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START Sensor Network User Manual

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1 Contents

2 Overview

The WilliamsRDM START sensor network is an intrusion detection sensor network for perimeter security in both urban and rural environments. The system uses a unique Radio Frequency (RF) tripwire system to detect the movement of people and vehicles through a mesh network of sensor nodes. Once deployed, the sensor nodes from a self-configuring, self-healing mesh network for data communication and intrusion sensing. The mesh network monitors the communication links for variations in the radio environment to detect intruders. The sensor nodes can be easily camouflaged since radio signals will travel through most objects and still detect intruders allowing complete camouflage of the equipment. Each sensor node has an integrated GPS to provide position information eliminating the need to document the location of each sensor node during deployment.

The system can also interface with sensors that utilize the Qual Tron Inc. sensor interface allowing sensors such as the Qual Tron passive Infrared (IR), magnetic and seismic sensors to be use with the system. Additionally, the system is compatible with the Scorpion laser tripwire system and Telonics PT-100 sensor system. This ability allows existing inventory of sensors to be used modernizing them so that they can be monitored remotely on the START web-based user interface. This allows the existing inventory of sensors to be displayed on a map using the sensor node's GPS coordinates and allows it to trigger cameras if desired. This remote sensor functionality can be used along with the RF tripwire system or can be used independently using the start mesh network to communicate the external sensor detections to the user interface.

The system can function independently as a long-range trigger for trail cameras, or it can also use a cellular connection via a cluster node for remote live monitoring, configuration, and text message-based alerts. For security, each device is configured from the factory with a unique owner ID tied to the owning organization so that only sensor nodes from that organization will work together. This prevents other organizations from collecting data from another organization's sensor network. The sensor nodes have an integrated tamper function that will activate a sensor node if it is removed from its deployed location. Once the tamper is activated it updates its position every few seconds so that its location can be accurately tracked. For applications that use the optional remote monitoring capabilities a web-based application with mapping function provides for simple and easy monitoring and configuration of the system. Figure 1 shoes an example of the web-based application map.

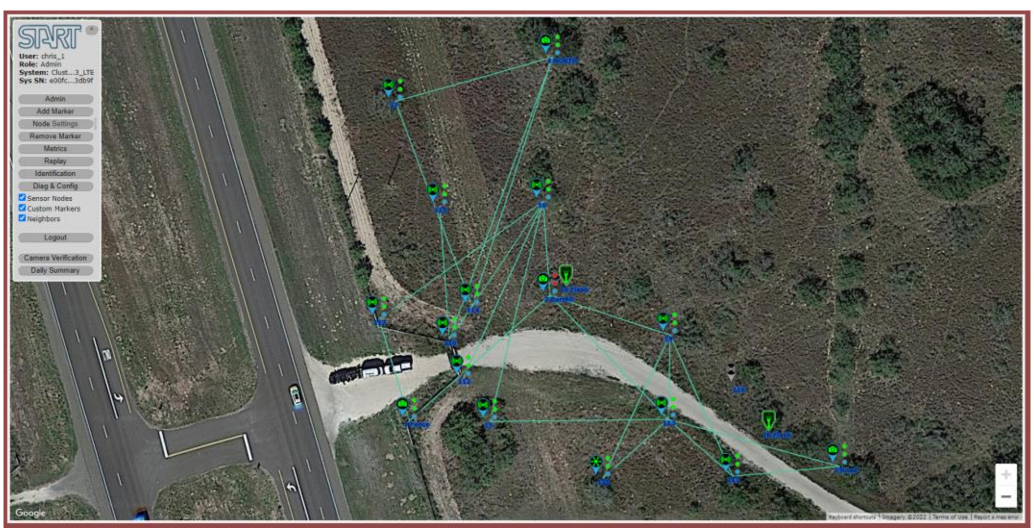

Figure 1: WilliamsRDM Sensor Network Web Application

Key Features

- RF tripwire uses radio frequency signals to detect personnel or vehicle intrusions.

- Easy to install and hide since the entire unit can be camouflaged.
- Integrated GPS allows quick and easy deployment.
- Integrated movement-based tamper function
- Works with WilliamsRDM's covert solar power devices to provide uninterrupted operation.
- Can be used to trigger Spartan GoCam, Ghost, GoLive or GoLive2 cameras with an eyepatch trigger module.
- Can be used to trigger Buckeye Cameras with an eyepatch trigger module.
- Interfaces with sensors that use the Qual Tron 4 Pin interface such as the seismic, Passive IR, and Magnetic sensors as well as the Scorpion laser tripwire system and Telonics PT-100 systems.
- 1-2 Week sensor node operation on battery power
- 5 – 7 Day cluster node operation on battery power
- Simple Single Pushbutton User Interface
- Unique Owner ID to keep systems purchased by different organizations separate.
- Can be remotely monitored and configured using a web-based application.
- E-mail based text alerts to multiple users.

3 Sensor Network Kits

The WilliamsRDM START system is flexible and can be deployed in a variety of ways. The specific contents of the deployment kit may vary depending on the kit configuration ordered. Below are two example deployment kit versions of the START sensor network. The first is a 3-node system which functions as a remote camera trigger for Spartan and Buckeye cameras. The second version is a 25-node system which includes 6 cameras and can be monitored remotely from the internet using an included cluster node.

3.1 3-Node System

The START sensor network 3-node system is a small remote camera trigger system for rapid deployment. The system consists of 3 sensor nodes and a trail camera eyepatch trigger module. For this system the sensor nodes come preconfigured from WilliamsRDM to act as a remote camera trigger system allowing a camera to be triggered from long distances. 3-Node systems can be combined to monitor larger areas but, all cameras will be triggered when a detection is made. This feature allows nodes from different kits to be mixed and matched as long as the owner IDs match. The included eyepatch trigger module can be connected to any of the 3 sensor nodes and when the system detects an intrusion it will trigger the camera to take a picture. The tripwire sensitivity settings are preset at the factory for good general-purpose performance that works in most conditions. For this system the user is unable to change the system sensitivity or other system settings.

If a larger 25-node sensor network system is purchased in the future, then the sensor nodes from the 3-node system can be linked to the new system to provide remote monitoring and configuration capabilities. For this to work the owner ID of the 25-node system must match the owner ID of the 3-node system. If the 3-node system functionality is desired again in the future, then any 3 sensor nodes can be configured to act as a 3-node system using the web-based user interface or the factory reset button can be pressed to reset the sensor nodes back to their default settings which support the 3-node system.

3.1.1 3-Node System Kit Contents

The 3-node sensor network system consists of the following items:

1. 3 Sensor Nodes
    a. Sensor Node
    b. Antenna
    c. Antenna Cable
    d. Rodent Braiding for rodent protection and camouflage

2. 3 Covert Solar Rocks for the Sensor Nodes
3. 1 Camera Trigger Module (Camera Model Specific)
    a. Depending on the system the trigger module may support either the Spartan GoCam, Ghost, GoLive, GoLive2 cameras or the Buckeye camera.
4. 1 Covert Solar Rock for Trail Camera (Camera Model Specific)

3.2 25-Node System

The START sensor network 25-Node system is the full featured sensor network system designed for rapid deployment to monitor an area for activity. The system includes 25 sensor nodes as well as a cluster node to provide cellular communication for remote monitoring and configuration capabilities. A web-based application allows the user to see the location of sensor nodes on a satellite map of the area. The system can be monitored live, and alerts can be set up to notify users of activity when away from the web page. System settings can be configured. These settings include mapping cameras to a sensor node, changing tripwire sensitivity settings, renaming sensor nodes, enabling, or disabling tripwire links, etc. The system also includes 6 eyepatch trigger modules and 6 cameras that are preconfigured to work with the web application.

3.2.1 25-Node System Kit Contents

The 25-node sensor system consists of the following items.

1) 25 sensor nodes
    a. Sensor Node
    b. Antenna
    c. Antenna Cable
    d. Rodent Braiding for rodent protection and camouflage
2) 6 Spartan Go-Live Camera Trigger Modules
3) 6 Spartan Go-Live Cameras pre-linked to the system
4) Cluster node kit which provides the cellular connection for the system
    a. Cluster Node
    b. Cellular Antenna
    c. Cellular Antenna Cable
    d. Sensor Network Antenna
    e. Sensor Network Antenna Cable
    f. Solar Power Y-Adapter
    g. Rodent Braiding for rodent protection and camouflage
5) 27 Covert Solar Rocks (25 for the sensor nodes and 2 for the cluster node)
6) 6 Covert Solar Rocks for Spartan Go-Live Cameras
7) Access to the WilliamsRDM START sensor network web application
8) WilliamsRDM CamoWraps (Optional)
9) Covert Remote IR Flash (Optional)
    a. See Separate User Manual

4 Sensor Node Kit

Figure 2 shows the sensor node Kit which consists of the Sensor Node, Antenna, Antenna Cable, and rodent resistant braiding. The antenna is connected to the sensor node via the antenna cable. Rodent braiding is used to protect the antenna cable from rodents as well as to camouflage the antenna cable and antenna more easily. Optionally the antenna can be attached directly to the sensor node, but we found that using the cable allows the antenna to be more easily camouflaged. Mounting hardware is not included since it varies depending on the deployment environment.

Figure 2: Sensor Node Kit

4.1 Sensor Node

The Sensor Node is shown in Figure 3. The sensor node has a single power button and multi color LED for user input and feedback. It also has an accessory connector for attaching items such as covert solar devices and eyepatch camera trigger modules. Lastly the sensor node has an antenna connector for attaching the antenna to the device. The sensor node has an internal GPS to allow for easy deployment and reporting of location information to the web application if a cluster node is used. The unit also has a built-in tamper function to report if it has been moved from its mounting location.

Figure 3: START Sensor Node

4.2 Sensor Node User Interface

There is a single pushbutton on the sensor node as well as a multi-color LED to indicate status. With the unit off pressing the power button on the sensor node will turn on the sensor node which will be indicated by the LED. Once powered on, pressing and releasing the power button will turn on the LED status indicator for several seconds. Finally, pressing and holding the power button until the LED turns off (about 3 seconds) will turn off the sensor node. Figure 4 shows the status LED functions and durations while Table 1 shows the meaning of the various LED color and blink patterns. To maintain covert deployments the LED only lights up when the power button is pressed.

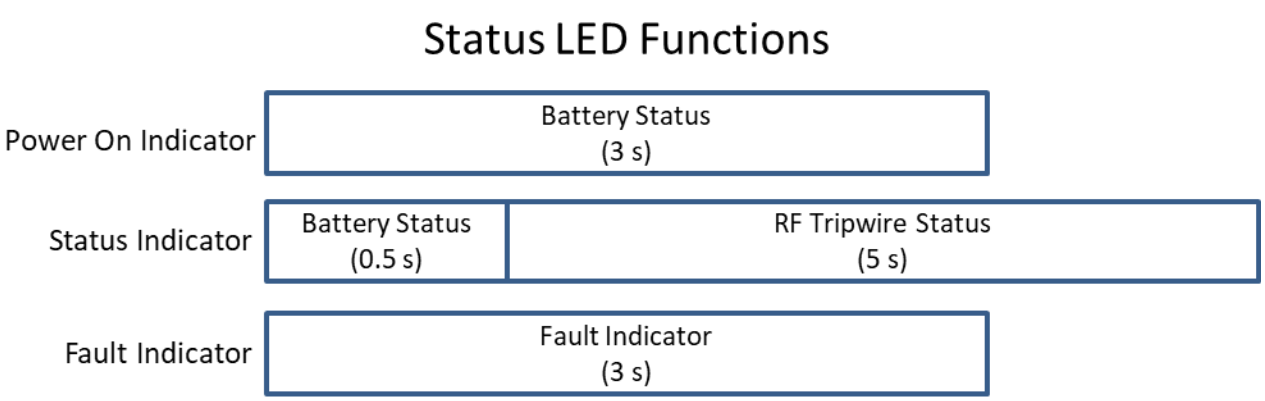

Figure 4: Status LED

Table 1: LED Status Indicator

Battery Status	
LED Indicator	Meaning
Green	Battery OK
Red	Battery < 25%
RF Tripwire Status	
LED Indicator	Meaning
Green	RF Tripwire OK
Red	RF Tripwire Too Far
Blue	No GPS Lock (Wait for GPS Lock)
Fault Indicator	
LED Indicator	Meaning
Blinking Red	Battery Exhausted
Blinking Blue	Missing Configuration Data (Contact WilliamsRDM)
Factory Reset Button Pressed	
LED Indicator	Meaning
Purple	Factory Reset Button Pressed

4.2.1 Power on

To turn on the sensor node press the power button until the LED turns on. Once powered on the sensor node will display the battery status for 3 seconds. As shown in Table 1 green indicates the battery is OK while red indicates that the battery is below 25%.

4.2.2 Power Off

To power off the sensor node press and hold the power button until the LED turns off. To check that the sensor node is powered off quickly press and release the power button. If the LED does not illuminate, then the sensor node is powered down. If you press the button too slowly then the sensor node may power back on as indicated by the LED illuminating.

4.2.3 Status Check

To check the status of the sensor node press and release the power button while the node is powered on. As shown in Figure 4 the LED will show battery status for 0.5 seconds and then it will show the RF tripwire signal status for 5 seconds to aid in positioning the sensor node. The Battery status indicator uses the same color meaning as the power on test but is only displayed for 0.5 seconds. The RF Tripwire status is used to help with positioning of the sensor nodes during deployment. A green indicates that the Tripwire is OK which indicates that at least at least one sensor node is within range of this node such that the tripwire should operate properly. A red LED indicates that there are no other sensor nodes close enough to create reliable tripwires with. To resolve the issue this node should be moved closer to the node that you want to create a tripwire with. The RF Tripwire status indicator updates in real time so you will see the node transition from red to green once you get within tripwire range of another sensor node.

A blue LED indicates that the sensor node has not gotten a valid GPS lock and is not able to reliably communicate with other sensor nodes. This indication is typically present for about a minute after the unit is powered on but can last 5-10 minutes if the node was moved over a long geographical distance since it was last powered on, or the node has been powered off for an extended period of several days. To resolve this issue leave the sensor node powered on preferably outdoors to allow it to get a GPS lock. The system may be able to get a GPS lock indoors, but this is not always possible.

4.2.4 Fault Indicator

When powering on the sensor node or checking the status there are a few fault conditions that can be displayed. Figure 4 shows that the fault indicator duration is 3 seconds while Table 1 shows the LED indicator meaning. These indicators are not displayed unless the power button is pressed.

4.2.4.1 Battery Exhausted Indicator

A blinking red LED indicates that the battery is exhausted, and the node is in a low power mode waiting to be recharged. In this mode the sensor node is not communicating or otherwise operating. If the node is attached to a battery charger or a covert solar power source, it will charge. Once the battery rises over 60% the node will automatically restart and resume operation. It will cut off again once the battery is discharged back to 0%. If the sensor node is power cycled it will turn back on if the battery is above 0%.

4.2.4.2 Missing Configuration Indicator

A blinking blue LED indicates that the node is missing configuration data. Contact WilliamsRDM for additional information.

4.3 Battery

The sensor node is powered from an internal rechargeable 3.6V 6500mAh lithium battery pack. A fully charged battery pack will power the node for about 2 weeks. Nodes with a camera trigger attached will consume more power and will not run for quite as long.

The sensor node is designed to be charged from a WIlliamsRDM covert solar device such as a solar rock. With a covert solar device attached, the sensor node can run nearly indefinitely. The sensor node's battery will charge even when powered off. If the sensor node is in the low battery fault state and powered on it will automatically restart and resume operating once it charges over 60%.

If charging indoors from a wall outlet is desired, please contact WilliamsRDM for an 8173-2 AC wall adapter.

4.3.1 Battery Replacement

If the battery pack needs to be replaced, please contact WilliamsRDM for a part number and additional information.

4.4 Factory Reset

A sensor node can be reset to its factory default settings by pressing and holding the factory reset button for more than 5 seconds (unit the sensor node reboots). The factory reset button is located inside of the sensor node enclosure and can be accessed by removing the two screws holding the back cover on, see Figure 5. Once the button is pressed the user interface LED will turn purple indicating the button press. Holding the button down until the user interface LED blinks and changes from purple to another color (About 5 seconds) initiates a factory reset. Factory reset is especially useful when setting up a 3-Node system using nodes that may have been configured differently as part of a larger system. You can take any 3 nodes factory reset them and they will work as a 3-node system. Additionally, the factory reset can be used to restore the settings on a sensor node if they are in an unknown state and causing issues. The Factory Reset does not affect the Node ID or Owner ID configuration data.

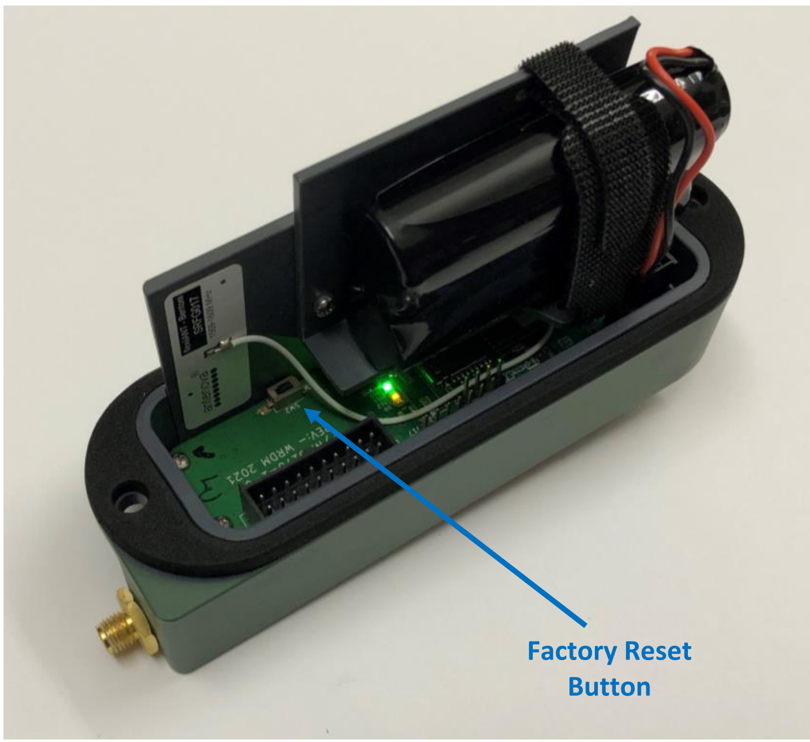

Figure 5: Sensor Node Factory Reset Button Location

4.5 Connecting a Covert Solar Power Source

To support long deployments WilliamsRDM covert solar devices can be used to power the sensor nodes. Figure 6 shows a WilliamsRDM covert solar rock (P/N: 8160-1) connected to the sensor node via the Accessory Port on the front of the sensor node. The covert solar devices should be placed in a sunny area for best performance. The covert solar devices each have a 15ft cable which can be buried for improved camouflage performance. If additional distance is needed, please contact WilliamsRDM for additional information on solar power extension cables and Y-adapters which can be used to parallel solar rock for additional power.

Figure 6: Covert Solar Rock Connected to Sensor Node

4.6 Antenna Positioning

The Sensor node antenna is designed for omnidirectional operation so that sensor nodes can be placed anywhere around the node. The antenna should be mounted upright to ensure an omnidirectional antenna pattern. If the antenna is tilted significantly, it may cause dead spots in coverage. The sensor node kit includes an antenna cable. While the antenna can be connected directly to the sensor node, we have found that using the antenna cable makes it easier to hide the sensor node by placing the node near the base of a tree or post and then running the antenna up the post using the cable then camouflaging as needed. In special longer-range applications, it may be useful to use directional antennas. When selecting an antenna select one that operates at 2.4GHz and has a male RP-SMA connector.

5 External Sensor Interface (8170-2)

The sensor network is capable of interfacing with External Sensors that use the Qual Tron 4-pin sensor interface using the 8170-2 sensor node see Figure 7. The 8170-2 sensor node has the same functionality as the standard 8170-1 sensor rode with the addition of the external sensor connector which supports interfacing with Qual Tron compatible sensors. The interface uses the standard 4-pin Qual Tron interface with relay contact output used on many of their sensors. This sensor node can function as an RF tripwire sensor and/or with an external qual Tron compatible sensor. Some of the Qual Tron Compatible sensors that the sensor network works with include Seismic, Magnetic and Passive IR sensors as well as the Scorpion Laser Tripwire System by Applied Design Concepts Inc. which also uses the Qual Tron interface. The main purpose of this interface is to allow existing sensor equipment in inventory to be used and modernized by allowing it to trigger cameras and making it available over the internet for remote monitoring.

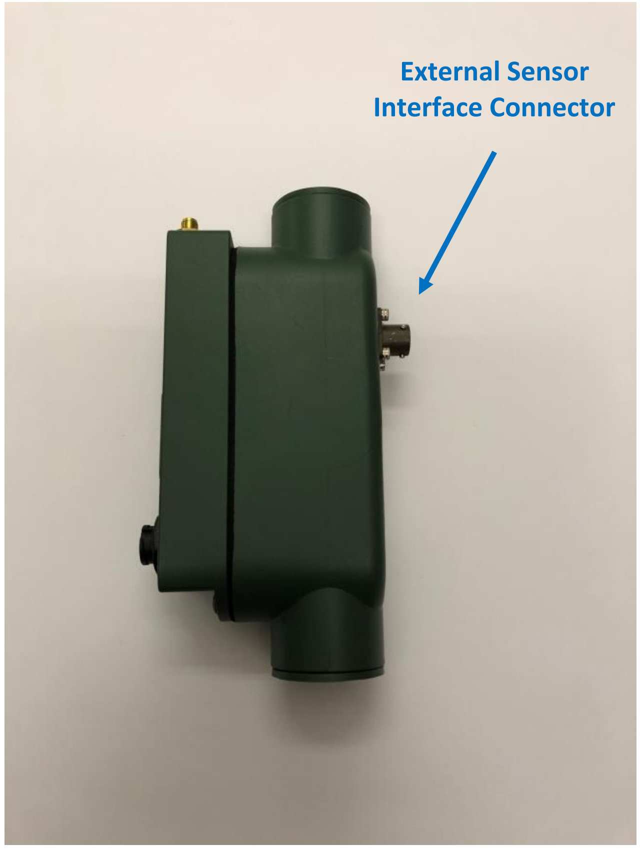

Figure 7: Sensor Node with Qual Tron Interface (8170-2)

5.1 Qual Tron Sensors

The 8170-2 sensor node is compatible with the standard 4-pin Qual Tron Inc. sensor connector with sensors that have a relay contact output. Some of the sensors that we have tested the sensor network with include the PIRH (Passive IR Sensor), MSSH (Seismic Sensor) and the MAGH (Magnetic Sensor) see Figure 8. The 8170-2 sensor node may work with other Qual Tron compatible sensors, but these are the ones we have tested the START sensor network with. For detailed information on the performance and settings of the Qual Tron sensors see the user manual for the sensor.

Figure 8: Qual Tron Sensors

The sensors plug directly into the sensor node and are automatically detected, powered, and monitored by the sensor node. Detections made by the sensor are reported through the mesh network back to the cluster node for remote monitoring or to cameras to take pictures of the event. There is no need to use external batteries with the Qual Tron sensors since they are powered from the sensor node. When using the Qual Tron sensors do NOT put batteries into the sensors as this may affect the ability for the sensor node to detect if the external sensor is connected. The Sensor nodes use the power draw form the Qual Tron sensor to detect the presence of the sensor so installing batteries may prevent the sensor node from detecting the device. For example, the MSSH sensor has room for several 9V batteries installing these batteries will prevent the sensor node from detecting it.

5.2 Scorpion Laser Tripwire System

The 8170-2 sensor node is also compatible with the Scorpion Laser Tripwire system since it uses the 4-pin Qual Tron sensor interface. The Scorpion laser system from Applied Design Concepts Inc. is a laser tripwire system. For detailed information on the setup and the operation and of the Scorpion system please refer to the Scorpion user manual. The Parts of the system that are relevant to the START system consist of an Emitter and Detector two interface cables and a Battery Box. One Interface cables is used to connect the detector to an 8170-2 sensor node and the second interface cable is used to connect the Emitter to either the Scorpion battery box or another 8170-2 sensor node which can be used to supply power to the Emitter. For long term deployments the Emitter can be connected to a solar powered 8170-2 sensor node to act as a solar powered rechargeable power source eliminating the need to change batteries in the Emitter.

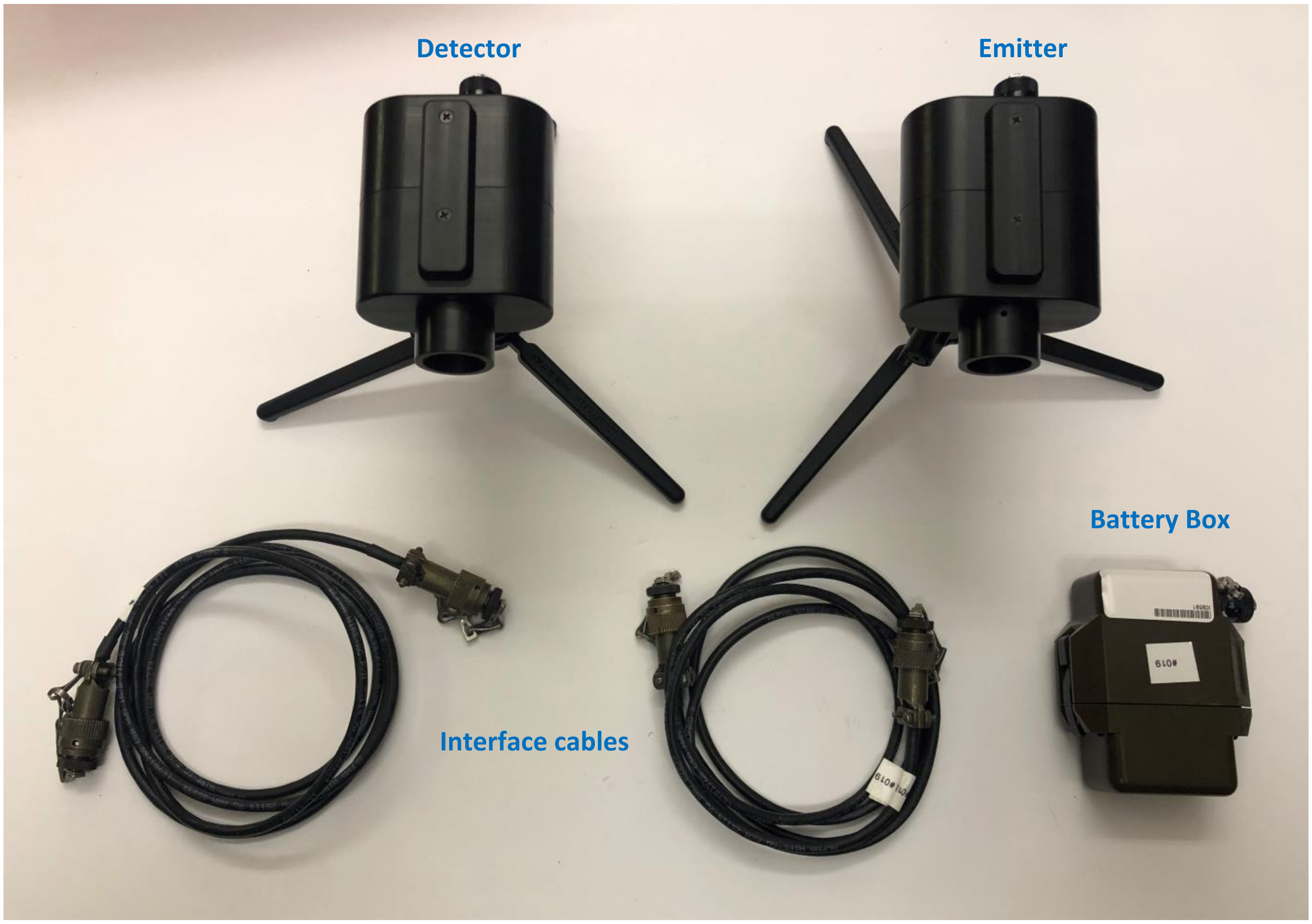

Figure 9: Scorpion Laser Tripwire System

When the sensor the Emitter is connected to the 8170-2 sensor node the Emitter is automatically detected as and external sensor and will communicate detections through the sensor network to the cluster node for remote monitoring or to cameras to take pictures. If the Emitter is connected to an 8170-2 sensor node it is detected as an external sensor and is provided power, but it never sends a detection signal because it is only an Emitter and not a Detector.

5.3 Telonics PT-100 Sensor System

The 8170-2 sensor node is also compatible with the Telonics PT-100 sensor system using the 8201-1 interface cable. For detailed information on the setup and the operation of the Telonics PT-100 system please refer to the PT-100 user manual and software programming manual. Figure 10 shows and example Telonics PT-100 system which consists of the following components:

1) PT-100 Processor/Transmitter (Voice Model)
2) PG-400 Programmer
3) Programming Cable
4) IF-540 IR Sensor Long Range
5) IF-520 IR Sensor
6) SP-500 Single Seismic Sensor
7) SP-500P Connectable Multi Sensor Seismic String

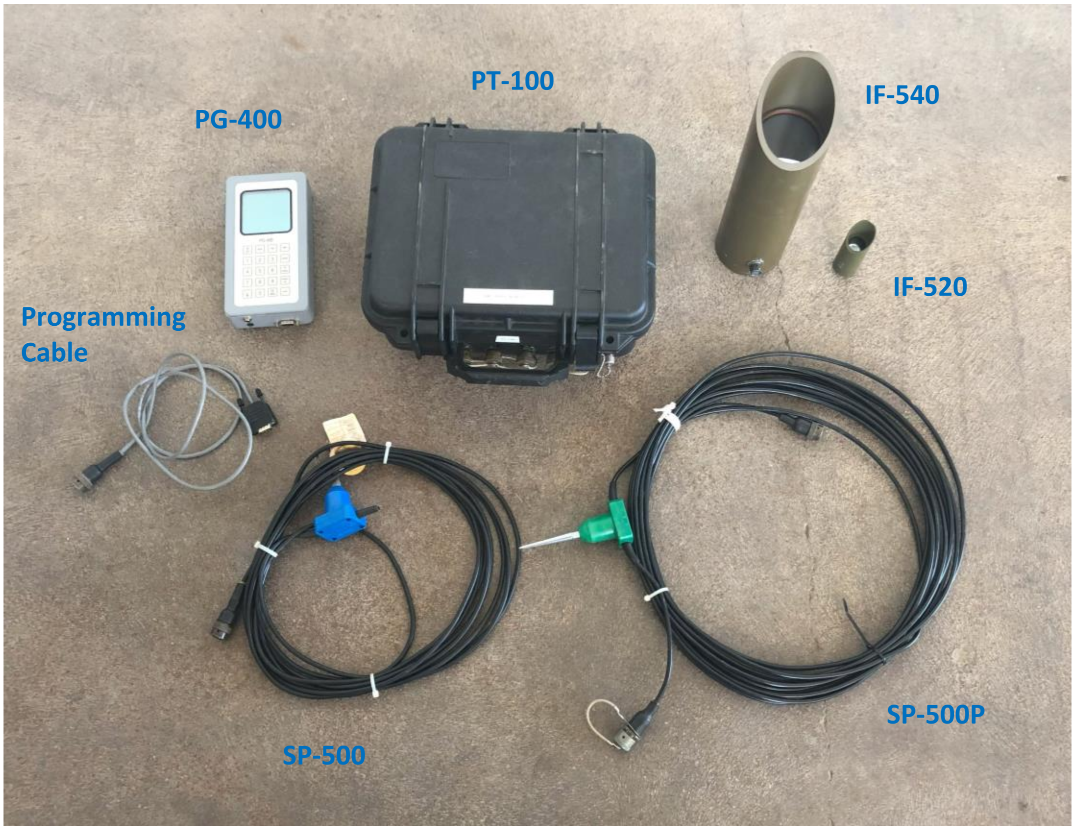

Figure 10: Telonics PT-100 system

The Telonics system supports additional sensors such as a magnetometer which is not shown in the picture above. To use the Telonics PT-100 system with the START sensor network the PT-100 remote camera trigger function must be enabled as described in the PT-100 user software programming manual. Once enabled, the camera trigger signal is generated by the PT-100 Processor/Transmitter when the PT-100 detects an intrusion on any one of the attached Telonics sensors. To connect the PT-100 to the 8170-2 sensor node, one end of the 8201-1 interface cable is connected to the Programmer "P" port on the PT-100 processor/transmitter unit which is where the camera trigger signal is located. The other end of the 8201-1 interface cable connects to the external sensor connector on the 8170-2 sensor node. When the interface cable is connected to the 8172-1 sensor node the sensor node automatically detects that and external sensor is attached and will communicate detections through the sensor network to the cluster node for remote monitoring or to cameras to take pictures.

Using the PT-100 camera trigger and 8172-1 interface cable will trigger the START sensor node when any sensor connected to the PT-100 is triggered but, there is no way for the START sensor network to tell which sensor was triggered. To better indicate that a sensor node is attached to a PT-100 system as well as what sensor or sensors are attached to the PT-100 the user can use the "Node Settings" feature on the START GUI to change the name or label of the sensor node to something more descriptive. By default, the sensor node labels are the same as their Node ID's. Figure 11 shows an example where the sensor node label was changed to "PT-100 IR Sensor" to indicate that a PT-100 with an IR sensor is attached. This label is changed manually and can be set to nearly anything the user desires.

Figure 11: Sensor Node Label Change

5.4 External Sensor Configuration Options

The following sections describe options for the for the 8170-2 external sensor interface settings.

5.4.1 Camera Triggering

When an external sensor is triggered, the system can be configured to command a camera to take a picture. See section 11.2.2 for information on how to configure the camera trigger node list. By default, external sensors will trigger any cameras within the system. As explained in section 11.2.2 the camera node can be configured with a list of nodes what will cause it to trigger a camera to take a picture.

5.4.2 External Sensor Only System

If desired the system can be configured to use only external sensors and not use the RF tripwire. This could be useful if the user wants to deploy Qual Tron or similar sensors as they did in the past and be able to remotely monitor them through the START map enabled user interface. The easiest way to do this is to us the Inclusion List described in section 11.3.2. The user would configure all sensor nodes to use the Inclusion List Mode with no nodes on the node list. Sending this command tells the sensor nodes to tripwire only with nodes on the list, which is empty, this effectively disables the tripwire system allowing the system to only use external sensors.

5.4.3 Isolated External Sensor Camera Trigger

There are scenarios where the user may want to deploy a single external sensor which is used to trigger a camera. This configuration would use a single 8170-2 sensor node with an external sensor, eyepatch trigger module, camera, and optional covert solar device for extended deployments. This sensor node can be completely isolated from other sensor nodes and would not need to have the antenna installed. The external sensor would plug into the sensor node along with the eyepatch camera trigger and optional covert solar device. By default, the 8170-2 sensor node will trigger any sensor node within the network since the network only consists of a single node it will trigger itself to take a picture. This could be useful in many scenarios where you may want to have an external sensor trigger a cellular game camera which could be remotely monitored. In this scenario the sensor node is basically acting as a solar powered battery pack and camera trigger. Since this function works by default you may need to factory reset the sensor node if the settings were changed when used in another configuration.

6 Trail Camera Eyepatch Trigger Module

The sensor network has the ability to trigger game cameras to provide pictures of activity and intrusions within the network. To trigger a trail camera an eyepatch trigger module is placed over the PIR motion sensor of the trail camera and connected to the accessory port of the sensor node. When activity is detected by the sensor network the eyepatch triggers the camera to take a picture by activating the trail camera's passive infrared (PIR) motion sensor. WilliamsRDM has four variants of the trail camera eyepatch trigger module to support both Spartan and Buckeye cameras. P/N 8175-1 is for the Spartan Ghost and GoLive cameras, P/N 8182-1 is for the Spartan GoCam, P/N 8179-1 is for the Spartan GoLive2 and P/N 8159-1 is for the Buckeye cameras. The system can then be configured to trigger the camera when an intrusion is detected by the system. Figure 12 shows a picture of the eyepatch attached to a Spartan GoLive camera.

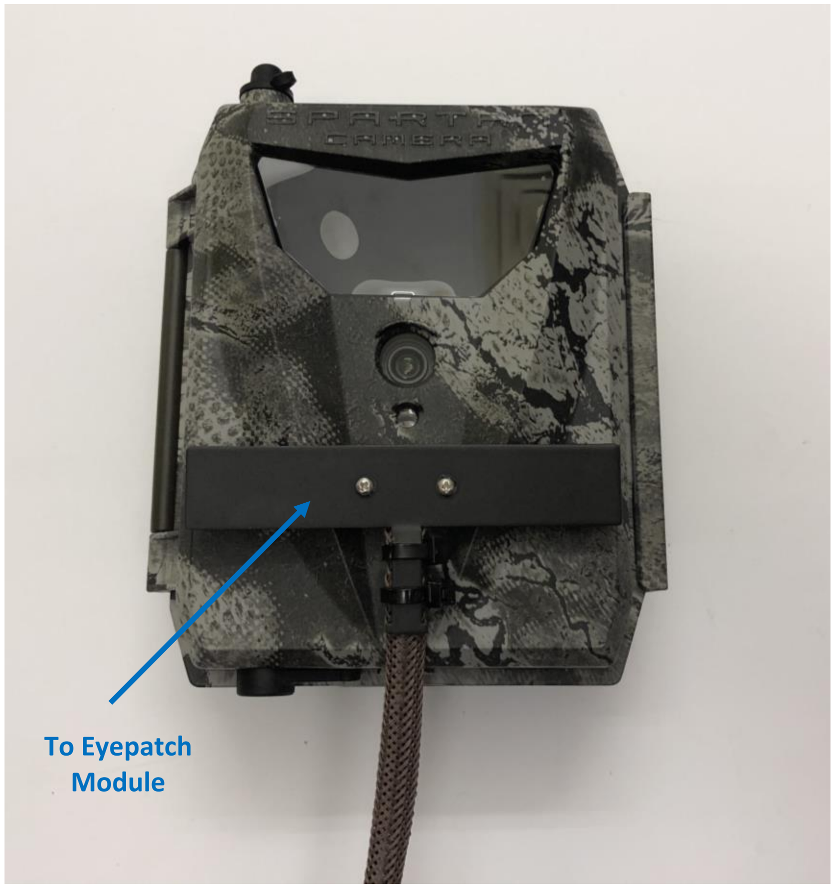

Figure 12: Eyepatch Attached to Camera

The eyepatch trigger module attaches to the sensor node accessory connector as show below in Figure 13. The end of the eyepatch cable has a Y-adapter. One end plugs into the sensor node's accessory connector and other end can be plugged into a WilliamsRDM covert solar device. The eyepatch only works with sensor nodes and does **NOT** work with the cluster node.

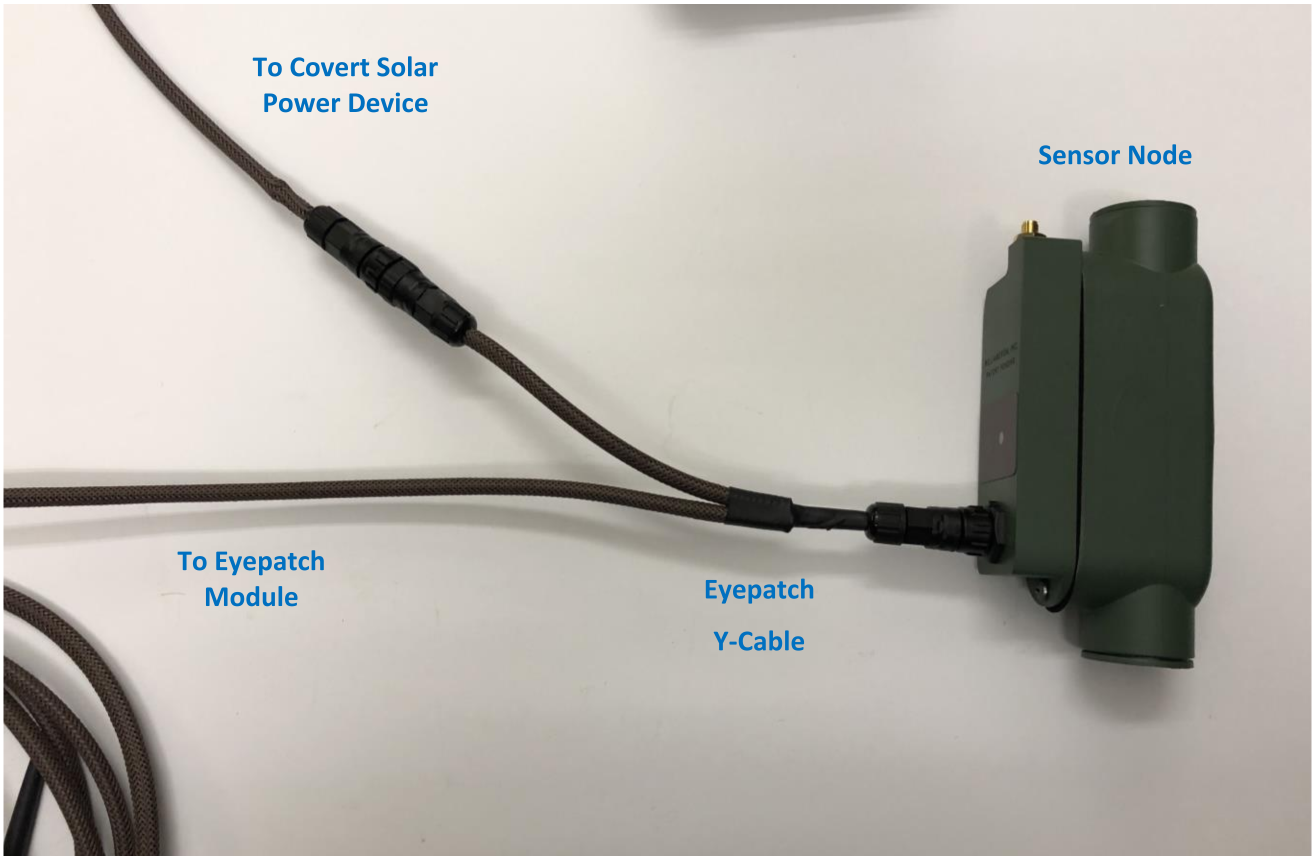

Figure 13: Eyepatch Connection to Sensor node

If using the cluster node and the web-based application the user can map which cameras are triggered by which sensor nodes and/or tripwire links. Finally, if monitoring the system via the web-based user interface the sensor node icon will change to a camera icon indicating that an eyepatch module is attached to that sensor node.

When mounting a camera in the field care should be taken to minimize the strain on the eyepatch module cable. The module is attached to the camera using magnets but too much weight or sharp movement on the cable can cause the eyepatch to come disconnected. It is recommended to add strain relief to support the cable slightly below the camera to ensure the eyepatch module does not become detached from the camera. Figure 14 shows a Spartan GoLive camera mounted to a light pole with the eyepatch module and cable strain relief clearly visible. In this example the strain relief is accomplished using zip ties.

Figure 14: Eyepatch Module Strain Relief

6.1 Spartan Ghost and GoLive Camera Eyepatch 8175-1

The Spartan Ghost and GoLive camera eyepatch is shown in Figure 15. The installation kit includes the eyepatch cable and two adhesive backed magnets. This version of the eyepatch works with either the Spartan Ghost or GoLive Cameras see Figure 16.

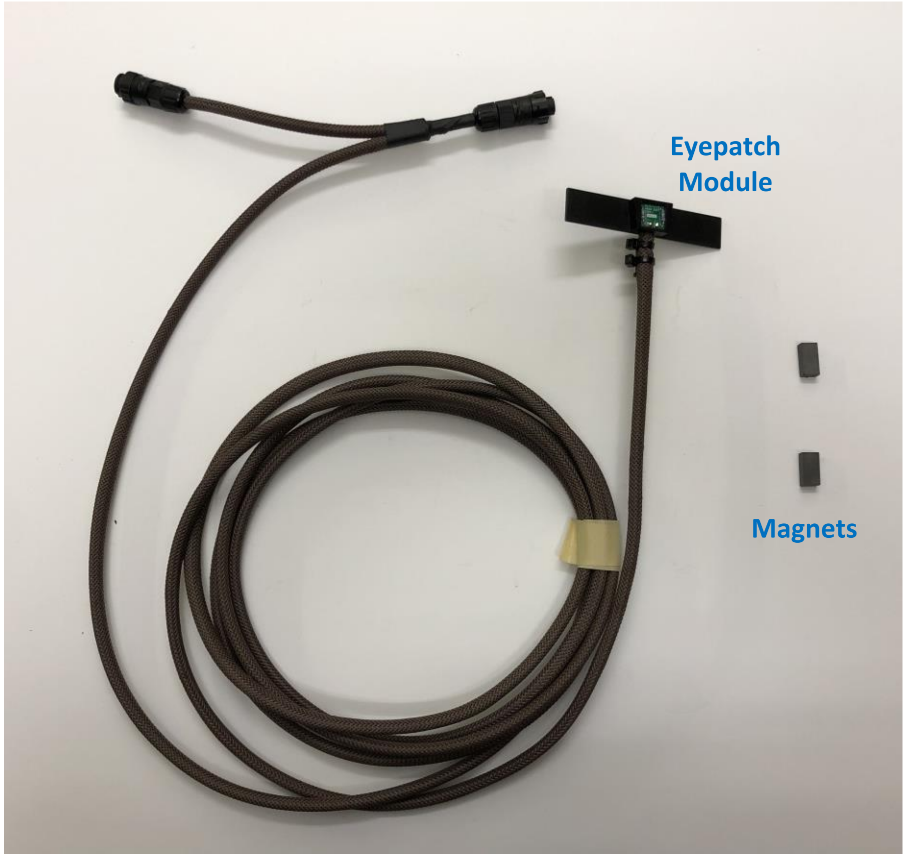

Figure 15: Spartan Ghost and GoLive Eyepatch Kit

Figure 16: Spartan Golive/Ghost Camera

To install the eyepatch on the camera you first need to attach the magnets to the plastic housing of the camera. This process only needs to be done once. To complete this task magnetically attach the magnets to the eyepatch by placing them at the ends with the adhesive facing outward as shown in Figure 17. Once the magnets are magnetically attached remove the backing from the tape to expose the adhesive as indicated in Figure 17.

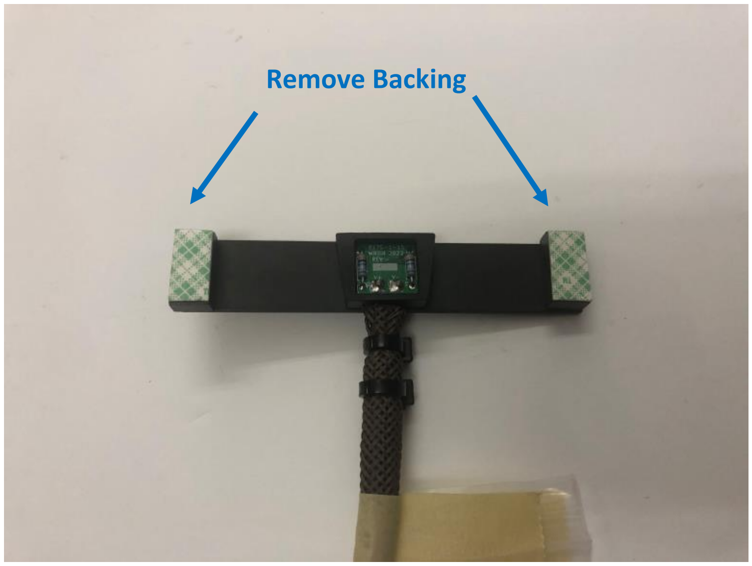

Figure 17: Attach Magnets to the Eyepatch

One the backing is removed from the adhesive on the magnets take the eyepatch and align eyepatch module with the PIR motion sensor on the camera and press down and hold until the adhesive sets (5-10 seconds) see Figure 18.

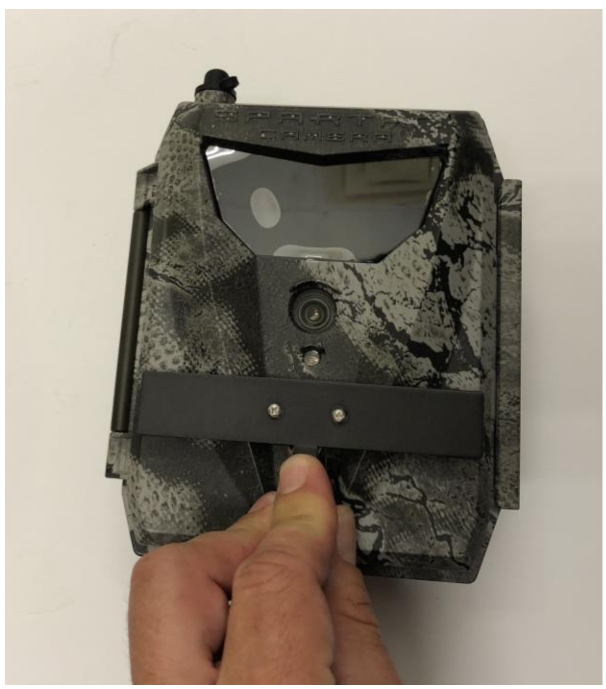

Figure 18: Attach the Eyepatch Magnets to the Camera Housing

Once the Adhesive sets the eyepatch can be removed and the magnets will stay attached to the camera as shown in Figure 19. Now the eyepatch can be attached and removed easily using the magnets.

Figure 19: Magnets attached to the Camera Housing

6.2 Spartan GoLive 2 Camera Eyepatch 8179-1

The Spartan GoLive 2 Eyepatch Kit is shown in Figure 20. The installation kit consists of the eyepatch and a set screw used to hold the eyepatch onto the camera. This version of the eyepatch works with the Spartan GoLive 2 camera shown in Figure 21.

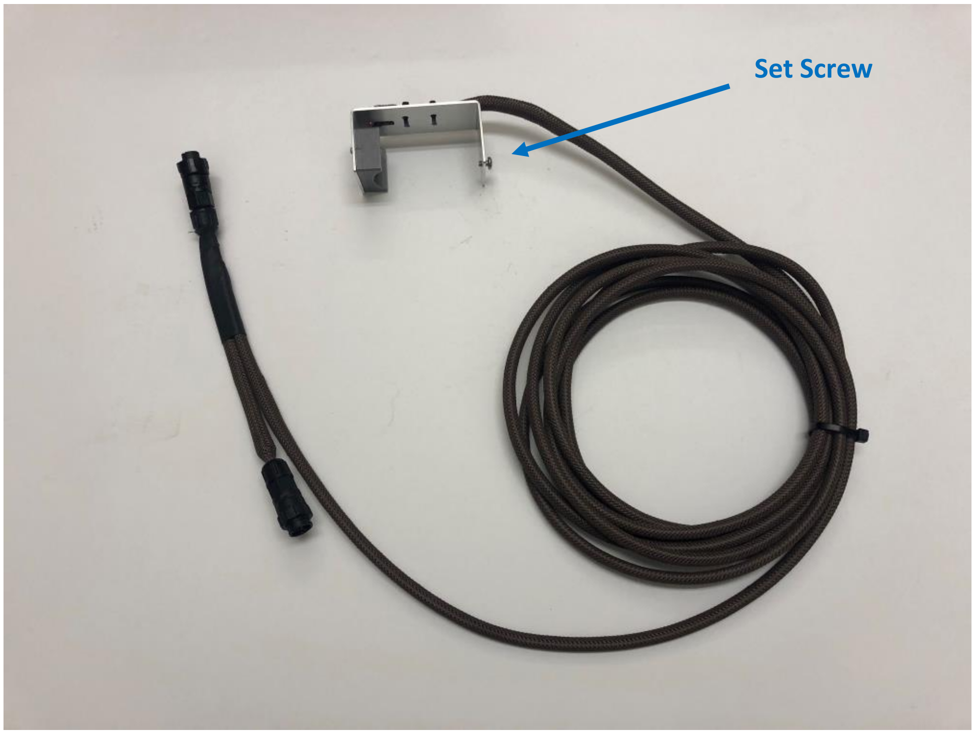

Figure 20: Spartan GoLive 2 Eyepatch Kit

Figure 21: Spartan GoLive 2 Camera

To install the eyepatch on the camera simply clip the eyepatch over the top of the camera starting over the camera's IR motion sensor and pulling the eyepatch down over the back of the camera, see Figure 22. Once the eyepatch is seated on the top of the camera tighten the set screw to secure the eyepatch from moving, see Figure 23.

Figure 22: Clip the Eyepatch Over the Top of the Camera

Figure 23: Tighten the Set Screw on the Back of the Eyepatch

6.3 Spartan GoCam Camera Eyepatch 8182-1

The Spartan GoCam camera eyepatch is shown in Figure 24. The installation kit includes the eyepatch cable and two adhesive backed magnets. This version of the eyepatch works with the Spartan GoCam Camera see Figure 25.

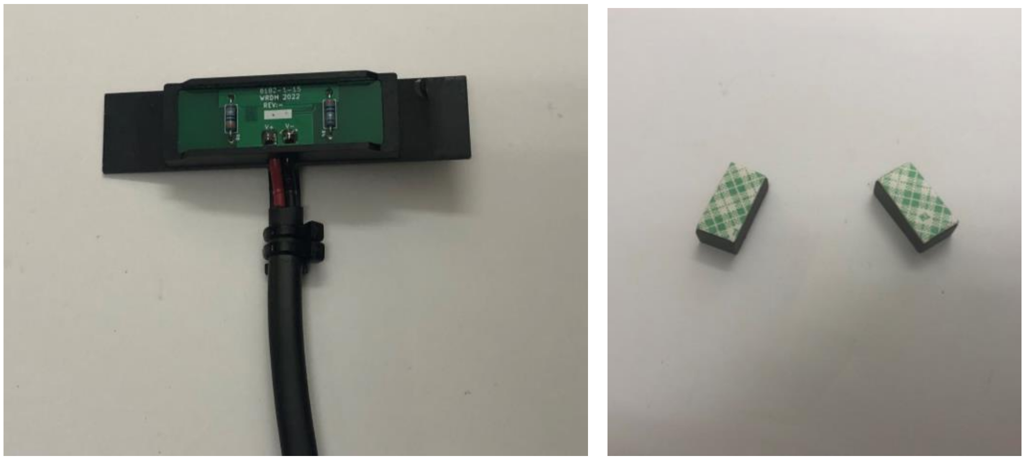

Figure 24: Spartan GoCam Eyepatch Kit

Figure 25: Spartan GoCam Camera

To install the eyepatch on the camera you first need to attach the magnets to the plastic housing of the camera. This process only needs to be done once. To complete this task magnetically attach the magnets to the eyepatch by placing them at the ends with the adhesive facing outward as shown in Figure 26. Once the magnets are magnetically attached remove the backing from the tape to expose the adhesive as indicated in Figure 26.

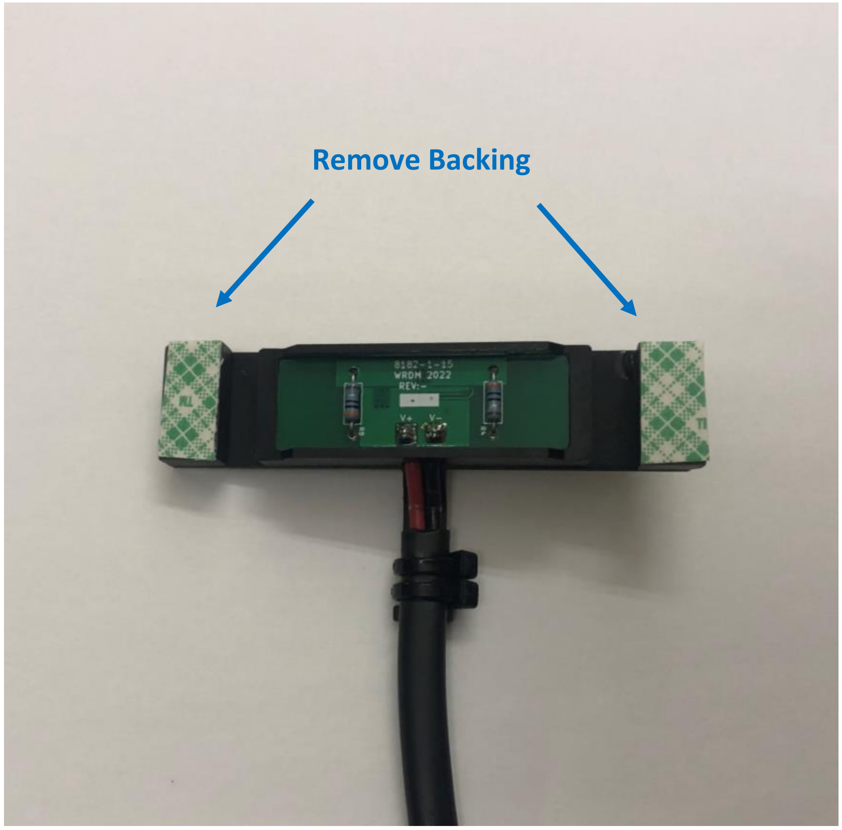

Figure 26: Attach Magnets to Eyepatch

One the backing is removed from the adhesive on the magnets take the eyepatch and align eyepatch module with the PIR motion sensor on the camera and press down and hold until the adhesive sets (5-10 seconds) see Figure 27.

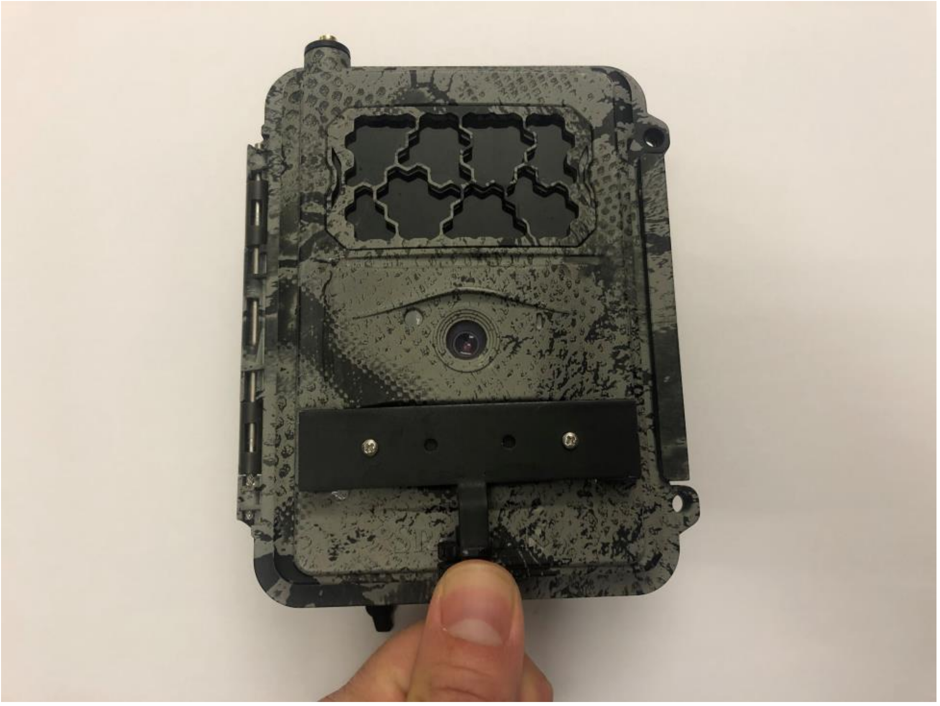

Figure 27: Attach Eyepatch Magnets to Camera Housing

Once the Adhesive sets the eyepatch can be removed and the magnets will stay attached to the camera as shown in Figure 28. Now the eyepatch can be attached and removed easily using the magnets.

Figure 28: Magnets Attached to the Camera Housing

6.4 Buckeye Camera Eyepatch 8159-1

For details on the Buckeye Camera Eyepatch 8159-1 please contact WilliamsRDM Inc.

6.5 Camera Settings to Support the Eyepatch

To ensure the eyepatch can trigger the camera, the camera's settings need to be changed so that the PIR motion sensor is set to high sensitivity if available. Additionally, the picture timeout should be set to 0 or as low as possible to ensure the camera can take a picture as quickly as possible. From testing, we have found that the Spartan Cameras have a 25s to 60s delay between pictures due to the picture upload time. The Buckeye cameras work differently and have a shorter delay between taking pictures.

7 Cluster Node Kit (Included with 25-node system)

The cluster node kit is show below in Figure 29. The kit consists of the Cluster Node, Cellular Antenna, Cellular Antenna Cable, Sensor Network Antenna, Sensor Network Antenna Cable, covert solar power Y-adapter and Rodent Braiding. The Cluster node provides the cellular communication link to allow a sensor network to be remotely monitored and configured using a web-based application. Mounting hardware is not included since it varies depending on the deployment environment.

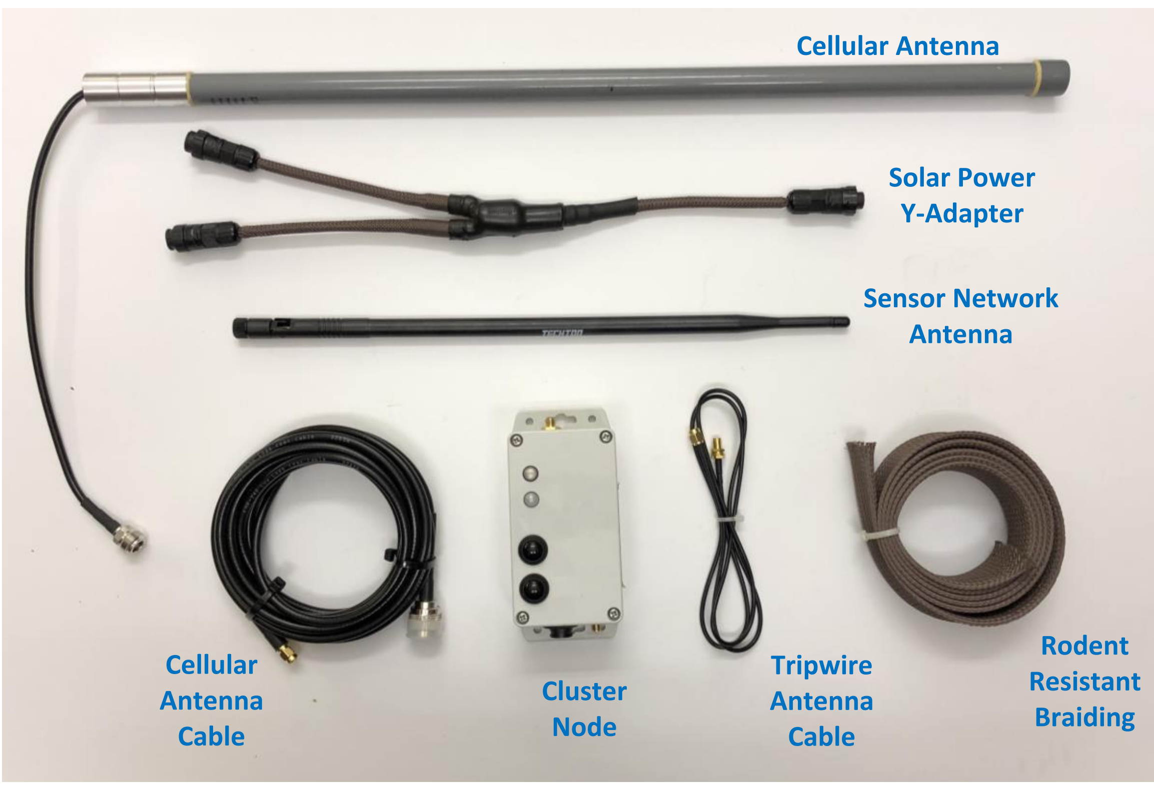

Figure 29: Cluster Node Kit

7.1 Cluster Node

The cluster node is shown below in Figure 30. The cluster node has a power button and multi-color LED status indicator that functions the same as on the sensor node. The node status indicator provides status of the cluster node about the sensor network. The cellular status button and cellular status indicator are used to determine if the cluster node has cellular service. The sensor network antenna connector is used to attach the sensor network antenna allowing communication and tripwire capabilities with other nodes in the sensor network. The cellular antenna connector is used to attach the cellular antenna cable and antenna to the sensor node. The solar power input connector is used to attach covert solar devices to the cluster node to provide long duration covert operation. When powering the cluster node from solar power, the Y-adapter is used to connect two covert solar rocks to the cluster node to provide additional power. The Cluster node is **NOT** capable of triggering cameras using the eyepatch trigger cable.

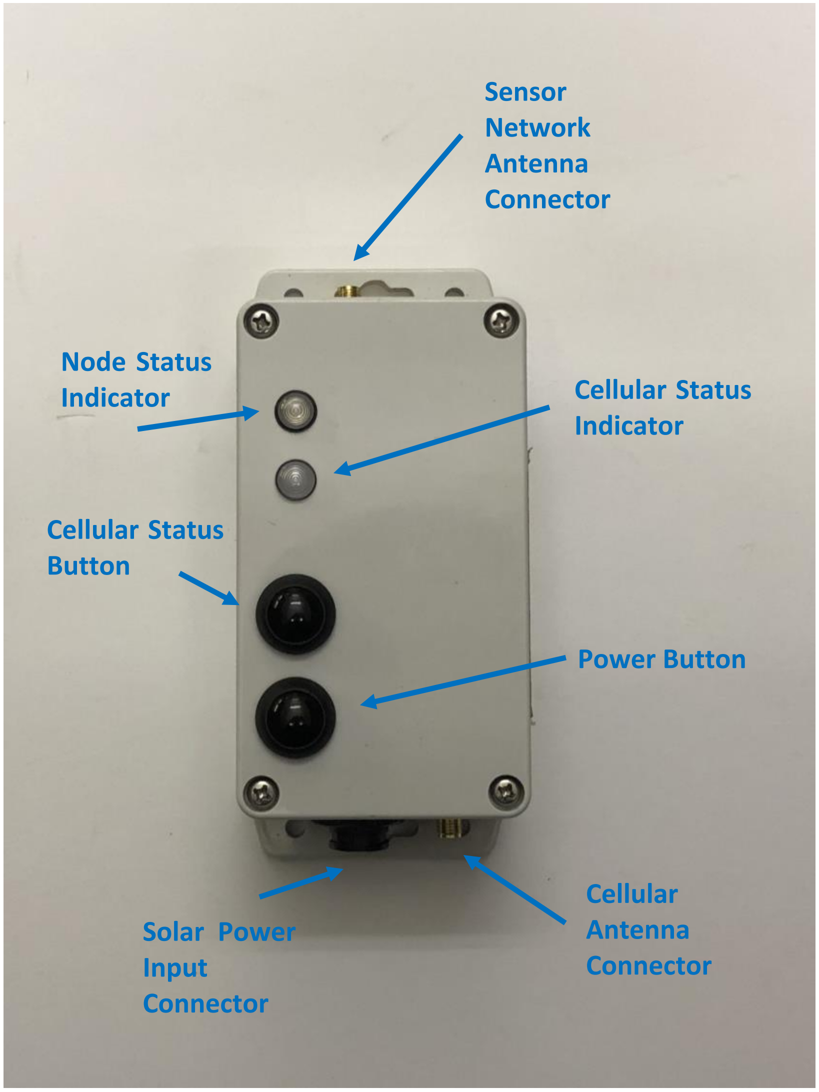

Figure 30: START Cluster Node

7.2 Cluster Node User Interface

There are two buttons on the cluster node as well as a multi-color sensor network status indicator and a single-color cellular status indicator. With the unit off, pressing the power button on the cluster node will turn on the cluster node as indicated by the status LED. Once powered on, pressing and releasing the power button will turn on the LED status indicator for several seconds. Finally, pressing and holding the power button until the LED turns off (about 3 seconds) will turn off the cluster node. Figure 31 shows the status LED functions and durations while Table 2 shows the meaning of the various LED color and blink patterns. To maintain covert deployments the LED only lights up when the power button is pressed.

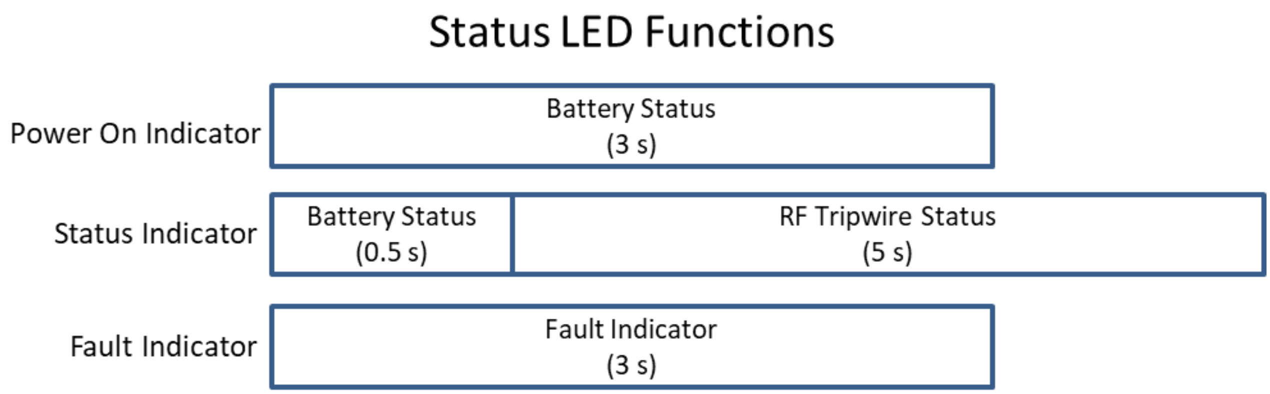

Figure 31: Cluster Node Status LED

Table 2: Cluster Node LED Status Indicator

Battery Status	
LED Indicator	Meaning
Green	Battery OK
Red	Battery < 25%
RF Tripwire Status	
LED Indicator	Meaning
Green	RF Tripwire OK
Red	RF Tripwire Too Far
Blue	No GPS Lock (Wait for GPS Lock)
Fault Indicator	
LED Indicator	Meaning
Blinking Red	Battery Exhausted
Blinking Blue	Missing Configuration Data (Contact WilliamsRDM)
Factory Reset Button Pressed	
LED Indicator	Meaning
Purple	Factory Reset Button Pressed

To check the cellular connection of the sensor node press and hold the cellular status pushbutton. The cellular status indicator will only illuminate while the button is pressed. Table 3 shows the Cellular Status indicator blink pattern and meaning.

Table 3: Cellular Status LED Indicator

Cellular Status Indicator	
LED Indicator	Meaning
Breathing Slowly (fades on & off)	Cellular Connected
Rapidly Blinking	Registering
Blinking	Trying to Connect
Off	No Cellular Connection Please Wait

7.2.1 Power on

To turn on the cluster node press the power button until the status LED turns on. Once powered on the cluster node will display the battery status for 3 seconds. As shown in Table 1 green indicates the battery is OK while red indicates that the battery is below 25%.

7.2.2 Power Off

To power off the cluster node press and hold the power button until the LED turns off. To check that the cluster node is powered off quickly press and release the power button. If the LED does not illuminate, then the cluster node is powered down. If you press the button too slowly then the cluster node may power back on as indicated by the node status LED illuminating.

7.2.3 Sensor Network Status Check

To check the status of the cluster node press and release the power button while the cluster node is powered on. As shown in Figure 31 the LED will show battery status for 0.5 seconds and then it will show the RF tripwire signal strength status for 5 seconds to aid in positioning the cluster node. The Battery status indicator uses the same color meaning as the power on test but is only displayed for 0.5 seconds. The RF Tripwire status is used to help with positioning of the cluster node during deployment. A green indicates that the Tripwire is OK which indicates that at least one sensor node is within range of this node such that the tripwire should operate properly. A red LED indicates that there are no other sensor nodes close enough to create reliable tripwires with. To resolve the issues this node should be moved closer to the other nodes that you want to create a tripwire with. The RF Tripwire status indicator updates in real time so you will see the indicator transition from red to green once you get within tripwire range of another sensor node.

A blue LED indicates that the cluster node has not gotten a valid GPS lock and is not able to reliably communicate with other sensor nodes. This indication is typically present for about a minute after the unit is powered on but can last 5-10 minutes if the node was moved over a long geographical distance since it was last powered on, or the node has been powered off for an extended period of several days. The resolve the issue leave the sensor node powered on preferably outdoors to allow it to get a GPS lock. The system may be able to get a GPS lock indoors, but this is not always possible.

7.2.4 Fault Indicator

When powering on the cluster node or checking the status there are a few fault conditions that can be displayed. Figure 31 shows that the fault indicator duration is 3 seconds while Table 1 shows the LED indicator meaning.

7.2.4.1 Battery Exhausted Indicator

A blinking red LED indicates that the battery is exhausted, and the node is in a low power mode waiting to be recharged. In this mode the cluster node is not communicating to other nodes or the cellular network or otherwise operating. If the node is attached to a battery charger or a covert solar power source, it will charge. Once the battery rises over 60% the node will automatically restart and resume operation. It will cut off again once the battery is discharged back to 0%. If the cluster node is power cycled it will turn back on if the battery is above 0%.

7.2.4.2 Missing Configuration Indicator

A blinking blue LED indicates that the node is missing configuration data. Contact WilliamsRDM for additional information.

7.2.5 Cellular Status Check

To check the status of the cellular connection press and hold the cellular status button and observe the blink pattern of the cellular status LED. As indicated in Table 3 a breathing LED indicates that cluster node is connected via a cellular connection. If the LED is Off that means that there is currently no cellular connection. This typically happens right after the cluster node is powered on and the cellular radio is starting up. You typically need to wait a minute or two for the cellular connection to be established.

7.3 Battery

The cluster node is powered from an internal rechargeable 3.6V 6500mAh lithium battery pack. A fully charged battery pack will power the cluster node for 5 to 7 days.

The cluster node is designed to be charged from a WIlliamsRDM covert solar device such as a solar rock. With a covert solar device attached, the sensor node can run nearly indefinitely. The sensor node's battery will charge even when powered off. If the sensor node is in the low battery fault state and powered on it will automatically restart and resume operating once it charges over 60%.

If charging indoors from a wall outlet is desired, please contact WilliamsRDM for an 8173-2 AC wall adapter.

7.3.1 Battery Replacement

If the battery pack needs to be replaced, please contact WilliamsRDM for a part number and additional information.

7.4 Factory Reset

Similar to a sensor node the cluster node has a factory reset button located inside of the enclosure. Pressing and holding this button for longer than 5 seconds initiates a factory reset and restores the cluster node's settings to the default values. When the factory reset button is pressed the user interface LED turns purple. Then holding the button until the user interface LED changes from purple to another color indicates the factory reset has occurred. This feature is useful if previous settings are causing issues and the user wants to restore the default settings. The Factory Reset does not affect the Node ID or Owner ID configuration data.

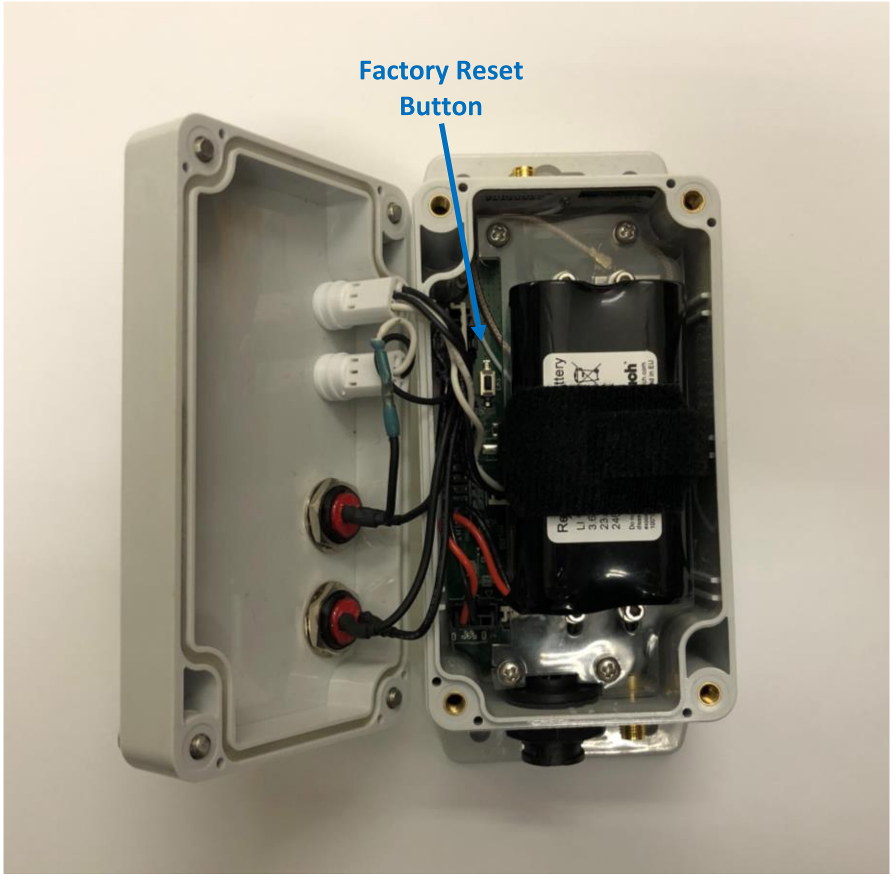

Figure 32: Cluster Node Factory Reset Button

7.5 Connecting a Covert Solar Power Source

Since the cluster node consumes more power than a sensor node because of its cellular radio, and thus the cluster node requires two 8160-1 covert solar rocks to provide continuous power. The included solar Y-adapter allows two covert solar devices to be connected to the cluster node. Using multiple solar devices also provides redundancy by allowing the covert solar devices to be placed in different locations. For example, one rock could provide power in the morning while the other solar rocks provides power in the afternoon. The covert solar devices should be placed in a sunny area for best performance. The covert solar devices each have a 15ft cable which can be buried for improved camouflage performance. If additional distance is needed, please contact WilliamsRDM for additional information on solar power extension cables.

7.6 Cellular Antenna Positioning

The cellular antenna for the cluster node should be oriented upright and mounted as high as possible for best performance especially in areas with poor cellular coverage. If needed a directional antenna can be purchased separately. The cellular antenna uses a female N-Type connector to interface with the cellular cable.

7.7 Tripwire Antenna Positioning

The tripwire antenna is designed for omnidirectional operation so that sensor nodes can be placed anywhere around the cluster node. The antenna should be mounted upright to ensure an omnidirectional antenna pattern. If the antenna is tilted significantly, it may cause dead spots in coverage. The cluster node kit includes an antenna cable. While the antenna can be connected directly to the sensor node, we have found that using the antenna cable makes it easier to hide the cluster node by placing the node near the base of a tree or post and then running the antenna up the post using the cable then camouflaging as needed. In special longer-range applications, it may be useful to use directional antennas. When selecting an antenna select one that operates at 2.4GHz and has a male RP-SMA connector.

8 RF Tripwire System

The Sensor Nodes use a 2.4GHz Radio Frequency (RF) Tripwire detection system to sense the presence of people and/or vehicles moving between the sensor nodes. The RF tripwire system works by sensor nodes monitoring the radio signal characteristics of messages that are continually transmitted between sensor nodes. If a sensor node detects a significant change in the signal between nodes it registers a detection and triggers a trail camera to take a picture via the eyepatch module. The sensor nodes continually monitor the environment and adapt to changing environmental conditions such as wind, rain, parked vehicles and objects.

Figure 33 shows an example of a 3-node system with an intruder entering the monitored area. When the person moving between the two sensor nodes is detected by the tripwire between those nodes a message is sent to the camera to take a picture.

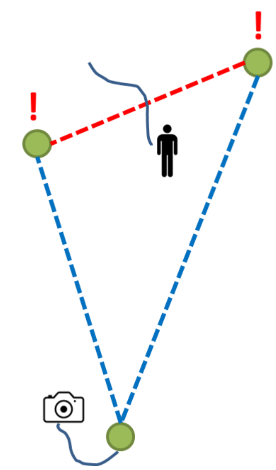

Figure 33: RF tripwire Example

The RF tripwire between the nodes is depicted in Figure 33 as line but, it is actually an area between the sensor nodes as depicted in Figure 34. Because of this area an object can trigger a detection even when it is not directly between the sensor nodes. For example, a car, truck or large group of people might be detected several feet away from the imaginary line between the sensor nodes.

Figure 34: RF Tripwire Detection Area

Antenna Height and orientation also play an important role in the RF tripwire detection performance. Figure 35 shows a side view of a single tripwire showing the approximate detection area. When setting up the system it is ideal to place the antennas as upright as possible to ensure an omnidirectional detection pattern as well as to put the midpoint of the antenna at the approximate height of the center of mass of the target to be detected. We typically put the antenna height such that the midpoint is slightly above any brush and about waist level. In the example shown in Figure 35 a person would be much easier to detect while the smaller animal would be harder to detect since it is lower to the ground and out of the detection area which minimizes false alarms from animals. If it was desired to detect larger object such as tucks or vehicles the antennas could be placed higher up. Placing the antennas too close to the ground can reduce detection range and cause reduced sensitivity and/or false alarms from low brush moving in the wind.

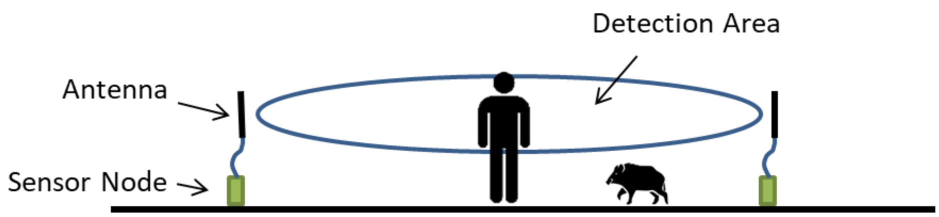

Figure 35: RF Tripwire Antenna Height

Because of the shape of the detection area the RF tripwire sensitivity is greater the closer the object is to the sensor node. For example, a small object that is detected near one of the sensor nodes, might not be detected at the half-way point between the sensor nodes. The idea is that the more an object interacts with the detection area the greater the chance for detection. If the antenna is placed too high, then only the persons head will interact with the detection area which makes it harder to detect.

Antenna movement can cause false detections. For best performance the antenna should be mounted to a rigid object that won't sway or move too much in the wind. For example, mounting the antenna to a fence post, T-post or tree trunk should work well but attaching the antenna to a thin branch of a tree or bush will probably result in reduced sensitivity and/or false alarms when the wind is blowing.

The system does adapt to changing weather conditions such as wind or rain as well as other environmental factors such as someone parking a truck within the system. When the weather changes suddenly the system will likely register some alerts until the system adapts. This is easy to identify because a large part of the system alerts at the same time whereas an intruder moves through the system triggering a few nodes at a time. When the system adapts, the sensitivity is reduced to eliminate the false alarms. For example you might not be able to detect a single person with some tripwires during a rainstorm but larger groups and vehicles will still likely be detected. Once the rainstorm passes the sensitivity will automatically increase.

To get the best detection performance from the sensor network try to keep obstructions such as bushes and trees out of the line of sight between sensor nodes. Also keep in mind that the closer objects are to the line of sight between the sensor nodes the greater the chance for the system to reduce sensitivity when those objects move in the wind. When deploying the sensor network, it tends to work best when the nodes are placed to cover natural clearings and paths instead of trying to detect through the thickest part of the brush.

Node spacing is also important for best performance with a closer node spacing always being better. Sometimes the spacing is dictated by the available natural camouflage. From testing we have had good success with 40-100ft spacing but the system can work out to 300ft depending on the environment and the target size you are wanting to detect. If you are looking to detect vehicles larger distances will work fine but, if you are looking to detect an individual person, then closer spacings are recommended. From our experience groups are easier to detect than single individuals and vehicles are easier to detect than groups. But, it is beneficial to try adjusting the tripwire settings to adjust the tradeoff between sensitivity and false detections.

When deploying the sensor nodes, the LED status indicator provides a positioning aid to ensure the user does not place sensor nodes so far apart that the tripwire will not work. Sensor nodes can communicate with each other over a much longer distance than they can use the RF tripwires for detection which allows groups of nodes or remote cameras to function far away from the tripwire portion of the network. To use the positioning aid, press and release the power button and the sensor node LED will come on as indicated in 4.2. If the tripwire status indicator is green then this node is within range of another node such that the tripwire should operate. If the LED is red then this node is too far away from any other nodes to form a reliable tripwire. This indicator only indicates that there is at least one node within range but ideally there are multiple nodes within range for redundancy.

8.1 RF Tripwire Deployment Scenarios

The following sections provide some examples of how to deploy the sensor network in different scenarios.

8.1.1 Communication Range and Camera Positioning

Before going through some deployment scenarios, it is important to understand that the sensor nodes can communicate over a much further range than they can perform tripwire sensing. This provides some useful capabilities for the system. For example, clusters of sensor nodes capable of forming tripwires could be placed around and relay their data to the cluster node for remote monitoring. Additionally, a camera trigger eyepatch can be connected to a sensor node that is located hundreds of feet from an active tripwire and still trigger the camera even though there is no active tripwire between the node with the camera attached and the tripwire.

We have found that tripwire links work best in the 40 to 120ft range through clearings in wooded areas. This can go as far as 200 to 300ft in ideal situations but, may only be able to detect larger groups and vehicles. Additionally, these larger tripwire spans provide a much larger area for a person to hide in. For example, finding a person that is hiding in a 300ft wide area is harder than finding them in a 100ft wide area. Lastly, the nodes can communicate much further depending on line-of-sight conditions which is useful for sending data to the cluster node or triggering cameras. Communication range is typically greater than 400ft. In ideal line of sight deployment communication range can reach over 600ft to 800ft.

If a longer communication range is needed, directional antennas can be used. While the sensor nodes come with omnidirectional antennas, directional antennas can be used to increase the range of the tripwire at the expense of 360-degree coverage. If a directional antenna is desired use a 2.4GHz antenna with a Male RP-SMA Connector.

Also, when positioning the camera, make sure that the camera's field of view covers as many of the triggering tripwires as possible. We have had situations where a target is detected but not in the field of view of the camera, in which case the camera takes a picture with nothing in the field of view. Then when the system triggers again the camera timeout prevents the camera from taking another picture. For best performance ensure the camera can see all or as many of the tripwire links that can trigger it as possible.

8.1.2 3-Node System RF Tripwire Default settings

Since the 3-node system uses preset factory default settings the tripwire is configured for the Rural Wooded – Medium sensitivity settings so that it functions in both wooded and non-wooded environments. These default settings work well but, they do adapt to the environment. If the system is deployed in an area with heavy traffic the system will adapt and reduce sensitivity which may result in some missed detections. After the system is set up it may take about 15 minutes for the system to adapt to the environment and be at its most sensitive.

8.1.3 3-Node System Deployment Scenarios

The 3-node system comes preconfigured from WilliamsRDM to act as a remote camera trigger system. Since there is no cluster node there is no way to change the node settings, so the preconfigured default settings are used. Once deployed, the 3 sensor nodes form tripwires with each other for detection. The eyepatch trigger can be plugged into any of the sensor nodes to trigger a camera. The tripwire settings are configured to a value that works well in most scenarios. If an 8170-2 sensor node with external sensor interface is used then an external sensor will trigger the camera by default.

The sensor nodes from three nodes systems can be mixed and matched assuming they have the same owner ID. Using this approach larger systems can be created. Care must be taken when setting up multiple 3-nodes systems near each other as they will communicate with each other and trigger each other's cameras. For example, if one three node system is in range of a second three node system, then whenever either system makes a detection then both systems will take a picture. This can be useful if you want to combine 3-node systems into a larger system, just be aware that all cameras in the system will be triggered if any detection is made.

The following scenarios discuss how a 3-node system could be deployed. If a 25-node system or a cluster node is purchased in the future, then these nodes could be monitored and reconfigured remotely as needed assuming all nodes have the same owner ID. This would allow cameras to be triggered by specific sensor nodes as well as other configuration options.

8.1.3.1 3-Node System Trail Monitoring

Figure 36 depicts how a 3-node system could be deployed to monitor a trail. The key aspect of this deployment is that there are two nodes on either side of the trail that are somewhat close together to improve sensitivity and reduce false alarms. The system is more sensitive the closer a target is to the sensor node so keeping sensor nodes close to the trail will improve performance. The Node with the camera attached can be placed up to several hundred feet away and will be triggered by any of the tripwire being broken.

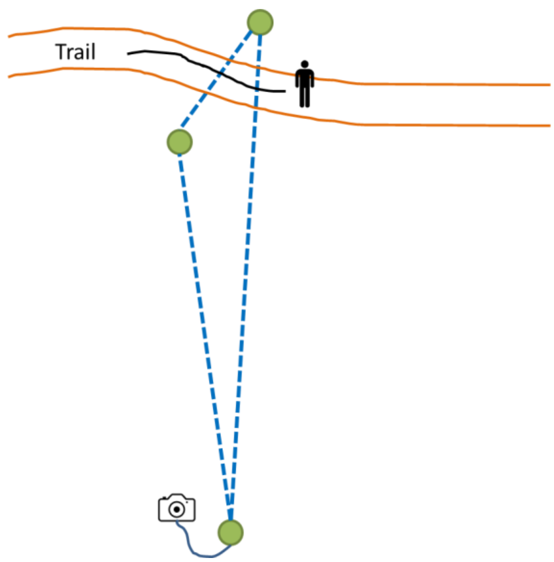

Figure 36: 3-Node System Trail Monitoring

8.1.3.2 3-Node System Multiple Path Monitoring

Figure 37 shows how a 3-node system could be deployed to monitor multiple paths or an area. The main aspect of this deployment is that the sensor nodes are in somewhat of a straight line. Placing one node in the center of the area to be monitored will keep the sensor node close to the possible intruders to improve detection performance. Depending on natural camouflage options the location of the center node may have to move but the idea is to keep the node near the middle of the area to be monitored.

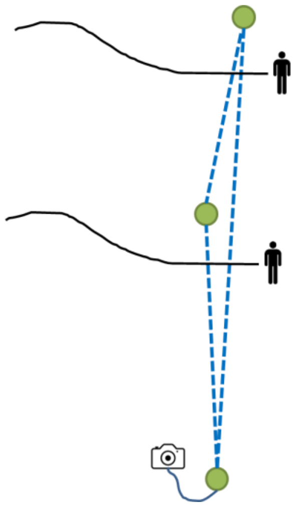

Figure 37: 3-Node System Multiple Path Monitoring

8.1.3.3 3-Node System Area Monitoring

Figure 38 depicts how a 3-node system could be used to monitor an area for intrusions. This could be used to monitor an oil well or some other area and detect if people enter or exit that area. One thing to keep in mind is that once someone enters the area they won't trigger the system again until they exit or get near one of the RF tripwires. Another thing to note is that when deploying the camera care should be taken to make sure both sides of the area are in view of the camera. If for example if the right side tripwire is not in the view of the camera, then someone could enter from the right and trigger the system and you would not see the person in the photo taken by the camera. They could then stay in the area and then leave on the right side again and while they trigger the system and a picture is taken, they may be outside of the camera's field of view.

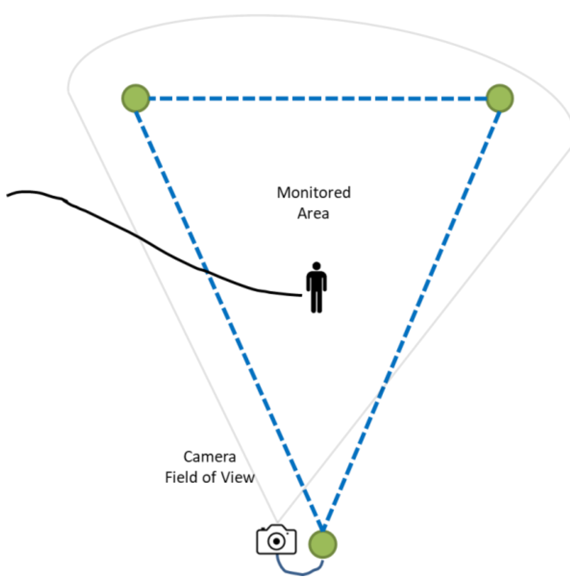

Figure 38: 3-Node System Area Monitoring

8.1.4 Multi-Node System Deployment Scenarios

The following scenarios depict the various ways to deploy a larger system such as a 25-node system. These scenarios are examples, and the user has the freedom to set up the system so that it best supports their needs.

8.1.4.1 Multi-Node System Trail/Road Monitoring

Figure 39 depicts an example of how to set up a multi-node system to monitor a road/trail with an intersection so that intrusions and direction of travel can be determined. Setting up the sensor nodes in a zig-zag pattern down the road works well. The diagonal tripwires allow objects to interact with the individual tripwire for a longer time than if they were perpendicular to the road. In typical deployments cameras are located so that they can see down the road to get a good view of the situation.

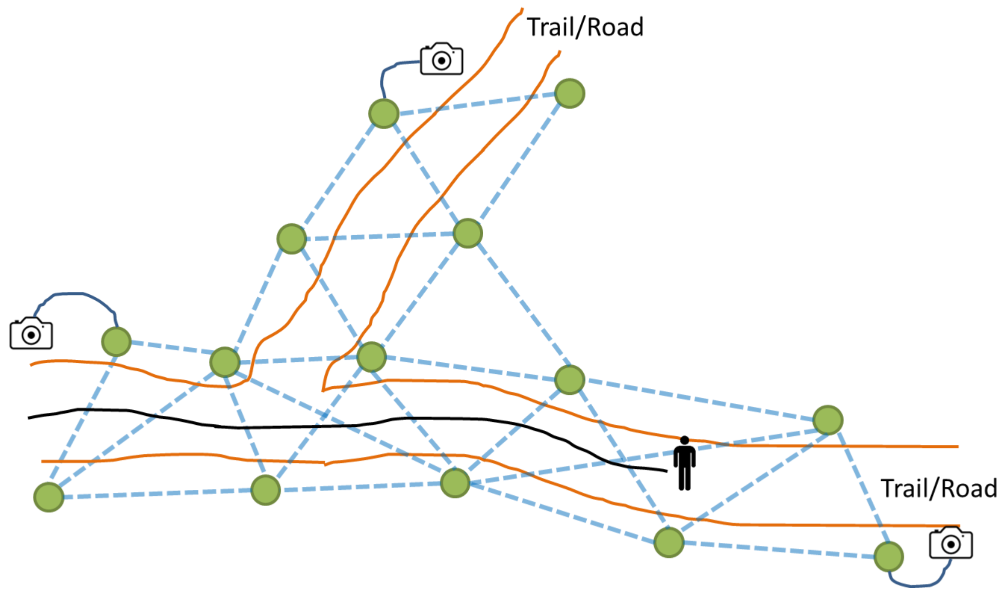

Figure 39: Multi Node System Trail/Road Monitoring

8.1.4.2 Multi Node System Area Monitoring

Figure 40 depicts an example multi-node area monitoring setup which allows movement to be tracked over an area. In this deployment the sensor nodes are placed in a rough grid pattern. In an actual deployment the nodes would be placed where there is some natural camouflage with the tripwires moving through clearings or open areas. Cameras are connected and located where they can get useful views of the area. When creating a grid pattern one thing to note is that if the nodes get very far apart the area they are monitoring is larger so if someone triggers a tripwire spanning a 200ft space then you only know they are somewhere in that area and it may be harder to locate that person. Additionally, longer spacings in a densely wooded area cause the system to reduce sensitivity to mitigate false alarms from wind which makes it harder to detect single individuals and you may only be able to detect large groups.

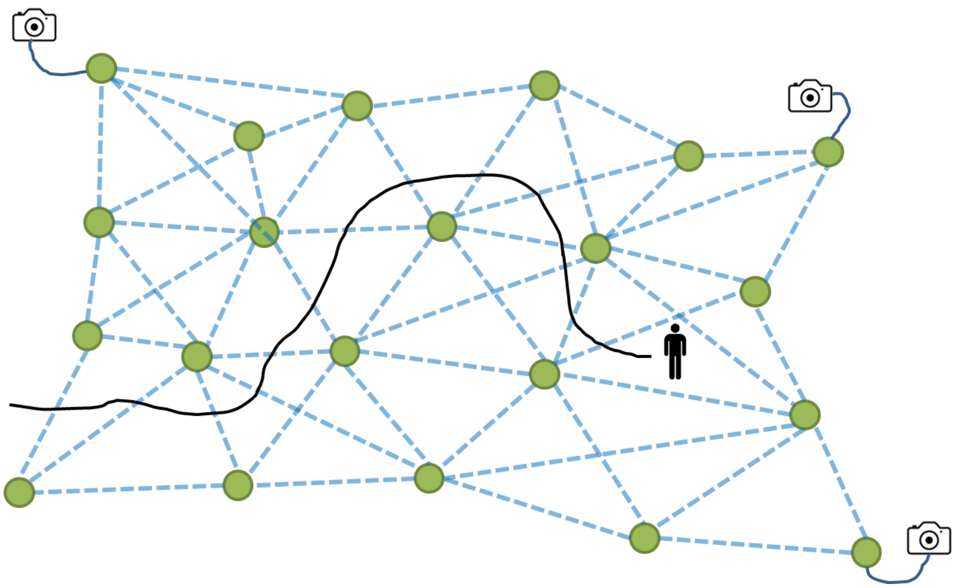

Figure 40: Multi-Node System Area Monitoring

8.1.4.3 Multi-Node System Boundary/Border Monitoring

Figure 41 depicts an example multi-node deployment along a boundary or border. This could be a properly boundary or other area that it is desired to know if there is unauthorized access. While it is possible to monitor a boundary using a single row of nodes, we recommend using multiple layers to add redundancy to the system. This redundancy serves two purposed the first is to ensure that the intruder is detected the second is to help mitigate false alarms. If a single detection event occurs in a multi row system, it is likely a false alarm since no other tripwire links were activated.

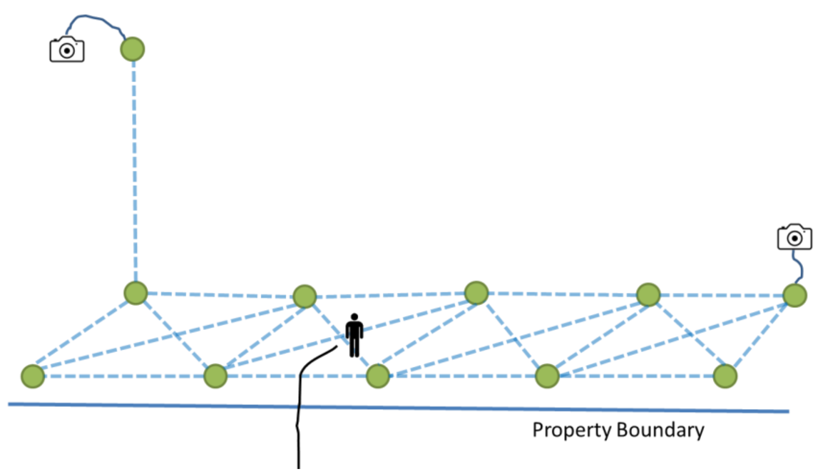

Figure 41: Multi-Node System Boundary/Border Monitoring

8.1.4.4 Multi-Node System Perimeter Monitoring

Figure 42 shows an example of a perimeter monitoring application. The nodes are set up around the perimeter of the area to be monitored. For example, the nodes could be attached to a fence line. In this example a single line of nodes is deployed to encompass the perimeter with cameras set up to capture images of any intruders.

In this application keeping the nodes spaced so that there are multiple tripwire connections between nodes will improve system performance since an intruding person activates multiple tripwires. For added redundancy additional rows of nodes can be added to provide layers of detection.

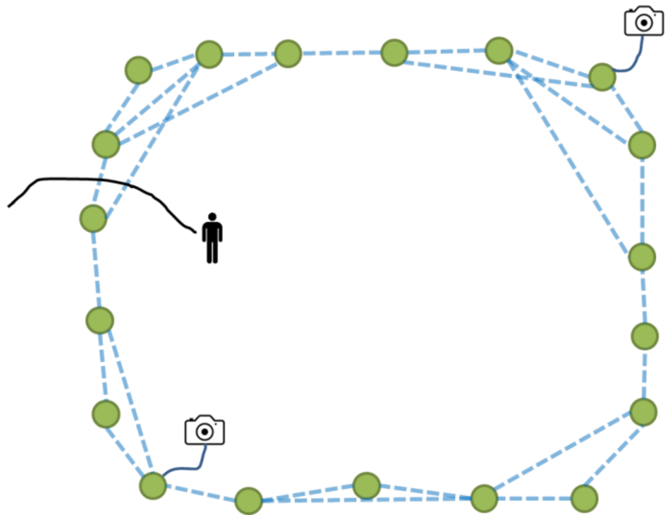

Figure 42: Multi-Node System Perimeter Monitoring

8.1.4.5 *Multi-Node System Key Spot Monitoring*

Figure 43 shows an example of a system set up to cover a large area using spot monitoring. The sensor nodes can communicate information further than they can perform tripwire intrusion detection. Small clusters of sensor nodes can be placed in key locations to help determine which way an intruder is traveling. If there are multiple trails as shown in the example below instead of fully covering the trail with sensor nodes small groups of sensor nodes could be strategically placed to determine which way a target has traveled. These small groups could be spaced further than would be used for a typical tripwire link but would be close enough to communicate detection information. Additionally, cameras can be added in key locations to determine what the target is.

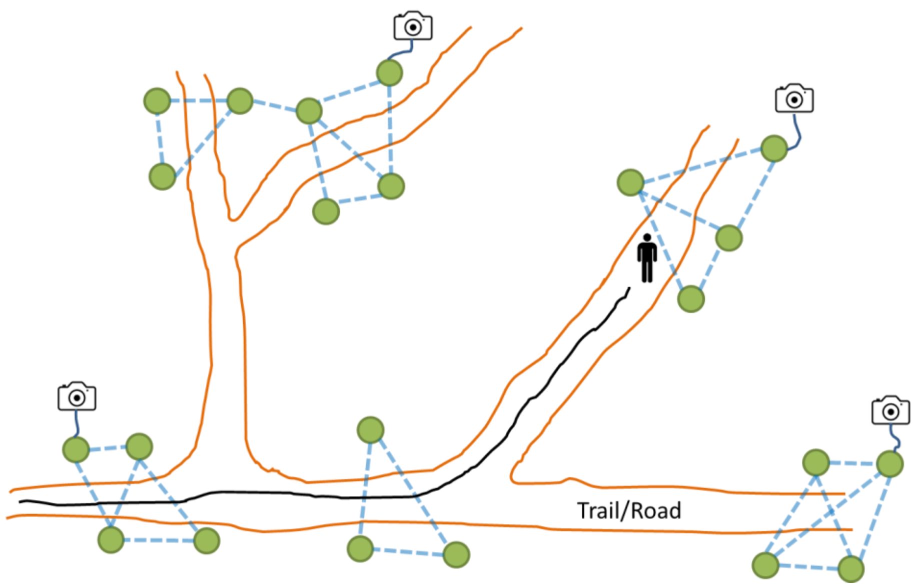

Figure 43: Multi-Node System Key Spot Monitoring

9 Equipment Mounting and Installation

Physical installation of the system is straightforward. The sensor nodes can be attached to tree trunks, bushes, T-posts, fence posts etc. using zip ties, hose clamps or other similar attachment items. For best GPS performance the sensor node should be mounted upright so that its internal antenna works best but, in an outdoor environment any orientation should work. The external tripwire antenna is the sensing component, so the location of the antenna is the most important with the goal of keeping it at about waist or midbody level with a person walking. The lower the antenna gets to the ground the more the range reduces and there is more of a chance for false alarms from brush moving in the wind and small animals. Additionally, mounting the antenna higher up is good for detecting vehicles while mostly excluding people. Additionally, it is best to keep the antenna rigidly mounted to keep it from moving too much in the wind since that can cause false alarms. Some movement is acceptable, but you will have to test this in your deployment environment. The sensor nodes can also be painted with standard spray paint, but care should be taken to keep the serial number and status LED useable.

9.1 Urban Deployment Examples

Figure 44 shows a picture of a sensor node installed in a flower bed. The sensor node is attached to a U-post to provide a stable location for the antenna. The antenna works best when placed above the metal portion of the U-Post since metal will affect the antenna's sensitivity. The antenna cable is loosely wrapped around the U-post to keep it organized. Figure 45 shows a close-up view where standard zip ties are clearly visible. Zip ties provide an easy way to attach the sensor node to various objects. Figure 46 shows the sensor node with the rodent braiding installed over the U-post and antenna. Adding the rodent braiding protects the wires from rodents and helps to camouflage the antenna, cable and U-post and can be painted to match the surrounding environment.

Figure 44: Sensor Node Mounted to a U-Post

Figure 45: Sensor Node U Post Mounting Close Up

Figure 46: Sensor Node with rodent braiding installed

Figure 47 shows a sensor node installed on a chain link fence. Again, as you can see in Figure 48 the sensor node is attached using zip ties. Finally, Figure 49 shows how the antenna is mounted to the upper portion of the chain link fence. Note the antenna is sticking up above the fence for best performance. In this application the antenna is fairly high but, the other sensor node that this one is creating a tripwire with is located closer to the ground, so the tripwire is effective for people and vehicles.

Figure 47: Sensor Node Mounted to a chain link Fence

Figure 48: Sensor Node Mounted to a chain link Fence Close Up

Figure 49: Antenna Mounted to a chain link Fence

Figure 50 shows a sensor node mounted to a light pole with the antenna connected directly to the sensor node. In this application the sensor node is mounted high up so that it mainly detects vehicles and not people. Since the sensor node is so high up the antenna is directly connected to the sensor node without the need for a cable. Mounting the antenna directly to the sensor node is acceptable if desired.

Figure 50: Sensor Node Mounted to a Light Pole

9.2 Rural Deployment Examples

The following examples depict some examples of sensor nodes deployed in rural environments. Figure 51 shows a sensor node deployed on a fence. The sensor node is hidden behind the tall dead grass while the Antenna is mounted to one of the fence posts sticking up just above the top with rodent braiding providing some camouflage. In this picture you can also see a solar rock which is being used to power the sensor node.

Figure 51: Sensor Node Rural Fence Deployment 1

Figure 52 shows another sensor node deployed along a fence. In this picture you can just see the sensor node near the base of the fence post. Again, the antenna in mounted to the post with some rodent braiding acting as camouflage. You can also see a solar rock which is used to power the sensor node.

Figure 52: Sensor Node Rural Fence Deployment 2

Figure 53, Figure 54 and Figure 55 show sensor node deployments near trees. Each of the units uses a U-post or PVC pipe pole to support the antenna with rodent braiding to provide camouflage. When placed near a tree trunk the sensor node pole and antenna is well camouflaged and the low brush hides the sensor node module.

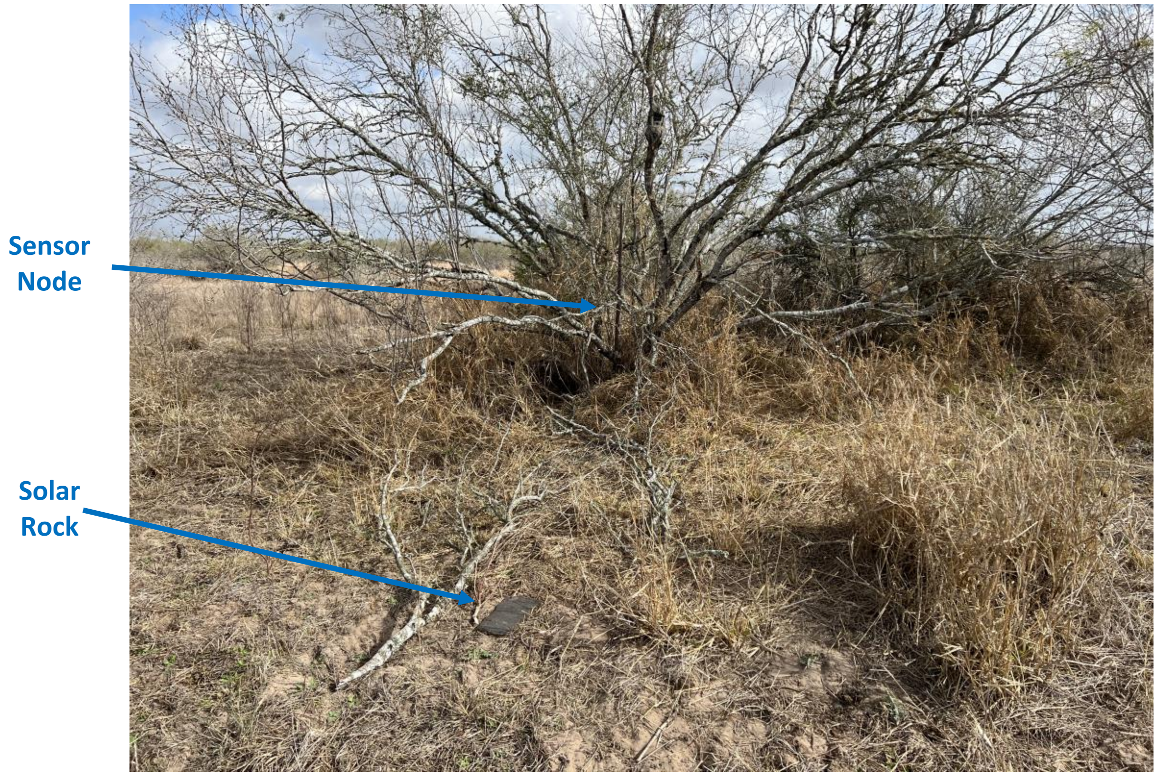

Figure 53: Sensor Node Rural Tree 1

Figure 54: Sensor Node Rural Tree 2

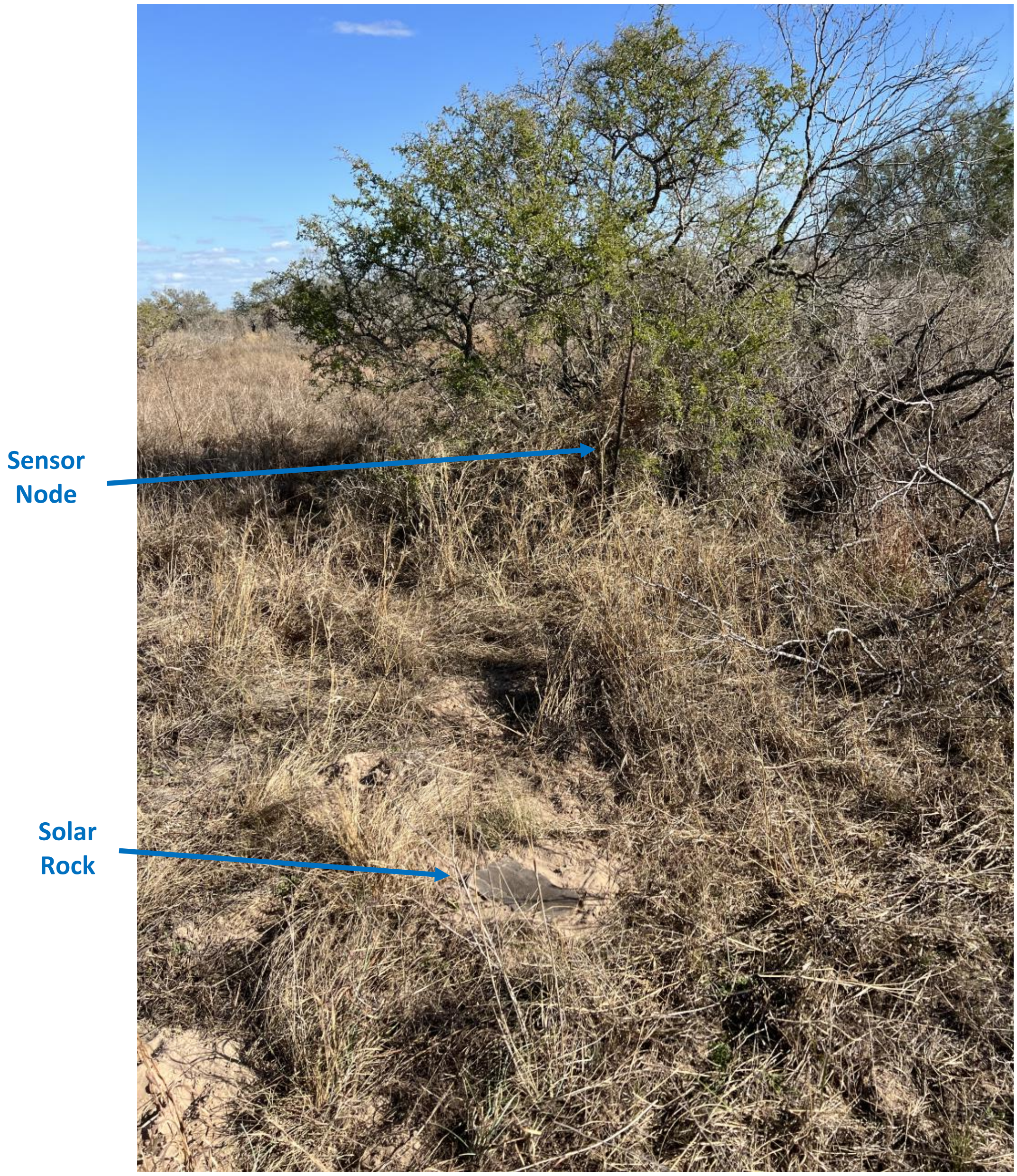

Figure 55: Sensor Node Rural Tree 3

Figure 56 shows an example of a sensor node with antenna pole in some brush. The pole is slightly more visible, but the rodent braiding helps disguise the antenna and mounting pole as a dead tree trunk. In this picture you can also see a solar rock which is providing power to the sensor node.

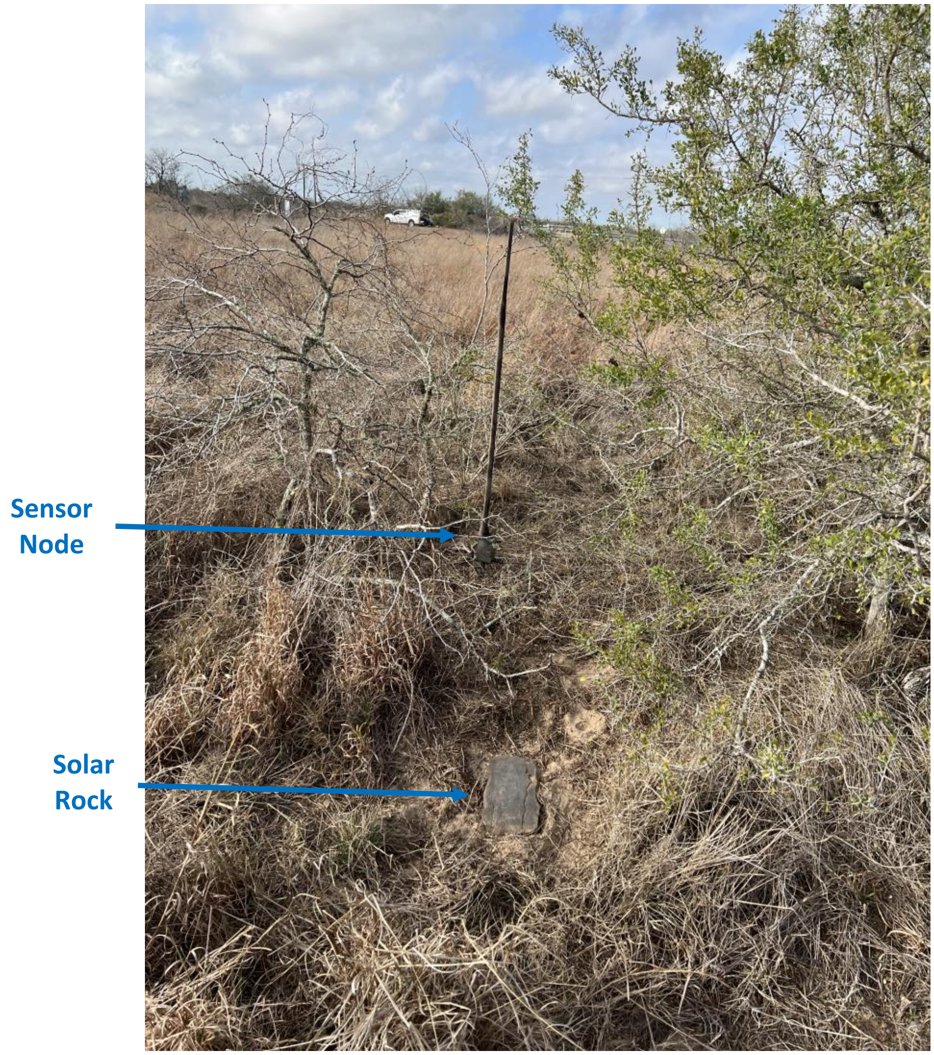

Figure 56: Rural Deployment Open Area

10 START Sensor Network Remote Monitoring (Requires Cluster Node)

Remote monitoring of the START sensor network requires a Cluster Node which provides the cellular interface as well as access to the START sensor network web application. Figure 57 shows a screenshot of the web application which provides mapping capabilities for the sensor network as well as allows the system to be configured and monitored remotely. Details of how to use the web application are provided in the START Web Application User Guide. The Web application provides the following features:

1) Live map of the nodes and detections
2) E-Mail message-based alerts
    a. Text Based Alerts available via cellular Carrier E-mail
3) Sensor and Cluster Node Status including battery health and charging status
4) System Configuration
5) Camera Images for a 25-node system with 6 cameras
6) Detection Replay Capabilities
7) Sensor Node Tamper Indications
8) Detection Metrics

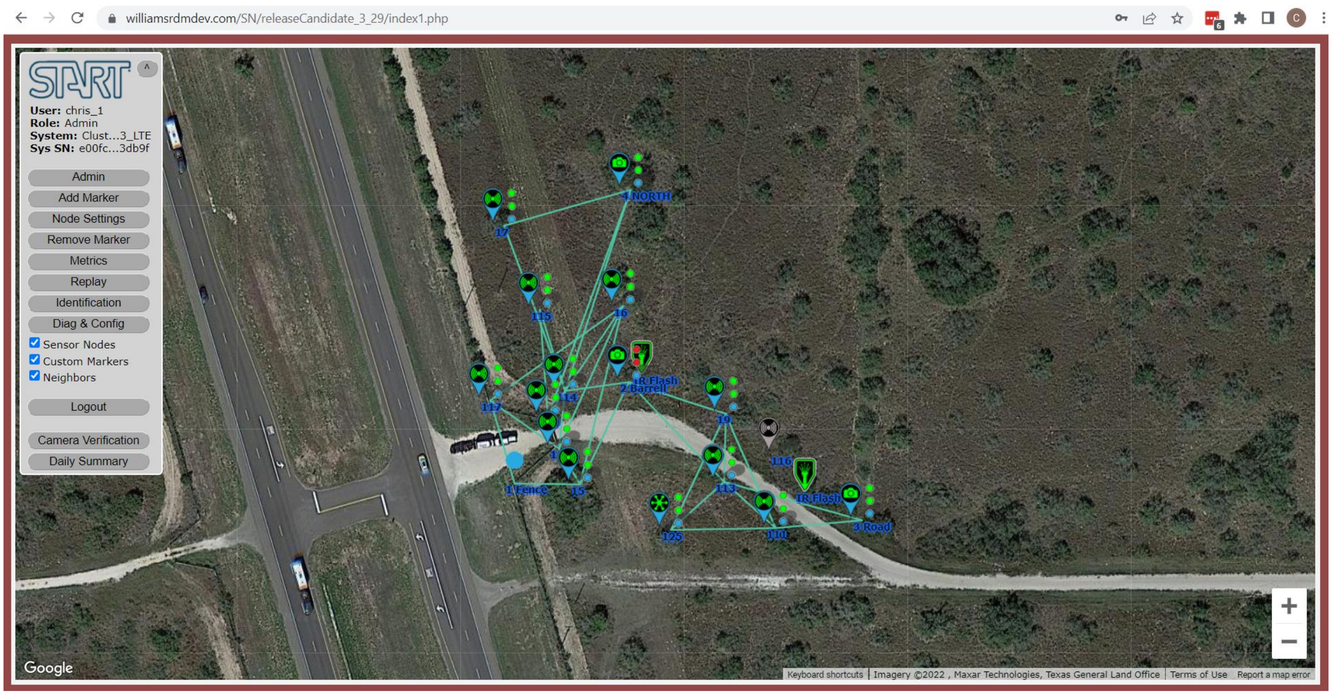

Figure 57: START Sensor Network User Interface

11 Configuration Settings (Requires Cluster Node)

The START sensor network has several settings that can be configured by the user. Changing system configuration settings requires a cluster node and access to the START web application. The following sections explain the settings that can be configured and how they are used. The specifics of how to use the web application to make those changes is documented in the web application user manual.

11.1 Quick Commands

There are several quick commands that can be used to improve the useability of the sensor network.

11.1.1 Identification Command

The identification command is used to tell a sensor node to perform a multicolor blink of its Status LED. This can be useful when there are a number of nodes in close proximity, and you want to identify one particular node in the group. To accomplish this, the user selects the desired node on the web base user interface and issues the identification command.

11.1.2 Status Update Command

The Status Update Command forces a sensor node to send in a status update. This is useful if you made a change to a sensor node or moved it, and you want to get an immediate status update. This command can be useful if you have added or cleaned off a covert solar device powering a sensor node and you want to get an immediate update on the charging status of the sensor node.

11.1.3 Factory Reset Command

The factory reset command can be used to factory reset a sensor node. The factory reset resets all the settings to the default configuration. The sensor node will still be able to communicate with the Cluster node since the Node ID and Owner ID are permanently set at WilliamsRDM. This command can be useful when setting up a new system and you want to clear the settings of the sensor nodes to have a consistent starting point.

11.2 Camera Configuration Options

Trail cameras can be triggered by the START sensor network using the eyepatch trigger module. The following sections describe the various settings and commands that can be used to configure the START sensor network to trigger a camera. When an eyepatch trigger module is connected to a sensor node it is automatically detected and the icon on the user interface changes to show a camera. This node is now a camera node as well as a sensor node. This feature is useful to determine what nodes have eyepatch trigger modules and cameras attached.

Trail cameras have timeouts between taking pictures when they upload a picture using cellular data. When a Spartan camera takes a picture for example it can take between 25s and 60s to upload the picture so careful planning is needed to get the most out of camera.

11.2.1 Camera Test Picture Trigger

When testing the system, it is helpful to be able to trigger a camera remotely. This can be helpful to see if a camera and/or eyepatch trigger module is working properly. This feature is helpful when there has been no activity on the system for a long duration and the user wants to make sure the cameras and eyepatch triggers are working properly.

11.2.2 Camera Node Trigger List

When a camera and eyepatch trigger is deployed the sensor network needs to be configured as to which sensor nodes trigger which cameras. By defaulted the sensor nodes are configured to trigger a camera on any detection within the system. So, in a newly deployed unconfigured system the camera will be triggered if any sensor node detects something on a tripwire or an external sensor. When setting up the system the user may want to limit which sensor nodes trigger the cameras to the sensor nodes in the field of view of the camera. One way to do this is by configuring the camera node (node with eyepatch trigger attached) with a list of nodes that will trigger the camera if they detect something on their tripwires. The camera list has a maximum of 12 entries. Figure 58 shows an example of how a camera connected to node 1 could be configured using the node trigger list. In this example the camera connected to node 1 is pointing to the right down the road and is configured to trigger if nodes 1,2,3,4,5,6 or 7 (nodes highlighted blue) detect anything on their tripwires. One thing to note when using the node trigger list method is that if any of the tripwires linking any of the sensor nodes on the list detect something the camera will be triggered. The tripwire links that will trigger the camera are highlighted red in this example. Care should be taken to avoid unintended links from triggering the camera. In this example some unintended triggers may be the tripwire links connecting node 11 and 12 to the other nodes on the camera node list. These links will trigger the camera since they are connected to nodes on the camera trigger list, but they are out of the view of the camera and may result in pictures without targets.

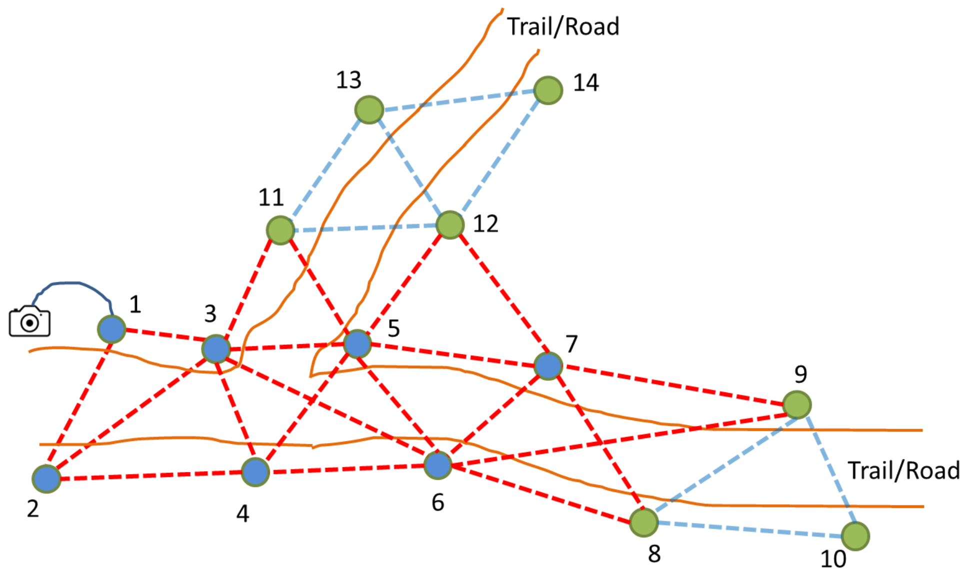

Figure 58: Example Camera Node Trigger List Setup

When using this method, the user needs to pay attention to where the camera is looking and try to list only the sensor nodes that have RF tripwire links in the field of view of the camera. Figure 59 shows an alternate camera list setup where camera 1 is configured with the camera node list of 1,2,4 and 6. This eliminates the links outside of the camera's field of view while still adequately monitoring the road.

Node 65535 is a special node ID indicating that all nodes will trigger the camera. By default, this node ID is loaded on the node trigger list and this indicates that any node detecting anything within the system will trigger the camera. If you send a list of nodes to the camera node and this special node ID is included in that list the list will be cleared and only 65535 will be present on the list indicating any node will trigger the camera.

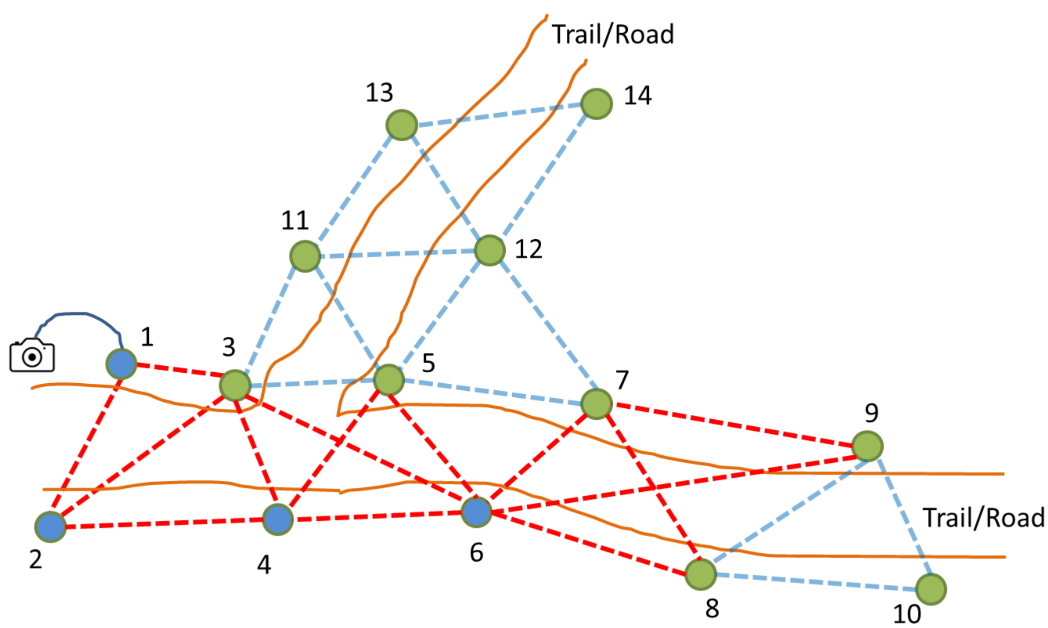

Figure 59: Alternate Example Camera Node Trigger List Setup

11.2.3 Sensor Node Link Trigger

In addition to the camera node list discussed previously the camera node can be configured using a link list which is a list of tripwire links that will trigger the camera. By default, the camera link list is cleared. A camera node (Sensor Node with an Eyepatch Trigger Attached) can be configured with a link list containing a maximum of 6 RF tripwire links that can be used to trigger the camera. Figure 60 shows an example of how a camera connected to node 1 could be configured using the node link list feature. The camera would be configured with the following links (3,4), (5,6), and (7,8). If a tripwire activates on any of these links the camera will be triggered to take a picture.

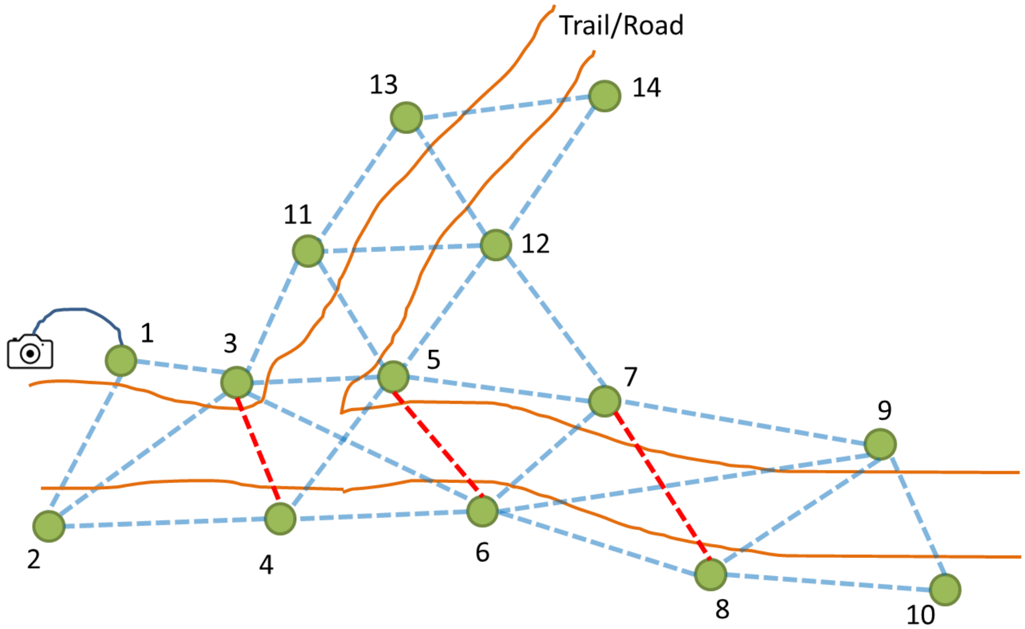

Figure 60: Camera Link List Trigger Example

The main benefit of this approach over the node list method is that it is very specific on which links trigger which cameras and eliminates the issues of unintended triggers by tripwires outside of the cameras field of view.

11.2.4 Camera Trigger Threshold

The camera trigger threshold setting is used to help reduce false pictures due to wind and other random environmental effects. The Camera Trigger threshold value represents the number of neighboring nodes that are also detecting a target in the nearby vicinity within the last several seconds. It acts as a confidence threshold for the camera so that it only takes a picture when a minimum number of sensor nodes are detecting an intrusion.

For example, if the Camera Trigger Threshold for a camera node is set to 0 then all detections from sensor nodes on the camera node list or all detection made on tripwire links on the link list will trigger the camera to take a picture since only 0 neighbor nodes are required. Alternatively, if the camera trigger threshold is set to 3 then the camera will only take a picture if a node on the camera node list or either of the nodes on the tripwire link list reports that at least 3 of its neighbors are also detecting an intrusion.

This setting can be set individually for each camera. If the value is set too high and there are not very many nodes, then the camera may not be triggered. For example, if there are only 3 nodes in a system and the camera trigger threshold is set to 4 then the camera will never be triggered. This setting is very useful in wooded areas where wind sometimes causes tripwires to activate and trigger a camera. Setting this value to somewhere between 2 and 5 ensures that random triggers don’t trigger the camera but, a target moving through the network will trigger system since it will activate many sensor nodes within a short timeframe.

11.3 Exclusion/Inclusion List Settings

Each sensor node supports a list of 12 nodes that can be set up as an exclusion list or inclusion list. This list is set on a node-by-node basis and is used to include or exclude neighbor nodes from acting as tripwires with the list holder node. The list can function as either an exclusion list or inclusion list but not both. Each list mode has its uses that will be outlined below.

11.3.1 Exclusion List

The exclusion list can be configured on a node and provides a list of up to 12 sensor nodes to **NOT** function as a tripwire with. This is used to eliminate tripwire links that are prone to false alarms. Figure 61 shows a system where the tripwire between nodes 5 and 12 is causing too many false alarms. This may be due to some object moving too much in the wind or some other factor. The link can be eliminated by adding node 12 to the exclusion list of node 5 and adding node 5 to the exclusion list of node 12. Note that the list must be updated on both nodes to eliminate the tripwire link. This is because each node forms a one directional link with its neighbors resulting in two links, one in each direction, between each pair of nodes.

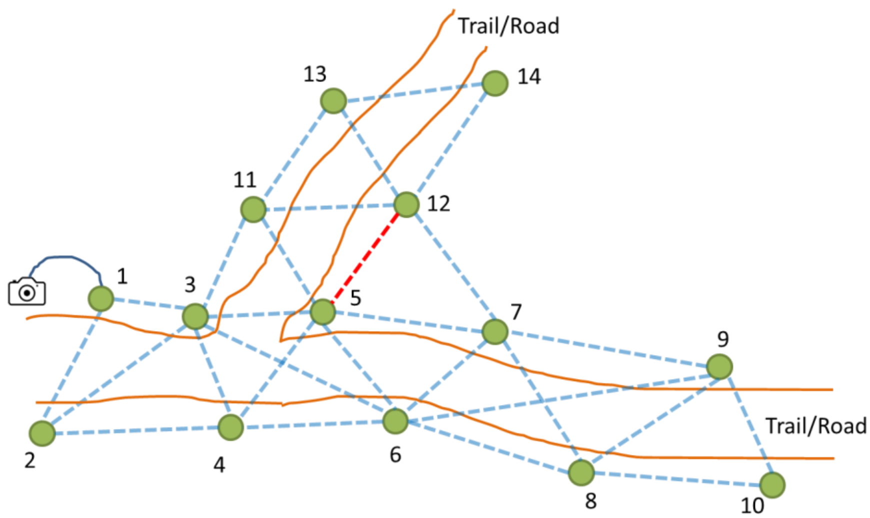

Figure 61: Exclusion List Example with Problematic Tripwire Link

Once the exclusion list is updated on nodes 5 and 12 in this example the tripwire between nodes 5 and 12 is deactivated and will not report any detections. Figure 62 shows the updated network with the deactivated tripwire link between nodes 5 and 12. To re-enable the tripwire link the list must be updated on each node to remove the desired nodes.

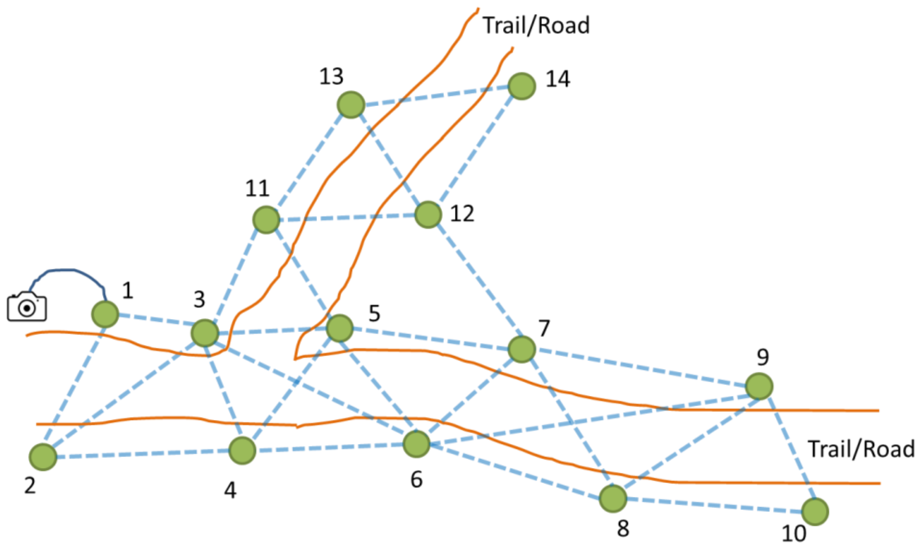

Figure 62: Exclusion List Complete Example

11.3.2 Inclusion List

The inclusion list can be configured on a sensor node and is a list of up to 12 sensor nodes that the node can form a tripwire link with. This feature is used when setting up groups of nodes that should function independently. For example, the 3 node system is configured such that the three nodes in the system are all on the inclusion list of all three nodes; this ensures that these nodes only form tripwire links with each other and not any external nodes.

Figure 63 shows and example of a sensor network system with three groups of nodes isolated using the inclusion list. In the upper part of the figure nodes 13, 14 and 12 are all on an inclusion list with each other. On the left side of the figure nodes 1,2,3,4,5 and 11 are on an inclusion list with each other. On the right-side nodes 6,7,8,9 and 10 are on an inclusion list with each other. These nodes only form tripwires with nodes on their inclusion list but they can still send data and communicate using the mesh network capabilities of the other nearby nodes not on the inclusion list. This list only controls tripwire links and does not limit mesh network communication capabilities.

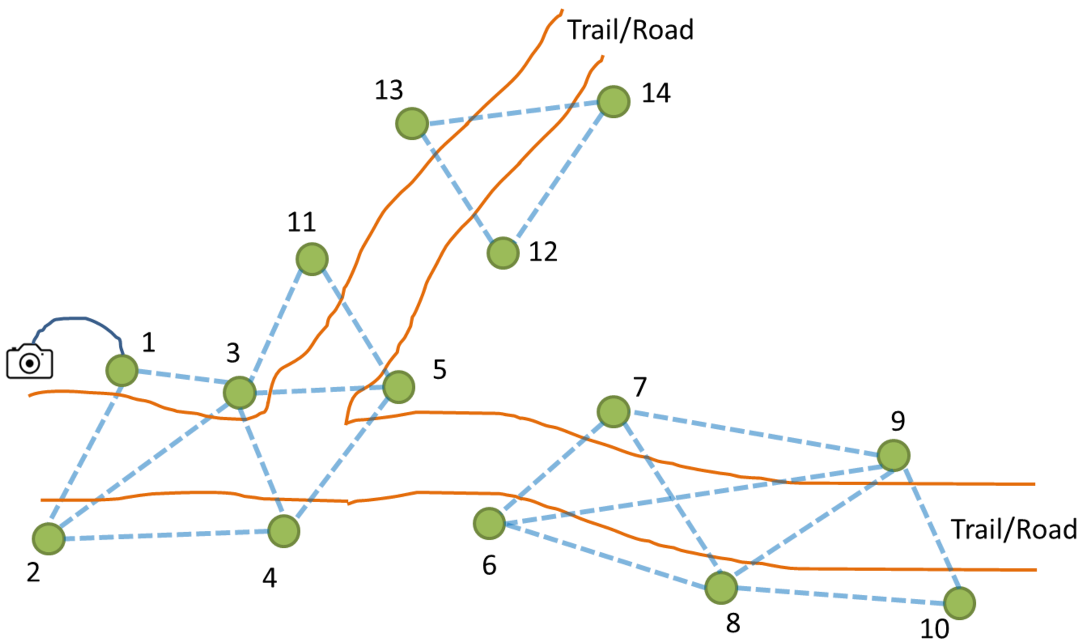

Figure 63: Inclusion List Example

One thing to consider about the inclusion list is that it only affects the node containing the list. For example, in Figure 64 if node 7 has an inclusion list with nodes 6,7,8,9 and 10 but node 5 has node 7 on its inclusion list a unidirectional tripwire link is formed between nodes 5 and 7 as indicated by the yellow tripwire link. This means that node 5 can report a tripwire detection between nodes 5 and 7 but node 7 cannot do this. This is something to keep in mind when creating inclusion or exclusion list.

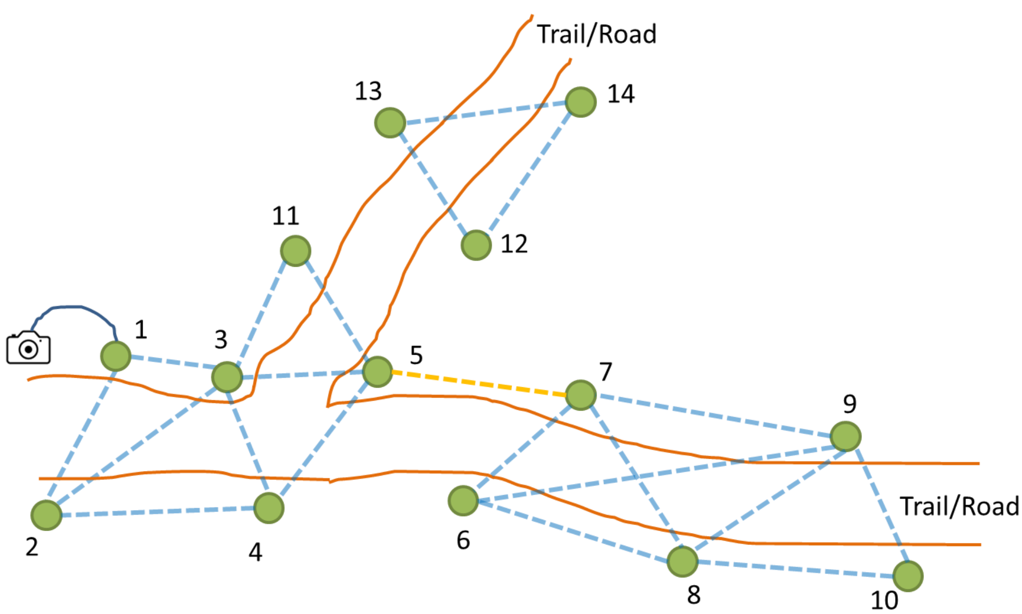

Figure 64: Unidirectional Link

11.4 Tripwire Sensitivity Settings

There are a several tripwire settings that can be adjusted on the sensor nodes to change the performance of the RF tripwire system. These settings can get complicated so WIlliamsRDM created several preset settings to help in deploying the system in both rural and urban environments. The settings are configured on a node-by-node basis with all tripwires generated by that node being controlled by that node's tripwire settings. The main reason for changing the settings is to reduce false alarms or to increase sensitivity. For detailed information about the various settings or to resolve issues contact WilliamsRDM for assistance with changing individual settings beyond the preset values.

11.4.1 Rural Settings

The rural settings were designed for use in rural wooded or grassy environments although they will also work well in urban environments. The settings are designed to adapt to changes in the environment fast enough to filter out most changes in wind speed and rain but, slow enough to minimize filtering out actual detections. There are three preset settings:

1) Rural Wooded – Low
2) Rural Wooded – Medium
3) Rural Wooded – High

The medium setting is the default setting of the sensor nodes and provides a nice blend between false alarms and detections. The high sensitivity is more sensitive but my result in additional false detections. However this false detection level may be able to be minimized by changing the camera trigger threshold or using the inclusion/exclusion list. The Low sensitivity results in lower false alarms as the expense of sensitivity. What this means is that while the node may not be able to detect a single person far away, it will likely be able to detect a group of people or vehicle.

Since these settings are configured on a node-by-node basis it may be advantageous to set nodes that may be triggering too often to less sensitive settings to reduce nuisance trips.

11.4.2 Urban Settings

The Urban settings are best for use in urban environments that don't have a lot of vegetation that can move in the wind. The urban settings no not adapt to the environment in the same way as the rural settings. The main difference is that the system does not reduce sensitivity when a lot of people or vehicles move through the network. As a result, the urban settings can handle more intrusions without adapting to the intrusions. If a large continuous group of people would continually walk through a system with the rural settings used the system would eventually adapt to the environment and change sensitivity to filter out the detections. The urban settings work differently and will not filter out the movement of the group. The settings will adapt to nonmoving objects such as vehicles parked within the system and will adapt to those stationary changes. There are three urban preset settings:

1) Urban – Low
2) Urban – Medium
3) Urban – High

The high sensitivity setting is more sensitive but may have more false alarms while the low sensitivity settings will have less false alarms but will also be less sensitive. Theses settings are set on a node-by-node basis and can be adjusted based on the requirements of the deployment.

12 Troubleshooting

The following section describes how to troubleshoot common issues with the sensor system.

1) Sensor Node is not triggering a camera.
    a. Ensure the remote camera trigger is properly installed on the camera.
    b. Test the remote camera trigger by pressing and releasing the power button on the sensor node with the remote camera trigger connected. This should trigger the camera to take a picture.

c. If the camera does not take a picture the remote camera trigger can be tested by removing it from the camera, placing your fingers over the circuit board on the font of the trigger and pressing and releasing the power button on the sensor node. When the power button is pressed you should feel the board heat up. If you feel the board heat up the trigger is working properly.

2) Camera is not uploading pictures.
   a. Check batteries in camera; it requires 12 AA batteries.
   b. Replace SD Card in Camera
   c. If replacing the SD card or batteries does not fix the issue, contact Spartan Camera
3) Sensor Node power button not turning on the sensor node.
   a. Battery is either dead or the device needs to be reset.
   b. To reset the sensor node, press and hold the power button for 5 seconds then press the button again to power on the sensor node. If this does not work the battery is probably discharged. Connect the sensor node to a covert solar device and allow it to recharge.

13 Frequently Asked Questions

Q1: How do I check that the sensor node is powered off?

A1: Quickly Press and Release the Power Button if the LED stays off then the sensor is off.

Q2: Can I recharge a sensor node without a covert solar device?

A2: Yes, with a separate 8173-2 AC charging Adapter.

Q3: Can the eyepatch camera triggers be used with the cluster node?

A3: No, the eyepatch camera triggers can only be used with the 8170-1 and 8170-2 sensor nodes.

Q4: How can I check the cellular connection without a laptop or phone?

A4: Press and hold the COMM STATUS button on the cluster node if the LED is slowly breathing on and off then then there is a cellular connection. After a power cycle this may take a few minutes.

Q5: Can multiple 3-node systems be used in the same area?

A5: Yes, but a detection by any sensor node will trigger all the cameras in the system.

Q6: Can an 8170-2 sensor node with external sensor interface kit be used with a 3-node system?

A6: Yes, by default any external sensor attached to the sensor node will trigger the camera in the 3 node system.

14 Component Part Numbers

Part Number	Description
8170-1	Sensor Node KIt
8170-2	Sensor Node with External Sensor Interface Kit
8171-1	Cluster Node Kit
RP-SMAM-F-4PC-1M	Sensor Network Antenna Cable

BC22385	Sensor Network Antenna
RRRN1.00DB	Rodent Sleeving
B075M9QY37	Cellular Antenna Cable
B074YWTCB1	Omni Cellular Antenna
8176-1	Solar Rock Y-Cable
8175-1	Spartan GoLive/Ghost Eyepatch Kit
8179-1	Spartan Golive 2 Eyepatch Kit
8182-1	Spartan GoCam Eyepatch Kit
8159-1	Buckeye Eyepatch Kit
8158-1	Remote IR Camera Flash
8160-1	Solar Rock for Sensor Node, Cluster Node and IR Flash (Other camouflage options available, contact WilliamsRDM for additional Information)
8173-2	AC Charging Adapter
8201-1	Telonics PT-100 interface Cable

15 Specifications

Below are the various specifications of the system

1) Operating Frequency: 2.4GHz
2) Cellular: LTE
3) Sensor Node
    a. Dimensions: 6.75” x 3.25” x 1.75”
    b. Weight: 0.86 lbs
    c. Battery: 3.6V 6500mAh
4) Cluster Node
    a. Dimensions: 5.75” x 2.5” x 2.5”
    b. Weight: 0.78 lbs
    c. Battery: 3.6V 6500mAh