



Self Backhaul UE Relay User Guide

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1 Overview

The document describes the product requirements for a Full Duplex UE Relay based on Kumu Networks' cancellation module. The product is designed to be paired with an external eNB, and backhaul the eNB data to the nearest macro base station using the same access frequencies used by the eNB (and the macro network).

This document focuses on the system requirements rather than the cancellation requirements.

2 Architecture & Theory of Operation

2.1 System Fit

The Relay is an LTE self-backhaul product that uses the existing cellular bands to provide the backhaul connection. This approach allows the use of the existing base stations without requiring additional backhaul equipment at the site. Below is a diagram of a self-backhaul node. In this configuration the Relay doesn't look any different to the macrocell than a smartphone.

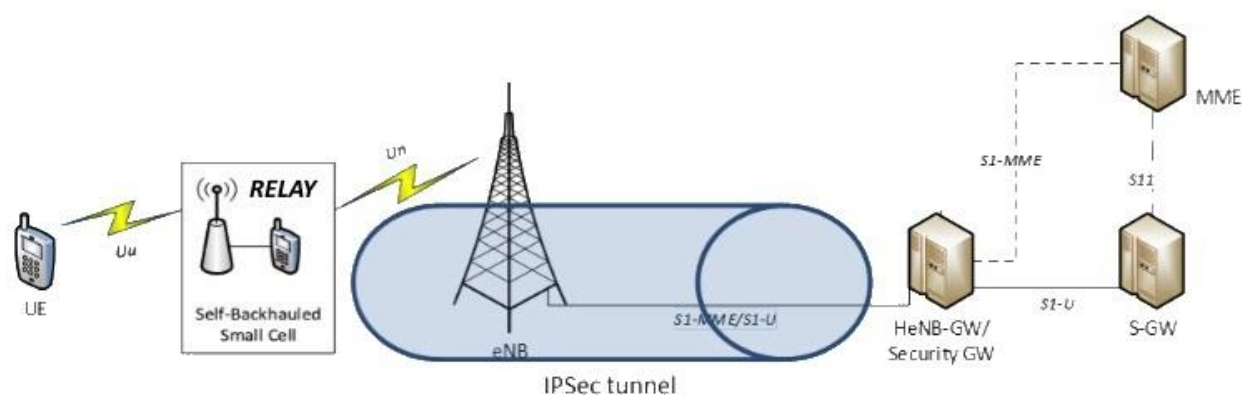


Figure 1 Relay network usage

2.2 Product Architecture

Conceptually an LTE self-backhaul Relay is an eNodeB with its Ethernet connection connected to a well provisioned cellphone that talks to a base station. In the case of the Kumu Relay product the EnodeB is external vendor equipment.

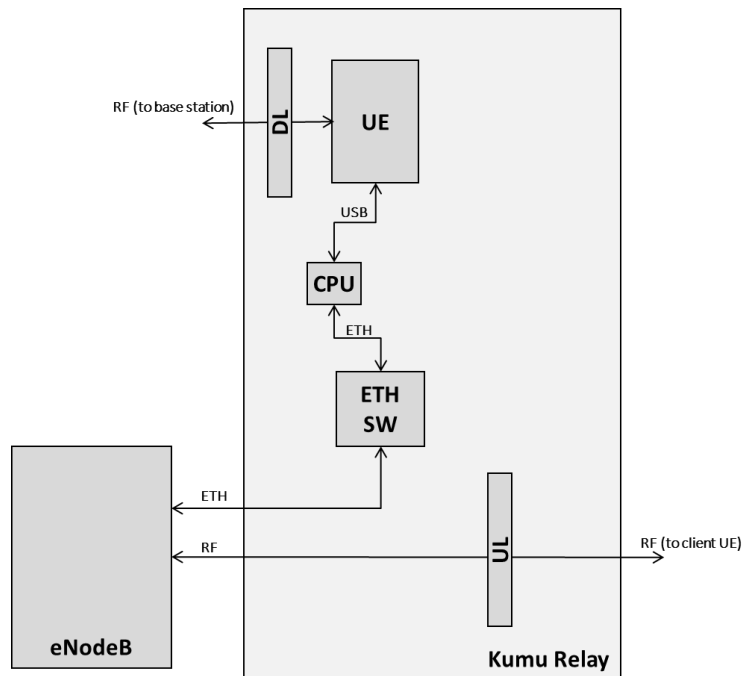


Figure 2 Relay data path block diagram

Additionally, the Kumu self-cancellation modules (indicated by the blocks UL and DL in the above figure) allow the Relay to operate in full duplex approaching close to 2x the spectral efficiency of competitor's products. The self-cancellation is used to cancel the leakage of a given ports transmit signal into the other ports receiver.

The CPU acts as a USB to Ethernet bridge as well as providing configuration, control and monitoring of the unit. The EPC termination is provided by the EPC attached to the base station where the Ethernet link from the attached eNode is encapsulated and forwarded via the internal UE air interface.

The control plane architecture is shown below where the physical layer connection is Ethernet for the cancellation module UL and DL and external debug port and USB to the UE module inside the Relay.

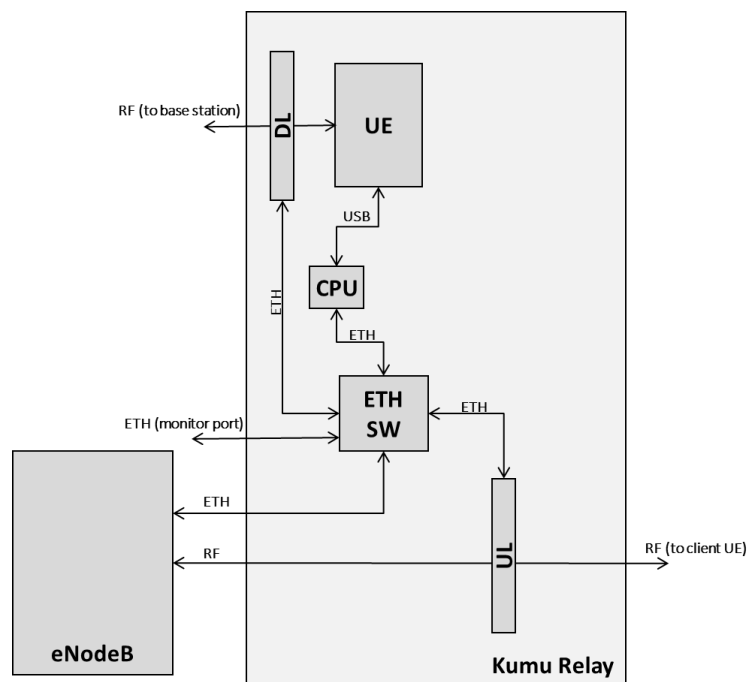
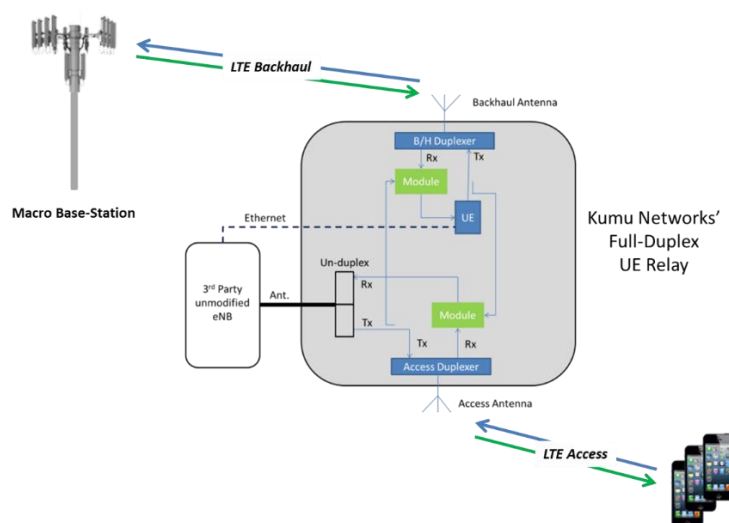


Figure 3 Relay control plane block diagram

To summarize, the UE Relay connects to the eNB via Ethernet port, for data transport, and via the antenna port, to enable self-interface cancellation for full-duplex operation. The UE Relay provides backhaul connectivity for the eNB in the form of LTE that transports the data through the operator commercial wireless network. Otherwise, only power is required for operation.



2.3 eNB Interoperability

The Full-Duplex UE Relay is designed to operate with any off-the-shelf eNB that meets the following criteria:

Technology	FDD LTE
Tx Power	2 x 5W (alpha) or 2 x 10W (beta)
Bandwidth	Single channel up to 20MHz
MIMO	2 x 2
Bands	B2 (PCS - North America) B3 (1800MHz - International)

Each band represents a separate SKU. Multi-band solution would be introduced in the future.

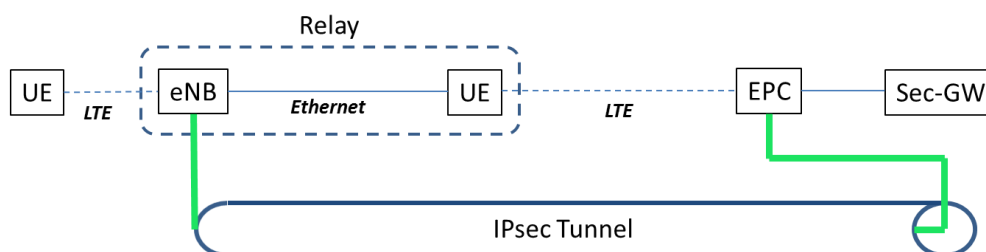
2.3.1 Physical Connectivity to Small Cell

The UE Relay connects to the eNB both via the data port and the RF ports:

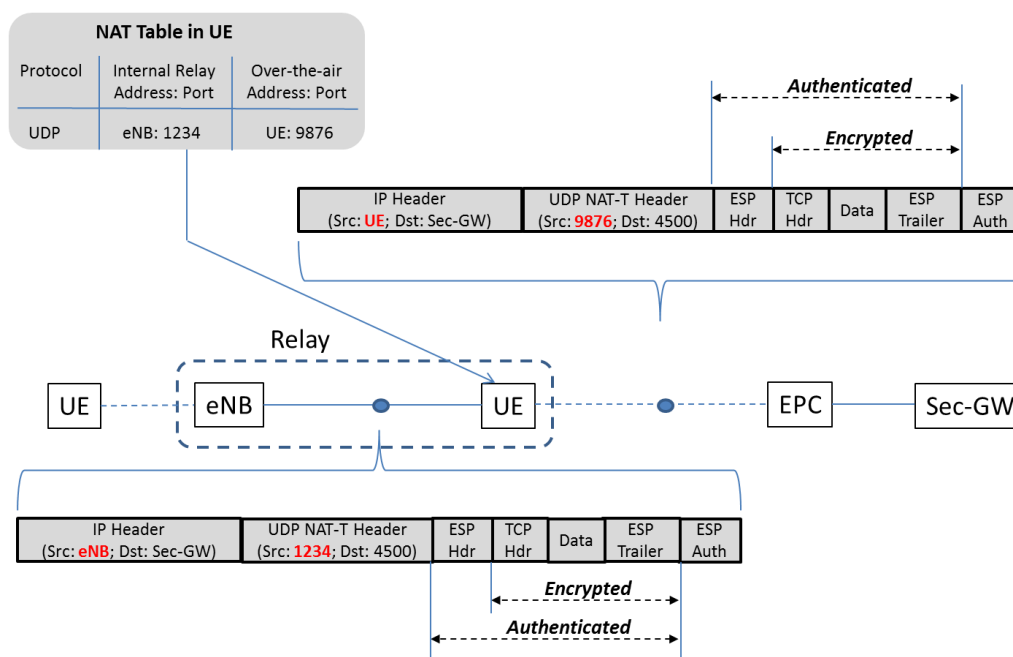
Data	RJ-45
Ant0	N-Type
Ant1	N-Type

2.4 Connectivity to Core Network

While the UE Relay provides backhaul to the Gi, it is the responsibility of the eNB to establish a secure connection to a Security Gateway (Sec-GW) of the operator, from which it would be further connected to the EPC.



The UE Relay attempts to be as transparent as possible for the small cell and the EPC. However, the UE Relay is not completely transparent in the fact that it performs Network Address Translation (NAT). The UE Relay performs NAT between the local subnet connecting it to the small cell and the IP address provided by the LTE operator to the UE Relay. To traverse the NAT function, the eNB is expected to support NAT-T or encapsulate IPsec traffic in UDP header.



2.5 Connectivity to Management

There are two options for connectivity of management/monitoring for the Kumu relay backhaul:

- 1) Provide out of band backhaul. The secondary Ethernet connection provides this functionality when connected to a microwave or other similar link
- 2) Use the in-band backhaul over the UE connection. In the current relay implementation, the UE supports a single APN.

As a result, the Kumu monitoring/management server must either:

- 1) Be able to reach the same protected subnet that the backhaul APN and ePC Security Gateway external interface are a part of
- 2) Be deployed into the operator network.

2.5.1 Keep alive

To UE Relay periodically PINGs the network to test connectivity in an attempt to quickly discover failures and take the necessary actions to restore normal operation. The following parameters are configurable for this feature:

- Destination IP address (typically the address of the Security Gateway)

2.5.2 Physical Ethernet Connectivity

The UE Relay exposes two Ethernet ports – one for local configuration/bring-up and the other for connectivity to the small cell. Each interface is pre-allocated an IP address that can be reprogrammed through the management interface.

2.6 UE Characteristics

The UE transmits at a maximum of 24dBm per 3GPP specifications, power controlled by the macro base station.

UE chip and stack vendor	Qualcomm MDM 9225	
UE Category	Cat-4	
Tx Power	1 x 24dBm at the UE module	
Bandwidth	5, 10, 15, 20MHz	
MIMO	1 x 2	
Full-Duplex Bands	B2 (PCS - North America) B3 (1800MHz - International)	Each band represents a single SKU. Multi-bands SKUs may be available in the future.

UE IP addresses are automatically assigned by the network. The UE is using IPv4 addresses for routing.

2.6.1 Transmitter requirements

Max power, Min power, ACLR,

2.6.2 SIM Card

The UE Relay uses 2FF (standard) SIM Card that can be inserted without opening the enclosure, through a slot with weather-protected door. It is recommended that the operator uses high-priority SIM card for this application.

2.6.3 SIM Card PIN (CPIN)

Through the management system, a CPIN can be configured to offer further network protection in case the SIM card is jeopardized.

2.6.4 APN Configuration

The UE Relay supports a single APN and can be configured via the GUI

2.6.5 RF Channel Configuration

Each UE Relay is designed to operate in a full-duplex mode in a single band (2, 3, 4, or 7). Within each band, an administrator needs to configure the specific channel of operation in the form of:

- EARFCN (Center Frequency)

2.6.6 Physical Cell ID (PCI)

The UE Relay allows an administrator to view the PCI the UE is connected to (if the UE is actually connected to the network). The administrator may reconfigure a different PCI to which the UE should connect. The administrator may also opt to “lock” the PCI to a specific desired physical cell.

3 Electrical HW Architecture & Functionality

External interfaces covered in the “electrical/mechanical/environmental” section below.

3.1 Access Front End

3.1.1 Unduplexer

Band	Manufacturer	Part Number
2	MCV-Microwave	DDCC1880-1960-60A2
3	MCV-Microwave	DDCC1747-1842-75A2

3.1.2 Duplexer

Band	Manufacturer	Part Number
2	MCV-Microwave	DDCC1880-1960-60B1
3	MCV-Microwave	DDCC1747-1842-75C1

3.1.3 Cancellation Module – Uplink

Consult relevant Band 2-3 Uplink Cancellation Module spec

3.2 Relay Backhaul

3.2.1 UE

3.2.2 Motherboard

Kumu PN	Description
820-000009 rev A	PC, Intel NUC NUC5i5RYK, USB3, 8GB DDR3 CT2KIT51264BF160B
820-000010 rev A	Module, 8GB Kit (4GBx2) DDR3L 1600 MT/s (PC3L-12800) SODIMM 204-Pin
820-000026 rev 1	Preprogrammed SSD with current Relay Gen5B baseline image

3.2.3 Switch

Kumu PN	Description
820-000008 rev A	Advantech Corp 5PORT GBE LITE MANAGE EKI-5725I-AE

3.2.4 Cancellation Module – Downlink

Consult relevant Kumu Band 2-3 Downlink Cancellation Module spec

3.2.5 Backhaul Duplexer Module

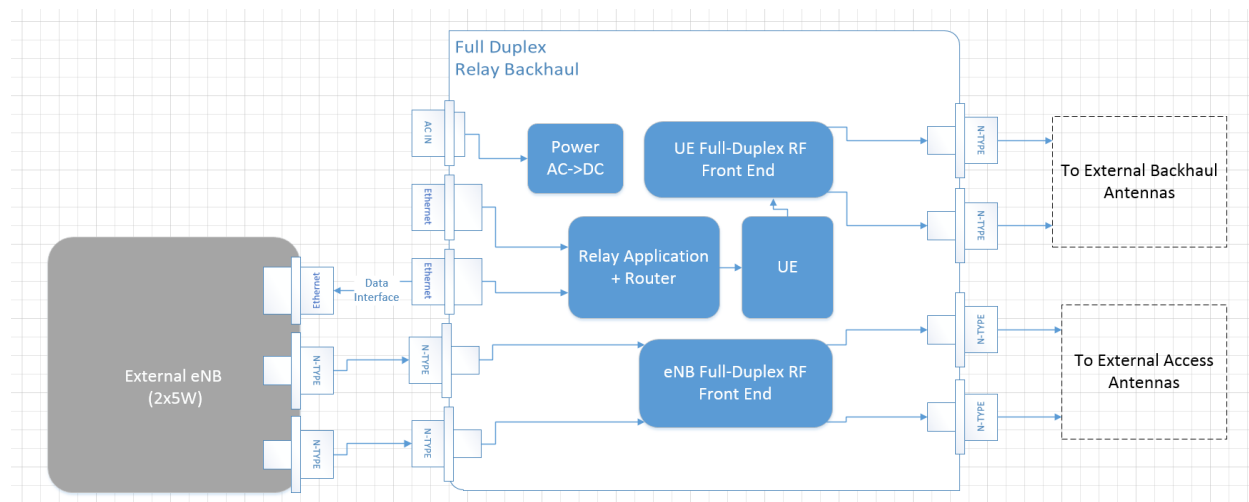
Consult relevant Kumu Band 2-3 Backhaul Duplexer spec

4 Software Architecture & Functionality

5 Testing

6 Electrical / Mechanical / Environmental

A functional block diagram of the relay is shown below for reference.



6.1 General Requirements

Power consumption	<150W
Physical size	10.25" x 20" x 5.25"
Weight	<13Kg
Operating Temperature	-20 ^c to 45 ^c
Storage Temperature	-40 ^c to 85 ^c
Altitude	Operating: 13,000 feet Non-Operating: 50,000 feet
Mounting	Pole or wall mounted
Environment	Outdoor, urban environment, with vehicles moving at 50Km/H 5 meters away ETSI EN 300 019-2-4?
Ingress Protection	IP65
Safety	UL 60950-1
Hazardous materials	RoHS
Certifications	FCC Part 15 (US) and CE (Europe) FCC Part 24/27.
MTBF	
Shock	IEC68-2-27
Vibration	IEC68-2-6 / IEC721-3-2

6.2 Electrical Interfaces

6.2.1 Ethernet Interfaces

The relay backhaul system provides two Ethernet interfaces. One is provided for the data connection to the external eNB. The second provides out of band management functionalities.

Connector	2xRJ45
Ethernet Standards	
IP rating	Compliant with overall system requirement
Cable type	Cat6

6.2.2 Power Interface

The relay accepts 110/220V standard inputs.

Power consumption	<150W
Input Range	90 - 264 Vac (Operating) 115/230 Vac (Nominal)
Input frequency	47 - 63 Hz
Input Current max	3.4 A @ 90 Vac full load
Inrush current	50 A
Protection	Transient protection and Hi Pot, Fuse
Connector	Phoenix 1521410 SACC-E-MINMS-3CON-PG13/0.5
IP rating	Compliant with overall system requirement

6.2.3 Access RF Interface (Antenna + eNB)

The access-side (eNB) interface provides the full-duplex front end functionality between the eNB and the antenna. There are four connections, two to the eNB and two to the antenna. They are: eNB 0/1 (from the eNB), and ANT0/1 (to the antennas).

The product is not shipped with an integrated eNB.

Specification	Description
Number of connectors	2 in (eNB), 2 out (ANT)
Connector Style	N-type
Impedance	50 ohm
IP rating	Compliant with overall system requirement
Output RF Max Power	37 dBm
Ergonomic	1.5 center to center min (allow for gloved hands)

6.2.4 Backhaul RF Interface (Antenna + UE)

The backhaul interface provides the full-duplex front end functionality between the UE and the antenna. There are two connectors as the UE is 1T2R.

Specification	Description
---------------	-------------

Number of connectors	2
Connector Style	N-type
Impedance	50 ohm
Reflection (input)	
IP rating	Compliant with overall system requirement
Max cable length	
Ergonomic	1.5 center to center (allow for gloved hands)
UE 3GPP Release	Rel 8
UE DL Category	
UE UL Category	
UE Power Class	3
UE Channel Bandwidth:	5/10/15/20 MHz
UE Spectrum:	Band 2, Band 3 (separate SKU)
UE Duplexing:	FDD and TDD
UE Category:	6
UE Downlink MIMO:	1x2 MIMO
UE Uplink MIMO:	SISO only
UE Transmission Modes:	TM 3/4/9
UE Modulation:	DL: QPSK / 16QAM / 64 QAM UL: QPSK / 16QAM
UE DL Carrier Aggregation:	N/A
UE UL Carrier Aggregation:	N/A
UE Peak Thru-put:	DL = TBD Mbit/s, UL = TBD Mbit/s

6.2.5 SIM Card

The SIM card is 4FF size and is accessible via a weatherproofed door on the side of the relay. Captive screws affix the door to the enclosure with an attached chain to prevent loss of the door during service.

6.2.6 LEDs

On the weatherproof door, there are two LEDs: one green and one red. The green LED will be used for indicating that the relay has power. The red will be used to indicate a fault condition.

7 Regulatory Information

The Kumu Self Backhaul UE Relay (Relay) transmits wireless signals and should only be used as instructed. Failure to use as instructed could expose the user to higher levels of radio emissions.

Product Support: For Technical Support or for help not available in this manual, visit the website at www.kumunetworks.com.

FCC Notice (United States):

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference in a commercial installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and the receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

CAUTION: Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

FCC Radiation Exposure Statement:

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance 20 cm between the radiator & your body.

CE Notice (European Notice)

The Conformité Européenne symbol found on this product indicates compliance to the EMC Directive of the European Union.

Kumu Networks Inc. hereby declares that this wireless device is in compliance with the essential requirements and other relevant provisions of the Radio Equipment Directive. A copy of the EU Declaration of Conformity is available at www.kumunetworks.com/euro/compliance.

Kumu's EU representative is Juergen Aurand, jaurand@kumunetworks.com



European Union—Disposal Information



The symbol above means that according to local laws and regulations your product and/or its battery shall be disposed of separately from household waste. When this product reaches its end of life, take it to a collection point designated by local authorities. The separate collection and recycling of your product and/or its battery at the time of disposal will help conserve natural resources and ensure that it is recycled in a manner that protects human health and the environment.

Pursuant to Article 12 of RED, the model number, KU5B01LTE03-EU is compliant for E-UTRA Band 3, 1710 – 1785 MHz UL, 1805 – 1880 MHz DL on a 100 KHz raster. The output power is limited to 23 dBm +/- 2 dB tolerance.

The unit is designed for indoor or outdoor use with external antennas and ENodeB microcell provided by the service provider. For installation and safety instructions consult the Kumu Networks *Self-Backhaul UE Relay Installation Guide*.

The exact list of member states the product will be sold is TBD. There are no restrictions concerning this product.

The following manufacturer's address label will be included in the shipping container:



Kumu Networks Inc.
960 Hamlin Court
Sunnyvale, CA 94089
USA