VectaStar for NGMN Backhaul

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CONTENTS

1 INTRODUCTION AND SUMMARY

The *NGMN Optimised Backhaul Requirements* specification defines high-level requirements to support next generation mobile networks. It lists ninety-one requirements that next generation mobile equipment must support. VectaStar is, in the terminology of this specification, Transport Equipment, and fifteen of the ninety-one requirements do not apply to this class of equipment.

In summary, VectaStar meets all of the absolute requirements and all but four of the optional requirements (see R18, R19, R40 and R55).

The remainder of this document reproduces the requirements and describes how VectaStar conforms to them. The format is:

R*n*: Text from requirement *n* of the *NGMN Optimised Backhaul Requirement* document, reproduced verbatim.

Description of how VectaStar conforms to the preceeding requirement.

2 NGMN REQUIREMENTS

2.1 BACKHAUL CONNECTIVITY

R1: The NGMN Backhaul solution **MUST** allow connecting each e-NB to one or several aGW's (i.e. S1 interface in 3GPP LTE standard) for multi-homing purpose (e.g. S1-flex in 3GPP LTE standard) or multi-operator RAN Sharing reason.
Typically up to 6 operators and 16 S1 interfaces per operator **MAY** be envisioned per e-NB.
Typically up to 16000 S1 interfaces per operator MAY be envisioned per aGW.

VectaStar provides a transparent IP transport substrate that allows any interconnection topology between e-NBs and aGWs.

R2: The NGMN Backhaul solution **MUST** allow connecting each e-NB to one or several e-NB's (i.e. X2 interface in 3GPP LTE standard). This list of inter-e-NB connections **MUST** be operator configurable. An auto-discovery mechanism **MAY** be used to reduce the operational effort (the exact protocol and mechanism to be used is for further study). To achieve that, the NGMN Backhaul solution **SHOULD** take advantage of local TNL switching function at any possible point of the NGMN Backhaul solution according to operator decision.
Typically up to 6 operators and 32 X2 interfaces **MAY** be envisioned per e-NB.

VectaStar network elements implement standard MAC address based learning switches to allow the usual internet protocols to perform auto-discovery of eNBs by one another. This occurs at the VectaStar hub or (at the operator's option) in the core network for segmentation purposes.

2.2 BACKHAUL SEGMENTATION

R3: It **MUST** be possible to build the E2E NGMN Backhaul solution (both e-NB <-> aGW interface and e-NB <-> e-NB interface) using several network segments (e.g. packet microwave, metro optical ring) either in a single or in a multi-administrative area environment.

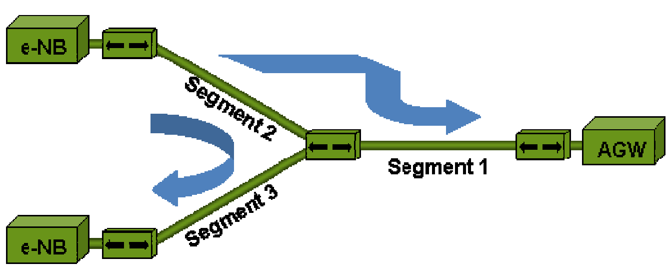


Diagram 1: Multi-Segment Backhaul

VectaStar does not impose any limitation on the segmentation of the backhaul solution. All VectaStar interfaces are fully compliant with the relevant standards (e.g. IEEE 802.3).

2.3 NETWORK VALUE IMPROVEMENT

2.3.1 SERVICE CLASSIFICATION

R4: The e-NB/aGW Transport Module **MUST** map the radio QoS Class Identifiers (QCI) to transport QoS markings (L2 and/or L3 according to operator design choice).

The transport QoS markings will then be used by the Transport Equipment to identify the traffic that needs to be carried in each Class of Service (CoS) supported over the Backhaul network. Each transport CoS **MUST** be marked in a different way at transport level (L2 and/or L3 according to operator design choice) to allow traffic to be differentiated in an E2E way.

> *VectaStar supports prioritisation across the point-to-multipoint radio link based on either IEEE 802.3p priority labels, IEEE 802.3q VLAN IDs or IP DSCP codepoints as assigned by the e-NB/aGW transport module. These labels are carried unaltered to allow the subsequent segment of backhaul to use the same mechanism to make the same identification.*

R5: As no unique mapping solution seems visible, mapping between QCI's and transport QoS markings at the e-NB/aGW Transport Module (as per **R4**) **MUST** be configurable.

> *This requirement does not apply to transport equipment.*

R6: The Transport Equipment **MUST NOT** modify the QCI-based classification and transport QoS marking done by the e-NB/aGW Transport Modules (i.e. preserve service CoS).
The Transport Equipment **MAY** add an underlying transport layer with different extra marking but **MUST** maintain the E2E QoS consistency (i.e. when several CoS exist it **MUST NOT** remark as highest priority traffic the traffic that the e-NB/aGW Transport Modules have previously marked as lowest priority traffic). Find an example below:

Examples of NGMN RAN Traffic		Example of QoS mapping in Transport Modules		Examples of QoS re-marking in Transport Equipment preserving QoS consistency	
UMTS	**WiMAX**	**Name**	**VLAN Priority**	**Class Type**	**VLAN Priority**
Network Sync (e.g. 1588v2)	Network Sync (e.g. 1588v2)	Network Control	7	High Priority	5
Mobility & Signaling traffic	Mobility & Signaling traffic	High-1	6		
Conversation Class (Real Time)	Class 1 (Interactive Gaming – Real time), Class 2 (VoIP, Video Conferencing – Real Time)	Expedited	5		
Streaming Class (Real Time)	Class 3 (Streaming Media – real time)	High-2	4		
Interactive Class (non	Class 4 (Information	Low-1	3	Assured	3

Real Time)	Technology – non Real Time)				
		Assured	2		
Background class (non Real Time)	Class 5 (Media Content Download – non Real Time)	Low-2	1	Best Effort	1
		Best Effort	0		

VectaStar transparently carries traffic and does not modify the QCI-based markings in any way. Internally flows are assigned a priority based on a notional flow identifier but this identifier is not visible outside the VectaStar system.

R7: The NGMN Backhaul solution **MUST** be able to support different classes of traffic with different QoS parameters guaranteed. At least 4 transport CoS **SHOULD** be supported. The performance attributes of each CoS are FFS and should be in line with the Standardized QCI characteristics specified by 3GPP in TS 23.203 V8.2.0.

VectaStar supports many different classes of services with parameters such as priority, committed information rate (CIR), peak information rate (PIR) and early packet discard configurable on per-flow basis.

2.3.2 SERVICES AGGREGATION

R8: The NGMN Backhaul solution **SHOULD** provide bandwidth savings by performing packet aggregation at any possible point in the network according to operator decision. This aggregation **MUST** be done in a differentiated way by taking into consideration the different transport marking levels.

As a point-to-multipoint radio system, VectaStar continuously and automatically performs on-air packet aggregation across multiple links. At the hub site, multiple radio sectors are aggregated onto a single core interconnection. At all points the priority assigned to each flow is taken into account in servicing queues.

R9: The NGMN Backhaul solution **SHOULD** support QoS-aware traffic shaping at the e-NB/aGW Transport Modules and at any demarcation point between the mobile operator and a third party transport provider taking into account the E2E delay budget (refer to **R48**).

VectaStar optionally performs traffic shaping to configurable PIRs and CIRs.

R10: The Transport Equipment **MUST** support queuing and forwarding using transport priority information. Priority **MUST** be able to be determined based on one or several methods (e.g. IP DSCP, Ethernet pbit). Not all these methods need to be implemented in the Transport Equipment but only the one(s) supported by each underlying transport technology (e.g. no mandatory need to support underlying Ethernet pbit marking if MPLS-based L3VPN is used to backhaul NGMN traffic).

VectaStar maintains separate internal queues to which traffic is directed on the basis of the IP DSCP codepoint, IEEE 802.3p priority label or IEEE 802.3q VLAN ID of traffic (see also R4).

R11: The e-NB/aGW Transport module **MUST** forward the traffic to the Transport Equipment in a fair way within the same CoS i.e. making sure that all QCI's included in the same transport CoS will get access to the allocated bandwidth in a Weighted Fair Queuing (WFQ) way.

This requirement does not apply to transport equipment.

2.3.3 Transport Resources Sharing

Bandwidth

R12: The NGMN Backhaul solution **MUST** provide Peak/Average Bandwidth in a flexible and granular way. The NGMN Backhaul service bandwidth profiles, consisting of peak and committed information rates, **SHOULD** be configurable in increments of 2 Mbps between rates of 2-30 Mbps and increments of 10 Mbps up to 100 Mbps, and increments of 100 Mbps beyond 100 Mbps. A "pay-as-you-grow" model (e.g. based on operator-defined licensing model) where hardware upgrades are not required **SHOULD** be considered.

VectaStar allows very fine grained control of PIR and CIR allocated to individual flows (granularity of 32Kbps). VectaStar allows operators to "pay-as-you-grow" in two complementary ways. Firstly, as a point-to-multipoint system, additional links may be added to a VectaStar sector simply by buying and deploying one additional terminal unit for each new link. No rework or additional equipment is needed at the hub. Secondly, VectaStar has licensed total sector capacity such that the per-sector capacity required by an operator can be scaled to demand and increased as demand grows.

R13: The NGMN Backhaul solution **MAY** provide up to 450/150 Mbps Downstream/Upstream (up to 3 sectors, each with one 20 MHz BW carrier assuming that all three sectors can simultaneously support the highest peak rate of 150/50Mbps, one Radio Access Technology) Peak Access Bandwidth where required (in those e-NB's specified by the operator). Peak Access Bandwidth relates to the instantaneous bursting of traffic in all sectors of the e-NB. This figure refers to the effective Bandwidth and does not include the transport protocol overhead or signalling overhead.
In case of the support of multiple carriers per sector (multi-band base station for instance), higher rates **MAY** be necessary.
Note: This requirement does not preclude that operator could use lower bandwidth NGMN Backhaul solutions for specific applications such as micro-site or rural cells.

VectaStar Gigabit provides 150Mbps (net) full duplex links using a 28MHz channel. VectaStar IP optimisation and 2+0 sectors provide full duplex sector bandwidths of over 500 Mbps (delivery scheduled for Q3 2010). Operating a 56MHz channel 2+0 sector provides a sector capacity of over 1000Mbps and a link capacity of over 500Mbps (delivery Q4 2010).

R14: The NGMN Backhaul solution **MUST** provide at least 150/50 Mbps Downstream/Upstream Minimum Access Bandwidth (99%-tile) where required (in those e-NB's specified by the operator). This figure assumes a 20 MHz BW carrier and refers to the effective Bandwidth and does not include the transport protocol overhead or signalling overhead.
Note: This requirement does not preclude that operator could use lower bandwidth NGMN backhaul solutions for specific applications such as micro-site or rural cells or when less than 20 MHz carriers are used.

See R13, VectaStar capacity exceeds these requirements. Additionally VectaStar continuously and automatically re-allocates capacity unused by one eNB to other eNBs in the same sector. Statistically, the peaks and troughs of utilisation from eNBs do not align perfectly. VectaStar exploits this statistical multiplexing gain to backhaul more eNBs per MHz of backhaul spectrum than is possible in a point-to-point system (where unused capacity on a link cannot be re-allocated). Therefore for areas with lower bandwidth eNB sites, many more such eNBs can be backhauled within a single VectaStar sector, thus driving down the relative cost of the backhaul network.

R15: The NGMN Backhaul solution **SHOULD** make use of any TNL optimisation or compression techniques (e.g. PPP-Mux, PPP Header Compression, IP Header Compression, Payload Compression) in order to improve bandwidth efficiency taking into account the E2E delay budget (refer to **R48**).
Header Compression **MAY** be implemented for e-NB's with low bandwidth requirements. Due to the extra delay introduced by Header Compression techniques in the overall E2E delay budget, if required Header Compression **MAY NOT** be applied to the most delay sensitive traffic (e.g. mobile gaming) in order to guarantee the maximum E2E delay budget.
Note: NGMN members consider valuable the standardization of IP header compression over Ethernet by the relevant standard body for the purpose of this requirement to be implemented over Ethernet links.

The VectaStar platform performs transparent IP optimisation to remove redundant information from L2 and L3 headers. This optimisation is invisible to the interconnected systems. Optimisation imposes a minimal latency overhead but may in any case be disabled for certain classes of traffic flow.

R16: In case of RAN Sharing, the e-NB/aGW transport modules **SHOULD** prioritise the traffic of a certain operator within a certain portion of the overall transport bandwidth. This will enable a fair use of transport resources in the case where the two operators have different strategies and, for instance, one uses only non-GBR bearers and the other one uses GBR bearers.

This requirement does not apply to transport equipment.

R17: The e-NB/aGW Transport Module **SHOULD** allow the reservation of transport bandwidth for daisy-chained network elements (e.g. legacy base stations).

This requirement does not apply to transport equipment.

MULTICAST/BROADCAST

R18: The NGMN Backhaul solution **SHOULD** be able to transfer all Multicast and Broadcast flows (e.g. MBMS traffic) by optimising resources with one or several stages of IP Multicast replication including the e-NB/MBMS-GW. It is up to the operator where to apply the multicast techniques.

VectaStar does not currently make special provision for IP multicast or broadcast, although it will transparently carry the packets to enable such applications. However, if MBMS traffic volume becomes significant, software upgrades to the platform could enable efficiency savings to be made.

R19: In multi-operator RAN sharing multicast and broadcast **SHOULD** be supported in single-operator situation and multi-operator situation where operators **MAY** use overlapping multicast address spaces.. The NGMN Backhaul solution **SHOULD** enable the coexistence of both situations for potential service development.

VectaStar does not currently make special provision for IP multicast or broadcast, although it will transparently carry the packets to enable such applications. However, if MBMS traffic volume becomes significant, software upgrades to the platform could enable efficiency savings to be made.

R20: The e-NB, the MBMS-GW, the MCE and the NGMN Backhaul solution **MUST** be able to use the same Multicast protocols used by Broadband applications (IGMP and/or PIM).

VectaStar transparently carries multicast traffic of any type.

TRANSPORT RESOURCE MANAGEMENT

R21: The e-NB/aGW **SHOULD** perform admission control for GBR bearers based on the availability of transport resources according to the operator specified provisioned bandwidth.

This requirement does not apply to transport equipment.

R22: The e-NB/aGW **SHOULD** perform QoS-aware UL/DL traffic shaping according to the operator specified provisioned bandwidth where:

- In the DL the scheduler **SHOULD NOT** schedule more traffic than transport capacity is available in the first mile.
- In the UL, when transport resources are not available, the UE scheduling grants **SHOULD** be reduced to avoid sending packets over the air interface that need to be dropped in the transport layer.

This requirement does not apply to transport equipment.

R23: The e-NB and the aGW **SHOULD** perform admission control based on the current availability and performance of transport resources; that is, taking into account the possibility of temporary backhaul bottleneck as opposed to NGMN air interface bottleneck. This mechanism **SHOULD** be applied finding the best trade-off between signalling overhead and network availability information consistency. To achieve this, the NGMN Backhaul solution **MAY** make use of any coordination mechanism between e-NB/aGW Transport Modules and Transport Equipment.

VectaStar provides fine-grained, real-time utilisation data that enables the eNB/aGW to determine how much un-utilised backhaul capacity exists.

R24: The NGMN Backhaul Solution **SHOULD** take advantage of any Load Balancing mechanism in order to efficiently optimise transport resources when possible. This requirement addresses any situation where:

- The e-NB balances calls to multiple aGW's (e.g. S1-Flex within 3GPP standard).
- Multiple paths are possible between one e-NB - aGW pair (e.g. 2 Ethernet ports in the e-NB/aGW are connected to different transport paths; multiple transport paths are possible in a microwave radio partial mesh).

VectaStar links may be made members of link aggregation groups (for example IEEE 802.3ad groups) in order to support load balancing and resiliency.

R25: The NGMN Backhaul Solution **SHOULD** take advantage of any possible exchange between e-NB/aGW and Transport Equipment (e.g. congestion indication, bandwidth reporting), in order to fully optimise the backhaul bandwidth optimisation and QoS performances. For instance a protocol like COPS, Diameter or ANCP **MAY** be used for bandwidth reporting but the exact mechanism to be used is FFS.

VectaStar provides fine-grained, real-time utilisation data and this may be made available using a variety of protocols.

2.3.4 E2E Service Manageability and Monitoring

Management and Traffic Engineering

R26: The NGMN Backhaul solution **MUST** provide in a multi-vendor environment powerful/efficient management and traffic engineering tools to reduce Opex thanks to:

- E2E Service level management
- E2E Integrated Element/Network/Service management
- Automation for E2E network and service creation/tear down

VectaStar provides a rich northbound interface that allows performance monitoring at the per-flow level and automated service creation and destruction. Differential access control may be applied to give operators in a shared backhaul scenario access only to their own configuration and performance data. Within this framework further restrictions may be applied, to give separate read-only, read-write and master access to different parties.

R27: The NGMN Backhaul solution **MUST** support standard MIB's.

VectaStar supports the following IETF standard MIBs: `SNMP-FRAMEWORK-MIB`, `SNMP-MPD-MIB`, `SNMP-COMMUNITY-MIB`, `SNMP-NOTIFICATION-MIB`, `SNMP-TARGET-MIB`, `SNMP-USER-BASED-SM-MIB`, `SNMP-VIEW-BASED-ACM-MIB`, `BRIDGE-MIB`, `DS1-MIB`, `SNMPv2-MIB`, `HOST-RESOURCES-MIB` *and* `IF-MIB`.

R28: The NGMN Backhaul solution **MUST** support a logical northbound interface for integration into other OSS packages. Northbound Configuration Management **MUST** address the configuration of the e-NB/aGW Transport Modules. No specific requirements are foreseen for this interface.

VectaStar presents a unified northbound interface from the VectaStar network management platform.

R29: The Transport Equipment **SHOULD** support a logical southbound interface for integrating any third-party Transport Equipment, e-NB/aGW Transport Module or NMS software into the OSS solution. No specific requirements are foreseen for this interface.

VectaStar supports integration of third-party equipment or modules, and presents standardised interfaces where possible to facilitate this.

R30: The NGMN Backhaul solution **MUST** be able to pro-actively, passively and on-demand monitor the OAM capabilities of the underlying network elements.
Note: "Pro-active monitoring": monitoring that is persistent and meant to identify events before or as they occur. Generally this method introduces extra traffic in the network.

VectaStar provides a range of monitoring hooks for passive and on-demand monitoring, and pro-actively monitors the state of various components of the system (links, interfaces and services).

R31: The NGMN Backhaul solution **MUST** support mechanisms for logging events (e.g. Syslog).

All VectaStar elements support syslog (both local and remote).

OAM

R32: The NGMN Backhaul solution **MUST** support OAM in a multi-vendor environment by simplifying network operations with reactive and proactive OAM tools like:

- Automatic notifications of alarms (some alarm types MUST be flexibly filtered according to operator's specific configuration)
- Per segment, per administrative area and E2E Connectivity Check
- Per segment, per administrative area and E2E Troubleshooting (Traceroute tool) to know the exact functional path of a connection

VectaStar provides a comprehensive set of alarms, and allows filtering and suppression based on alarm type, source and severity. Connectivity checks and traceroute are available on all network elements and interfaces, along with tools for deeper traffic inspection such as tcpdump, allowing 802.3p/q header level diagnosis.

R33: The NGMN Backhaul solution **MUST** be transparent to OAM flows of the RNL.

VectaStar provides a transparent Ethernet frame transport service which therefore transparently carries the RNL OAM traffic.

R34: The NGMN Backhaul solution **SHOULD** provide E2E or per segment QoS Performance monitoring (e.g. Delay, Jitter, PLR, PER).

VectaStar provides detailed, real-time measurements of PER and PLR. Addition of delay and jitter real-time monitoring is under consideration.

R35: If E2E connection of each operator can be distinguished in multi-operator RAN sharing environment, the NGMN Backhaul solution **SHOULD** support operator-specific E2E OAM.

This requirement does not apply to transport equipment.

2.4 NETWORK PERFORMANCE EXCELLENCE

2.4.1 SYNCHRONISATION DISTRIBUTION

R36: The NGMN Backhaul solution **MUST** support clock distribution to the e-NB for frequency synchronisation and **SHOULD** support phase/time alignment (for e-NB's with TDD mode of operation and for e-NB's supporting MBMS-SFN).

Note: Several methods have been considered for synchronisation as a single solution or combined together (the following list is not exclusive):

- Physical-based methods (e.g. Synchronous Ethernet) (Note: for frequency only)
- Long term stable oscillator (stable for months) (Note: for frequency only)
- Protocol-based methods (e.g. NTP, IEEE1588v2) with/without intermediate nodes support (e.g. transparent clock implementation in intermediate backhaul nodes for IEEE 1588v2)
- GNSS (e.g. GPS, Galileo, GLONASS, Beidou)

VectaStar supports the distribution of multiple SDH-quality clock domains throughout the system. These may be sourced from and sinked onto physical G.703, STM-1 or IEEE 802.3 interfaces. In addition, the low latency and jitter of the VectaStar system means that IEEE 1588v2 may be transparently carried by the VectaStar system between grandmaster clocks and slaves. In such a scenario the clock jitter performance exceeds the standard XXXX.

R37: The e-NB/aGW Transport Modules **SHOULD** support multi clock source input for synchronization, and be able to recover the synchronization from the most accurate source available at any given time according to the synchronisation hierarchy defined for failure protection.

This requirement does not apply to transport equipment.

2.4.2 BACKHAUL SOLUTION SERVICE AVAILABILITY

RELIABILITY AND FAULT RESTORATION

Note: Different types of protection could be implemented to achieve a certain operator-decided availability figure for a service or traffic type. Some examples are: service protection, link protection, node protection, etc. It is an operator design choice which protection mechanisms are implemented to achieve the operator-decided availability figure.

R38: The operator **MUST** be able to design the E2E NGMN Backhaul solution by reducing the availability figures of one (or several) Backhaul segment(s) to achieve a cost efficient solution.

> *This requirement does not apply to transport equipment according to the* NGMN Optimised Backhaul Requirements *specification (p.10). However, VectaStar does accommodate this design principle in numerous ways. For example, links and sectors may be provisioned in 1+0, 1+1 or 2+0 redundancy modes. Additionally, the RF planner may specify differing availability percentages for different links in the network.*

R39: It **SHOULD** be possible to perform in-service software upgrades of e-NB/aGW Transport Modules and Transport Equipment.

> *VectaStar supports in-service, over-the-air software upgrades. All network elements have an active and a staging software partition such that the upload of the software and the actual cutover to the new version may be decoupled.*

R40: The NGMN Backhaul solution **SHOULD** protect against failures of the forwarding control processor to increase reliability (e.g. Non-Stop Forwarding, Non-Stop Routing). Typically this **SHOULD** be required in the aGW Transport Module or in Transport Equipment where a failure would imply service outage for a number of e-NB's according to operator design choice.

> *In a VectaStar system the forwarding control processor and forwarding engine are tightly coupled and therefore failure of the former but not the latter is extremely unlikely. VectaStar elements may be deployed in 1+0, 1+1 or 2+0 redundant modes for reliability engineering.*

R41: Improved reliability of the NGMN Backhaul solution **MAY** be achieved by taking advantage of Path Protection with Fast Restoration (e.g. RSVP-TE based Fast Reroute as described in IETF RFC 4090).

> *VectaStar operates as a L2 network and therefore will transparently communicate RSVP-TE messages between the participating entities.*

R42: In particular, but not only, for Backhaul segments with high availability requirements, 99.99% service continuity (understood as mobile connectivity continuity) **SHOULD** be the target figure. This means that during 99.99% of the time, the NGMN Backhaul solution will not experience interruptions that would force mobile users to be disconnected and then force them to set up again their service connection. As a reference, the order of magnitude of such allowed interruption time (including radio, backhaul, etc.) is usually in the range of 500ms - 2s for a single outage.
Note: the 99.99% service continuity is only related to the NGMN Backhaul solution and does not include discontinuity due to e.g. e-NB itself (e.g. e-NB upgrade) or the radio layer.

> *VectaStar radio planning tools allow 99.99% service provisioning, taking advantage of VectaStar's 7-state hitless adaptive modulation to guarantee service even in the presence of severe rain-fade. VectaStar elements may be deployed in 1+0, 1+1 or 2+0 redundant modes for reliability engineering. Outage time dependent on the exact nature of the failure varies from under 50ms to 1 or 2s.*

R43: Operators wanting to guarantee a certain Quality of Experience (QoE) **SHOULD** have the option to define more stringent requirements. This means that the NGMN Backhaul solution will not experience interruptions that would impact QoE of mobile users. As a reference the order of magnitude of such allowed interruption time is in the range of 50ms - 250ms for real-time services like voice or TV streams.

> *See R42. To minimise interruption time certain network planning guidelines (such as 1+1 redundancy rather than 2+0) need to be followed.*

R44: In case the e-NB is connected to more than one aGW's, switching from the primary aGW to the secondary one **SHOULD** be coordinated between e-NB/aGW Transport Module and Transport Equipment to achieve the fastest protection as possible.

> *VectaStar participates in standard protection schemes such as 1:1 MSP and 'lights-out' protection.*

R45: The protection switching from the primary aGW to the secondary one **SHOULD** be achieved within 50ms - 250ms range.

> *See R42—R44.*

PERFORMANCE

R46: The NGMN Backhaul solution **MUST** guarantee the E2E SLA's (internal and external service agreements) and provide tools and metrics to monitor the SLA in particular in terms of performance and availability.
The complete set of performance attributes are FFS and should be in line with the Standardized QCI characteristics specified by 3GPP in TS 23.203 V8.2.0.

> *VectaStar provides a rich set of QoS parameters (see R7) and detailed, real-time performance measurements using standardised methodologies.*

R47: Different, flexible SLA's in terms of performance (e.g. Max delay, jitter, Max PLR, Max PER) **SHOULD** be provided to accommodate the needs of different Backhaul segments through the network and e-NB types with a reasonable cost model.

> *VectaStar provides a rich set of QoS parameters (see R7) and detailed, real-time performance measurements.*

R48: The NGMN Backhaul solution **MUST** guarantee E2E maximum two-way delay of 10 ms as specified in [1] and **SHOULD** guarantee 5 ms when and where required by the operator. This requirement **SHOULD** be met even in user mobility procedure.

> *The average latency across a VectaStar link is < 0.6ms, with 99.9% of packets experiencing a latency < 1.0ms.*

R49: Standardized definitions **MUST** be used when defining SLA's (e.g. Ethernet services as per the MEF Mobile Backhaul Implementation Agreement).

VectaStar uses standardised definitions and terminology wherever practical.

2.5 NETWORK FLEXIBILITY

2.5.1 USING STANDARDIZED PROTOCOLS

Note: All requirements in section **2.5.1** refer to the IP headers of any tunnelling protocol (e.g. GTP IP headers on S1 for 3GPP LTE) being transported by the Transport Equipment and to the user IP packets for functions such as header compression in the e-NB/aGW Transport Modules.

R50: The NGMN Backhaul solution **MUST** be hardware ready to support IPv4/IPv6 dual stack. Software support **SHOULD** be implemented when and where required.

VectaStar is IPv4/v6 ready. The control plane of the network elements is based on the Linux kernel therefore inheriting its long-standing IPv6 implementation.

R51: The NGMN Backhaul solution **MUST** provide a flexible and scalable way to migrate to full IPv6 environment in the future.

VectaStar elements may be configured as IPv6 or dual addressed at any time.

2.5.2 MOBILE PROTOCOL COMPATIBILITY

R52: The NGMN Backhaul solution **MUST** be able to simultaneously support existing mobile network generations (2G, 2.5G, 3G) which are not necessarily IP-based and IP-based Next-Generation Mobile Networks.

VectaStar supports TDM, ATM and Ethernet (IP) interfaces at all network elements and can therefore seamlessly support legacy equipment as well as NGMN equipment in the same network.

R53: The NGMN Backhaul solution **MUST** be compatible with existing and all-IP mobile core networks.

VectaStar supports TDM, ATM and Ethernet (IP) networks. VectaStar is in use throughout the world to backhaul the full range of 3GPP networks, from GSM networks with E1 links, through IMA and VC4 ATM-based HSPA and onto fully IP-based HSPA networks. By simultaneously supporting these technologies, VectaStar enables an operator to build capacity for the future while maintaining and enhancing their present investments.

2.5.3 SUPPORT MULTI-TRANSPORT AND MULTI-VENDOR TECHNOLOGIES

INFRASTRUCTURE TYPE

Note: This section is aimed to illustrate possible implementations but it actually does not include any requirement.

USE CASES:

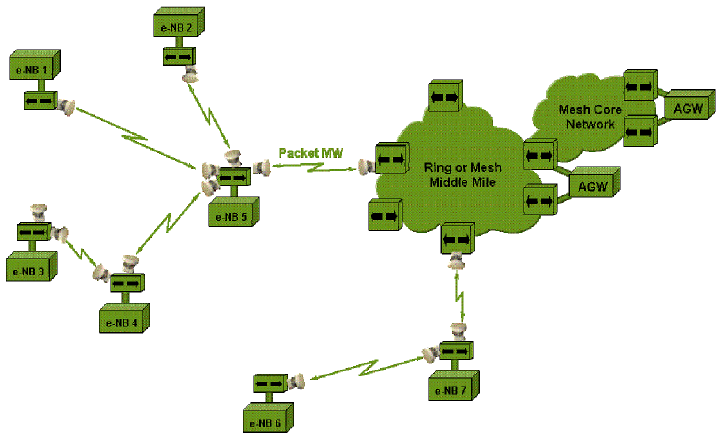
Several use case scenarios have been considered for NGMN backhaul implementation by combining some or all the following options (the list is not exhaustive):

- Topologies which could be applied in any segment of the NGMN Backhaul solution:
    - Star
    - Tree
    - Ring
    - Mesh
- Transmission technologies in any segment of the NGMN Backhaul solutions:
    - Point-to-Point microwave
    - Point-to-MultiPoint microwave
    - Leased lines
    - xDSL (e.g. VDSL2)
    - Point-to-Point Fibre
    - Point-to-Multipoint Fibre (e.g. GPON, GEPON)
    - In-band: flexible Self-Backhauling or overlay Backhauling network in same band
    - Power Line Communication (PLC)
    - WiMAX (as backhaul)
- Forwarding and encapsulation technologies in any segment of the NGMN Backhaul solution:
    - IEEE 802.1ad (Provider Bridge)
    - IEEE 802.1ah (Provider Backbone Bridge)
    - IEEE 802.1Qay (Provider Backbone Bridge - Traffic Engineering)
    - IEEE 802.1aq (Shortest Path Bridging)
    - Flat IP Routing (i.e. routing without VPN segregation)
    - VPLS
    - H-VPLS
    - L3VPN
    - Pseudowire (IETF PWE3)
    - T-MPLS (MPLS Transport Profile)
    - NG-SDH
- Each Backhaul segment could rely on either mobile-dedicated infrastructure or converged infrastructure (i.e. mixed with other networks like residential broadband or business).

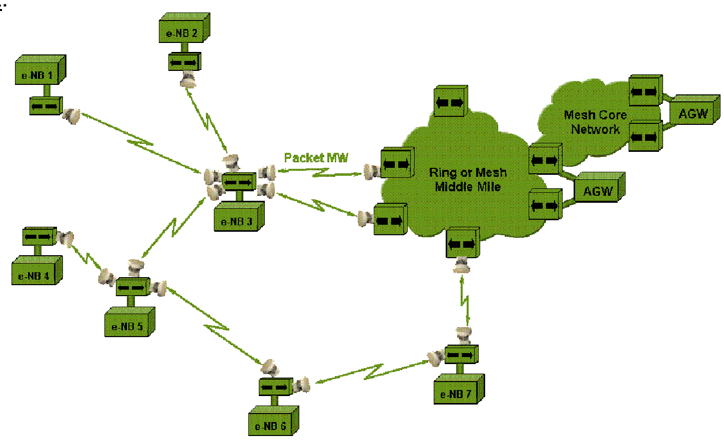
DIMENSIONING / SCALABILITY:

As an example 6 interfaces between e-NB and aGW (i.e. S1 in 3GPP LTE standard) and 20 interfaces between e-NB's (or X2 for 3GPP LTE) per e-NB could be implemented in a scenario where aGW's are deployed in the current 3GPP SGSN or RNC site and according to scenario 1, 2 or 3 below (or a combination of those).

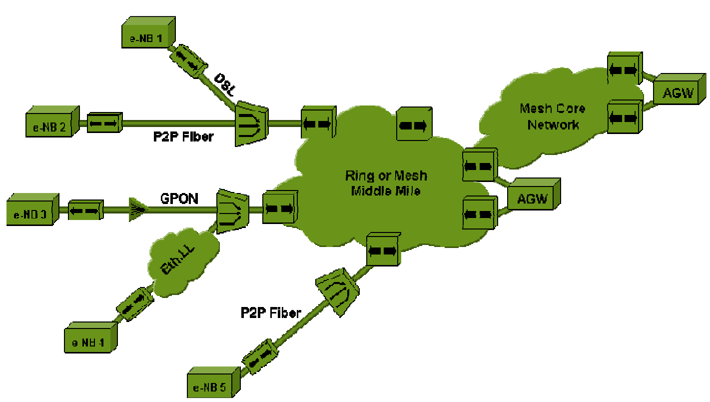
Scenario 1:



Scenario 2:



Scenario 3:



The following figures illustrate a possible worst case scenario where aGW's are deployed in current SGSN location and 8000 Micro/Macro e-NB's are distributed in the following way:

- Scenario 1 or 2: 5 Micro/Macro e-NB's per microwave chain, 20 microwave chains per "Metro Point of Concentration", 20 "Metro Point of Concentrations" per "Regional Point of Concentration", 4 "Regional Point of Concentration" per aGW site.

- Scenario 3: between 1 and 30 Micro/Macro e-NB's per MSAN (2 e-NB's + 5000 home triple play users per MSAN as average), between 2 and 20 MSAN's per "Metro Point of Concentration", between 5 and 15 "Metro Point of Concentrations" per "Regional Point of Concentration", between 3 and 8 "Regional Point of Concentration" per aGW site

Ownership

R54: It **MUST** be possible to rely on Backhaul segments which are either owned by the Mobile operator or leased from a Third Party.

> *VectaStar is readily deployable in either scenario and is especially well-suited to building out multi-operator backhaul facilities because of its strong, virtual circuit-based separation of traffic from different E2E flows.*

INTEROPERABILITY

R55: The NGMN Backhaul solution **MAY** be designed as an open system where each Transport Equipment could be replaced by any Transport Equipment of another supplier and could be managed with the same OSS solution.

> *VectaStar implements standardised interfaces wherever possible, both at the hardware level (relevant IEEE and ITU-T electrical and signalling standards) and in software.*

R56: The NGMN Backhaul solution **MUST** use standardized physical and transport protocols as defined by ITU-T, IEEE, IETF, etc. in order to guarantee interoperability in a multi-vendor environment.

> *VectaStar implements standard interfaces and protocols wherever possible and has a very large number of interoperability references, including participation at MEF interoperability events.*

2.5.4 EVOLVING EXISTING ARCHITECTURES WITH BUSINESS MODEL EVOLUTIONS

SCALABILITY

R57: The Control Plane/Provisioning functions which are used to build the logical connectivity between several e-NB's **MUST** be able to deal with all X2 connections per e-NB Transport Module without any constraint.

> *In a typical deployment, the IP X2 connections will be automatically discovered by the VectaStar system and no provisioning overhead exists.*

R58: The Control Plane/Provisioning functions which are used to build the logical connectivity between each e-NB and aGW's **MUST** be able to deal with all the S1 connections per e-NB Transport Module without any constraint.

In a typical deployment the IP S1 connections will be automatically discovered by the VectaStar system and no provisioning overhead exists.

R59: The Control Plane/Provisioning functions which are used to build the logical connectivity between each aGW and e-NB's **MUST** be able to deal with all the S1 connections per aGW without any constraint.

In a typical deployment the IP S1 connections will be automatically discovered by the VectaStar system and no provisioning overhead exists.

ECONOMICAL

R60: The NGMN Backhaul solution **MUST** be more cost-effective (i.e. lower cost per bit and more bandwidth-decoupled) than current Backhaul solutions based on PDH/SDH transport.

VectaStar provides one of the most cost effective and scalable transport technologies available due to the inherent advantages of point-to-multipoint radio technology (typically less than half the number of outdoor units required versus point-to-point to provide equivalent coverage). VectaStar's optimisation and statistical multiplexing gains compound this advantage by not transporting redundant data, and re-allocating the bandwidth thus saved to carrying more backhaul links.

2.6 NETWORK ELEMENT AND DATA SECURITY

R61: When the E2E NGMN Backhaul solution is considered as trusted by the mobile operator, the e-NB/aGW Transport Modules **SHOULD** be authenticated to the Transport Equipment physically directly connected to (e.g. using IEEE 802.1x). This will avoid an intruder accessing to all network elements connected to the trusted area throw the Ethernet connector in the e-NB/aGW Transport Modules.

VectaStar does not currently implement IEEE 802.1x authentication, but does implement alternate security measures such as MAC address filtering for ingressing Ethernet frames (such that frames from intruder equipment could be unilaterally dropped). The VectaStar air interface is proprietary and therefore is not susceptible to interception or tampering by third party equipment. VectaStar network elements support high-grade encryption for confidentiality and authorisation.

R62: When a segment of the NGMN Backhaul solution cannot be trusted by the mobile operator (i.e. when secured L2VPN or L3VPN's are not implemented) or the e-NB is not considered to be physically secured, encryption and integrity protection mechanisms **MUST** be implemented as part of the e-NB Transport Module and aGW Transport Module (or a Security Gateway implemented in the trusted mobile operator network) to secure all kinds of flows (data, control, management). In this case air interface ciphering function and IPSec encryption function **MUST** be implemented in the same single protected domain or tamper proof chip [2].

This requirement does not apply to transport equipment.

R63: The e-NB/aGW Transport Module **SHOULD** segregate data, control and management planes to limit the access (e.g. using VPN's).

This requirement does not apply to transport equipment.

R64: NGMN Backhaul solution security **MUST** be working from factory in a zero touch approach (e.g. certificates are already stored in the e-NB).

This requirement does not apply to transport equipment.

2.6.1 Network Element Security

R65: The NGMN Backhaul solution **MUST** support per management system user authentication and controlled access levels at the e-NB/aGW Transport Modules and Transport Equipment.

VectaStar supports standardised user-based access control for all network elements (SNMPv3 USM).

R66: The NGMN Backhaul solution **MUST** support secure e-NB/aGW Transport Module and Transport Equipment access by the management system user (e.g. SSH/SCP, SNMPv3).

VectaStar supports encrypted and authenticated access modes for SNMPv3 and ssh/scp across all network elements.

R67: The NGMN Backhaul solution **MUST** support protocols security at e-NB/aGW Transport Module and Transport Equipment (e.g. per peer queuing for protocols, protocol security with SHA-256 and TCP authentication).

The VectaStar control plane networking is based on the long-standing Linux network stack and thus inherits its class-leading security.

R68: The NGMN Backhaul solution **MUST** support CPU Overload Control at e-NB/aGW Transport Module and Transport Equipment.

VectaStar controls CPU load using a variety of techniques. Note that data plane load does not place any load on the CPUs in VectaStar network elements.

2.6.2 Data Plane Security

R69: In case of non-trusted NGMN Backhaul solution, communication between e-NB and aGW **MUST** be mutually authenticated and integrity and confidentiality protected.

This requirement does not apply to transport equipment.

R70: In case an e-NB is located in a non-trusted Backhaul, segment communication between e-NB and other network entities within trusted Backhaul segment **MUST** go through a SGW connecting the untrusted backhaul segment with the trusted backhaul segment. Communication between e-NB and SGW **MUST** be mutually authenticated and integrity and confidentiality protected.

VectaStar accommodates this design principle via strong segregation of traffic (see R71).

R71: The NGMN Backhaul solution **MAY** use any Access Control List, anti-spoofing filtering, FIB/RIB limitation, anti-DoS, Packet Inspection, Storm Avoidance, AAA mechanism, Logical flow-separation mechanism (such as VLAN/VPN etc.), or even some extra encryption mechanism to reach **R69** & **R70** objectives.

VectaStar provides packet-based firewalling, access control and strong separation of traffic onto virtual circuits. VectaStar therefore provides the tools required for operators to build secure, high integrity networks.

R72: The NGMN Backhaul solution **MUST** support line rate traffic filters (Layer 2 - Layer 4).

All VectaStar's traffic filtering and packet inspection operates at the full line rate of the relevant interface.

R73: The NGMN Backhaul solution **MAY** support traffic monitoring/mirroring capabilities.

VectaStar supports packet-level capture and inspection at all IP interfaces, and mirroring on a configurable per-flow basis.

2.6.3 Control Plane Security

R74: The Transport Equipment **MUST** assure secure exchange of control protocols (e.g. Transport Equipment routing/signalling). This **MAY** be achieved e.g. using authentication or choosing a non-IP encapsulated routing protocol.

The VectaStar intrinsic control protocols are encapsulated within non-user-accessible virtual circuits and there is therefore no possibility of user access or tampering with these protocols.

2.6.4 Management Plane Security

R75: The NGMN Backhaul solution **MUST** provide the ability to support single sign-on for administrator level privileges.

VectaStar provides for single sign-on via the standard ssh mechanisms (pre-authorised keys and ssh agent).

R76: A secure mechanism to protect OAM traffic (from to e-NB) by operation personnel intervention **MUST** always be available even if the NGMN Backhaul solution is considered trusted by the operator.

Using the multi-level access control features of the VectaStar NMS, low level operators can be prevented from interacting with traffic in any way.

2.7 NETWORK COST REDUCTION (TOTAL COST OF OWNERSHIP)

2.7.1 HARDWARE

BUILDING BLOCKS SIMPLICITY

R77: The NGMN Backhaul solution **MUST** be able to adapt and grow the number of physical interfaces according to the radio capacity requirements.

As a point-to-multipoint system, VectaStar has an inherent advantage when considering the growth of a network. Once the sectoral access point is in place, addition of another physical interface only requires the installation and alignment of a CPE (terminal) unit, rather than the planning and installation of two units in the case of a point-to-point link. VectaStar capacity can be progressively increased using the licensed capacity feature, and by deploying additional sectoral access points to create a 2+0 configuration, thereby doubling the sector capacity.

R78: Non-service impacting insertion of new interface cards/ plug-in units **MUST** be supported (e.g. hot insertion without requiring restart).

VectaStar supports hot addition of new terminals to sectors and new sectors to hubs. For the hub equipment, VectaStar supports hot insertion of SFP modules.

R79: RJ-45 and fibre optic connectors **SHOULD** be the targeted types for transmission modules in the NGMN Backhaul solution.

VectaStar uses RJ45 connectors for all copper Ethernet interfaces, and the LC fibre-optic connector for all optical interfaces.

FUNCTIONAL INTEGRATION AND HARDWARE RELIABILITY

R80: The NGMN Backhaul solution **SHOULD** be able to aggregate the traffic from all new and legacy BS's in a co-located site (e.g. multi RAT base station where only one e-NB Transport Module is required). In this case there **MUST** be hardware independence between the NGMN elements and legacy base stations collocated or in the case of multi Radio Access Technology base station so that an outage on one Radio Access Technology **MUST NOT** affect the performance of the other Radio Access Technologies.

VectaStar can aggregate traffic from legacy TDM and IP interfaces at a single CPE (terminal) site. An outage on any given interconnected element will not affect the performance of the other elements.

R81: Functional integration of the Transport Equipment in the e-NB Transport Module **SHOULD** also be considered (e.g. indoor unit of a microwave radio can be integrated in the e-NB Transport Module). For this purpose the introduction of Carrier Ethernet/MPLS features at the Transport Module **MAY** also be considered.

VectaStar terminals provide a 'zero footprint' solution such that the down-cable from the VectaStar outdoor unit is a standard Ethernet cable. Therefore there is no indoor equipment requiring integration into the e-NB.

R82: The NGMN Backhaul solution **MUST** offer the highest reliability figures that still make sense from an economic perspective.

By taking advantage of the inherent savings of a point-to-multipoint system (typically less than half the number of outdoor units compared to point-to-point), VectaStar provides ultra-reliable backhaul in a very economical fashion.

FOOTPRINT AND POWER REDUCTION

SPACE (THIS SECTION APPLIES TO MACRO AND MICRO E-NB ONLY)

R83: The NGMN Backhaul solution **SHOULD** be highly integrated in the cabinet of the e-NB, by optimising space as far as possible in outdoor deployments.

VectaStar terminals provide a 'zero footprint' solution such that the down-cable from the VectaStar outdoor unit is a standard Ethernet cable. Therefore there is no indoor equipment requiring integration into the e-NB.

R84: The Transport Equipment **SHOULD** share with the e-NB and other legacy BS's in a collocated site a single power supply and battery backup unit.

A VectaStar terminal is powered from a standard 48V telecoms supply and draws less than 70W. Therefore sharing the power supply and battery backup requires no additional equipment and minimal additional capacity.

POWERING

R85: The NGMN Backhaul solution **MUST** be in conformance with all well-known ITU-T/Continental/National standards concerning Power Supply.

VectaStar conforms to ETSI EN 300 132-2 for 48V telecoms supply.

R86: The NGMN Backhaul solution **MUST** be designed to achieve reduced power consumption targets on the whole system as well as individual components within the constraints of operational specifications.

VectaStar offers significant power savings relative to traditional point-to-point microwave systems. Operating half the number of outdoor units gives the first clear *advantage. Secondly the all-outdoor terminal design means there is only the outdoor unit to power, as opposed to an outdoor unit and an indoor unit. Finally since the backhaul terminal is all-outdoor, there is no additional air conditioning requirement due to the backhaul solution.*

R87: The mean power consumption of the NGMN Backhaul solution **MUST** be as low as possible to comply with environment protection and energy saving.

VectaStar terminals consume less than 70W. See also R86 for system level considerations that result in VectaStar networks having very low overall energy consumption.

R88: The hardware of NGMN Backhaul solution **SHOULD** support several power consumption modes adapted to the current traffic, the environmental conditions, etc. and **SHOULD** automatically switch to the mode with the lowest possible power consumption when possible.

Each terminal in a VectaStar sector independently operates continuous, automatic power control on its transmitting link. Therefore each terminal unit is only transmitting at enough power to hit its CNR target at the hub site (plus fast fading margin). As rainfade increases, the link TX power will increase to overcome this, and then decrease when conditions improve. In this way a VectaStar network is always using the minimum power necessary to meet the QoS guarantees.

ENVIRONMENTAL CONDITIONS

R89: The NGMN Backhaul solution **MUST** be in conformance with all well-known ITU-T/Continental/National standards concerning EMC, safety, resistibility, climatic, mechanic, and acoustic conditions.

VectaStar conforms to at least the following standards covering these areas: ETSI EN 301 489-1, ETSI EN 301 489-4, EN 60950-1, ETSI EN 300 019-1-4 (Classes 4.1E and 4.2H), ETSI EN 300 019-1-2 (Class 2.3) and ETSI EN 300 019-1-1 (Class 1.3). Other national and international standards typically follow or are a subset of these standards.

2.7.2 OPERATIONAL TOOLS IMPROVEMENT

R90: The NGMN Backhaul solution **MUST** contain all network enablers and tools to allow Self-Configured and Optimised Backhaul Networks in line with the SON concept as per [3], in particular Plug and Play configuration of the transmission in the e-NB (including the S1 and X2 interfaces).
As example reference for scenario 1 or 2 depicted in ***0***, the candidate steps **MAY** be:

- Pre-configuration of the e-NB (in factory)
- Installation of the e-NB on the cell site
- Installation of the Packet Microwave antenna (if integrated on the e-NB) or of the Packet Microwave station (if not integrated on the e-NB)
- Packet Microwave Radio configuration to connect the new antenna either to an existing chain or to an Aggregation PoP

- Physical connection of the e-NB to the Microwave station (if not integrated)
- Authentication of the e-NB to the Transport Network (e.g. using 802.1x) if required (e.g. e-NB and/or first Transport Equipment not physically secured)
- Set up of a "minimal" transport connection to access the Servers / Core Network
- Procedure to get the IP address of the e-NB (e.g. DHCP boot)
- Procedure to get the IP addresses of all the aGW's in the S1-Pool (in case of S1-Flex) (e.g. DNS request). Potentially one per operator in case of multi-operator RAN Sharing
- Procedure to get the IP address of the "TR-69"-like Auto-Configuration Server
- Transport parameters discovery with "DHCP boot"-like mechanism (e.g. using a "TR-69"-like Auto-Configuration Server)
- Authentication of the e-NB to the Core
- S1 transport connection set up (with or without IPSec) potentially with S1-Flex and multi-operator RAN Sharing
- Identification of the "radio neighbours" (ANR procedure to scan radio neighbours and get "Cell ID", etc.)
- Get the IP addresses of the radio neighbours (e.g. using an auto-discovery procedure or a centralized server)
- X2 transport connection set up (with or without IPSec)
- Synchronization distribution configuration from Core
- Transport Load Balancing configuration between the new site and two distinct network neighbours
- Multicast configuration
- Etc.

VectaStar provides a fully-described, open northbound interface allowing flexible, script-driven configuration and monitoring. In addition, standardised internet protocols are used wherever applicable, aiding operator familiarity with modes of operation. In this way VectaStar enables and participates in the self-optimising network model. The additional flexibility afforded by the area coverage model of point-to-multipoint simplifies the installation/connection/configuration steps of the packet microwave station as itemised above.

R91: The Self-Configured and Optimised Backhaul Networks procedure **MUST** be possible in a multi-operator RAN sharing configuration.

The design of VectaStar accommodates the multi-operator scenario throughout the control plane and data plane as described against above requirements.

3 DOCUMENT PROPERTIES

Revision	Action	Reference	Date Released
A00	Initial release		
A01	Incorporating feedback	L	2010-03-30

DOCUMENT REVISION HISTORY

This document is based on template DOC-TMPL-0005-C01