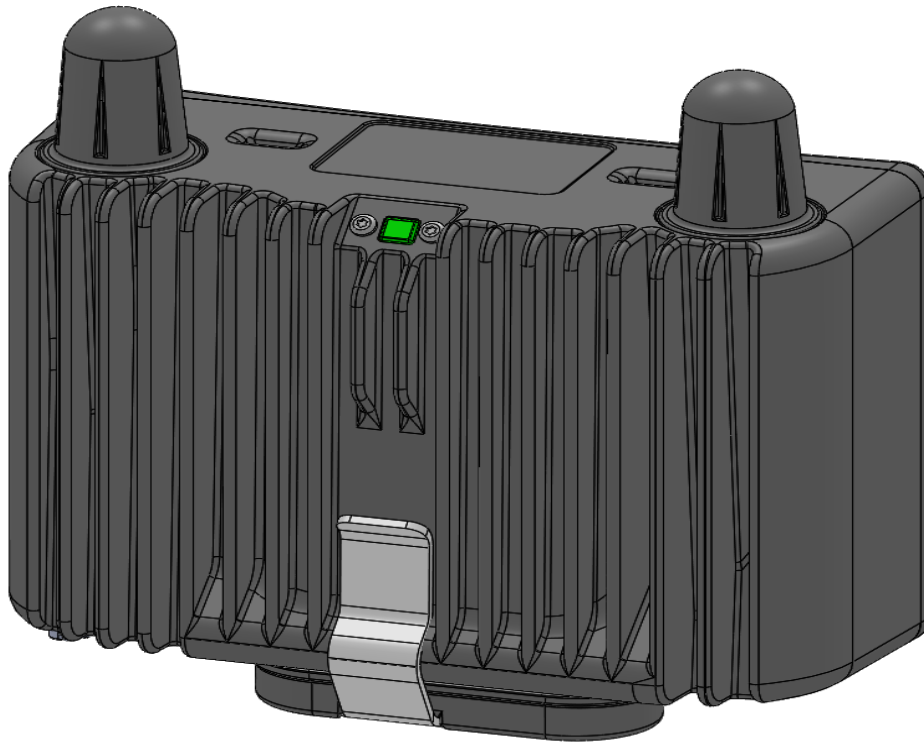# BreadCrumb® CX1 Version 11 User Guide

Model: BreadCrumb CX1

User Guide Version: 11.13.0 Rev A

Software Version: 11.13.0

Document Part Number: 03-100147-001

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Document Revision History

Revision	Date	Changes
11.12 Rev A	07/25/2016	Initial HTML document
11.13 Rev A	10/19/2016	Updated Power Table

Copyright Statement

FCC Statement

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 when the device is operated in a commercial environment. This device generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with this instruction manual, may cause harmful interference to radio communications. Operation of this device in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at their own expense.

Antennas

Antenna Installation WARNING
The BreadCrumb CX1 ships with 2dBi omni-directional antennas. SAR Compliance of the BreadCrumb CX1 is contingent on the use of these antennas.

IMPORTANT: Exposure to Radio Frequency Radiation
To satisfy FCC SAR RF exposure requirements for a body-worn device, the belt-clip must be used when wearing the BreadCrumb CX1. The belt clip is shown in this figure: BreadCrumb CX1 Enclosure Features (Back)

Maximum Certified Transmit Power
SAR compliance is contingent on operation of the wireless transmitter at certified power levels.

Safety

Warning
The BreadCrumb CX1 is not user serviceable. Repair must be performed at a Rajant designated service center by trained personnel.

Warning
The BreadCrumb CX1 single board computer assembly contains a Lithium button cell battery. Replacement of this battery should never be attempted by the user. The battery must be replaced by authorized repair personnel trained by Rajant Corporation. CAUTION: Risk of explosion if battery is replaced by an incorrect type. Dispose of used batteries according to the battery manufacturer's instructions.

Modifications

CAUTION
Changes or modifications not expressly approved by Rajant Corp. could void the user's authority to operate the equipment.

Rajant Products are compliant and warranted against manufacturing defects only so long as authorized Rajant-authorized accessories are used in deployment of Rajant Breadcrumbs. It is the responsibility of the operator and the installer to insure the system as installed operates within regional requirements.

Professional Installation Attestation

Rajant Corporation addresses the following items to ensure that the above referenced equipment is professionally installed:

The device will only be sold by Rajant Corporation or one of its authorized dealers. Rajant Corporation and its authorized dealers will be under strict marketing control and will only market and sell the device to professionals.

Professional installation is required for this device and will be performed only by someone knowledgeable of its use. Rajant Corporation will ensure that the device is only marketed and sold to professionals.

The device is not sold to the general public and is sold only for industrial or commercial use by professional installers.

Maximum Certified Power

The BreadCrumb CX1 may be operated at full certified power when configured with the granted antenna type. Operation of a radio at power levels that exceed the EIRP of the granted configuration is prohibited. See the tables below.

Table: Maximum Certified Power: FCC (United States)

BreadCrumb Model	Frequency Range (MHz)	Channel Bandwidth MHz	Maximum Certified Total Average Conducted Channel Power (dBm)	Antenna Type	Antenna Gain (dBi)	Maximum Certified EIRP (dBm)
CX1-3600	3650-3700	20	22.7	Omni-directional	2	27.7
CX1-3600	3650-3700	10	19.9	Omni-directional	2	24.9

GNU General Public License Statement

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Preface

Purpose and Scope

This manual provides information and guidance to all personnel who are involved with and use Rajant Corporation's BreadCrumb CX1.

This manual begins with an introduction to the BreadCrumb Kinetic Mesh Network. It then characterizes the features of the BreadCrumb CX1. Finally, it describes common deployment scenarios and provides concise step-by-step instructions for each scenario.

> **Note**
> Throughout this document, unless otherwise stated, the terms CX1 and BreadCrumb are used to refer to Rajant BreadCrumb CX1.

How to Use This Guide

This User Guide is an HTML document and is read using a web browser. The browser's right scroll bar, mouse scroll wheel, up/down cursor keys or Page Up/Page Down keys may be used to navigate sequentially forward or backward through the guide. In most browsers, CTRL-F can be used to search the guide and navigate to matching text. The Table of Contents at the left (or top for small windows) contains links to the starts of chapters and appendices. After a web link or cross-reference is clicked in the guide, the browser's back arrow should return to the previous page location.

Feedback Welcome

The user of this manual is encouraged to submit comments and recommended changes to improve this manual and all Rajant products. Please send your feedback to support@rajant.com. Please be sure to include the version and revision number of the manual or product you are using as well as the relevant document section numbers if appropriate.

Related Documentation

For additional information, refer to these documents:

- BC|Commander® Version 11 User Guide: This document contains information on the BC|Commander management application, which is used to configure BreadCrumbs before or during a deployment.
- BreadCrumb® Security Technical Brief

These documents are available in the support section of Rajant's website at http://www.rajant.com.

1. Introduction to BreadCrumbs

Rajant Corporation's (http://www.rajant.com) BreadCrumbs utilize the 802.11 wireless networking standards to form a wireless mesh network. The network is mobile, self-integrating, self-meshing, self-healing, and secure. The focus is on flexibility, adaptability, and simplicity.

The BreadCrumb Kinetic Mesh Network is intended for rapid deployment of a broadband wireless network into a situation or "hot zone." The network can be deployed as a stand-alone wireless network, or bridged to another network (such as the Internet) utilizing available reach-back communication links (such as a DSL, cable, or satellite modem).

BreadCrumbs provide high bandwidth for applications to stream video, audio and data over large distances. The network traffic can be secured by using different security features available on the BreadCrumb. This makes the network optimal for tactical deployments as well as emergency response situations since it offers robustness, stability and ease of setup in mission critical activities.

1.1 What is a BreadCrumb?

A BreadCrumb is an IEEE 802.11 (Wi-Fi) and Ethernet compatible networking device with the ability to connect to other BreadCrumbs or networking devices to form a BreadCrumb network. The BreadCrumb is specifically designed for the following scenarios:

- **Temporary Wireless Networks:** Networks that must be established quickly and with minimal effort for short-term use (e.g., a network established to provide a temporary network in a tactical situation).
- **Mobile Wireless Networks:** Networks in which the network infrastructure itself is mobile, in addition to client devices (e.g., a convoy viewing a video stream from a UAV).
- **Wireless Network Extension:** Networks in which a wireless network must be quickly extended around or through obstacles that block wireless communications (e.g., urban canyon networks, tunnels/caves, etc.)
- **Wired Network Extension:** Networks in which two or more wired LANs at different locations must be connected wirelessly (e.g., to securely connect combat service support computers with logistics bases)
- **Any Combination of the Above:** Most BreadCrumb deployments include elements from more than one of the above scenarios.

In many cases, BreadCrumbs will perform all of these tasks as shipped with no configuration necessary at all, providing an instant TAN (Tactical Area Network). Moreover, because BreadCrumbs use industry-standard 802.11 communications, client devices such as laptops, or cell phones require no special hardware, software, and little or no configuration to access a BreadCrumb network.

Note

Although all BreadCrumbs can be access points, most access points do not provide mesh capability. Traditional access points simply allow wireless devices within range to connect to a wired network; they do not extend range through other access points.

1.2 The Mesh Network

The key component of a BreadCrumb Mesh network is the ability for BreadCrumbs to connect, or mesh with each other. While this is generally handled automatically by BreadCrumbs, complex deployment scenarios require a basic understanding of how BreadCrumbs establish and maintain a mesh.

1.2.1 Mesh – A Definition

A mesh is a collection of BreadCrumbs (or other network devices), each of which is linked to one or more other BreadCrumbs. Data can move between BreadCrumbs via these links, possibly passing through several intermediate BreadCrumbs before arriving at its final destination.

The intelligence of a BreadCrumb network is in how it adapts rapidly to the creation or destruction of the links in the mesh as devices are moved, switched OFF or ON, blocked by obstructions, interfered with by other devices, or otherwise affected. This adaptation takes place automatically and immediately as needed.

1.2.2 BreadCrumb Mesh Connections

In order for two BreadCrumbs to establish a mesh link to each other, they must be set to the same radio channel and have the same Network ID. The Network ID is computed from:

- Network Name (simply a configurable name for the network, default is "Rajant Mesh Network")
- Network Key (a passphrase or key used for establishing mesh connections and obfuscating unencrypted network management traffic)
- Packet cipher setting
- MAC cipher setting
- Per-hop verification setting
- Key Sequence Number (defaults to 0)

To modify these settings via BC|Commander, the administrator must be logged in using the Crypto Officer credentials.

2. Description of a BreadCrumb CX1

BreadCrumb CX1 is a portable, wireless device deployable in most environments. It is light in weight, includes 2 external antennas and is designed to be completely mobile as worn by an individual. The BreadCrumb CX1 is powered by a removeable rechargeable battery.

2.1 Radios

The BreadCrumb CX1 contains one radio in the 3.6 GHz band.

2.2 Enclosure

The CX1 enclosure has been designed to be splashproof when an etherCON cable is attached and the battery door is closed. The enclosure dimensions are 133 mm x 128 mm x 59 mm (5.246" x 5.013" x 2.304") including antennas and without the belt clip (the belt clip is installed by the integrator). The external features of the enclosure are shown in the following figures:

Figure: BreadCrumb CX1 Enclosure Features (Front)

Figure: BreadCrumb CX1 Enclosure Features (Back)

Antennas

Integrator Installs the
Belt Clip
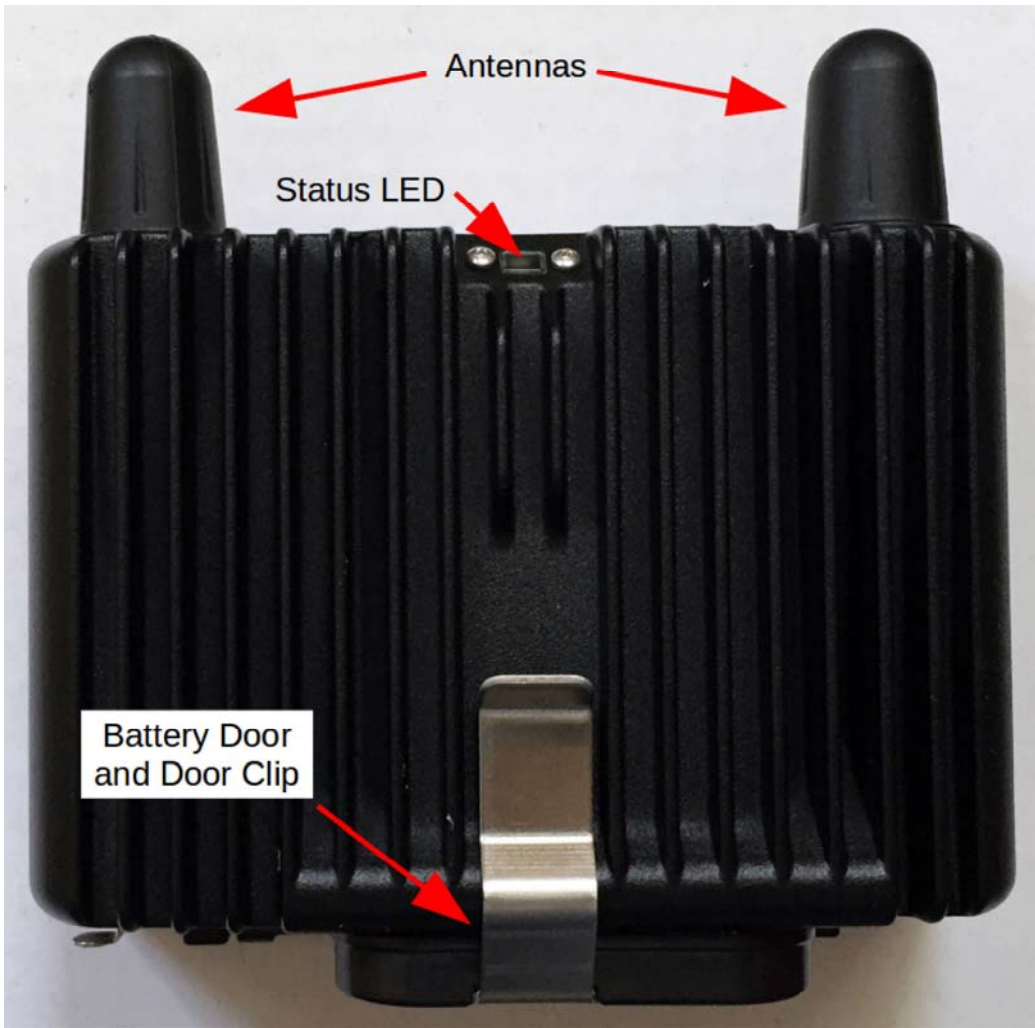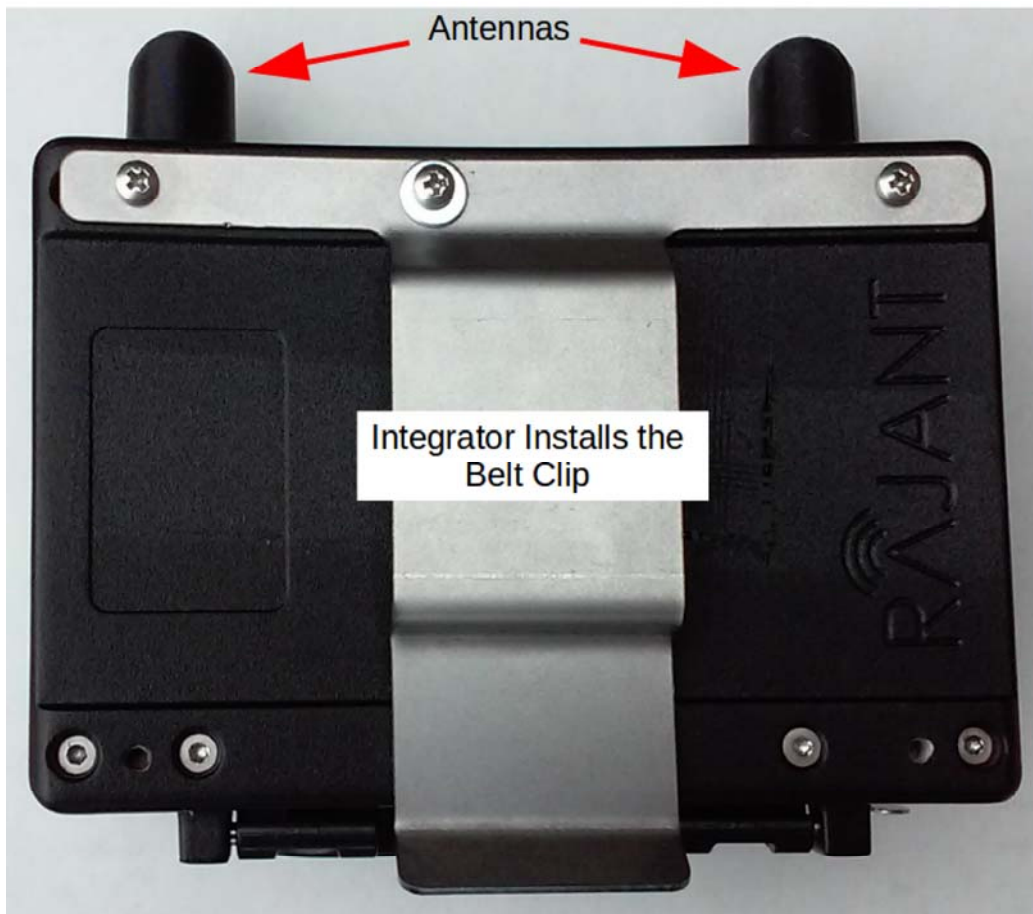
2.3 Antenna Connectors

The BreadCrumb CX1 provides two antennas located on the top of the enclosure (see the *Enclosure Top* figure above). The CX1 offers antenna diversity and Multiple-Input and Multiple-Output (MIMO) features so two antenna ports are utilized by the single radio.

Figure: BreadCrumb CX1 Enclosure (Top)

Antennas
Status LED
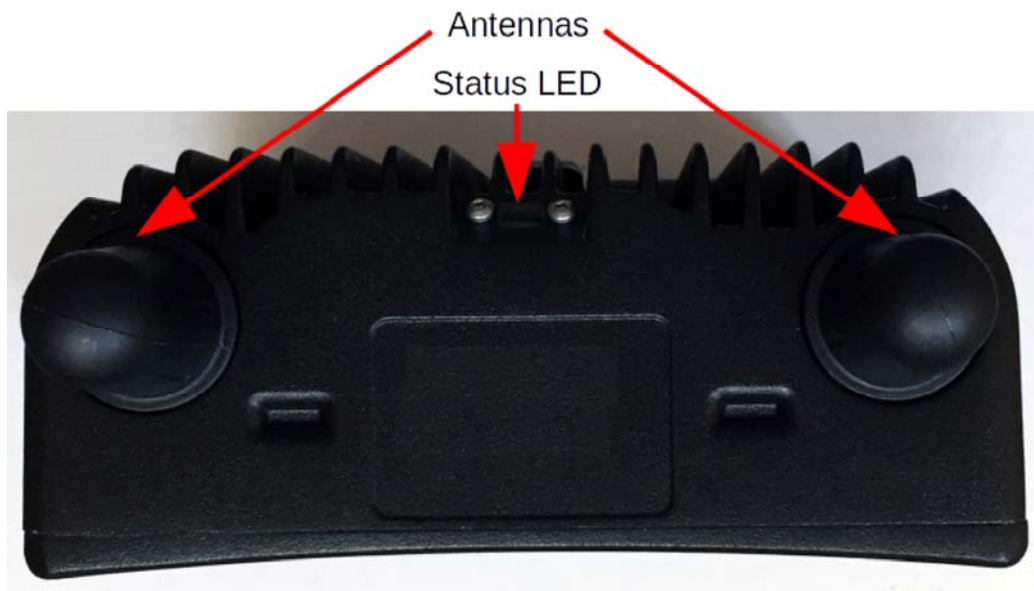
> **Warning**
>
> If it is necessary to service the antennas, to avoid possible damage to the BreadCrumb radio(s), always connect or disconnect external antennas with the power to the BreadCrumb CX1 turned off.

2.4 etherCON Connector

The etherCON connector of the BreadCrumb CX1 provides Ethernet and also outputs 500 mA of current at the voltage of the removeable rechargeable battery. The etherCON connector's power is required by the Green Go beltpack.

> **Warning**
>
> The output power on the CX1 etherCON connector may damage normal Ethernet ports on laptops and other devices. When connecting the CX1 etherCON to any device other than the Green Go beltpack, a customized Ethernet cable with no power lines must be used.

Figure: BreadCrumb CX1 Enclosure (Bottom)
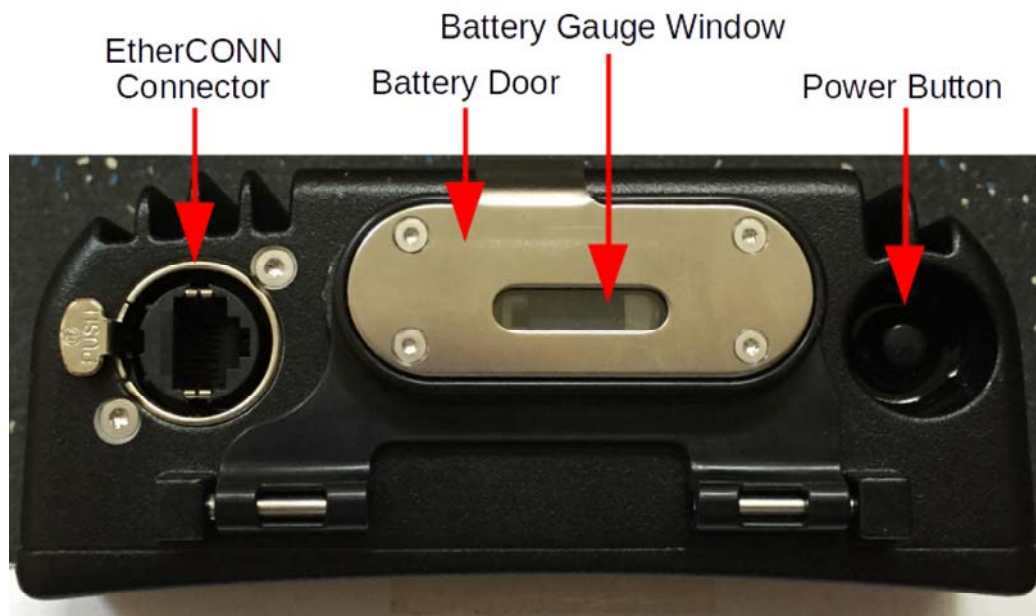
2.5 Power Requirements

The BreadCrumb CX1 is powered by a removable rechargeable smart lithium ion battery, Rajant part number 49-100009-001 Inspired Energy NC2040HD34, Battery, 10.8 V, 3.4 Ah, 37 Wh. The battery body is keyed to assist in proper insertion. When the battery is inserted into the CX1, the rectangular tab should be folded away from the battery gauge display on the end of the battery. The battery compartment door can then be clipped in the closed position.

The BreadCrumb CX1 does not include a battery charger. An external charger is required to charge the CX1 battery.

Figure: BreadCrumb CX1 Battery

Battery Safety

Handling

- Avoid shorting the battery.
- Do not immerse in water.
- Do not disassemble or deform the battery.
- Do not expose to, or dispose of the battery in fire.
- Avoid excessive physical shock or vibration.
- Keep out of the reach of children.
- Never use a battery that appears to have suffered abuse.

Charge & Discharge

- Battery must be charged in appropriate charger only.
- Never use a modified or damaged charger.

Storage

- Store in a cool, dry and well ventilated area.

Disposal

- Regulations vary for different countries. Dispose of in accordance with local regulations.

2.6 Status LED

The Status LED is capable of displaying warning and error codes, and link states. The LED Mode can be configured in BC|Commander to be ON (switchable), ALERTS ONLY (switchable), OFF (non-switchable), or OFF (switchable). When the LED Mode is ON, the BreadCrumb LED alternates between displaying the link state and any warnings or errors. When the LED Mode is OFF, the BreadCrumb LED does not display any warnings, errors, or the link state. When the LED Mode is set for ALERTS ONLY, the BreadCrumb LED alternates between displaying the link state and any warnings or errors only if there are warnings or errors to report. If there are no warnings or errors, the LED displays nothing.

The Status LED combines the three base colors of red, green and blue to display a broader spectrum of colors which indicate the current status of a BreadCrumb. The meanings of the color code indicators are given in the following table.

Table: Status LED Color Codes

Color	Status
White (red, green and blue LEDs together; may appear pale blue or pale green)	Powered on; start of boot process
Red-Blue-Green scrolling in succession	End of successful boot process
Solid Blue	Ready, but no connected Mesh peers (unit may have Ethernet peers)
Blinking Green	At least one connected Mesh peer; all peers are connected at less than 24 Mbps
Solid Green	At least one connected Mesh peer; one or more peers are connected at 24 Mbps or faster
Blinking Yellow (with short and long pauses between blinks)	Numeric warning code
Blinking Red (with short and long pauses between blinks)	Numeric error code
Blinking Yellow (blinking at an increasing rate)	BreadCrumb is in the process of installing firmware
All LED colors scrolling in rapid succession (with a short pause between every cycle)	Successful firmware installation; ready to reboot
All LED colors scrolling in rapid succession (with no pause)	Identify mode is ON

For more information on BreadCrumb Status LED numeric codes see Appendix Error and Warning Codes.

For a list of error and warning codes refer to Appendix Error and Warning Codes.

3. Appendices

Appendix A: Error and Warning Codes

All possible BreadCrumb error and warning codes are listed below.

A BreadCrumb can have multiple errors or warnings listed in the Alerts tab of BC|Commander but only one code will be flashed on the BreadCrumb's status LED. A few codes such as 811 and 335 are non-flashing alerts. For a BreadCrumb with other active alerts, the lowest number error code will flash on the BreadCrumb's status LED, and if there are no errors then the lowest number warning will flash.

Numeric error codes are flashed as groups of red (error) or yellow (warning) LED blinks. For example, a meshed BreadCrumb displays a green LED. If the BreadCrumb starts to display warning 37, the following would be seen: green (link state), yellow blinks 3 times, short pause, yellow blinks 7 times, long pause of green (link state), yellow blinks 3 times, short pause, yellow blinks 7 times, etc.

Code	Firmware Upgrade Codes (1*)
11	Flash image file does not exist.
12	Current flash image version is greater than versions of files found on USB drive.
13	No flash image files found.
14	Unable to mount USB drive.
15	Unable to retrieve next boot image number.
16	Unable to set fail safe boot mode.
17	Unlocking of /dev/mtd0 failed.
18	fconfig for SetMainBoot failed.
19	Copying of zImage failed.
111	Copying of ramdisk failed.
112	FIS directory update of ramdisk failed.
113	Copying of etc failed.
114	FIS directory update of /etc failed.
115	Copying failed.
116	Flash unbundle failed.
117	Version information in flash file name and breadcrumb-buildinfo.conf do not match.

1171	Platform information in flash file name and breadcrumb-buildinfo.conf do not match.
118	Untar failed.
119	FIS directory update of kernel failed.
121	Failed to unmount /etc.
122	In Failsafe mode, but no USB drive detected.
123	BreadCrumb will be in failsafe mode and unable to communicate with other BreadCrumbs after next reboot.
124	Failed to suspend bcconfigd.
125	Failed to set boot path to next image.
126	Failed to erase end of next file system image.
127	Failed to copy file system image.
128	Failed to checksum file system image.
129	Failed to create directory for next file system image.
131	Failed to mount next file system image.
132	Failed to create directory for settings.
133	Failed to copy current settings to next file system image.
134	Failed to unmount next file system image.
135	Failed to copy init image.
136	Failed to copy bootloader image.
137	This flash image may not be installed onto this BreadCrumb.
138	Failed to copy failsafe file system.
141	Error retrieving flash file.
142	The version you are installing does not support the configured Packet Cipher
143	The version you are installing does not support the configured MAC Address Cipher
144	The version you are installing does not support the configured Per-hop Authentication algorithm
145	The version you are installing does not support the configured security policy

146	Failed to verify consistent country settings
147	The configured countries are not consistent
151	Pre-manufacturing install process failed
152	Firmware install failed
153	Post-manufacturing install process failed
154	The autorun is missing required symbols
21	Recovery log detected. To clear this message, please take a diagnostic snapshot and upload to https://secure.rajant.com.
22	Internal error detected. Please take a diagnostic snapshot and upload to https//secure.rajant.com. This message will be cleared on the next reboot.
Code	**Self-Test Codes (3*)**
31	Hardware configuration not set. Factory initialization required.
311	Hardware error detected.
32	BreadCrumb has been zeroized.
321	BreadCrumb is being zeroized.
33	Radio(s) not detected.
331	Radio in MANUAL compliance mode is violating country regulation.
332	Spectrum Access not granted
333	Low Battery
334	Gas gauge not initialized. To initialize, please power off unit and fully charge.
335	Non-compliant radio configuration in use
34	Cannot read /dev/nand6 information, or cannot resize or format /dev/nand6.
36	Hardware monitor missing.
37	Failed to configure ethernet port
38	Resetting radio due to error.
381	Noise floor threshold exceeded
382	Radar detection paused radio

383	Radio resumed from radar pause
385	Radio(s) failed to initialize
Code	**FIPS Codes (4*)**
41	FIPS Power-on self-tests failed.
411	FIPS DRBG power-on self test failed.
412	FIPS DRBG continuous test failed.
413	FIPS DRBG health check failed.
414	Kernel integrity check failed.
415	Filesystem integrity check failed.
416	FIPS USB test vector data missing.
417	FIPS Invalid configuration.
418	Flash image may not be installed while in FIPS mode.
42	Mixed SecNet/Non-SecNet configuration.
43	Rekeying error.
44	Rekeying error.
45	Rekeying error.
46	Rekeying error.
47	Rekeying error.
48	Rekeying error.
49	Rekeying error.
431	Rekeying error.
432	Rekeying error.
433	Rekeying error.
434	Rekeying error.
435	Rekeying error.
436	Rekeying error.

	Status override CPLD feature not available (wrong CPLD version).
Code	**Fatal and Serious Codes (5*)**
51	instamesh fatal error.
52	hostapd fatal error.
521	disabling HT40 operation to prevent conflict with a nearby BSS
522	IEEE 802.11 TKIP countermeasures initiated
53	Taking over as APT master
54	fatal error.
541	Software error
55	Low memory - automatic reboot scheduled.
56	APT peer bridge settings do not match
57	logwatcher start timeout
Code	**Battery Gas Gauge Codes (6*)**
61	Battery gas gauge i2c device could not be found.
62	Incorrect gas gauge revision 1 EEPROM settings.
63	Incorrect gas gauge revision 2 EEPROM settings.
64	Incorrect gas gauge revision 3 EEPROM settings.
65	Unknown gas gauge revision.
66	Incorrect ME3 gas gauge revision 0 EEPROM settings.
67	Internal battery charger disabled.
Code	**Other Codes (7, *8*, 9*)**
71	Host flapping detected.
72	Critical I2C failure.
73	Invalid channel configured.
74	Bad factory configuration.
741	Signing key installation failure.

	Unsupported hardware component.
76	Potential loop detected, turned off port
77	Model is not supported in this version of firmware. Contact support.
81	reserved
811	Default Network Key is in use.
82	reserved
83	reserved
84	reserved
85	reserved
86	reserved
87	reserved
88	reserved
89	reserved
91	Invalid SSL Handshake Priority String:

Appendix B: Ports and Protocols

Table: Ports and Protocols

Service	From	To	Protocol
BreadCrumb Discovery	Ephemeral port on BC|Commander workstation	224.0.0.224, port 35057 (UDP IPv4 multicast); FF02::1, port 35057 (UDP IPv6 multicast); BreadCrumb IPv4 or IPv6 addresses, port 35057 (UDP IPv4 or IPv6 unicast)	IPv4 UDP, IPV6 UDP
BreadCrumb Discovery	BreadCrumb IPv4 or IPv6 address, port 35057	Ephemeral port on BC|Commander workstation (UDP IPv4 or IPv6 unicast);FF02::1, port 35057 (UDP IPv6 multicast) at BreadCrumb startup	IPv4 UDP, IPv6 UDP
BCAPI (BC|Commander)	Ephemeral port on BC|Commander workstation	BreadCrumb IPv4 or IPv6 addresses, port 2300 (default)	IPv4 TCP, IPv6 TCP
BC|Enterprise	Ephemeral port on BC|Enterprise workstation	BC|Connector TCP port 23000	IPv4 TCP IPv6 TCP
BC|Enterprise	Ephemeral port on BC|Enterprise workstation	BC|Enterprise workstation ports 9090 and 3000	IPv4 TCP IPv6 TCP
BC|Enterprise Client	Browser on client worstation	BC|Enterprise workstation port 8888	IPv4 HTTP IPv6 HTTP
BC|Connector	Ephemeral port on BC|Connector workstation	BreadCrumb IPv4 or IPv6 addresses, port 23000	IPv4 UDP, IPV6 UDP
APT Discovery - v10 Compatibility Mode	BreadCrumb ethernet interface, raw ethernet	FF:FF:FF:FF:FF:FF (raw Ethernet broadcast)	ARP (see note below)
APT - v10	BreadCrumb ethernet interface IPv6 link-	BreadCrumb ethernet interface IPv6 link-local address port 2210	

Compatibility Mode	local address, ephemeral port	for the service listener, ephemeral port for data flow	IPv6 UDP
APT - v11	BreadCrumb ethernet interface IPv6 link-local address, ephemeral port	BreadCrumb ethernet interface IPv6 link-local address port 2210 for the service listener, ephemeral port for data flow	IPv6 UDP
RPT	BreadCrumb IPv4 or IPv6 address, ephemeral port	BreadCrumb IPv4 or IPv6 address, SCTP port 2210 for the service listener, ephemeral port for data flow	IPv4 or IPv6 SCTP
TRoIP Audio RTP Traffic	BreadCrumb IPv4 address, ephemeral port	IPv4 multicast address 225.0.0.1-225.0.2.255 port 24680	IPv4 UDP
Remote Packet Capture	Remote Packet Capture Client (typically RRADS)	BreadCrumb configured TCP port (default:5825)	IPv4 TCP

Note

APT Discovery in v10 Compatibility Mode may be truncated by some third-party equipment.

Appendix C: Rajant End User License Agreement

The BreadCrumb® Wireless LAN System

Rajant Corporation End User License Agreement

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Version 2, June 1991

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