-level user password to protect the switch from unauthorised persons. The levels that are supported are Guest, Operator and Admin and the associated rights per user level are shown in the table below:

Table 6: Siemens Ruggedcom RSG2488 User Levels and Rights

Rights	User Type		
	Guest	**Operator**	**Admin**
View Settings	✓	✓	✓
Clear Logs	✗	✓	✓
Reset Alarms	✗	✓	✓
Clear Statistics	✗	✓	✓
Change Basic Settings	✗	✓	✓
Change Advanced Settings	✗	✗	✓
Run Commands	✗	✗	✓

7.3.10.11 will allow for logs to be sent to multiple (up to five) configurable syslog servers (or collectors). Each server will be able to be sent logs of varying severity.

7.3.11 Switch Security

7.3.11.1   The RSG2488 switch will include security features to allow Eskom to comply with North American Electric Reliability Corporation - Critical Infrastructure Protection (NERC CIP) security standards, policy 001 - 009, where applicable.

7.3.11.2   The switch will provide the relevant features in order to comply with the Cyber Security Standard for Operational Technology, EST 240 – 55410927, where applicable.

7.3.11.3   The RSG2488 will support Remote Authentication Dial In User Service (RADIUS) for both user and administrative authentication.

7.3.11.4   The RSG2488 will be able to authenticate to AAA (Authentication, Authorization and Accounting) servers via both RADIUS and TACACS+.

7.3.11.5   The RSG2488 will comply with IEEE 802.1X-2010, port-based network access control.

7.3.11.6   The RSG2488 will support multiple levels of privileges per user.

7.3.11.7   All encryption on the RSG2488 will utilise 128 bit AES or better.

7.3.12   Management Tools

7.3.12.1   The RSG2488 switch's management will be accessible via a web browser that supports HTTPS and via a serial connection.

7.3.12.2   Different web browsers will be supported i.e. Mozilla's Firefox web browser on Linux and Windows or Internet Explorer on Windows.

7.3.12.3   The management Command Line Interface (CLI) will be accessible via Secure Shell (SSH).

7.3.12.4   The RSG2488 will allow for remote access for configuration purposes via a physically separated management port.

7.3.12.5   The RSG2488 will support the Simple Network Management Protocol (SNMP) version 1, version 2c and version 3.

7.3.12.6   The RSG2488 will support Remote Network Monitoring (RMON) for event logging, viewing of device statistics, proactive monitoring, problem detection and reporting.

8. LAYER 2 SWITCH REQUIREMENTS

The Layer 2 Switch will perform the function required of bay, station and gateway switches by providing physical connectivity to the bay IEDs, the Gateway(s), HMI(s), router and other equipment. Each bay and gateway switch will have a single link to a backbone switch. The station switch will connect to two backbone switches.

Listed below are the requirements for the Layer 2 switch. A modular switch, the Siemens Ruggedcom RSG2100 (hereafter referred to as RSG2100), is described as it is the offered product for the bay, station and gateway switch role. The offered switch supports up to 19 Ethernet ports (3 of which are gigabit capable).

8.1   ENVIRONMENTAL, ELECTRICAL AND MECHANICAL REQUIREMENTS

The RSG2100 will be substation hardened and ruggedized to be able to withstand the following, without the performance being out of limits, reliability being compromised or the life cycle being shortened.

8.1.1   Environmental

The RSG2100 will be:

8.1.1.1   compliant with Class C3, as per IEC 60870-2 part 1, Table 1; except for temperature.

8.1.1.2   capable of operating within a temperature range of -40°C to 85°C, with passive cooling.

8.1.2   Altitude

The RSG2100 will operate within an altitude range between 0 – 2500m. The RSG2100 has been fully tested up to 2000m, but will operate up to 2500m, however other environmental specifications may be affected (e.g. lower max temperature).

8.1.3   EMI Immunity

The RSG2100 will provide error-free operation when exposed to EMI stress and electrical surges, as per Class 2 requirements of IEEE 1613.

8.1.4   Electrical

The RSG2100:

8.1.4.1   will operate within an electrical interference environment, where equipment is situated within high voltage switching compounds (132 kV or above) such that it is subject to high levels of radiated electrical interference, due to its physical placement or its direct connection to electrical plant.

8.1.4.2   will not be affected by other device frequencies.

8.1.4.3   will not generate any interference, which could hinder its own performance or the performance of the other equipment in its vicinity.

8.1.5   Power Supply

8.1.5.1   The power supply voltages are selectable at time of order placement.

8.1.5.2   The voltage options are: 48 Vdc, 110 Vdc and 220 Vdc.

8.1.5.3   The voltage tolerances will be as per Table 1.

8.1.5.4   Dual, redundant power supplies will be provided as per the order code of the equipment with separate inputs per power supply to be able to draw from separate power sources. Please refer to Table 37 in Appendix A for details of offered products and items.

8.1.5.5   The option for a hot swappable power supply will not be available with the RSG2100 product and can only be replaced at the factory or at an approved service centre.

8.1.5.6   The power supply connectors will be screw-type terminal block. Please refer to Table 37 in Appendix A for details of offered products and items).

8.1.6   Mechanical Shock and Vibration

The RSG2100 will comply with Class Bm, as per IEC 60870-2 part 1, section 4.2.2.

8.2   HARDWARE

8.2.1   Switching Fabric

8.2.1.1   The switching fabric bandwidth will be at least twice the total capacity of connecting modules. The capacity will be 9.2 Gbit/s.

8.2.1.2   The RSG2100 will not allow head of line blocking.

8.2.1.3   The RSG2100 will utilise the store-and-forward method for switching.

8.2.1.4   The switching latency on the RSG2100 unit will be 7 µs.

8.2.2   Gigabit Fibre Ports

A Gigabit fibre port will be used to link a bay and gateway switch to a RSG2488 backbone switch, whereas two gigabit fibre ports will be used to connect a station switch to the RSG2488 backbone switches.

The Gigabit fibre ports (please refer to Table 37 in Appendix A for details of offered products and items):

8.2.2.1   will support multimode communication (1000Base-SX) with a wavelength of 850 nm.
            For module slot 5, the following options exist:

Table 7: Siemens Ruggedcom RSG2100 1000Base-SX Gigabit fibre modules (Slot 5)

Module Code	Description
E02	FG01 = 2 x 1000SX - Multimode, 850nm, LC, 500m
E08	FG51 = 2 x 1000SX SFP - Multimode, 850nm, LC, 500m

For module slot 6, the following options exist:

Table 8: Siemens Ruggedcom RSG2100 1000Base-SX Gigabit fibre modules (Slot 6)

Module Code	Description
F02	1FG01 = 1 x 1000SX - Multimode, 850nm, LC, 500m
F08	1FG51 = 1 x 1000SX SFP - Multimode, 850nm, LC, 500m

8.2.2.2   will support single mode communication (1000Base-LX) with a wavelength of 1310 nm.

For module slot 5, the following options exist:

Table 9: Siemens Ruggedcom RSG2100 1000Base-LX Gigabit fibre modules (Slot 5)

Module Code	Description
E03	FG02 = 2 x 1000LX - Singlemode, 1310nm, SC connectors, 10km
E04	FG03 = 2 x 1000LX – Singlemode, 1310nm, LC connectors, 10km
E05	FG04 = 2 x 1000LX – Singlemode, 1310nm, SC connectors, 25km
E06	FG05 = 2 x 1000LX – Singlemode, 1310nm, LC connectors, 25km
E07	FG50 = 2 x 1000LX SFP - Blank (no optical transceiver)
E09	FG52 = 2 x 1000LX SFP – Singlemode, 1310nm, LC, 10km
E10	FG53 = 2 x 1000LX SFP - Singlemode, 1310nm, LC, 25km
E12	FG70 = 2 x 1000LX GBIC - Blank (no optical transceiver)
E13	FG71 = 2 x 1000LX GBIC - Singlemode, 1310nm, SC, 10km
E14	FG72 = 2 x 1000LX GBIC - Singlemode, 1310nm, SC, 25km

For module slot 6, the following options exist:

Table 10: Siemens Ruggedcom RSG2100 1000Base-LX Gigabit fibre modules (Slot 6)

Order Code	Description
F03	1FG02 = 2 x 1000LX - Singlemode, 1310nm, SC connectors, 10km
F04	1FG03 = 2 x 1000LX – Singlemode, 1310nm, LC connectors, 10km
F05	1FG04 = 2 x 1000LX – Singlemode, 1310nm, SC connectors, 25km

F06	1FG05 = 2 x 1000LX – Singlemode, 1310nm, LC connectors, 25km
F07	1FG50 = 2 x 1000LX SFP - Blank (no optical transceiver)
F09	1FG52 = 2 x 1000LX SFP – Singlemode, 1310nm, LC, 10km
F10	1FG53 = 2 x 1000LX SFP - Singlemode, 1310nm, LC, 25km
F12	1FG70 = 2 x 1000LX GBIC - Blank (no optical transceiver)
F13	1FG71 = 2 x 1000LX GBIC - Singlemode, 1310nm, SC, 10km
F14	1FG72 = 2 x 1000LX GBIC - Singlemode, 1310nm, SC, 25km

8.2.2.3   will support LC connectors.

8.2.2.4   will be modular to allow for future expansion or repairs.

8.2.2.5   will support a minimum of 2 Ethernet gigabit ports on separate modules as per the tables above where a module is required in slot 5 and one in slot 6.

8.2.3   10Base and 100Base Ethernet Ports

The Ethernet ports will consist of a combination of various copper and/or fibre ports, based on the requirements of the connecting bay devices.

8.2.3.1   The fibre ports (please refer to Table 37 in Appendix A for details of offered products and items):

8.2.3.1.1 will support multimode communication (10Base-FL) with a wavelength of 850nm. This is available as an Ethernet Module for Slots 1, 2, 3, 4, 7, 8, 9 and 10.

Table 11: Siemens Ruggedcom RSG2100 10Base-FL fibre modules (Slots 1-4, 7-10)

Module Code	Description
A01	FL01 = 2 x 10FL - Multimode, 850nm, ST

8.2.3.1.2 will support multimode communication (100Base-FX) with a wavelength of 1300nm. These will be available as Ethernet Modules for Slots 1, 2, 3, 4, 7, 8, 9 and 10.

Table 12: Siemens Ruggedcom RSG2100 100Base-FX fibre modules (Slots 1-4, 7-10)

Module Code	Description
A03	FX01 = 2 x 100FX - Multimode, 1300nm, ST
A04	FX02 = 2 x 100FX - Multimode, 1300nm, SC
A05	FX11 = 2 x 100FX – Multimode, 1300nm, LC

8.2.3.1.3 will support LC, ST and SC connectors.

8.2.3.2   The copper ports:

8.2.3.2.1 will support both 10Base-TX and 100Base-TX. This will be available as an Ethernet Module for Slots 1, 2, 3, 4, 7, 8, 9 and 10.

Table 13: Siemens Ruggedcom RSG2100 10/100Base-TX fibre modules (Slots 1-4, 7-10)

Module Code	Description
A01	TX01 = 2 x 10/100Tx RJ45

8.2.3.2.2 will support RJ45 connectors.

8.2.3.3 Ethernet ports will be modular for facilitating future expansion or repairs.

8.2.3.4 The RSG2100 will support up to 16 Ethernet ports that cater for all combinations of 10/100Base modules. The RSG2100 will also support up to 3 Ethernet ports that cater for 1000Base communications. The RSG2100 will not be capable of thirty-two ports.

8.2.3.5 The RSG2100 will support up to 16 Ethernet ports that cater for all combinations of 10/100Base modules. The RSG2100 will also support up to 3 Ethernet ports that cater for 1000Base communications.

8.2.4 General

8.2.4.1 The RSG2100 will be made of heavy duty steel (18 AWG galvanized steel) and supplied with the option to mount in a standard 19" rack panel or on a DIN rail, with all associated accessories as per order code. Please refer to Table 37 in Appendix A for details of offered products and items.

8.2.4.2 The RSG2100 will have terminal blocks for power and I/O connections that are rated for industrial applications. Please refer to Table 37 in Appendix A for details of offered products and items.

8.2.4.3 There will be an order option to add a protective coating on the circuit board, to protect against dust and moisture. Please refer to Table 37 in Appendix A for details of offered products and items.

8.2.4.4 There will be a dedicated RS232 console port utilizing a RJ45 connector for switch management.

8.2.4.5 There will be a number of module ordering options allowing the use of appropriate, utility grade Small Form-factor Pluggable (SFP) modules, if and when required. Note that the SFP modules must be approved by Siemens to ensure overall conformance of the unit to published specifications. Please refer to Table 37 in Appendix A for details of offered products and items.

8.3 REQUIRED FUNCTIONALITY

8.3.1 Virtual Local Area Networks (VLANs)

The RSG2100:

8.3.1.1   will support up to 255 configured VLANs in the identification number range 1 to 4094.

8.3.1.2   will comply with IEEE 802.1Q-2005.

8.3.1.3   will support the double-tagging of an Ethernet frame/QinQ functionality [refer to IEEE 802.1ad-2005].

8.3.1.4   will not support the Multiple VLAN Registration Protocol (MVRP) for automatically propagating VLAN information across a network. Only GVRP will be supported.

8.3.1.5   will support VLAN assignment per port, for untagged traffic.

8.3.2   Spanning Tree Protocol

The RSG2100:

8.3.2.1   will be able to "heal" the network with a speed of less than 5 ms per hop.

8.3.2.2   will support mesh topologies of up to 160 devices.

8.3.2.3   will support the Rapid Spanning Tree Protocol (RSTP) [refer to IEEE 802.1D-2004].

8.3.2.4   will support the Multiple Spanning Tree Protocol (MSTP) [refer to IEEE 802.1Q-2005].

8.3.3   Link Aggregation

The RSG2100:

8.3.3.1   will allow for the linking of Ethernet ports into one logical trunk for higher bandwidths.

8.3.3.2   will not comply with IEEE 802.1AX-2008 as only static link aggregation will be supported.

8.3.4   Traffic Prioritisation

The RSG2100:

8.3.4.1   will allow for the classification of priorities based on MAC address, port, tags and IP Type of Service (TOS).

8.3.4.2   will allow time critical data to be classified as higher priority.

8.3.4.3   will supports numerous priority queues for TOS.

8.3.4.4   will comply with the QoS Prioritisation schemes in the IEEE 802.1Q-2005 standard rather than the IEEE 802.1Q-2011 standard.

8.3.5   Port Configuration

The RSG2100:

8.3.5.1   will allow for automatic configuration of ports.

8.3.5.2   will allow for automatic crossover detection.

8.3.5.3   will allow for manual configuration of media type state, speed and duplex state.

8.3.5.4   will have the capability to disable ports that are not being used.

8.3.5.5   will allow a port to be configured to a specific VLAN.

8.3.5.6   will be capable of limiting which VLANs are accessible through a trunk port.

8.3.5.7   will allow the limiting of the number of MAC addresses admissible per port.

8.3.5.8   will allow the limiting of the number of VLANs per port. This is only applicable to trunk ports as edge ports can only be assigned to a single VLAN.

8.3.6   Port Rate Limiting

The RSG2100:

8.3.6.1   will have the ability to limit traffic on a per-port basis.

8.3.6.2   will allow the traffic limiting selection to be either Broadcast; Multicast; or Unicast, which is essential for managing network traffic.

8.3.7   Port Based Access Control

The RSG2100:

8.3.7.1   will provide a means for authenticating and authorising devices attached to the Ethernet ports.

8.3.7.2   will comply with IEEE 802.1X-2010.

8.3.8   Port Mirroring

The RSG2100 will support port mirroring that is essential for network monitoring and troubleshooting on live networks.

8.3.9   Time Synchronization

8.3.9.1   The RSG2100 will support the Simple Network Time Protocol (SNTP) that is used to synchronise the internal system clocks of itself and other allowing for correct correlation of time stamped events for troubleshooting.

8.3.9.2   The RSG2100 will not support IEEE 1588 version 2 and IEEE C37.238-2011.

8.3.9.3   The RSG2100 will be able to function as a SNTP server and client.

8.3.10   Other Requirements

The RSG2100:

8.3.10.1 will provides a Link Fault Indication (LFI) under all failure conditions, to allow devices at the far end of a fibre connection to detect a link failure.

8.3.10.2 will allow for Fast Link Detection (FLD) for quicker discovery of new devices or links in the network.

8.3.10.3 will allow FLD to be automatically turned off, as a failsafe, in the case of a large number of link state changes propagating across the network.

8.3.10.4 will be unable to auto-sense the IP version as it is a layer 2 device.

8.3.10.5 will perform auto-negotiation and automatic crossover detection for copper Ethernet ports, i.e. 10/100Base-TX and 10/100/1000Base-TX.

8.3.10.6 will support the Link Layer Discovery Protocol (LLDP) [refer IEEE 802.1AB-2009].

8.3.10.7 will support the Internet Group Management Protocol (IGMP) version 3 [refer to RFC 3376] that is used in managing the membership of multicast groups; however source based multicast filtering is not supported.

8.3.10.8 will be able to perform IGMP snooping.

8.3.10.9 will not support the Multiple MAC Registration Protocol (MMRP) that allows multicast traffic in bridged LANs to be confined to areas of the network where it is required. [refer to IEEE 802.1Q-2005]

8.3.10.10 will support multi-level user password to protect the switch from unauthorised persons. The levels that are supported are Guest, Operator and Admin and the associated rights per user level are shown in the table below:

Table 14: Siemens Ruggedcom RSG2100 User Levels and Rights

Rights	User Type		
	Guest	**Operator**	**Admin**
View Settings	✓	✓	✓
Clear Logs	✗	✓	✓
Reset Alarms	✗	✓	✓
Clear Statistics	✗	✓	✓
Change Basic Settings	✗	✓	✓
Change Advanced Settings	✗	✗	✓
Run Commands	✗	✗	✓

8.3.10.11 will allow for logs to be sent to multiple (up to five) configurable syslog servers (or collectors). Each server will be able to be sent logs of varying severity.

8.3.11 Switch Security

8.3.11.1 The RSG2100 will include security features to allow Eskom to comply with North American Electric Reliability Corporation - Critical Infrastructure Protection (NERC CIP) security standards, policy 001 - 009, where applicable.

8.3.11.2   The RSG2100 switch will be configured to comply with the Cyber Security Standard for Operational Technology, EST 240 – 55410927 as far as is practical.

8.3.11.3   The RSG2100 will support Remote Authentication Dial-In User Service (RADIUS) for both user and administrative authentication.

8.3.11.4   The RSG2100 will be able to authenticate to AAA (Authentication, Authorization and Accounting) servers via both RADIUS and TACACS+.

8.3.11.5   The RSG2100 will comply with IEEE 802.1X-2010, port-based network access control.

8.3.11.6   The RSG2100 will support multiple levels of privileges per user.

8.3.11.7   All encryption on the device will be 128 bit AES or better.

8.3.12   Management Tools

8.3.12.1   The RSG2100 switch's management will be accessible via a web browser that supports HTTPS and via a serial connection.

8.3.12.2   Different web browsers will be supported i.e. Mozilla's Firefox web browser on Linux and Windows or Internet Explorer on Windows.

8.3.12.3   The management Command Line Interface (CLI) will be accessible via Secure Shell (SSH).

8.3.12.4   The RSG2100 will allow for remote access for configuration purposes via a physically separated management port.

8.3.12.5   The RSG2100 will support the Simple Network Management Protocol (SNMP) version 1, version 2c and version 3.

8.3.12.6   The RSG2100 will support Remote Network Monitoring (RMON) for event logging, viewing of device statistics, proactive monitoring, problem detection and reporting.

9. ROUTER REQUIREMENTS

The router will be the single point of entry into the substation LAN and will be the common connection point for all VLANs. There is one Siemens Ruggedcom RX1500 router (hereafter referred to as RX1500) offered to be installed in each control room and each router is physically connected to at least one WAN link. On the LAN side, the router shall be physically connected to the RSG2100 Gateway switch.

In addition to routing, the router will function as a basic stateful firewall, NTP server; DHCP server; IPsec VPN server and client; and a RADIUS client. The device cannot provide RADIUS server capabilities.

Listed below are the hardware and software capabilities of the RX1500 router.

9.1 ENVIRONMENTAL, ELECTRICAL AND MECHANICAL REQUIREMENTS

The Siemens Ruggedcom RX1500 will be substation hardened and ruggedized to be able to withstand the following, without the performance being out of limits, reliability being compromised or the life cycle being shortened.

9.1.1 Environmental

The RX1500:

9.1.1.1   will comply with Class C3, as per IEC 60870-2 part 1, Table 1; except for temperature.

9.1.1.2   will operate within a temperature range of -40°C to 85°C, with passive cooling.

9.1.2   Altitude

The RX1500 will operate correctly within an altitude range between 0 m to 2500 m.

9.1.3   EMI Immunity

The RX1500 will provide error-free operation when exposed to EMI stress and electrical surges, as per Class 2 requirements of IEEE 1613.

9.1.4   Electrical

The RX1500:

9.1.4.1   will operate within an electrical interference environment, where equipment is situated within high voltage switching compounds (132 kV or above) such that it is subject to high levels of radiated electrical interference, due to its physical placement or its direct connection to electrical plant.

9.1.4.2   will not be affected by other device frequencies.

9.1.4.3   will not generate any interference, which could hinder its own performance or the performance of the other equipment in its vicinity.

9.1.5   Power Supply

9.1.5.1   The power supply voltages will be selectable at time of order placement. Please refer to Table 38 in Appendix A for details of offered products and items.

9.1.5.2   The voltage options are: 48 Vdc, 110 Vdc and 220 Vdc.

9.1.5.3   The voltage tolerances will be as per Table 1.

9.1.5.4   Dual, redundant power supplies will be provided (dependent on the order code of the equipment) with separate inputs per power supply to be able to draw from separate power sources. Please refer to Table 38 in Appendix A for details of offered products and items.

9.1.5.5   The power supplies will be hot swappable.

9.1.5.6   The power supply connectors will be screw-type terminal block.

9.1.6   Mechanical Shock and Vibration

The RX1500 will comply with Class Bm, as per IEC 60870-2 part 1, section 4.2.2.

9.2   HARDWARE

9.2.1   Router Fabric

9.2.1.1   The router's maximum throughput for the stipulated frame sizes when all Ethernet ports are being used will be (assuming total 8 Gigabit ports):
Maximum throughput for 64 byte frames: 7.991 Gbps

Maximum throughput for 512 byte frames: 7.999 Gbps

Maximum throughput for 1518 bytes frames: 7.999 Gbps

9.2.1.2   The router's latency for the frame sizes indicated will be:
Latency for 64 byte frames: 1.9 us

Latency for 512 byte frames: 1.9 us

Latency for 1518 byte frames: 1.9 us

9.2.2   Ethernet Ports

The Ethernet ports will be provided as a combination of copper and fibre ports. The ports will be used to link to the Gateway Switch and the WAN. Please refer to Table 38 in Appendix A for details of offered products and items.

9.2.2.1   The fibre ports:

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9.2.2.1.1   will support multimode communication (1000Base-SX) with a wavelength of 850nm.

Table 15: Siemens Ruggedcom RX1500 1000Base-SX Gigabit fibre modules

Module Code	Description
B36	FG50 = 2x 1000LX SFP Blank (no optical transceiver)

9.2.2.1.2   will support single mode communication (1000Base-LX) with a wavelength of 1310nm.

Table 16: Siemens Ruggedcom RX1500 1000Base-LX Gigabit fibre modules

Module Code	Description
B33	FG03 = 2x 1000LX SFP Singlemode 1310 nm LC 10km
B36	FG50 = 2x 1000LX SFP Blank (no optical transceiver)

9.2.2.1.3   will support multimode communication (100Base-FX) with a wavelength of 1300nm.

Table 17: Siemens Ruggedcom RX1500 100Base-FX fibre modules

Module Code	Description
B16	4FX11 = 4x 100FX – Multimode 1300nm LC connectors 2km
B21	FX50 = 4x 100FX SFP Blank (no optical transceiver)
B26	6FX50 = 6x 100FX SFP Blank (no optical transceiver)

9.2.2.1.4   will support LC and ST connectors.

9.2.2.2   The copper ports:

9.2.2.2.1   will support 100Base-TX.

Table 18: Siemens Ruggedcom RX1500 100Base-TX modules

Module Code	Description
B01	6TX01 = 6x 10/100TX RJ45
B02	CG01 = 2x 10/100/1000TX RJ45

9.2.2.2.2   will Support 1000Base-TX.

Table 19: Siemens Ruggedcom RX1500 1000Base-TX module

Module Code	Description
B02	CG01 = 2x 10/100/1000TX RJ45

9.2.2.2.3   will support RJ45 connectors.

9.2.2.3   Ethernet ports will be modular and facilitate future expansion or repairs.

9.2.2.4   The RX1500 will support as a minimum two 1000Base Ethernet ports and two 100Base Ethernet ports dependent on module selection.

9.2.3   WAN Ports

The WAN ports will be used to link to the BME or Telecoms router. This connection can be Ethernet or E1. Please refer to Table 38 in Appendix A for details of offered products and items.

9.2.3.1   The RX1500 will support Channelized - E1 connections.

Table 20: Siemens Ruggedcom RX1500 Channelized T1/E1 modules

Module Code	Description
B41	TC1 = 1x T1/E1 RJ48 (Channelized)
B42	TC2 = 2x T1/E1 RJ48 (Channelized)
B43	TC4 = 4x T1/E1 RJ48 (Channelized)

9.2.3.2   The RX1500 does not support X.21 connections.

9.2.3.3   WAN ports will be modular and allow for appropriate selection of WAN module, future expansion or repairs.

9.2.3.4   The RX1500 will support, as a minimum, 2 WAN ports dependent on module selection.

9.2.4   Serial Ports

The serial ports will be used to link serial devices directly to the router. The serial ports:

Table 21: Siemens Ruggedcom RX1500 serial port module

Module Code	Description
B03	S01 = 6 x RS232/RS422/RS485 RJ45

9.2.4.1   will support RS232 (software selectable).

9.2.4.2   will support RS422 (software selectable).

9.2.4.3   will support RS485 (software selectable).

9.2.4.4   will support RJ45 connectors.

9.2.4.5   will be modular to allow for appropriate module selection, future expansion or repairs.

9.2.4.6   will support 6 serial ports per module.

9.2.5   General

9.2.5.1   The RX1500 will be made of aluminium and supplied with the option to mount in a standard 19" rack panel or on a DIN rail, with all associated accessories. Please refer to Table 38 in

Appendix A for details of offered products and items.

9.2.5.2   The RX1500 will have terminal blocks for power and I/O connections that are rated for industrial applications.

9.2.5.3   There will be an ordering option to add a protective coating on the circuit board, to protect against dust and moisture. Please refer to Table 38 in Appendix A for details of offered products and items.

9.2.5.4   There will be a dedicated RS232 console port using a DB9 connector for router setup and management.

9.2.5.5   There will be a number of ordering options to use appropriate utility grade Small Form-factor Pluggable (SFP) modules, if and when required, provided the correct module is installed. Please refer to Table 38 in Appendix A for details of offered products and items.

9.3   REQUIRED FUNCTIONALITY

9.3.1   Virtual Private Network (VPN)

The RX1500:

9.3.1.1   will support both Layer 2 and Layer 3 VPNs using IPsec and L2TP.

9.3.1.2   will support the following secure VPN protocols:

9.3.1.2.1   Internet Protocol Security (IPsec)

9.3.1.2.2   Secure Socket Layer (SSL) – not for VPN purposes. SSL VPNs are only possible using the Siemens Ruggedcom APE1404CKP module running Check Point.

9.3.1.2.3   Transport Layer Security (TLS) – not for VPN purposes

9.3.1.3   will support the following encryption methods:

9.3.1.3.1   Triple Data Encryption Algorithm (3DES)

9.3.1.3.2   128-bit Advanced Encryption Standard (AES128)

9.3.1.3.3   256-bit Advanced Encryption Standard (AES256)

9.3.1.4   will comply with IEEE 802.1Q-2005 and IEEE 802.1D-2004.

9.3.1.5   will support tunnels to be created to a host, a port on a host or to a whole site.

9.3.1.6   will support the creation of Generic Object Oriented Substation Events (GOOSE) tunnels.

9.3.2   Virtual Local Area Networks (VLANs)

The RX1500:

9.3.2.1   will support the configuration of up to 255 VLANs using identifier range 1 to 4095.

9.3.2.2   will comply with IEEE 802.1Q-2005.

9.3.2.3   **not** support the double-tagging of an Ethernet frame/QinQ functionality [refer to IEEE 802.1Q-2011].

9.3.2.4   will not support the Multiple VLAN Registration Protocol (MVRP) for automatically propagating VLAN information across a network. Only GVRP will be supported.

9.3.2.5   will support VLAN assignment per port, for untagged traffic.

9.3.3   Spanning Tree Protocol

The RX1500:

9.3.3.1   will be able to "heal" the network with a speed of less than 5ms per hop.

9.3.3.2   will support mesh topologies of up to 160 devices.

9.3.3.3   will support the Rapid Spanning Tree Protocol (RSTP) [refer to IEEE 802.1D-2004].

9.3.3.4   will support the Multiple Spanning Tree Protocol (MSTP) [refer to IEEE 802.1Q-2005].

9.3.4   Link Aggregation

The RX1500:

9.3.4.1   will allow for the linking of Ethernet ports into one logical trunk for higher bandwidths.

9.3.4.2   will comply with IEEE 802.3ad-2000 Link Aggregation.

9.3.5   Traffic Prioritisation

The RX1500:

9.3.5.1   will allow for the classification of priorities based on MAC address, port, tags and IP Type of Service (TOS).

9.3.5.2   will allow time critical data to be classified as higher priority.

9.3.5.3   will support numerous priority queues for TOS.

9.3.5.4   will comply with the QoS Prioritisation schemes in the IEEE 802.1Q-2005.

9.3.6   Firewall

The RX1500:

9.3.6.1   will support a firewall that allows for stateful packet inspection.

9.3.6.2   will support Network Address Translation (NAT) as well as IP Address Masquerading.

9.3.6.3   will be able to perform port forwarding.

9.3.6.4   will be able to filter on source and destination address and ports.

9.3.7   Routing Protocols

The RX1500:

9.3.7.1   will support the Open Shortest Path First (OSPF) version 2, routing protocol.

9.3.7.2   will support Routing Information Protocol (RIP) versions 1 and 2, and the Border Gateway Protocol (BGP).

9.3.7.3   will support the Virtual Router Redundancy Protocol (VRRP).

9.3.7.4   will support Static Routing.

9.3.7.5   will support the Point-to-Point Protocol (PPP).

9.3.7.6   will support High-Level Data Link Control (HDLC) on T1/E1 lines.

9.3.7.7   will not comply with IEEE 802.1AX-2008 as only static link aggregation will be supported.

9.3.8   WAN Authentication protocols

The RX1500 will support the Challenge Handshake Authentication Protocol (CHAP).

9.3.9   Port Configuration

The RX1500:

9.3.9.1   will allow for automatic configuration of ports.

9.3.9.2   will allow for automatic crossover detection.

9.3.9.3   will allow for manual configuration of media type state, speed and duplex state.

9.3.9.4   will have the ability to disable ports that are not being used.

9.3.9.5   will allow a port to be configured to a specific VLAN.

9.3.9.6   will be capable of limiting which VLANs are accessible through a trunk port.

9.3.9.7   will allow the setting of a limit of the number of MAC addresses learned per port.

9.3.9.8   will allow the limiting of the number of VLANs that may traverse a trunk port.

9.3.10   Port Rate Limiting

The RX1500:

9.3.10.1   will have the ability to limit traffic on a per-port basis.

9.3.10.2   will allow the choice between Broadcast; Multicast; or Unicast limiting, which is essential for managing network traffic.

9.3.11   Port Based Access Control

The RX1500:

9.3.11.1   will provide a means for authenticating and authorising devices attached to the Ethernet ports.

9.3.11.2   will comply with IEEE 802.1X-2004.

9.3.12   Time Synchronization

9.3.12.1   The RX1500 will support the Simple Network Time Protocol (SNTP) that is to be used to synchronise its own internal clock and the internal system clocks of devices on the network allowing for correct correlation of time stamped events for troubleshooting.

9.3.12.2   The RX1500 will be able to perform the function of a Network Time Protocol (NTP) server.

9.3.12.3   The RX1500 will be able to perform the function of a Network Time Protocol (NTP) client.

9.3.12.4   The RX1500 device will not support IEEE 1588 version 2 and IEEE C37.238-2011.

9.3.12.5   There will be no option for a GPS receiver for the RX1500.

9.3.13   Other Requirements

The RX1500:

9.3.13.1   will be able to perform the function of a Dynamic Host Control Protocol (DHCP) server, with option 82 supported.

9.3.13.2   will allow for centralised password management by means of a RADIUS server.

9.3.13.3   will not directly provide Intrusion Detection and Prevention System (IDS/IPS) services. These are however available when using the Siemens Ruggedcom APE1404CKP module running Check Point.

9.3.13.4   will support Integrated Routing and Bridging (IRB) when using Layer 2 tunnelling. This allows a protocol to be bridged as well as routed on the same interface on the router. This can be used to forward VLAN headers.

9.3.13.5   will allow for inter VLAN routing.

9.3.13.6   will allow for IP multicast routing.

9.3.13.7   will support serial IP encapsulation.

9.3.13.8 will provides a fault indication under all failure conditions. This will be user configurable.

9.3.13.9 support the Link Layer Discovery Protocol (LLDP) [refer to IEEE 802.1AB-2005 rather than IEEE802.1AB-2009].

9.3.13.10 will support the Internet Group Management Protocol (IGMP) version 2 [refer to RFC 2236] that is used in managing the membership of multicast groups, however version 3 as per RFC4604 is planned to be supported in the next major firmware release.

9.3.13.11 will support multi-level user password to protect the switch from unauthorised persons. The levels that are supported are Guest, Operator and Admin and the associated rights per user level are shown in the table below:

Table 22: Siemens Ruggedcom RX1500 Router User Level and Rights

Rights	User Type		
	Guest	Operator	Admin
View Settings	✓	✓	✓
Clear Logs	✗	✓	✓
Reset Alarms	✗	✓	✓
Clear Statistics	✗	✓	✓
Change Basic Settings	✗	✓	✓
Change Advanced Settings	✗	✗	✓
Run Commands	✗	✗	✓

9.3.13.12 will allow for logs to be sent to multiple (up to five) configurable syslog servers (or collectors). Each server can be sent logs of varying severity.

9.3.13.13 will allow for WAN Loopback test functions.

9.3.14 Router Security

9.3.14.1 The RX1500 will include security features to allow Eskom to comply with North American Electric Reliability Corporation - Critical Infrastructure Protection (NERC CIP) security standards, policy 001 - 009, where applicable.

9.3.14.2 The RX1500 will be configured to comply with the Cyber Security Standard for Operational Technology, EST 240 – 55410927 as far as is practical.

9.3.14.3 The RX1500 will support Remote Authentication Dial-In User Service (RADIUS) for both user and administrative authentication.

9.3.14.4 The RX1500 will be able to authenticate to AAA (Authentication, Authorization and Accounting) servers via both RADIUS and TACACS+.

9.3.14.5 The RX1500 will comply with IEEE 802.1X-2010, port-based network access control.

9.3.14.6 The RX1500 will support multiple levels of privileges per user.

9.3.14.7 All encryption on the device will be 128-bit AES or better.

9.3.15 Management Tools

9.3.15.1 The RX1500's management interface will be accessible via a web browser that supports HTTPS and via a serial connection.

9.3.15.2 Different web browsers will be supported i.e. Mozilla's Firefox web browser on Linux and Windows or Internet Explorer on Windows.

9.3.15.3 The management Command Line Interface (CLI) will be accessible via Secure Shell (SSH).

9.3.15.4 The RX1500 will allow for remote access for configuration purposes via a physically separated management port.

9.3.15.5 The RX1500 will support the Simple Network Management Protocol (SNMP) version 1, version 2c and version 3.

10. LAYER 3 SWITCH REQUIREMENTS

The Layer 3 switch is intended to be used in cases where it is more practical to use a single device that combines the functionality of a traditional Layer 2 switch and a router. Listed below are the requirements for the Layer 3 switch.

10.1   ENVIRONMENTAL, ELECTRICAL AND MECHANICAL REQUIREMENTS

The device offered is the Siemens Ruggedcom RX1500 (hereafter referred to as RX1500) which will be substation hardened and ruggedized to be able to withstand the following, without the performance being out of limits, reliability being compromised or the life cycle being shortened.

10.1.1 Environmental

The RX1500:

10.1.1.1   will comply with Class C3, as per IEC 60870-2 part 1, Table 1; except for temperature.

10.1.1.2   will operate within a temperature range of -40°C to 85°C, with passive cooling.

10.1.2 Altitude

The RX1500 will operate correctly within an altitude range between 0 m to 2500 m.

10.1.3 EMI Immunity

The RX1500 will provide error-free operation when exposed to EMI stress and electrical surges, as per Class 2 requirements of IEEE 1613.

10.1.4 Electrical

The RX1500:

10.1.4.1   will operate within an electrical interference environment, where equipment is situated within high voltage switching compounds (132 kV or above) such that it is subject to high levels of radiated electrical interference, due to its physical placement or its direct connection to electrical plant.

10.1.4.2   will not be affected by other device frequencies.

10.1.4.3   will not generate any interference, which could hinder its own performance or the performance of the other equipment in its vicinity.

10.1.5 Power Supply

10.1.5.1   The power supply voltages will be selectable at time of order placement. Please refer to Table 38 in Appendix A for details of offered products and items.

10.1.5.2   The voltage options are: 48 Vdc, 110 Vdc and 220 Vdc.

10.1.5.3   The voltage tolerances will be as per Table 1.

10.1.5.4 Dual, redundant power supplies will be provided (dependent on the order code of the equipment) with separate inputs per power supply to be able to draw from separate power sources.

10.1.5.5 The power supplies will not be hot swappable.

10.1.5.6 The power supply connectors will be screw-type terminal block.

10.1.6 Mechanical Shock and Vibration

The device will comply with Class Bm, as per IEC 60870-2 part 1, section 4.2.2.

10.2   HARDWARE

10.2.1 Switching Fabric

10.2.1.1 The RX1500's switching fabric bandwidth will be at least twice the total capacity of connecting modules. The capacity will be 10 Gbit/s.

10.2.1.2 The RX1500 switch does not allow head of line blocking.

10.2.1.3 The RX1500 switch will utilise the store-and-forward method for switching.

10.2.1.4 The switching latency on the RX1500 unit will be 7 µs.

10.2.2 Gigabit Fibre Ports

The Gigabit fibre ports will be used to link to the backbone switches. The Gigabit fibre ports (please refer to Table 38 in Appendix A for details of offered products and items):

10.2.2.1.1   will support multimode communication (1000Base-SX) with a wavelength of 850 nm.

Table 23: Siemens Ruggedcom RX1500 Switch 1000Base-SX Gigabit fibre modules

Module Code	Description
B36	FG50 = 2x 1000LX SFP Blank (no optical transceiver)

10.2.2.1.2   will support single mode communication (1000Base-LX) with a wavelength of 1310 nm.

Table 24: Siemens Ruggedcom RX1500 Switch 1000Base-LX Gigabit fibre modules

Module Code	Description
B33	FG03 = 2x 1000LX Singlemode 1300 nm LC, 10km
B36	FG50 = 2x 1000LX SFP Blank (no optical transceiver)

10.2.2.2 will support LC connectors.

10.2.2.3 Ethernet ports will be modular and facilitate future expansion or repairs.

10.2.2.4 The device will support as a minimum 2 Ethernet gigabit ports on separate modules.

10.2.3 Ethernet Ports

The Ethernet ports will be provided as a combination of copper and/or fibre ports, depending on ordering codes. Please refer to Table 38 in Appendix A for details of offered products and items.

10.2.3.1 The fibre ports:

10.2.3.1.1 will support multimode communication (10Base-FL) with a wavelength of 850 nm.

Table 25: Siemens Ruggedcom RX1500 Switch 10Base-FL fibre module

Module Code	Description
B15	FL01 = 3x 10FL / 100SX, Multimode, 850nm, ST, 2km

10.2.3.1.2 will support multimode communication (100BaseFx) with a wavelength of 1300nm.

Table 26: Siemens Ruggedcom RX1500 Switch 100Base-FX fibre modules

Module Code	Description
B16	4FX11 = 4x 100FX – Multimode 1300nm LC connectors 2km
B21	FX50 = 4x 100FX SFP Blank (no optical transceiver)
B26	6FX50 = 6x 100FX SFP Blank (no optical transceiver)

10.2.3.1.3 will support LC, ST and SC connectors.

10.2.3.2 The copper ports:

10.2.3.2.1 will support 10Base-TX

Table 27: Siemens Ruggedcom RX1500 Switch 10Base-TX modules

Module Code	Description
B01	6TX01 = 6x 10/100TX RJ45
B02	CG01 = 2x 10/100/1000TX RJ45

10.2.3.2.2 will support 100Base-TX

Table 28: Siemens Ruggedcom RX1500 Switch 100Base-TX modules

Module Code	Description
B01	6TX01 = 6x 10/100TX RJ45

Module Code	Description
B02	CG01 = 2x 10/100/1000TX RJ45

10.2.3.2.3   will support 1000Base-TX

Table 29: Siemens Ruggedcom RX1500 Switch 1000Base-TX module

Module Code	Description
B02	CG01 = 2x 10/100/1000TX RJ45

10.2.3.2.4   will support RJ45 connectors.

10.2.3.3   Ethernet ports will be modular and facilitate future expansion and repairs.

10.2.3.4   The device will support as a minimum a total of 16 Ethernet ports that caters for all combinations of 10/100Base modules, with the option to size the switch to a lower port count for smaller installations.

The combination of 10Base and 100Base Ethernet ports will range from:

- No 10Base and 16 fixed 100BaseFx Ethernet ports *or* 24 SFP 100BaseFx Ethernet ports

- 12 10BaseFL and no 100Base Ethernet ports

-

24 10/100BaseTx ports.

10.2.4 WAN Ports

The WAN ports will be used to link to the BME or Telecoms router. This connection will be Ethernet or E1. Please refer to Table 38 in Appendix A for details of offered products and items.

10.2.4.1   The router will support Channelized- E1 connections.

Table 30: Siemens Ruggedcom RX1500 Switch Channelized T1/E1 modules

Module Code	Description
B41	TC1 = 1x T1/E1 RJ48 (Channelized)
B42	TC2 = 2x T1/E1 RJ48 (Channelized)
B43	TC4 = 4x T1/E1 RJ48 (Channelized)

10.2.4.2   The router does not support X.21 connections.

10.2.4.3   WAN ports will be modular and allow for appropriate selection of WAN module, future expansion or repairs.

10.2.4.4   The device will support as a minimum 2 WAN ports, depending on module selection.

10.2.5 Serial Ports

The serial ports will be used to link serial devices directly to the RX1500 switch. The serial ports:

Table 31: Siemens Ruggedcom RX1500 Switch serial port module

Module Code	Description
B03	S01 = 6x RS232/RS422/RS485 RJ45

10.2.5.1   will support RS232 (software selectable).

10.2.5.2   will support RS422 (software selectable).

10.2.5.3   will support RS485 (software selectable).

10.2.5.4   will support RJ45 connectors.

10.2.5.5   will be modular to allow for appropriate module selection, future expansion or repairs.

10.2.5.6   will support 6 serial ports per module.

10.2.6 General

10.2.6.1   The RX1500 will be made of aluminium and supplied with the option to mount in a standard 19" rack panel or on a DIN rail, with all associated accessories.

10.2.6.2   The RX1500 will have terminal blocks for power and I/O connections that are rated for industrial applications.

10.2.6.3   There will be an ordering option to add a protective coating on the circuit board, to protect against dust and moisture.

10.2.6.4   There will be a dedicated RS232 console port using a DB9 connector for router setup and management.

10.2.6.5   There will be a number of ordering options to use appropriate utility grade Small Form-factor Pluggable (SFP) modules, if and when required, provided the correct module is installed.

10.3   REQUIRED FUNCTIONALITY

10.3.1 Virtual Local Area Networks (VLANs)

The RX1500:

10.3.1.1   will support the configuration of up to 255 VLANs with VLAN identifiers in the range 1 to 4095.

10.3.1.2   will comply with IEEE 802.1Q-2005.

10.3.1.3   will **not** support the double-tagging of an Ethernet frame/QinQ functionality [refer to IEEE 802.1Q-2005 rather than IEEE 802.1Q-2011].

10.3.1.4   will not support the Multiple VLAN Registration Protocol (MVRP) for automatically propagating VLAN information across a network. Only GVRP will be supported.

10.3.1.5   will support VLAN assignment per port, for untagged traffic.

10.3.2 Virtual Private Network (VPN)

The RX1500:

10.3.2.1   will support both Layer 2 and Layer 3 VPNs using IPsec and L2TP.

10.3.2.2   will support the following secure VPN protocols:

10.3.2.2.1   Internet Protocol Security (IPsec)

10.3.2.2.2   Secure Socket Layer (SSL) – not for VPN purposes. SSL VPNs are only possible using the Ruggedcom APE1404CKP module running Check Point.

10.3.2.2.3   Transport Layer Security (TLS) – not for VPN purposes

10.3.2.3   will support the following encryption methods:

10.3.2.3.1   Triple Data Encryption Algorithm (3DES)

10.3.2.3.2   128-bit Advanced Encryption Standard (AES128)

10.3.2.3.3   256-bit Advanced Encryption Standard (AES256)

10.3.2.4   will comply with IEEE 802.1Q-2005 and IEEE 802.1D-2004.

10.3.2.5   will support tunnels to be created to a host, a port on a host or to a whole site.

10.3.2.6   will support the creation of Generic Object Oriented Substation Events (GOOSE) tunnels.

10.3.3 Spanning Tree Protocol

The RX1500:

10.3.3.1   will be able to "heal" the network with a speed of less than 5ms per hop

10.3.3.2   will support mesh topologies of up to 160 devices.

10.3.3.3   will support the Rapid Spanning Tree Protocol (RSTP) [refer to IEEE 802.1D-2004].

10.3.3.4   will support the Multiple Spanning Tree Protocol (MSTP) [refer to IEEE 802.1Q-2005].

10.3.4 Traffic Prioritisation

The RX1500:

10.3.4.1   will allow for the classification of priorities based on the MAC address, ports, tags and IP Type of Service (TOS).

10.3.4.2   will allow time critical data to be classified as higher priority.

10.3.4.3   will support numerous priority queues for TOS.

10.3.4.4   will comply with the QoS Prioritisation schemes in the IEEE 802.1Q-2005.

10.3.5   Firewall

The RX1500:

10.3.5.1   will support a firewall that allows for stateful packet inspection.

10.3.5.2   will support Network Address Translation (NAT) as well as IP Address Masquerading.

10.3.5.3   will be able to perform port forwarding.

10.3.5.4   will be able to filter on source and destination address and ports.

10.3.6   Routing Protocols

The RX1500:

10.3.6.1   will support the Open Shortest Path First (OSPF) version 2, routing protocol.

10.3.6.2   will support Routing Information Protocol (RIP) versions 1 and 2, and the Border Gateway Protocol (BGP).

10.3.6.3   will support the Virtual Router Redundancy Protocol (VRRP).

10.3.6.4   will support Static Routing.

10.3.6.5   will support the Point-to-Point Protocol (PPP).

10.3.6.6   will support High-Level Data Link Control (HDLC) on T1/E1 lines.

10.3.6.7   will comply with IEEE 802.3ad-2000, rather than IEEE 802.1AX-2008.

10.3.7   WAN Authentication Protocols

The RX1500 will support the Challenge Handshake Authentication Protocol (CHAP).

10.3.8   Port Configuration

The RX1500:

10.3.8.1   will allow for automatic configuration of ports.

10.3.8.2   will allow for automatic crossover detection.

10.3.8.3   will allow for manual configuration of media type state, speed and duplex state.

10.3.8.4   will have the ability to disable ports that are not being used.

10.3.8.5   will allow a port to be configured to a specific VLAN.

10.3.8.6   will be capable of limiting which VLANs are accessible through a trunk port.

10.3.8.7   will allow the setting of a limit of the number of MAC addresses learned per port.

10.3.8.8   will allow the limiting of the number of VLANs that may traverse a trunk port.

10.3.9   Port Rate Limiting

The RX1500:

10.3.9.1   will have the ability to limit traffic on a per-port basis.

10.3.9.2   will allow the choice between Broadcast; Multicast; or Unicast limiting, which is essential for managing network traffic.

10.3.10   Port Based Access Control

The RX1500:

10.3.10.1   will provide a means for authenticating and authorising devices attached to the Ethernet ports.

10.3.10.2   will comply with IEEE 802.1x-2004.

10.3.11   Link Aggregation

The RX1500:

10.3.11.1   will allow for the linking of Ethernet ports into one logical trunk for higher bandwidths.

10.3.11.2   will comply with IEEE 802.3ad-2000, rather than IEEE 802.1AX-2008.

10.3.12   Port Mirroring

The RX1500 will support port mirroring that is essential for network monitoring and troubleshooting on live networks.

10.3.13   Time Synchronization

10.3.13.1 The RX1500 will support the Simple Network Time Protocol (SNTP) that is to be used to synchronise its internal clock and the internal system clocks of devices on the network allowing for correct correlation of time stamped events for troubleshooting.

10.3.13.2 The RX1500 will be able to perform the function of a Network Time Protocol (NTP) server.

10.3.13.3 The RX1500 will be able to perform the function of a Network Time Protocol (NTP) client.

10.3.13.4 The RX1500 device will not support IEEE 1588 version 2 and IEEE C37.238-2011.

10.3.13.5 There will be no option for a GPS receiver for the RX1500.

10.3.14 Other Requirements

The RX1500:

10.3.14.1 will be able to perform the function of a Dynamic Host Control Protocol (DHCP) server, with option 82 supported.

10.3.14.2 will allow for centralised password management by means of a RADIUS server.

10.3.14.3 will **not** directly provide Intrusion Detection and Prevention System (IDS/IPS) services. These are however available when using the Siemens Ruggedcom APE1404CKP module running Check Point.

10.3.14.4 will supports Integrated Routing and Bridging (IRB) when using Layer 2 tunnelling. This will allow a protocol to be bridged as well as routed on the same interface on the router. This can be used to forward VLAN headers.

10.3.14.5 will allow for inter-VLAN routing.

10.3.14.6 will allow for IP multicast routing.

10.3.14.7 will support serial IP encapsulation.

10.3.14.8 will provide a fault indication under all failure conditions. This will be user configurable.

10.3.14.9 will allow for Fast Link Detections (FLD) for quicker discovery of new devices or links in the network.

10.3.14.10 will allow FLD to be automatically turned off, as a failsafe, in the case of a large number of link state changes propagating across the network.

10.3.14.11 will support the Link Layer Discovery Protocol (LLDP) [refer to IEEE 802.1AB-2005 rather than IEEE 802.1AB-2009].

10.3.14.12 will support the Internet Group Management Protocol (IGMP) version 3 [refer to RFC 4604] that is used in managing the membership of multicast groups.

10.3.14.13 will be able to perform IGMP snooping.

10.3.14.14 will **not** be able to auto-sense the IP version.

10.3.14.15 will be able to perform auto-negotiation and automatic crossover detection.

10.3.14.16 will not support the Multiple MAC Registration Protocol (MMRP) that allows multicast traffic in bridged LANs to be confined to areas of the network where it is required. [refer to IEEE 802.1Q-2011]

10.3.14.17 will support multi-level user password to protect the switch from unauthorised persons. The levels that will be supported are Guest, Operator and Admin and the associated rights per user level are shown in the table below:

Table 32: Siemens Ruggedcom RX1500 Switch User Levels and Rights

Rights	User Type		
	Guest	**Operator**	**Admin**
View Settings	✓	✓	✓
Clear Logs	✗	✓	✓
Reset Alarms	✗	✓	✓
Clear Statistics	✗	✓	✓
Change Basic Settings	✗	✓	✓
Change Advanced Settings	✗	✗	✓
Run Commands	✗	✗	✓

10.3.14.18 will allow for logs to be sent to multiple (up to five) configurable syslog servers (or collectors). Each server will be able to be sent logs of varying severity.

10.3.14.19 will allow for WAN Loopback test functions.

10.3.15 Switch Security

10.3.15.1 The RX1500 switch will include security features to allow Eskom to comply with North American Electric Reliability Corporation - Critical Infrastructure Protection (NERC CIP) security standards, policy 001 - 009, where applicable.

10.3.15.2 The RX1500 switch will be configured to comply with the Cyber Security Standard for Operational Technology, EST 240 – 55410927 as far as is practical.

10.3.15.3 The RX1500 will support Remote Authentication Dial-In User Service (RADIUS) for both user and administrative authentication.

10.3.15.4 The RX1500 will be able to authenticate to AAA (Authentication, Authorization and Accounting) servers via both RADIUS and TACACS+.

10.3.15.5 The RX1500 will comply with IEEE 802.1X-2004, port-based network access control.

10.3.15.6 The RX1500 will support multiple levels of privileges per user.

10.3.15.7 All encryption on the device will be 128-bit AES or better.

10.3.16 Management Tools

10.3.16.1 The RX1500 switch's management interface will be accessible via a web browser that supports HTTPS and via a serial connection.

10.3.16.2 Different web browsers will be supported i.e. Mozilla's Firefox web browser on Linux and Windows or Internet Explorer on Windows.

10.3.16.3 The management Command Line Interface (CLI) will be accessible via Secure Shell (SSH).

10.3.16.4 The RX1500 will allow for remote access for configuration purposes via a physically separated management port.

10.3.16.5 The RX1500 will support the Simple Network Management Protocol (SNMP) version 1, version 2c and version 3.

10.3.16.6 The RX1500 will support Remote Network Monitoring (RMON) for event logging, viewing of device statistics, proactive monitoring, problem detection and reporting.

11. SERIAL PORT SERVER REQUIREMENTS

The serial port server that has been offered is the Siemens Ruggedcom RS416 (hereafter referred to as RS416) that will be used to provide serial over IP sockets as a means of supporting remote engineering to legacy equipment using proprietary protocols and RS422/RS485 bus architectures. Listed below are the requirements for the Serial Port Server.

11.1 ENVIRONMENTAL, ELECTRICAL AND MECHANICAL REQUIREMENTS

The RS416 will be substation hardened and ruggedized to be able to withstand the following, without the performance being out of limits, reliability being compromised or the life cycle being shortened.

11.1.1 Environmental

The RS416 will be:

11.1.1.1   compliant with Class C3, as per IEC 60870-2 part 1, Table 1; except for:

- Rate of change of temperature
- Solar Radiation
- Condensation
- Precipitation
- Ice and frost

11.1.1.2   capable of operating within a temperature range of -40°C to 85°C, with passive cooling.

11.1.2 Altitude

The device will operate within an altitude range between 0 – 2500m. The units have been fully tested up to 2000m, but will continue to function up to 2500m, however the environmental specification could be indicated (e.g. lower max temperature).

11.1.3 EMI Immunity

The RS416 will provide error-free operation when exposed to EMI stress and electrical surges, as per Class 2 requirements of IEEE 1613.

11.1.4 Electrical

The RS416:

11.1.4.1   will operate within an electrical interference environment, where equipment is situated within high voltage switching compounds (132 kV or above) such that it is subject to high levels of radiated electrical interference, due to its physical placement or its direct connection to electrical plant.

11.1.4.2   will not be affected by other device frequencies.

11.1.4.3   will not generate any interference, which could hinder its own performance or the performance of the other equipment in its vicinity.

11.1.5   Power Supply

11.1.5.1   The power supply voltages will be selectable at time of order placement. Please refer to Table 39 in Appendix A for details of offered products and items.

11.1.5.2   The voltage options are: 48 Vdc, 110 Vdc and 220 Vdc.

11.1.5.3   The voltage tolerances will be as per Table 1.

11.1.5.4   Dual, redundant power supplies with separate inputs per power supply to be able to draw from separate power sources. Please refer to Table 39 in Appendix A for details of offered products and items.

11.1.5.5   There will be no option for a hot swappable power supply with the RS416.

11.1.5.6   The power supply connectors will be screw-type terminal block. Please refer to Table 39 in Appendix A for details of offered products and items.

11.1.6   Mechanical Shock and Vibration

The RS416 will comply with Class Bm, as per IEC 60870-2 part 1, section 4.2.2.

11.2   HARDWARE

11.2.1   Switching Fabric

11.2.1.1   The switching fabric bandwidth will be at least twice the total capacity of connecting modules. The capacity will be 3.8 Gbit/s.

11.2.1.2   The RS416 does not allow head of line blocking.

11.2.1.3   The RS416 will utilise the store-and-forward method for switching.

11.2.1.4   The switching latency on the RS416 unit will be 7 µs.

11.2.2   Serial Ports

The serial ports:

11.2.2.1   will have surge protection and will be fully independent 2 kV (RMS) isolated serial ports.

11.2.2.2   will be protected from Electro Static Discharges (ESD) as defined in IEC61000-4-2 Level 1 (2kV) for both contact and air discharges.

11.2.2.3   will support DB9 female connectors and RJ45 connectors. Phoenix type screw terminals will not be supported. Please refer to Table 39 in Appendix A for details of offered products and items.

11.2.2.4   will support Universal Serial Ports where RS232 or RS485 are to be provided on the same physical connector that is software configurable.

11.2.2.5   will allow for the data rate to be selected on a per port basis, in the software.

11.2.2.6   will support the following data rates:

   a)   1200

   b)   4800

   c)   9600

   d)   19200

   e)   38400

   f)   57600

   g)   115200

11.2.2.7   will support the following options for flow control signalling when RS232 is setup:

   a)   RTS/CTS hardware handshaking – not supported

   b)   Xon/Xoff software handshaking

   c)   No flow control

11.2.2.8   will allow data byte frames to be configurable as follows:

   a)   Seven or eight bits data length

   b)   Even/odd or no parity bit

   c)   One or two stop bits

11.2.2.9   will **not** support 120 Ohm terminating resistors as used in RS485 busses. External resistors will be required where necessary.

11.2.2.10   will support the following connection types:

11.2.2.10.1   Active - always on and connection is initiated by the device to the remote host,

11.2.2.10.2   Passive - where connection is initiated from the remote host to the device as required by the remote host, and

11.2.2.10.3   On-Demand is **not** supported - where the connection is initiated from the device to the remote host once serial data has been captured and is ready for transmission, after which a timeout function will be used to disconnect the host.

11.2.2.11   will support an inactivity timeout function on the IP socket that once elapsed will terminate the connection.

11.2.2.12   will support a predefined limitation on the amount of IP socket connections that can be made to a port.

11.2.2.13   will support the use of a terminating character to force the transmission of the serial data.

11.2.2.14   will support any ASCII or bit-based protocol. It is however prudent that any required protocol should be tested.

11.2.2.15   will not support a small device option with 2 serial ports

11.2.2.16   will support a medium device option with 4 to 8 serial ports

11.2.2.17   will support a large device option with 16 ports that will be modular to allow for appropriate module selection, future expansion or repairs.

11.2.3   Ethernet Ports

The Ethernet ports will be provided as a combination of copper and/or fibre ports, based on the requirements of the connecting bay devices.

11.2.3.1   The fibre ports:

11.2.3.1.1   will support multimode communication (10Base-FL) with a wavelength of 850 nm installable in slot 5 or slot 6 of the device.

Table 33: Siemens Ruggedcom RS416 10Base-FL fibre module

Order Code	Description
E02	FL01 = 2 x 10FL - Multimode, 850nm, ST

11.2.3.1.2   will support multimode communication (100Base-FX) with a wavelength of 1300 nm installable in slot 5 or slot 6 of the device.

Table 34: Siemens Ruggedcom RS416 100Base-FX fibre modules

Order Code	Description
E03	FX01 = 2 x 100FX - Multimode, 1300nm, ST
E04	FX02 = 2 x 100FX - Multimode, 1300nm, SC
E05	FX11 = 2 x 100FX - Multimode, 1300nm, LC
E06	FX03 = 2 x 100FX - Multimode, 1300nm, MTRJ

11.2.3.1.3   will support LC, ST and SC connectors.

11.2.3.2   The copper ports:

11.2.3.2.1   will support both 10Base-TX and 100Base-TX installable in slot 5 or slot 6 of the device.

Table 35: Siemens Ruggedcom RS416 10/100Base-TX module

Order Code	Description
E01	TX01 = 2 x 10/100Tx RJ45

11.2.3.2.2   will support RJ45 connectors.

11.2.3.3   Ethernet ports will be modular and facilitate future expansion and repairs.

11.2.3.4   The RS416 will support 2 Ethernet ports as a minimum.

11.2.4   General

11.2.4.1   The RS416 will be made of heavy duty steel (18 AWG galvanized steel) and supplied with the option to mount in a standard 19" rack panel or on a DIN rail, with all associated accessories as per order code. Please refer to Table 39 in Appendix A for details of offered products and items.

11.2.4.2   The RS416 will have terminal blocks for power and I/O connections that are rated for industrial applications.

11.2.4.3   There will be an order option to add a protective coating on the circuit board, to protect against dust and moisture. Please refer to Table 39 in Appendix A for details of offered products and items.

11.2.4.4   The RS416 will have supporting software, in the form of Rugged Director, that will be used to create virtual communication ports on both Windows and Linux systems. These virtual ports will enable transparent communications to the serial ports.

11.2.4.5   There will be a dedicated RS232 console port on a RJ45 connector for switch management.

11.2.4.6   The RS416 will not support Small Form-factor Pluggable (SFP) modules. All fibre port options will be fixed.

11.3   REQUIRED ETHERNET FUNCTIONALITY

11.3.1   Virtual Local Area Networks (VLANs)

The RS416:

11.3.1.1   will support VLAN tagging.

11.3.1.2   will comply with IEEE 802.1Q-2005.

11.3.1.3   will support the double-tagging of an Ethernet frame/QinQ functionality [refer to IEEE

802.1ad-2005 rather than IEEE 802.1Q-2011].

11.3.1.4   will not support the Multiple VLAN Registration Protocol (MVRP) for automatically propagating VLAN information across a network. Only GVRP will be supported.

11.3.1.5   will support VLAN assignment per port, for untagged traffic.

11.3.2   Link Aggregation

The RS416:

11.3.2.1   will allow for the linking of Ethernet ports into one logical trunk for higher bandwidths.

11.3.2.2   will not comply with IEEE 802.1AX-2008 as only static link aggregation will be supported.

11.3.3   Serial IP Encapsulation

The RS416:

11.3.3.1   will support serial IP encapsulation

11.3.3.2   will be able to handle the serial IP encapsulation of all the protocols listed in the hardware section (11.2.1.14).

11.3.4   Spanning Tree Protocol

The RS416:

11.3.4.1   will support the Rapid Spanning Tree Protocol (RSTP) [refer to IEEE 802.1D-2004].

11.3.4.2   will support the Multiple Spanning Tree Protocol (MSTP) [refer to IEEE 802.1Q-2005].

11.3.5   Traffic Prioritisation

The RS416:

11.3.5.1   will allow for the classification of priorities based on the MAC address, port, tags and IP Type of Service (TOS).

11.3.5.2   will allow time critical data to be classified as higher priority.

11.3.5.3   will support numerous priority queues for TOS.

11.3.5.4   will comply with the QoS Prioritisation schemes in the IEEE 802.1Q-2005.

11.3.6   Port Configuration

The RS416:

11.3.6.1   will allow for automatic configuration of ports.

11.3.6.2   will allow for automatic crossover detection.

11.3.6.3   will allow for manual configuration of media type state, speed and duplex state.

11.3.6.4   will have the capability to disable ports that are not being used.

11.3.6.5   will allow a port to be configured to a specific VLAN.

11.3.6.6   will be capable of limiting which VLANs are accessible through a trunk port.

11.3.6.7   will allow limiting of the number of MAC addresses admissible per port.

11.3.6.8   will allow limiting of the number of VLANs per port. This will only be applicable to trunk ports as edge ports can only be assigned to a single VLAN.

11.3.7   Port Rate Limiting

The RS416:

11.3.7.1   will have the ability to limit traffic on a per-port basis.

11.3.7.2   will allows for Broadcast; Multicast; or Unicast port rate limiting, which is essential for managing network traffic.

11.3.8   Port Based Access Control

The RS416:

11.3.8.1   will provide a means for authenticating and authorising devices attached to the Ethernet ports.

11.3.8.2   will comply with IEEE 802.1X-2004.

11.3.9   Security Requirements

11.3.9.1   The RS416 will include security features to allow Eskom to comply with North American Electric Reliability Corporation - Critical Infrastructure Protection (NERC CIP) security standards, policy 001 - 009, where applicable.

11.3.9.2   The RS416 will be configured to comply with the Cyber Security Standard for Operational Technology, EST 240 – 55410927 as far as is practical.

11.3.9.3   The RS416 will support Remote Authentication Dial-In User Service (RADIUS) for both user and administrative authentication.

11.3.9.4   The RS416 will be able to authenticate to AAA (Authentication, Authorization and Accounting) servers via both RADIUS and TACACS+.

11.3.9.5   The RS416 will comply with IEEE 802.1X-2004, port-based network access control.

11.3.9.6   The RS416 will support multiple levels of privileges per user.

11.3.9.7   The RS416 will support multi-level user passwords (guest, operator and admin levels).

11.3.10   Management Tools

11.3.10.1   The RS416's management interface will be accessible via a web browser that supports HTTPS or via a serial connection.

11.3.10.2   Different web browsers will be supported i.e. Mozilla's Firefox web browser on Linux and Windows or Internet Explorer on Windows.

11.3.10.3   The management Command Line Interface (CLI) will be accessible via Secure Shell (SSH).

11.3.10.4   The RS416 will support the Simple Network Management Protocol (SNMP) version 1, version 2c and version 3.

11.3.10.5   The RS416 will support Remote Network Monitoring (RMON) for event logging, viewing of device statistics, proactive monitoring, problem detection and reporting.

12. GENERAL REQUIREMENTS

12.1   NETWORK MANAGEMENT SOFTWARE (NMS) REQUIREMENTS

The NMS that has been offered is the Siemens RuggedNMS product. The NMS:

12.1.1   can be viewable remotely using a web browser over an encrypted session.

12.1.2   will work with the Mozilla Firefox web browser on Linux and not just with Internet Explorer on Windows.

12.1.3   will only be accessible via a command line interface via Secure Shell (SSH) for system maintenance purposes.

12.1.4   will support scalable licenses for the number of nodes supported with no upper limit.

12.1.5   will allow for early detection and repair of faults.

12.1.6   will generate standard and custom reports and graphs on network statistics for the purpose of performance management.

12.1.7   will maintain a log containing the users who logged in, with timestamps for traceability.

12.1.8   will allow for bulk remote uploads of new configurations.

12.1.9   will allow for bulk remote upgrade of firmware.

12.1.10   will provide information on link status throughout the network.

12.1.11   will provide information on device status throughout the network.

12.1.12   will provide information on levels of traffic in different segments of the network.

12.1.13   will provide information on available services on the network.

12.1.14   will support auto discovery, to discover the network that can be configured to include or exclude various ranges or devices.

12.1.15   will provide automatically generated visual maps of the network, showing devices, their links and statuses.

12.1.16   will support SNMP v1, v2c or v3 traps.

12.1.17   will provide support for Remote Monitoring and LLDP.

12.1.18   will support the Linux or Windows operating system.

12.1.19   will have manually configurable thresholds.

12.1.20   will be able to send events by email, SMS or outside programs.

12.1.21   will use SNMP as the management protocol.

12.2   SFP MODULE REQUIREMENTS

The SFP Modules used with the Siemens Ruggedcom products will be:

12.2.1   manufactured by third parties such as Avago but only approved modules are certified to operate with the equipment.

12.2.2   certified by Siemens to be fully compliant with the overall requirements of the product they are being used in.

12.2.3   software locked to the Siemens Ruggedcom devices based on the SFP device ID. It will therefore not be possible to use modules that are not certified by Siemens.

12.2.4   Uncertified third party SFP modules will not be able to be used with the Siemens Ruggedcom devices.

12.3   TESTING AND APPROVAL

This section of the document is not part of the Functional Design Specification document and will be provided as a separate document.

12.4   WARRANTY

This section of the document is not part of the Functional Design Specification document and will be provided as a separate document.

12.5   SOFTWARE LICENSES

This section of the document does not form part of the Functional Design Specification document.

12.6   DOCUMENTATION

This section of the document is not part of the Functional Design Specification document and will be provided separately.

12.7   TRAINING

This section of the document is not part of the Functional Design Specification document and will be provided separately.

12.8   SPARES

This section of the document is not part of the Functional Design Specification document and will be provided separately.

12.9   SUPPORT AND MAINTENANCE

This section of the document is not part of the Functional Design Specification document and will be provided separately.

13. AUTHORISATION

This document has been seen and accepted by:

Name	Designation
W Meades	System Control Engineer – Telecommunications and Networking
S Dayabhai	System Control Manager
D Bhana	Project Manager

14. REVISION

Date	Rev.	Compiler	Remarks
April 2017	3	T Craven	Amendments as per Eskom comments
October 2016	2	P Diamandis	Changes to read in the future tense
October 2016	1	P Diamandis	Updated with Eskom's comments
August 2016	0	P Diamandis	For review

15. DEVELOPMENT TEAM

The following people were involved in the development of this document:

- P Diamandis
- W Meades
- S Dayabhai

16. ACKNOWLEDGEMENTS

Not Applicable.

APPENDIX A – EQUIPMENT ORDER CODES

The tables below are an extract from the offered product schedule listing the offered configuration options and product items pertaining to each of the networking commodities. Please note that these are subject to change and have been included here for convenience.

Table 36: Gigabit (Backbone) Switch - Offered Items

Configuration Option	Product	Order Code
Backbone Switch Gb Switch Opt. 1: 8 x 1000BaseSx, LC; 19" rack; 48 VDC PS	RSG2488	6GK6024-8GS22-2DA0-Z A05+B05+C00+D00+E00+F00+G60+H60
Gb Switch Opt. 2: 16 x 1000BaseSx, LC; 19" rack; 48 VDC PS	RSG2488	6GK6024-8GS22-2DA0-Z A05+B05+C05+D05+E00+F00+G60+H60
Gb Switch Opt. 3: 24 x 1000BaseSx, LC; 19" rack; 48 VDC PS	RSG2488	6GK6024-8GS22-2DA0-Z A05+B05+C05+D05+E05+F05+G60+H60
Gb Switch Opt. 4: 8 x 1000BaseLx, LC; 19" rack; 110 VDC PS	RSG2488	6GK6024-8GS23-3DA0-Z A07+B07+C00+D00+E00+F00+G60+H60
Gb Switch Opt. 5: 16 x 1000BaseLx, LC; 19" rack; 110 VDC PS	RSG2488	6GK6024-8GS23-3DA0-Z A07+B07+C07+D07+E00+F00+G60+H60
Gb Switch Opt. 6: 24 x 1000BaseLx, LC; 19" rack; 110 VDC PS	RSG2488	6GK6024-8GS23-3DA0-Z A07+B07+C07+D07+E07+F07+G60+H60
Gb Switch Opt. 7: 8 x 1000BaseLx, LC; 19" rack; 110 VDC PS	RSG2488	6GK6024-8GS23-3DA0-Z A07+B07+C00+D00+E00+F00+G60+H60
Gb Switch Opt. 8: 16 x 1000BaseLx, LC; 19" rack; 110 VDC PS	RSG2488	6GK6024-8GS23-3DA0-Z A07+B07+C07+D07+E00+F00+G60+H60
Gb Switch Opt. 9: 24 x 1000BaseLx, LC; 19" rack; 110 VDC PS	RSG2488	6GK6024-8GS23-3DA0-Z A07+B07+C07+D07+E07+F07+G60+H60
Gb Switch - 48VDC PS, screw terminal block	RSG2488	6GK6024-8GS22-2DA0-Z A00+B00+C00+D00+E00+F00+G60+H60
Gb Switch - 110VDC PS, screw terminal block	RSG2488	6GK6024-8GS23-3DA0-Z A00+B00+C00+D00+E00+F00+G60+H60
Gb Switch - 220VDC PS, screw terminal block	RSG2488	6GK6024-8GS23-3DA0-Z A00+B00+C00+D00+E00+F00+G60+H60
Gb Switch - 48VDC PS, pluggable terminal block	RSG2488	6GK6024-8GS25-2DA0-Z A00+B00+C00+D00+E00+F00+G60+H60
Gb Switch - 110VDC PS, pluggable terminal block	RSG2488	6GK6024-8GS26-3DA0-Z A00+B00+C00+D00+E00+F00+G60+H60
Gb Switch - 220VDC PS, pluggable terminal block	RSG2488	6GK6024-8GS26-3DA0-Z A00+B00+C00+D00+E00+F00+G60+H60
Gb Switch - Multimode fiber port module: 1000BaseSx , 850nm, LC	RSG2488	6GK6000-8FG01-4EA0
Gb Switch - Singlemode fiber port module: 1000BaseLx , 1310nm, LC	RSG2488	6GK6000-8FG03-4EA0
Gb Switch - Multimode SPF module: 1000BaseSPF	RSG2488	6GK6000-8FG51-4EA0
Gb Switch - Singlemode SPF module: 1000BaseSPF	RSG2488	6GK6000-8FG53-4EA0
Gb Switch - PTP enabled base module	RSG2488	6GK6000-8PT01-4EA0

Table 37: Layer 2 Switch (Station and Bay Switch) - Offered Items

Configuration Option	Product	Order Code

Configuration Option	Product	Order Code
Station Switch L2 Switch Opt. 1: 2 x 1000BaseSx, LC; 4 x 100BaseTx, RJ45 ; 6 x 100BaseFx, LC; 19" rack; 48VDC PS; rear ports ; front display	RSG2100	6GK6021-0AS22-2DB0-Z A01+B01+C00+D00+E02+F00+G05+H05+J05+K00
Bay Switch L2 Switch Opt. 4: 2 x 1000BaseSx, LC ; 4 x 100BaseFx, ST; 4 x 100BaseTx, RJ45; 19" rack; 110 VDC PS; rear ports ; front display	RSG2100	6GK6021-0AS23-3DB0-Z A01+B01+C00+D00+E02+F00+G03+H03+J00+K00
L2 Switch Opt. 2: 2 x 1000BaseSx, LC; 4 x 100BaseTx, RJ45 ; 6 x 100BaseFx, ST; 19" rack; 110VDC PS	RSG2100	6GK6021-0AS23-3DB0-Z A01+B01+C00+D00+E02+F00+G03+H03+J03+K00
L2 Switch Opt. 3: 2 x 1000BaseSx, LC; 4 x 100BaseTx, RJ45 ; 6 x 100BaseFx, ST; 19" rack; 220VDC PS	RSG2100	6GK6021-0AS23-3DB0-Z A01+B01+C00+D00+E02+F00+G03+H03+J03+K00
L2 Switch Opt. 5: 2 x 1000BaseSx, LC ; 4 x 100BaseFx, ST; 4 x 100BaseTx, RJ45; 19" rack; 220 VDC PS	RSG2100	6GK6021-0AS23-3DB0-Z A01+B01+C00+D00+E02+F00+G03+H03+J00+K00
L2 Switch Opt. 6: 2 x 1000BaseSx, LC ; 4 x 100BaseFx, ST; 4 x 100BaseTx, RJ45; 19" rack; 48 VDC PS	RSG2100	6GK6021-0AS22-2DB0-Z A01+B01+C00+D00+E02+F00+G03+H03+J00+K00
L2 Switch Opt. 7: 2 x 1000BaseSx, LC ; 4 x 100BaseFx, LC; 4 x 100BaseTx, RJ45; 19" rack; 110VDC PS	RSG2100	6GK6021-0AS23-3DB0-Z A01+B01+C00+D00+E02+F00+G05+H05+J00+K00
L2 Switch Opt. 8: 2 x 1000BaseSx, LC ; 4 x 100BaseFx, LC; 4 x 100BaseTx, RJ45; 19" rack; 220VDC PS	RSG2100	6GK6021-0AS23-3DB0-Z A01+B01+C00+D00+E02+F00+G05+H05+J00+K00
L2 Switch Opt. 9: 2 x 1000BaseSx, LC; 6 x 100BaseFx, ST; 2 x 100BaseTx, RJ45; 19" rack; 48VDC PS	RSG2100	6GK6021-0AS22-2DB0-Z A01+B00+C00+D00+E02+F00+G03+H03+J03+K00
L2 Switch Opt. 10: 2 x 1000BaseSx, LC; 6 x 100BaseFx, LC; 2 x 100BaseTx, RJ45; 19" rack; 110VDC VDC PS	RSG2100	6GK6021-0AS23-3DB0-Z A01+B00+C00+D00+E02+F00+G05+H05+J05+K00
L2 Switch Opt. 11: 2 x 1000BaseSx, LC; 8 x 100BaseTx, RJ45; 19" rack; 110VDC PS	RSG2100	6GK6021-0AS23-3DB0-Z A01+B01+C01+D01+E02+F00+G00+H00+J00+K00
L2 Switch Opt. 12: 4 x 100BaseFx, ST; 6 x 100BaseTx, RJ45; 19" rack; 48VDC PS	RSG2100	6GK6021-0AS22-2DB0-Z A01+B01+C01+D00+E00+F00+G03+H03+J00+K00
L2 Switch Opt. 13: 4 x 100BaseFx, LC; 6 x 100BaseTx, RJ45; 19" rack; 110VDC PS	RSG2100	6GK6021-0AS23-3DB0-Z A01+B01+C01+D00+E00+F00+G05+H05+J00+K00
L2 Switch Opt. 14: 10 x 100BaseFx, ST ; 4 x 100BaseTx, RJ45; 19" rack; 48VDC PS	RSG2100	6GK6021-0AS22-2DB0-Z A01+B01+C00+D03+E00+F00+G03+H03+J03+K03
L2 Switch Opt. 15: 10 x 100BaseFx, ST ; 4 x 100BaseTx, RJ45; 19" rack; 110 VDC PS	RSG2100	6GK6021-0AS23-3DB0-Z A01+B01+C00+D03+E00+F00+G03+H03+J03+K03
L2 Switch Opt. 16: 10 x 100BaseFx, ST ; 4 x 100BaseTx, RJ45; 19" rack; 220VDC PS	RSG2100	6GK6021-0AS23-3DB0-Z A01+B01+C00+D03+E00+F00+G03+H03+J03+K03
L2 Switch Opt. 17: 2 x 1000BaseSx, LC; 2x10BaseFL, ST; 2x100BaseFx, ST; 2x100BaseTx, RJ45; 19" rack; 48VDC PS	RSG2100	6GK6021-0AS22-2DB0-Z A01+B00+C02+D00+E02+F00+G03+H00+J00+K00
L2 Switch Opt. 18: 2x1000BaseSx, LC; 6x10BaseFL, ST; 2x100BaseFx, ST; 2x100BaseTx, RJ45; 19" rack; 220VDC PS	RSG2100	6GK6021-0AS23-3DB0-Z A01+B02+C02+D02+E02+F00+G03+H00+J00+K00
L2 Switch Opt. 19: 2x1000BaseSx, LC; 6x10BaseFL, ST; 2x100BaseFx, ST; 2x100BaseTx, RJ45; 19" rack; 110VDC PS	RSG2100	6GK6021-0AS23-3DB0-Z A01+B02+C02+D02+E02+F00+G03+H00+J00+K00
L2 Switch Opt. 20: 2x1000BaseSx, LC; 10x10BaseFL, ST; 2x100BaseFx, ST; 2x100BaseTx, RJ45; 19" rack; 48VDC PS	RSG2100	6GK6021-0AS22-2DB0-Z A01+B02+C02+D02+E02+F00+G02+H02+J03+K00
L2 Switch Opt. 21: 2x1000BaseSx, LC; 10x10BaseFL, ST; 2x100BaseFx, ST; 2x100BaseTx, RJ45; 19" rack; 220VDC PS	RSG2100	6GK6021-0AS23-3DB0-Z A01+B02+C02+D02+E02+F00+G02+H02+J03+K00
L2 Switch Opt. 22: 2 x 1000BaseSx, LC; 16 x 100BaseFx, ST; 19" rack; 110VDC PS	RSG2100	6GK6021-0AS23-3DB0-Z A03+B03+C03+D03+E02+F00+G03+H03+J03+K03
L2 Switch Opt. 23: 2 x 1000BaseSx, LC; 16 x 100BaseFx, LC; 19" rack; 48VDC PS	RSG2100	6GK6021-0AS22-2DB0-Z A05+B05+C05+D05+E02+F00+G05+H05+J05+K05

Configuration Option	Product	Order Code
L2 Switch - 48VDC PS, screw terminal block	RSG2100	6GK6021-0AS22-2DB0-Z A00+B00+C00+D00+E00+F00+G00+H00+J00+K00
L2 Switch - 110VDC PS, screw terminal block	RSG2100	6GK6021-0AS23-3DB0-Z A00+B00+C00+D00+E00+F00+G00+H00+J00+K00
L2 Switch - 220VDC PS, screw terminal block	RSG2100	6GK6021-0AS23-3DB0-Z A00+B00+C00+D00+E00+F00+G00+H00+J00+K00
L2 Switch - 48VDC PS, pluggable terminal block	RSG2100	6GK6021-0AS25-5DB0-Z A00+B00+C00+D00+E00+F00+G00+H00+J00+K00
L2 Switch - 110VDC PS, pluggable terminal block	RSG2100	6GK6021-0AS26-6DB0-Z A00+B00+C00+D00+E00+F00+G00+H00+J00+K00
L2 Switch - 220VDC PS, pluggable terminal block	RSG2100	6GK6021-0AS26-6DB0-Z A00+B00+C00+D00+E00+F00+G00+H00+J00+K00
L2 Switch - Multimode fiber port module: 10BaseFL , 850nm, ST	RSG2100	6GK6000-8FL01-2AA0 (2x 10FL - Multi mode ports, 850nm, ST connectors Equivalent to FL01)
L2 Switch - Multimode fiber port module: 100BaseFx , 1300nm, LC	RSG2100	6GK6000-8FX11-2AA0 (2x 100FX - Multi mode, 1300nm, LC connectors Equivalent to FX11)
L2 Switch - Multimode fiber port module: 100BaseFx , 1300nm, SC	RSG2100	6GK6000-8FX02-2AA0 (2x 100FX - Multi mode ports, 1300nm, SC connectors Equivalent to FX02)
L2 Switch - Multimode fiber port module: 100BaseFx , 1300nm, ST	RSG2100	6GK6000-8FX01-2AA0 (2x 100FX - Multi mode ports, 1300nm, ST connectors Equivalent to FX01)
L2 Switch - Copper port module: 100/1000 BaseTx, RJ45	RSG2100	6GK6000-8CG01-2BA0 (Gigabit Copper Media Module CG01 (2x10/100/1000TX RJ45))
L2 Switch - Multimode fiber port module: 1000BaseSx , 850nm, LC	RSG2100	6GK6000-8FG01-1AA0 (1x 1000SX MM port, LC connectors 500m 850nm Equivalent to 1FG01)
L2 Switch - Multimode fiber port module: 1000BaseSx , 850nm, LC	RSG2100	6GK6000-8FG01-2AA0 (2x 1000SX MM ports, LC connectors 500m 850nm Equivalent to FG01)
L2 Switch - Multimode SPF module: 1000BaseSPF	RSG2100	6GK6000-8FG51-1AA0 (1 x 1000LX SFP - Multimode, 850nm, LC, 500m. Equivalent to 1FG51)
L2 Switch - Singlemode SPF module: 1000BaseSPF	RSG2100	6GK6000-8FG53-2AA0 (2 x 1000LX SFP - Singlemode, 1310nm, LC, Long Reach 25km Equivalent to FG53)

Table 38: Router and Layer 3 Switch - Offered Items

Configuration Option	Product	Order Code
Router Opt. 1: 2 x 100BaseFx,ST; 2 x 100BaseTx, RJ45; 19" rack; 48VDC PS	RX1500	6GK6015-0AM22-2DC0-Z A01+B01+C04+D00+E00
Router Opt. 2: 2x1000BaseSx, LC ; 2x100BaseFx, LC; 2x E1 ; 2x RS232/ RS422/ RS485 RJ45; 19" rack; 48VDC PS - NOT OFFERED	RX1500	6GK6015-0AM22-2DC0-Z A01+B31+C06+D42+E03
Router Opt. 3: 2x1000BaseSx, LC ; 2x100BaseFx, ST; 2x E1 ; 2x RS232/ RS422/ RS485 RJ45; 19" rack; 110VDC PS	RX1500	6GK6015-0AM23-3DC0-Z A01+B31+C04+D42+E03
Router Opt. 4: 2x1000BaseSx, LC ; 2x100BaseFx, LC or ST; 2x E1 ; 2x RS232/ RS422/ RS485 RJ45; 19" rack; 220 VDC PS	RX1500	6GK6015-0AM23-3DC0-Z A01+B31+C04+D42+E03
Router Opt. 7: 2x1000BaseLx, LC ; 2x100BaseFx, LC; 2x E1 ; 2x RS232/ RS422/ RS485 RJ45; 19" rack; 48VDC PS	RX1500	6GK6015-0AM22-2DC0-Z A01+B33+C06+D42+E03
Router Opt. 8: 2x1000BaseLx, LC ; 2x100BaseFx, ST; 2x E1 ; 2x RS232/ RS422/ RS485 RJ45; 19" rack; 220VDC PS	RX1500	6GK6015-0AM23-3DC0-Z A01+B33+C04+D42+E03

Configuration Option	Product	Order Code
Router Opt. 15: 4 x 1000BaseSFP; 2 x 1000BaseSx, LC; 2 x 100/1000BaseTx, RJ45; 19" rack; 110VDC PS	RX1500	6GK6015-0AM23-3DC0-Z A01+B31+C36+D36+E02
Router - 48VDC PS, screw terminal block	RX1500	6GK6015-0AM22-2DC0-Z A01+B00+C00+D00+E00
Router - 110VDC PS, screw terminal block	RX1500	6GK6015-0AM23-3DC0-Z A01+B00+C00+D00+E00
Router - 220VDC PS, screw terminal block	RX1500	6GK6015-0AM23-3DC0-Z A01+B00+C00+D00+E00
Router - 48VDC PS, pluggable terminal block	RX1500	6GK6015-0AM25-5DC0-Z A01+B00+C00+D00+E00
Router - 110VDC PS, pluggable terminal block	RX1500	6GK6015-0AM26-6DC0-Z A01+B00+C00+D00+E00
Router - 220VDC PS, pluggable terminal block	RX1500	6GK6015-0AM26-6DC0-Z A01+B00+C00+D00+E00
Router - RS232/ RS422/ RS485 universal serial port module, RJ45	RX1500	6GK6015-0AL20-0KB0 (S01 Line Module 6x RS232/RS422/RS485 via RJ45)
Router - Copper port module: 100/1000 BaseTx, RJ45	RX1500	6GK6015-0AL20-0FC0 (CG01 Line Module 2 x 10/100/1000 TX RJ45)
Router - WAN port module: Channelised-E1	RX1500	6GK6015-0AL20-0HB0 (E01 Line Module Single E1 75 Ohms via BNC (Channelized/Unchannelized))
Router - Multimode fiber port module: 100BaseFx , 1300nm, LC	RX1500	6GK6015-0AL20-0BC0 (4FX11 Line Module 4x 100FX Multimode LC 2km)
Router - Multimode fiber port module: 100BaseFx , 1300nm, ST	RX1500	6GK6015-0AL20-0BE0 (FX01 Line Module 2 x 100FX - Multimode, 1300nm, ST connector, 2km)
Router - Multimode fiber port module: 1000BaseSx , 850nm, LC	RX1500	6GK6015-0AL20-0DB0 (FG01 Line Module 2 x 1000SX - Multimode, 850nm, LC, 500nm)
Router - Singlemode fiber port module: 1000BaseLx , 1310nm, LC	RX1500	6GK6015-0AL20-0EC0 (FG03 Line Module 2 x 1000LX - Singlemode, 1310nm, LC connectors, 10km)
Router - Multimode SPF module: 1000BaseSPF	RX1500	6GK6015-0AL20-0DC0 (FG51 Line Module 2 x 1000SX SFP - Multimode, 850nm, LC, 500m)
Router - Singlemode SPF module: 1000BaseSPF	RX1500	6GK6015-0AL20-0EG0 (FG53 Line Module 2 x 1000LX SFP - Singlemode, 1310nm, LC, 25km)
Router - Multimode SPF module: 100BaseSPF	RX1500	6GK6015-0AL20-0BK0 (6FX51 Line Module 6 x 100FX SFP Multimode, 1310 nm, LC, 2km)

Table 39: Serial Port Server - Offered Items

Configuration Option	Product	Order Code
Serial Port Server Opt. 1 - 2 x RS232/ RS422/ RS485 2 or 4 wire universal serial ports; 2 x 100BaseTx ports RJ45; 19" rack; 110VDC PS; rear ports ; front display	RS416	6GK6041-6AT23-3DB0-Z A02+B00+C00+D00+E01+F00
Serial Port Server Opt. 2 - 2 x RS232/ RS422/ RS485 2 or 4 wire; 2 x 100BaseTx RJ45; 19" rack; 48VDC PS	RS416	6GK6041-6AT22-2DB0-Z A02+B00+C00+D00+E01+F00
Serial Port Server Opt. 3 (medium Opt. -retro fit sites, no Fx) - 8 x RS232/ RS422/ RS485 2 or 4 wire; 4 x 100BaseTx, RJ45; 19" rack; 110VDC PS	RS416	6GK6041-6AT23-3DB0-Z A02+B02+C00+D00+E01+F01
Serial Port Server Opt. 4 (medium Opt. -retro fit sites, no Fx) - 8 x RS232/ RS422/ RS485 2 or 4 wire; 4 x 100BaseTx, RJ45; 19" rack; 48VDC PS	RS416	6GK6041-6AT22-2DB0-Z A02+B02+C00+D00+E01+F01
Serial Port Server Opt. 5 (medium Opt.) - 8 x RS232/ RS422/ RS485 2 or 4 wire; 2 x 100BaseTx, RJ45; 2 x 100BaseFx LC ; 19" rack; 110VDC PS	RS416	6GK6041-6AT23-3DB0-Z A02+B02+C00+D00+E01+F05

Configuration Option	Product	Order Code
Serial Port Server Opt. 6 (medium Opt.) - 8 x RS232/ RS422/ RS485 2 or 4 wire; 2 x 100BaseTx, RJ45; 2 x 100BaseFx ST ; 19" rack; 48VDC PS	RS416	6GK6041-6AT22-2DB0-Z A02+B02+C00+D00+E01+F03
Serial Port Server Opt. 7 (medium Opt.) - 8 x RS232/ RS422/ RS485 2 or 4 wire; 2 x 100BaseTx, RJ45; 2 x 100BaseFx SC ; 19" rack; 110VDC PS	RS416	6GK6041-6AT23-3DB0-Z A02+B02+C00+D00+E01+F04
Serial Port Server Opt. 8 (large Opt. -retro fit sites, no Fx) - 16 x RS232/ RS422/ RS485 2 or 4 wire; 4 x 100BaseTx RJ45; 19" rack; 110VDC PS	RS416	6GK6041-6AT23-3DB0-Z A02+B02+C02+D02+E01+F01
Serial Port Server Opt. 9 (large Opt. -retro fit sites, no Fx) - 16 x RS232/ RS422/ RS485 2 or 4 wire; 4 x 100BaseTx RJ45; 19" rack; 48VDC PS	RS416	6GK6041-6AT22-2DB0-Z A02+B02+C02+D02+E01+F01
Serial Port Server Opt. 10 (large Opt.) - 16 x RS232/ RS422/ RS485 2 or 4 wire; 2 x 100BaseTx RJ45; 2 x 100BaseFx LC ; 19" rack; 110VDC PS	RS416	6GK6041-6AT23-3DB0-Z A02+B02+C02+D02+E01+F05
Serial Port Server Opt. 11 (large Opt.) - 16 x RS232/ RS422/ RS485 2 or 4 wire; 2 x 100BaseTx RJ45; 2 x 100BaseFx ST ; 19" rack; 48VDC PS	RS416	6GK6041-6AT22-2DB0-Z A02+B02+C02+D02+E01+F03
Serial Port Server Opt. 12 (large Opt.) - 16 x RS232/ RS422/ RS485 2 or 4 wire; 2 x 100BaseTx RJ45; 2 x 100BaseFx SC ; 19" rack; 48VDC PS	RS416	6GK6041-6AT22-2DB0-Z A02+B02+C02+D02+E01+F04
Serial Port Server - RS232/ RS422/ RS485 2 or 4 wire module, DB9	RS416	6GK6000-8SA00-0AA0 (4 port serial interface module (4 x RS232/RS422/RS485 via DB9) Equivalent to 3D)
Serial Port Server - RS232/ RS422/ RS485 2 or 4 wire module, RJ45	RS416	6GK6000-8SB00-0AA0 (4 port serial interface module (4 x RS232/RS422/RS485 via RJ45) Equivalent to 3R)
Serial Port Server - MM fiber module: 10BaseFL , 850nm, ST	RS416	6GK6000-8FL01-2AA0 (2x 10FL - Multi mode ports, 850nm, ST connectors Equivalent to FL01)
Serial Port Server - MM fiber module: 100BaseFx , 1300nm, LC	RS416	6GK6000-8FX11-2AA0 (2x 100FX - Multi mode, 1300nm, LC connectors Equivalent to FX11)
Serial Port Server - MM fiber module: 100BaseFx , 1300nm, SC	RS416	6GK6000-8FX02-2AA0 (2x 100FX - Multi mode ports, 1300nm, SC connectors Equivalent to FX02)
Serial Port Server - Copper port module: 10/100 BaseTx, RJ45	RS416	6GK6000-8TX01-2AA0 (2x 10/100Tx RJ45 ports Equivalent to TX01)

APPENDIX B – MANUFACTURER'S LETTER OF STANDARDS COMPLIANCE

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Date	June 10, 2016

Subject: ESKOM Protection Transmission Tender CORP3158, Technical Compliance

With reference to the above tender, {Siemens Ruggedcom}, as the manufacturer of the Siemens Ruggedcom range of networking hardware, hereby confirm that the RSG2488, RSG2100, RX1500 and RS416 units (as applicable) do comply with the values and standards as indicated in the table of specifications below.

While we warrant our products to be free of defects for five (5) years and stand by our quality and technical specifications, it must be considered for some of the standards referred to in the table below and our product documentation, it may not be possible to test and/or certify all requirements. However, our products are tested against the most common requirements and use cases.

Specified in Tender	Available on Products
Switching fabric equals at least double total port rate	RSG2488 – 63 Gb/s RS416 – 3.8 Gb/s
802.1Q-2011	802.1Q-2005
802.1D-2004	802.1D-2004
802.1AX-2008	Only static Link Aggregation
802.1x-2010	802.1x-2004
IEEE1588v2 (RSG2488)	IEEE1588v2
IEEE C37.238-2011 (RSG2488)	IEEE C37.238-2011
NERC CIP – 001 to 009	These units include security features to help customers fulfill NERC-CIP requirements
Class C3 as per IEC60870-2 part 1, table 1 (except for temperature)	Compliant. Temperature range is -40 to +85C
Class Bm as per IEC60870-2 part 1, Section 4.2.2	Compliant. Vibration 2g @ 10-150Hz. Shock 30g @ 11 msec

Sincerely yours,

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