

Skywire™ BeagleBone Black Cape User Manual

NimbeLink Corp

Updated: June 2016



© NimbeLink Corp. 2016. All rights reserved.

NimbeLink Corp. provides this documentation in support of its products for the internal use of its current and prospective customers. The publication of this document does not create any other right or license in any party to use any content contained in or referred to in this document and any modification or redistribution of this document is not permitted.

While efforts are made to ensure accuracy, typographical and other errors may exist in this document. NimbeLink reserves the right to modify or discontinue its products and to modify this and any other product documentation at any time.

All NimbeLink products are sold subject to its published Terms and Conditions, subject to any separate terms agreed with its customers. No warranty of any type is extended by publication of this documentation, including, but not limited to, implied warranties of merchantability, fitness for a particular purpose and non-infringement.

XBee is a registered trademark of Digi International, Inc

NimbeLink is a registered trademark, and Skywire is a trademark, of NimbeLink Corp. All trademarks, service marks and similar designations referenced in this document are the property of their respective owners.

Table of Contents

1. INTRODUCTION

- 1.1 OVERVIEW
- 1.2 PRODUCT DESCRIPTION
- 1.3 ORDERABLE PARTS
- 1.4 ADDITIONAL RESOURCES

2. GETTING STARTED

- 2.1 OPERATING MODES
- 2.2 MOUNTING YOUR CAPE
- 2.3 SKYWIRE™ PLACEMENT
- 2.4 UART CONFIGURATION
- 2.5 USB CONNECTION
- 2.6 DEVICE TREE OVERLAY
- 2.7 SENDING A TEXT MESSAGE
- 2.8 ESTABLISHING A TCP/IP CONNECTION
- 2.9 SKYWIRE™ GPS, GLONASS, AND M2MLOCATE EXAMPLES
- 2.10 POINT TO POINT PROTOCOL (PPP) CELLULAR INTERNET VIA SKYWIRE™ USB CONNECTION EXAMPLE

1. Introduction

1.1 Overview

This document is the System Reference Manual for the Skywire™ BeagleBone Black Cape. Throughout the document Skywire™ BeagleBone Black Cape will often be referred to as 'the cape,' although it may be referred to by its full name.

The NimbeLink Skywire™ modem is available with bundled data plans from leading cellular carriers.

The Skywire™ cellular modem and antennas are sold separately.

Make sure you check the Nimbelink's Skywire™ BeagleBone Black Cape product page for the most up to date information.

1.2 Product Description

Connect the BeagleBone Black development platform to the Internet of Things (IoT) quickly and easily with Nimbelink's Skywire™ BeagleBone Black Cape. Whether you are a hobbyist or a developer preparing a product for launch, Nimbelink's cape and your choice of NimbeLink Skywire™ plug-in cellular modems will provide the cellular connectivity you need. Cellular connectivity is just one of the capabilities Nimbelink's BeagleBone Black Cape offers including:

- Built-in CAN transceivers for equipment and vehicle data connections
- Built-in socket for XBee modules for wireless communications
- Nimbelink's EVDO and LTE Skywire™ modems provide GPS with a high speed cellular connection
- Skywire's™ Verizon ODI certification eliminates the long wait for certification
- Two additional USB-A receptacles add flexibility
- Nimbelink's optional bundled, no-contract cellular plans are easy and affordable

1.3 Orderable Parts

Table 1.1 Orderable Parts				
Number	Description	Manufacturer	Carrier	Network Type
NL-AB-BBBC	Skywire™ BeagleBone Black Cape	Nimbelink		
NL-SW-1XRTT-V	Skywire™ 1xRTT Cellular Modem without data plan. 2G Modem.	Nimbelink	Verizon	CDMA 1xRTT
TG.30.8113	Primary & Diversity Cellular Antenna	Taoglas		
NL-SW-EVDO-V	Skywire™ EVDO Cellular Modem without Data plan. 3G Modem.	Nimbelink	Verizon	CDMA EVDO
MA.301.A.AB.001	3G Primary Antenna, GPS/GLONASS Antenna for Skywire™ EVDO*	Taoglas		

*Antenna is a dual cellular & GPS antenna

1.4 Additional Resources

- Nimbelink's Skywire™ [BeagleBone Black Cape Product Page](#)
- Nimbelink's Skywire™ [BeagleBone Black Cape Device Tree Overlay](#)
- Nimbelink's Skywire™ [BeagleBone Black Cape Schematic](#)
- Nimbelink's Skywire™ [BeagleBone Black Cape Github](#)
- Nimbelink's [Skywire™ 2G 1xRTT Product Page](#)
- Nimbelink's [Skywire™ 3G CDMA/EVDO Product Page](#)
- Telit's [CE910 Hardware User Guide](#)
- Telit's [DE910 Hardware User Guide](#)

2. Getting Started

2.1 Operating Modes

2.1.1 Introduction

Nimbelink's Skywire™ BeagleBone Black Cape is designed to allow the cape to be compatible with as many BeagleBone Black capes as possible while still providing cellular connectivity. Every cape will utilize different I/O's from the BeagleBone. To allow the Skywire™ cellular modem to always have a non conflicted communication path with the BeagleBone the Skywire's™ UART signal is routed to a MUX. This allows the modem to communicate with the BeagleBone over any one of four different UART connections. Alternatively the user can also communicate between the Skywire™ cellular modem and the BeagleBone via USB.

Upon initialization of the cape by the Device Tree overlay the default operating mode will set the I/O connections as shown in Table 3.1.

Table 3.1 Default Operating Mode Connections		
PIN	Connection	Connected Device
P9-24	CAN1 RX	CAN1
P9-26	CAN1 TX	CAN1
P9-21	UART2 TX	XBee Socket
P9-22	UART2 RX	XBee Socket
P9-11	UART4 RX	Skywire™ Socket
P9-13	UART4 TX	Skywire™ Socket
P8-8	SKY ON-OFF	Skywire™ On Off Signal
P8-9	SKY DTR	Skywire™ DTR

If the user wishes to use a different UART to communicate with the Skywire™ or CAN0 they will need to unload the device tree overlay and reload the corresponding device tree overlays to use the I/O's they desire.

2.2 Mounting Your Cape

The cape is designed to mount on top of the BeagleBone Black or another cape. To mount the cape on the BeagleBone Black orient the notch on the left side of the cape with the Ethernet connector as shown below in figures 3-2 and 3-3. Carefully align the pins and press the cape down onto the Beagle bone's P8 and P9 connectors.



Figure 3-1



Figure 3-2

Removing a cape can be difficult. Gently rock the cape back and forth to remove. Attempting to remove the cape in one swift motion may damage the P8 and P9 pins.



Figure 3-3

2.3 Skywire™ Placement

The Skywire™ Cellular modem is designed to be placed as shown below in figure 3-1.

To mount your Skywire™ Cellular modem follow these steps:

1. Gather the following:
 - a. Skywire™ BeagleBone Black Cape
 - b. Skywire™ Cellular Modem
 - c. U.FL extractor tool (Always use a U.FL extractor tool when placing or removing U.FL cables on the Skywire™ modem to avoid damaging the U.FL connectors).
2. Line up your Skywire's™ cellular U.FL connector(s) with the circles inside the capes Skywire™ sockets footprint. Depending on the type of Skywire™ Modem you have you might have one or two U.FL connections.
3. To avoid damage to the U.FL connector an U.FL removal tool should be used when attaching/removing the U.FL connector. If your Skywire™ is using GPS attach the GPS antenna cable (ANT1) to the bottom of the Skywire™. If you are not using your Skywire's™ GPS or if your Skywire™ does not support GPS continue to step 4.
4. Carefully seat your Skywire™ into the capes Skywire™ socket (J6). Take care to ensure that the pins are correctly aligned. Failure to properly align the pins may damage your Skywire™.
5. Attach ANT3s U.FL cable to the top U.FL connector on the Skywire™. If you are using a Skywire™ with the cellular diversity antenna option attach ANT2s U.FL cable to the bottom U.FL connector.

2.4 UART Configuration

By default the capes UART connection between the Skywire™ and the BeagleBone Black defaults to UART4. To begin using the cape no additional configuration is needed at the MUX's to enable the UART communication.

The Skywire™ defaults to an 115200 BAUD rate, 0 bit data, no parity, and 1 stop bit. The clear to send (CTS) and ready to send (RTS) signals are not implemented.

2.5 USB Connection

The Skywire™ has a hardwired USB connection to the capes USB hub. To interface with the Skywire™ via USB simply connect the capes upstream USB port to the Beagle bone's downstream USB port (the USB-A receptacle on the BeagleBone) and the Skywire™ will be visible to the BeagleBone. Current Linux distributions have

USB devices drivers for the Skywire™ 3G CMDA/EVDO modem. Users using other modems via USB will need to add USB device descriptors to their Linux build.

2.6 Device Tree Overlay

The capes device tree overlay is installed by default in the Debian 3.8.13-bone68 kernel. The Debian kernel can be updated by issuing the following commands on your BeagleBone:

```
cd /opt/scripts/tools/  
  
git pull  
  
sudo ./update_kernel.sh
```

The device tree is also available for download from [Nimbelink's Skywire™ BeagleBone Black Cape Github](#).

Older Debian kernels, that cannot be updated, will need to add the capes information to the capemgr to make the capes device tree automatically load. This can be done by adding "CAPE=NL-AB-BBBC:00D0" to /etc/default/capemgr.

2.7 Sending a Text Message

The following is a demonstration on how to send a text message using the Skywire™ BeagleBone Black Cape. This demonstration assumes the user has knowledge of how to connect to the BeagleBone Black, and has a BeagleBone Black running Debian 3.8.13-bone68.

You will need the following for this demonstration:

- Nimbelink's Skywire™ BeagleBone Black Cape
- BeagleBone Black C
- Terra Term (or a terminal emulator of your choice) on the user computer
- Picocom (or a terminal emulator of your choice) installed on the BeagleBone Black
- Skywire™ Cellular Modem with antenna (This demonstration uses a 3G CDMA/EVDO modem (Part#:NL-SW-EVDO-V))
- 2.5A 5V Power Supply for the BeagleBone Black

Step 1: Mount your cape on the BeagleBone Black

Align your cape so the P9/P8 headers are lined up and the square cutout is aligned with the BeagleBone Black's Ethernet port. Then gently push the P9/P8 headers together, take care to ensure that the pins are properly aligned and that you are not bending any pins.

Step 2: Connect your Skywire™ Cellular Modem

Orient the Skywire™ Cellular Modems cellular U.FL connectors with the two circles inside the Skywire™ Cellular Modem Socket footprint on the cape. Check to make sure that all the pins are aligned with the headers then gently push the modem into the socket.

Using an U.FI connector tool connect the primary cellular antenna cable to the Skywire's™ primary cellular antenna connector (X1). Attach the cellular antenna to the SMA jack attached to the primary cellular antenna cable.

Step 3: Power up and connect to the BeagleBone Black

Plug in the 5V power supply (2.5A recommended) to the BeagleBone Black. LEDs D2, D3, and D14 will illuminate on your cape. Open Tera Term and initiate a connection to the BeagleBone Black

Step 4: Connect to the Skywire™ cellular modem

The Skywire™ cellular modems on off pin are pulled to ground by default causing the Skywire™ to turn on. The on off signal can be controlled by pin P8.8, please refer to the reference schematic for further information.

On devices running Debian 3.8.13Bone68, the device tree overlay will automatically load upon bootup. The device tree overlay for the cape will configure the cape to initiate UART 2 (for the XBee socket), UART4 (for the Skywire™ socket), CAN1, and 2 GPIOs to control the Skywire's DTR and on/off signals.

Check that there are no jumpers connected to J5 or J8-6. This will cause the Skywire™ sockets to connect to its default UART connection (UART4). The Skywire™ Cellular Modems have a default UART baud rate of 115200. Initiate the UART connection on the BeagleBone Black using picocom by issuing the following command:

```
picocom -b 115200 /dev/ttyO4
```

Step 5: Test Serial Communication

In the terminal program, type the letters:

AT

Followed by the enter key. The terminal should respond with:

OK

Step 6: Test Network Connectivity

In the terminal program, type the letters:

AT+CREG?

Followed by the Enter key. The terminal should respond with:

+CREG: 0,1

Or

+CREG: 0,5

For all other responses, review network status responses online.

Step 7: Activate Modem



Skywire™ Cellular modems do not come with an active cellular plan. NimbeLink provides reduced rate Verizon M2M data plans for Skywire™ products. If you are using a new Skywire™ cellular module, it does not have an active cellular plan. To activate a Verizon data plan, visit <http://go.nimbelink.com> and fill out the “Cellular Data Plan Activation Request Form”.

Step 8: Send Modem Activation String

In the terminal program, type the letters:

ATD*22899;

Followed by the Enter key and the module will begin the activation process. This can take several minutes. The terminal should respond with:

OK

#OTASP: 0

#OTASP: 1

#OTASP: 2

NO CARRIER

For all other responses, review network status responses online.



Reset Power, and repeat steps 4 through 6 before continuing.

Step 9: Send SMS Message

In the terminal program, type the letters:

AT+CMGF=1

Followed by the Enter key and the terminal should respond with:

OK

Substitute the destination phone number for the example 5554443333.

Then type:

AT+CMGS="+15554443333"

Followed by the Enter key and the terminal should respond with:

>

At this point you can type a custom message (keep to less than 160 characters). To send the message, press the *CTRL* and *Z* keys at the same time. If successful, the terminal should respond with:

+CMGS: xx

Step 10: Receive SMS Message

In the terminal program, type the letters:

AT+CMGF=1

Followed by the Enter key and the terminal should respond with:

OK

Then type:

AT+CMGL="REC UNREAD"

Followed by the Enter key, If the terminal responds with

OK

Then there are no messages. Otherwise, the terminal responds with the first message in the form:

```
+CMGL=index, message_status, address, [address_text],  
[time_stamp] [,address_type, body_length] <CR> <LF>  
sms_message_body[<CR> <LF> +CMGL: ...]
```

This is an example:

```
+CMGL: 0,"REC UNREAD","555444333","",20130925202238  
SMS message
```

2.8 Establishing a TCP/IP connection

Please refer to the Skywire™ TCP Socket Examples available [here](#).

2.9 Skywire™ GPS, GLONASS and m2mLocate Examples

Please refer to the Skywire™ GPS, GLONASS and m2mLocate Examples available [here](#)

2.10 Point to Point Protocol (PPP) cellular internet via Skywire™ USB Connection Example

The Skywire™ has a hardwired USB connection to the capes USB hub. To interface with the Skywire™ via USB simply connect the capes upstream USB port to the BeagleBone's downstream USB port (the USB-A receptacle on the BeagleBone) and the Skywire™ will be visible to the BeagleBone. Current Linux distributions have USB devices drivers for the Skywire™ 3G CMDA/EVDO modem. Users using other modems via USB will need to add USB device descriptors to their Linux build.

This demonstration uses a BeagleBone Black running Debian 3.8.13-bone68, Skywire™ BeagleBone Black Cape Rev D, Skywire™ 3G EVDO modem, and a Taoglas TG.30.8113 Cellular antenna.

For the Skywire™ 3G EVDO modem we will use the USB interface to the modem, which provides the greatest bandwidth and more reliable connection. The USB connection eliminates issues concerning flow control often encountered with traditional UART connections and PPP protocol.

We will connect the Skywire™ to the BeagleBone Black, configure the PPP link, and bring up a connection between the BeagleBone Black and the internet entirely over the cellular connection. This example assumes the cape and Skywire™ have already been mounted to your BeagleBone Black

Step one: Install the PPP

Install the PPP package by issuing the following commands:

```
sudo apt-get update  
sudo apt-get install ppp
```

Step Two: Connect to the Skywire™ Cellular Modem via USB

Connect to the Skywire™ Cellular modem via the capes USB hub by using the USB type A to mini-B cable that was provided with the cape. Plug the USB A connection into the BeagleBone and the USB mini-B into the cape.

Issue the following command:

```
lsusb
```

An output resembling the following should appear, this confirms that the BeagleBone sees the USB devices:

```
root@beaglebone:~# lsusb  
Bus 001 Device 008: ID 0424:2514 Standard Microsystems Corp.  
USB 2.0 Hub  
Bus 001 Device 001: ID 1d6b:0002 Linux Foundation 2.0 root hub  
Bus 002 Device 001: ID 1d6b:0002 Linux Foundation 2.0 root hub  
Bus 001 Device 009: ID 1bc7:1010
```

Device 008 is the onboard USB hub and device 009 is the Skywire™ cellular modem, the device numbers may be different on your system.

If the Skywire™ and USB hub are not present in the lsusb response, restart the BeagleBone Black.

Step Three: Interface to the Skywire™ Cellular Modem

The Skywire™ EVDO modem presents (4) USB devices,

```
/dev/ttyUSB0  
/dev/ttyUSB1
```

```
/dev/ttyUSB2
```

```
/dev/ttyUSB3
```

The device `"/dev/ttyUSB3"` is the command and data interface to the

EVDO modem. To configure the PPP daemon for use with this Telit modem, two files need to be created in the `/etc/ppp/peers` directory. First, as superuser (root) create `"/etc/ppp/peers/verizon"` with the following contents,

```
/dev/ttyUSB3  
115200  
connect "/usr/sbin/chat -v -f /etc/ppp/peers/verizon-chat"  
noauth  
defaultroute  
usepeerdns  
local  
debug  
updetach
```

Although a serial port speed of 115200 is called out, the actual serial speed on the USB connection is ignored and the interface runs as fast as the modem and the host is capable.

Next, create `"/etc/ppp/peers/verizon-chat"` with the following contents,

```
" 'ATZ'  
'OK' 'ATDT#777'  
'CONNECT' "
```

NOTE: The Verizon chat file starts and ends with two apostrophes, not quotations.

This completes configuration of the PPP daemon.

Step Four: Activate the PPP link

To bring up the PPP link issue the command:

```
pon verizon
```

Confirm the link is active by issuing the following command:

ifconfig ppp0

This command should respond with the following:

```
root@beaglebone:~# ifconfig ppp0
ppp0 Link encap:Point-to-Point Protocol
      inet addr:10.88.240.7 P-t-P:66.174.177.132 Mask:255.255.255.255
      UP POINTOPOINT RUNNING NOARP MULTICAST MTU:1500 Metric:1
      RX packets:12 errors:0 dropped:0 overruns:0 frame:0
      TX packets:14 errors:0 dropped:0 overruns:0 carrier:0
      collisions:0 txqueuelen:3
      RX bytes:1342 (1.3 KiB) TX bytes:771 (771.0 B)
```

The BeagleBone Black is now communicating to the internet via the Skywire Cellular modem. Try pinging a website, for example:

Ping google.com

To bring down the PPP connection issue the following command:

poff verizon