To increase the wireless network's area of coverage for both indoor and outdoor applications, the Horizon utilizes a custom meshing feature that allows increased coverage areas without the added expense of hard cabling or adding an additional point to point radio link.

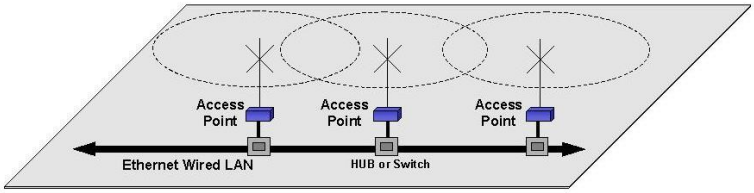

Figure 1: Conventional Access Point Diagram

With a conventional IEEE 802.11 (Wi-Fi) Access Point (AP) network, all of the APs have to be interfaced to a common network either by hardwire, see Figure 1, or a separate, dedicated RF backbone. The Horizon radios can create this RF backbone, bridge Ethernet networks connected to the wired Ethernet port and provide the wireless canopy for mobile clients simultaneously.

When programmed in any of the three Access Point (AP) Modes (Bridge, Router or Masquerade), the Horizon will create a wireless network with other Horizon units in radio range that are programmed in the Peer table during setup. This feature adds the increased functionality of repeaters to the typical Ethernet Bridge configuration.

ESTeem IndustrialMESH Network

One of the most powerful features of the wireless Peer configuration between Access Points (AP's) is the ability to input multiple communication routes and designate the priority for each of these routes to create a wireless Mesh network. The ESTeem Horizon will automatically change communication routes in the network if a route has failed. The new route will be based upon the priority level set during configuration. This wireless Meshing technology allows the RF network to "self-heal" if any of the communication paths fail.

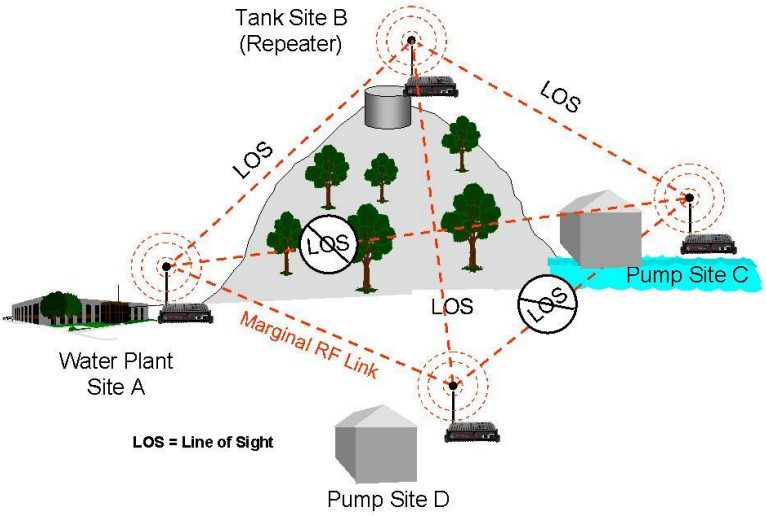

Figure 2: Small Mesh Network Diagram

The routing priority is manually set during the configuration of the Horizon. A manual path configuration is far superior to standard "self-discovery" networks, because you have direct control over the best RF paths and can easily identify any failed routes for easy troubleshooting. For example, Figure 2 shows a typical wireless Ethernet system used in the Water/Waste Water Industry. The problem with a standard "self-discovery" Mesh network is the selection of routes. Notice that the communication between the Water Plant (Site A) and Pump Site D has a marginal link, but it is the most direct route between the Ethernet devices.

This scenario poses the question, which path will the network select? The ESTeem Mesh Network takes out the guessing games by allowing the user to select and prioritize all communication routes in the system. In our example we would want the primary link to go through Tank B (Repeater) and use the direct link only if this primary link fails. The following sections will show how this completed.

Configuration

The configuration of the wireless paths is completed during setup of the Access Point modes. All three Access Point modes support repeating and Meshing features. You can also configure the Mesh networking directly through the web configuration setup (Chapter 5). Figure 3 shows an example peer table from the setup menus. For the Horizon to communicate with another Horizon, select Yes must at ***Enable Peer Capability***. Next, the Serial Number or Wireless LAN (WLAN) MAC address of each Horizon that will have direct communications must be added to the Peer List. Finally, ***enabling the link*** allows the corresponding Horizon to be

included in the communication routing. Mobile clients do not require input in the repeater peer table. If multiple Mesh routes are configured, you will also need to set the values for Priority and Path Length (explained in Rapid Spanning Tree below). For multiple examples of repeater configurations, please refer to Chapter 3 of this user's manual.

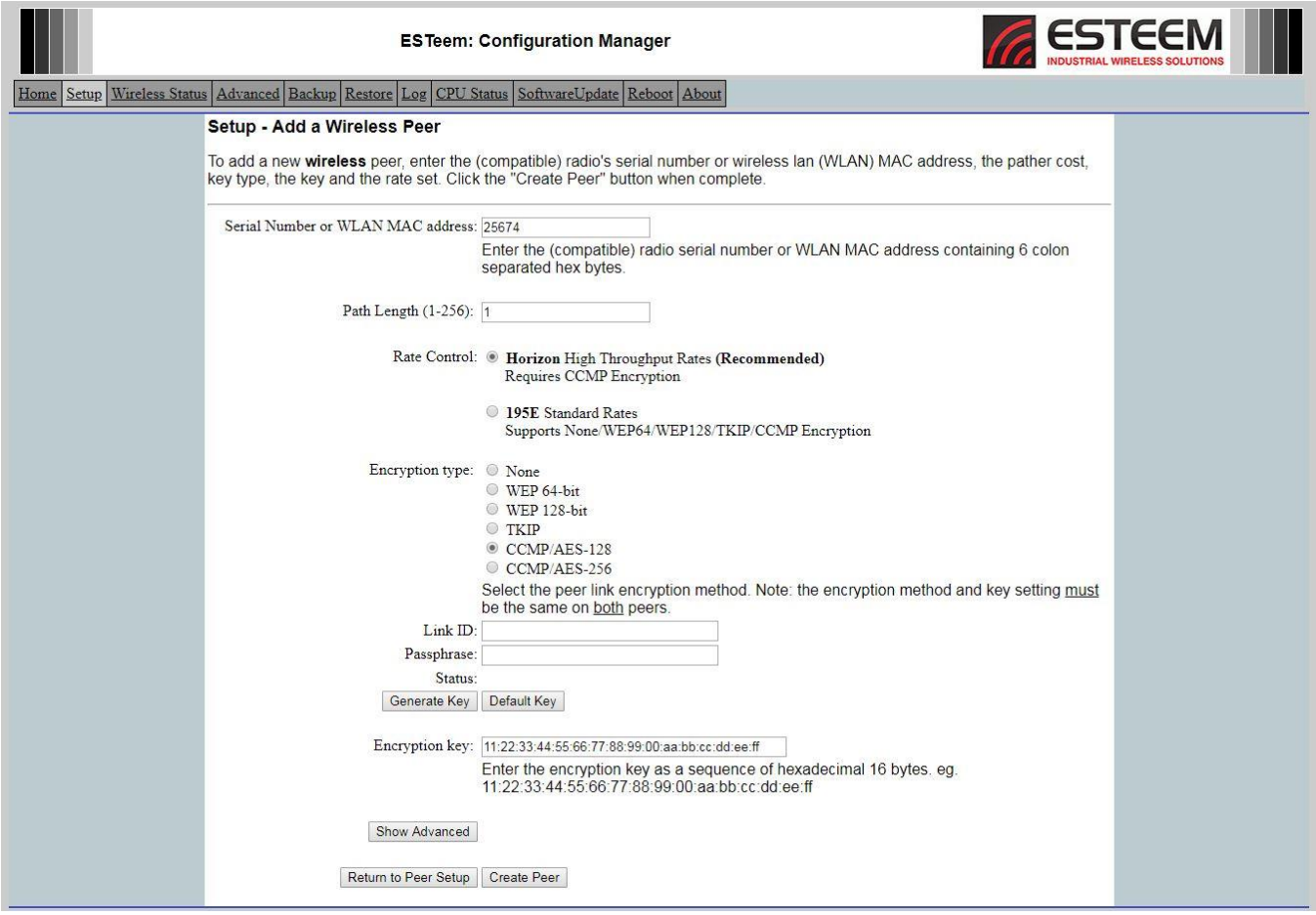

Figure 3: Repeater Configuration Example

Rapid Spanning Tree Protocol (RSTP)

The ESTeem Horizon uses standard Ethernet Rapid Spanning Tree Protocol (RSTP) to determine the radio routing structure of the wireless network. The primary purpose of RSTP is to make sure that "network loops" are not created. A network loop is having two communication paths to the same destination where the remote device would receive the same data multiple times. If there were no way to control the data flow, this data would be constantly passed around this loop causing a "packet storm" that would shut down the entire network. The Spanning Tree Protocol will block all these redundant links.

The RSTP operation begins by determining which Ethernet device on the network will be the Root Bridge. All Ethernet networks have a Root Bridge that is selected by the lowest MAC address. All path lengths are evaluated against this Root Bridge device to determine routing and which paths will be blocked. On a wired Ethernet network, the location of the Root Bridge is not really important, but in a wireless network selection of the Root Bridge is critical to the wireless network routing. Let's use one of the Example network diagrams from Chapter 3 to continue the discussion (Figure 4).

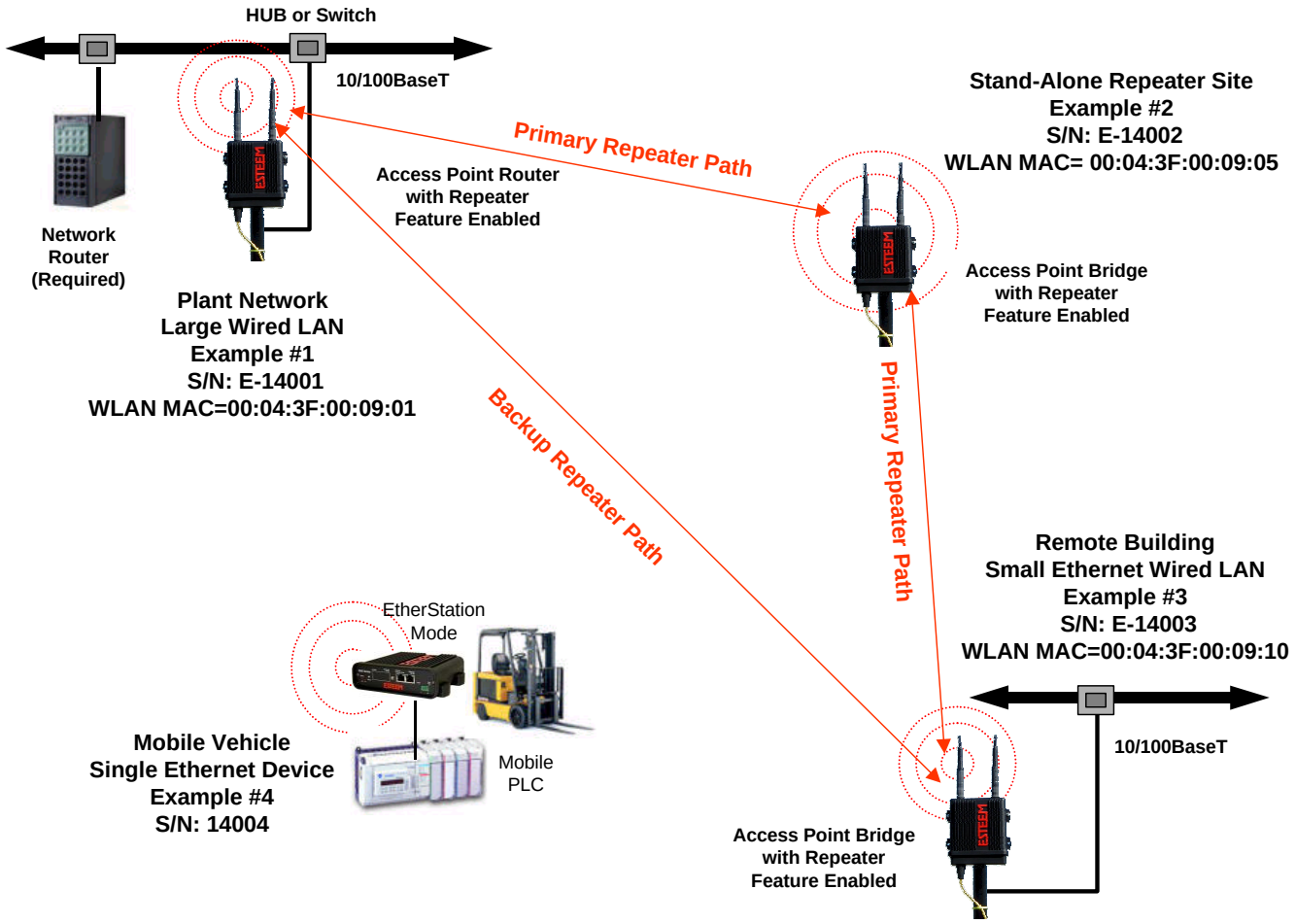

Figure 4: Programming Example #1 Diagram

RSTP Phases

The following sections describe the process of the RSTP in the ESTeem Horizon as how it would happen in the above example.

Learning Phase - Once properly configured, each Horizon will begin to search out the other Horizon units in radio range that are programmed in the AP Repeater Peer table. All Horizon's will calculate their routes to every Horizon in the network based upon the lowest "path length" to the Root Bridge. Path length is the total number of wireless links (repeater peer links) to transmit a packet through the wireless network to the Root Bridge. ***Note: The Root Bridge in a network should be the Horizon where the majority of the data flow is processed.*** In every wireless network of two or more radios, the Root Bridge should be user defined. If not defined, the Horizon with the lowest MAC address will be designated as the Root Bridge.

In Figure 4, the Plant network (Example 1) is the most logical location for the Root Bridge based upon the amount of data flow. Setting this site as the root bridge is discussed below in Root Bridge.

Blocking and Forwarding Phase – To ensure you do not have a network loop situation due to redundant paths in your wireless network, the Model Horizon will recognize and disable (block) one or more redundant links and provide back up links should the primary link fail. This establishes a wireless mesh network with a series of forwarding links, based upon the shortest path length to the Root Bridge.

For example, looking at Figure 4, the Remote Building has two routes to the Root Bridge (Plant Network – Example #1); directly to the site and through the repeater. The direct link between the two sites is the shortest route (lowest Path Length) and will be selected as the primary route unless overridden by manually changing the Path Length in the configuration.

Path Length

If more than one communication path to the Root Bridge is found, the Horizon must determine which route to take based upon the lowest Path Length. The default path length to all links in the Horizon network is 1. If the Path Lengths are equal then the lowest MAC address will determine the priority route. In the ESTeem Mesh Network we want to directly control all data flow so do **not** want the routes to be automatically determined.

Looking again at our Example in Figure 4, if we made no changes to the default path length of 1 (note values in Figure 3) the lowest path length would be direct from the Remote Building to the Root Bridge (Plant Network).

Link Description	Total Path Length
Direct from Remote Building	1
Remote Build to Root Bridge Through Repeater	2 (Length 1 to repeater + Length 1 to Master = 2)

To configure the Horizon to select the repeater as the primary radio path, set the path length value for the direct link greater than 2 (such as a value of 3) to make this the primary radio path. The lowest path length will identify the highest priority. The Model Horizon will use this routing, but also switch to direct communication if the repeater were to disappear.

Root Bridge

In any Access Point Repeater network consisting of more than two sites, one Model Horizon should be designated as the Root Bridge. Only one Model Horizon can be designated as the Root Bridge in a given network and should be located where the majority of the Ethernet data flow is processed. This site may be the Master location in a SCADA network or could be configured at a repeater site. Selection is important because all Model Horizon's **NOT** configured as the Root Bridge will choose routing based upon the Path Length to the Root Bridge. If you have any question as to which site in your AP Repeater application should be the Root Bridge, contact ESTeem Customer Support at 509-735-9092 or e-mail your application to support@esteem.com.

The Root Bridge will be selected in one of two ways: the Root Bridge can be manually set (recommended) during the configuration of the Repeater Peer table (Figure 3) **or** the Root Bridge designation will default to the lowest MAC address of all the Model Horizon's in the network. The manual Root Bridge configuration is located in the "Advanced Settings" section.

Redundant Backup

The ESTeem Horizon configured in Access Point mode will automatically function as a redundant backup if two Horizons are installed at the same location (Figure 7). If two Horizons are connected to the same switch, one of the Horizons will be **Blocked** when the Rapid Spanning Tree Protocol is completed. The network will continue to use this route until any problem with the original Model Horizon is detected and the second Horizon will begin operation at that site.

Redundant Master Configuration

The configuration in Figure 7 will also provide a redundant backup for the Master Site (Root Bridge). Configure both Horizons as Root Bridges (see above) giving the primary Root Bridge a value of 1 and the secondary Root Bridge a value of 2.

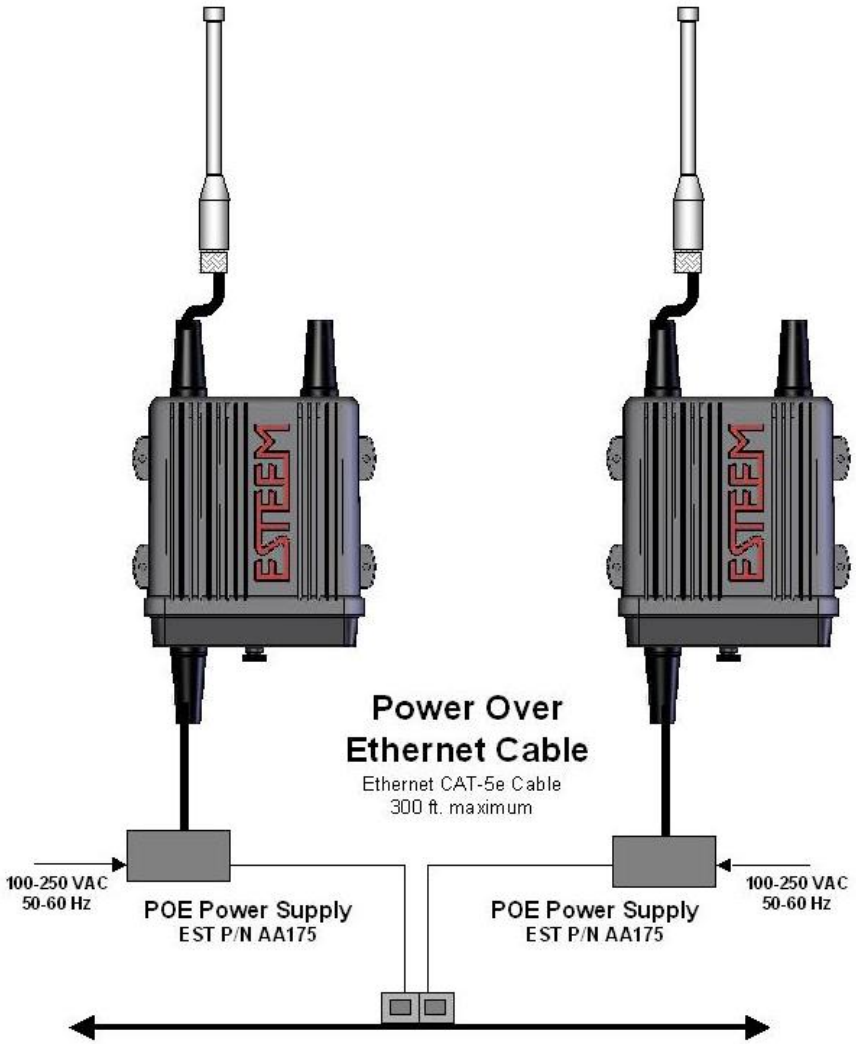

Figure 7: Redundant Backup Diagram

Dual Network SSID

There is a new feature in the Horizon series called the Dual Network SSID. This feature will give the Horizon a second SSID, separate wireless network (if required) and use a unique Ethernet port for each network connection. This feature can be used for providing a WiFi guest account or having an isolated control system and WiFi access within a single Horizon radio network by steering each to a unique Ethernet interface.

Figure 8 shows an example of how the second SSID function could be used. The first SSID "ESTeemWiFi" can be used in and around the Master and remote facilities to provide wireless access to mobile clients in the network. This first SSID will be directed to Ethernet port #1 (ETH0) on Horizon by default. The second SSID "ESTeemControl" would be used exclusively for providing a wireless Ethernet network for the control hardware and would use the 2nd Ethernet port (ETH1) by default. The two wireless networks are configured independently and there is no "cross talk" between the networks.

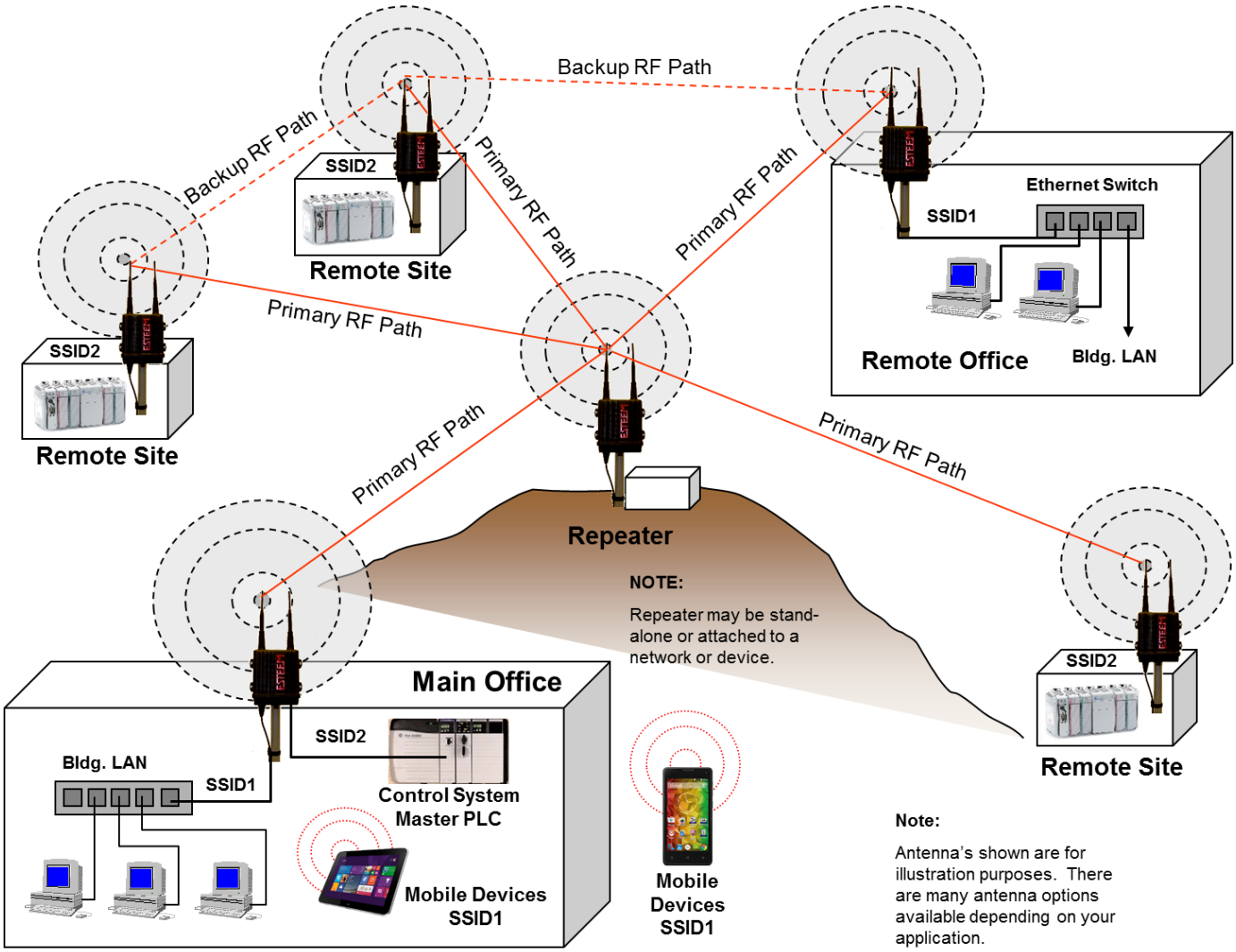

Figure 8: Redundant Backup Diagram

This Dual Network SSID feature only works in the AP Bridge mode of operation. The configuration of the second SSID is done through the Advanced Tab (Figure 9) by selecting Wireless LAN Settings>wlan1 device. Select the Enable wlan1=On (Figure 10)

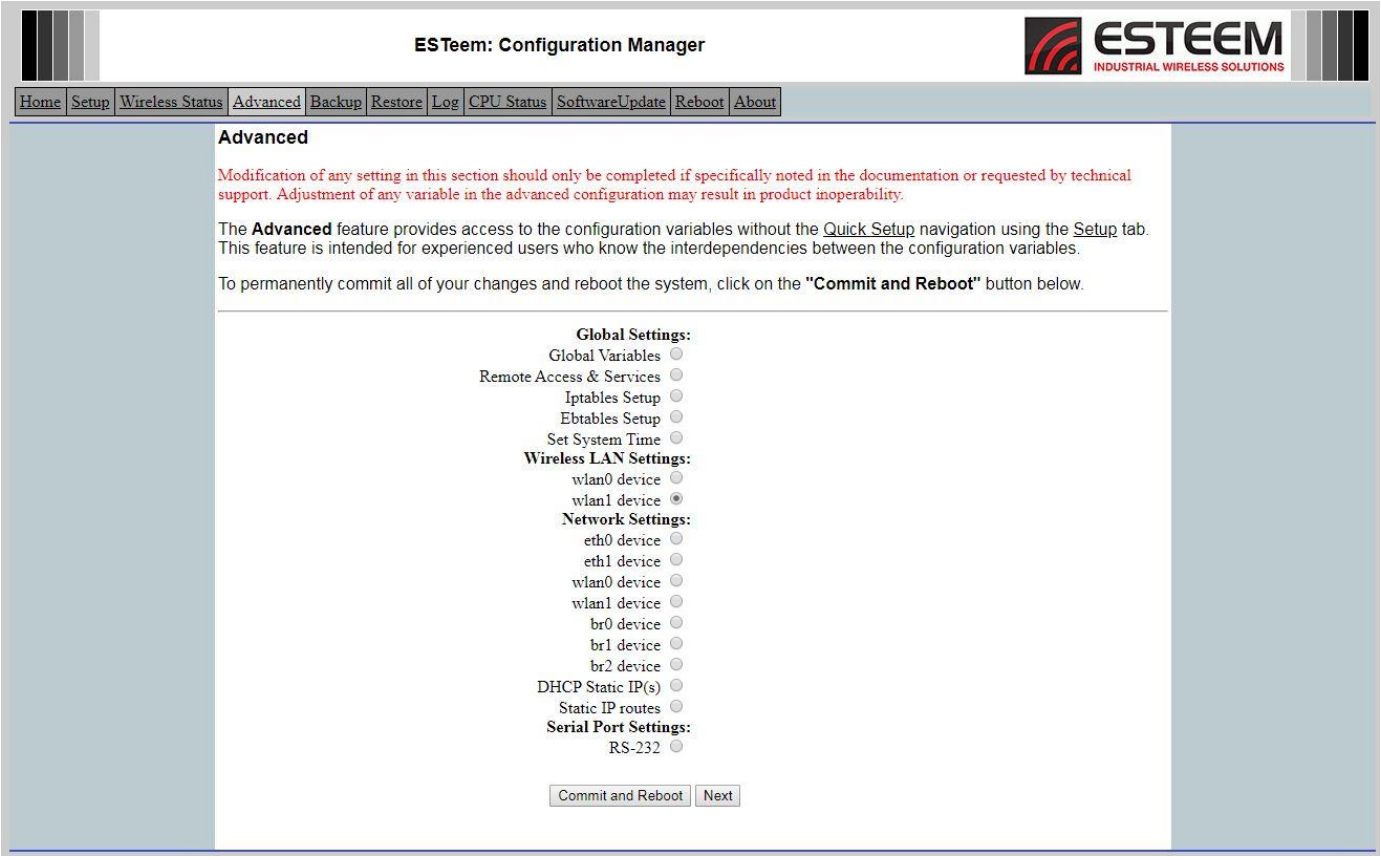

Figure 9: Advanced Menu

and press the "Setup" button with the Basic Chain selected to complete the configuration. The configuration of the second SSID is an identical step by step as described in Chapter 3 – Example Applications for AP Bridge mode. This second wireless network will operate simultaneously with the first AP Bridge SSID configured in the Setup tab.

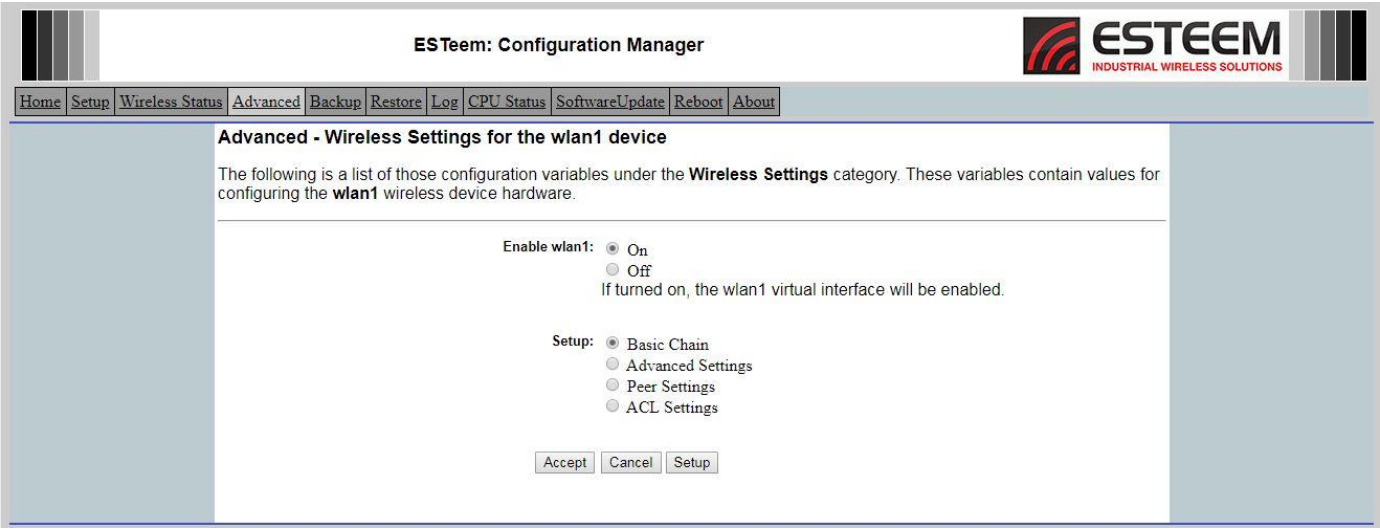

Figure 10: wlan1 Interface Configuration