

LTE GPS Antenna Guide Cisco Integrated Services Router (ISR G2) and Connected Grid Router

For All Verizon Wireless 4G Services

Revision 3.53

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Introduction

LTE offers a valuable last mile access option for remote locations, kiosks, temporary sites, vehicle communications and machine-to-machine applications. Benefits of 4G wireless access include reach, mobility, cost (depends on usage and plan) and performance. This document is focused on Cisco ISR LTE GPS capability. The information is appropriate for Cisco 1900, 2900, 3900 with EHWIC-4G-LTE-V, C819G-4G-V, and CGR2010 with GRWIC-4G-LTE-V. This document is organized in the following fashion:

- ISR LTE GPS overview
- GPS use cases
- Guidelines for GPS antenna installation and placement
- ISR LTE GPS configuration and use
- Sample configuration for collecting GPS coordinates and radio statistics for an ISR
- Sample configuration for synchronizing the ISR clock via GPS time reference
- Sample Configuration for displaying the geographical location of an ISR via web browser
- Frequently Asked Questions

ISR LTE GPS Overview

The Global Positioning System (GPS) is a U.S.-owned utility that provides users/devices with positioning, navigation, and timing services. This system consists of three domains, or “segments”: the space segment, the control segment, and the user segment. The U.S. Air Force develops, maintains, and operates the space and control segments.

The space segment consists of 24 satellites that transmit their position and the time. The control segment consists of a management system to monitor and control the satellites, for example keeping them in the appropriate orbits. The user segment consists of a GPS receiver (separate device, or a function in a multi-function device) that receives the information from multiple satellites and calculates its 3-dimensional position on Earth. A Cisco ISR with LTE interface can be a GPS receiver (requires IOS 15.3(3)M2 or later M release. GPS can be built using different technologies.

Satellite GPS

A passive GPS via the satellite system is where a device receives signal from 3 or more Satellites to derive its location.

Active GPS

This general term often denotes that a device’s satellite GPS receiver is amplified, or powered, to better receive signal.

Assisted GPS

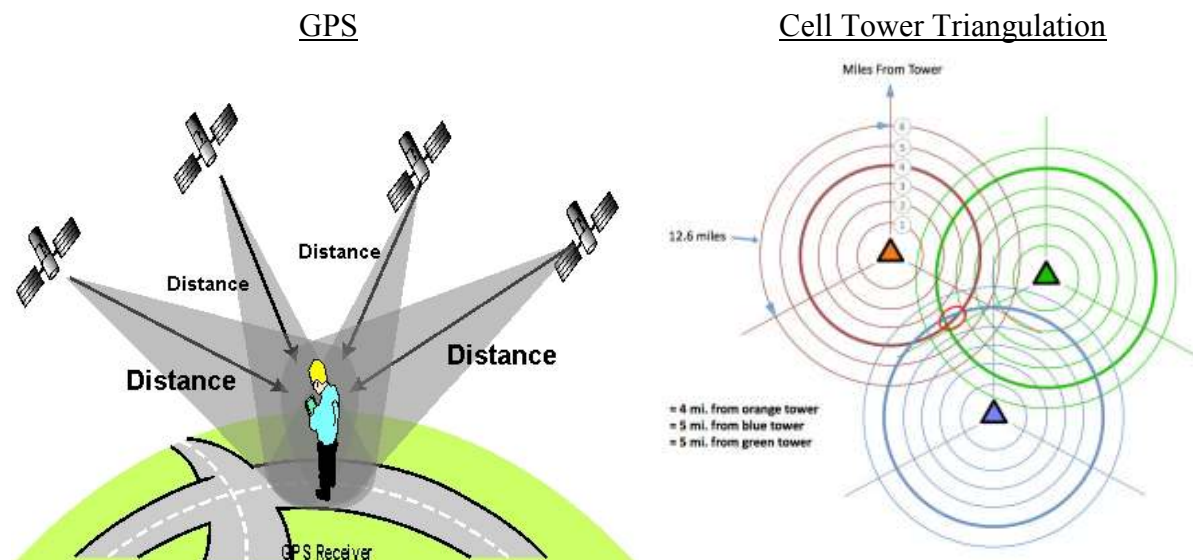
This technique allows a GPS receiver to more quickly obtain its coordinates by providing the device information to better obtain satellite location (orbital info, to lock into satellites faster) and assisting in calculation based on incomplete information from the receiver (provides for more computing/calculating power and better knowledge of satellite position). Assisted GPS therefore requires two-way communications to the GPS receiver and an IP data path.

Cell Tower Triangulation

Location based services can be a feature provided from cellular wireless networks. It is based upon radio signal strength to/from a device relative to multiple cell towers. By comparing the signal strength between the LTE device and multiple cell towers, an approximate distance from each and thus location is derived based on the intersection. Although called Triangulation, the comparison for location may be to 2, 3, 4 or more cell towers.

Both systems provide significant benefits, and can be used together, or separately. The key to leveraging GPS is in having an application or service that correlates the data into meaningful information.

The Cisco ISR with EHWIC-4G-LTE-V, C819G-4G-V, and CGR2010 with GRWIC-4G-LTE-V, all provide GPS coordinates via satellite, using active GPS. The ISR or CGR today do not currently support cell tower triangulation. For satellite GPS, what is needed is a GPS antenna and simple IOS configuration.



Below is a comparison of these two location-based technologies, followed by 3 use case examples.

Characteristic	Satellite-Based GPS	Cell Tower Triangulation-Based
Method of obtaining coordinates	Received signals from multiple satellites	Signal strength from device to multiple cell towers
Calculating entity	The end device (ISR/CGR)	The cellular wireless network
Accuracy	10-30 feet	50-150 feet
Applicable while on-the-move	Yes	Yes
Applicable to stationary devices	Yes (requires antenna with line-of-site to the sky, e.g. antenna at window or outside for indoor device)	Yes (requires sufficient signal strength/quality to 3 towers, via LTE device's indoor or outdoor antennas)
Storage location of GPS coordinates	Initially in the end device, can be sent via the IP network to any service	Initially in the cellular network, can be sent to any service or device with a relationship to the service provider
Requires an antenna	Yes (GPS satellite)	Yes (LTE)
Common reason for coordinate loss	Direct line of sight to sky inhibited	Access to at least 3 cell towers inhibited
Affected by weather issues	Possibly, but not common	No
Affected by cellular network issues	No	Possibly, but rare
Method to purposefully disable GPS	Blocking or removing GPS antenna	Cell signal jamming
When to use	When there is a system to collect and process the GPS coordinate data When more coordinate accuracy is needed When the device may be out of cellular wireless coverage	When the LTE provider offers GPS services that process the data When the accuracy provided is sufficient When the LTE device has no satellite GPS ability
When not to use	When the LTE device has no satellite GPS function	When the LTE device may be out of cellular wireless coverage
When to use methods together	Whenever possible, for high availability of GPS coordinates.	Whenever possible, for high availability of GPS coordinates.
Challenge to using both methods together	Integrating/combining the data into one GPS application or service	Integrating/combining the data into one GPS application or service

ISR LTE GPS Use Case Examples

GPS can be used for many purposes within multiple vertical and common-use applications. Below a few examples are listed. The key to fully leveraging GPS for business, scientific, academic or non-profit endeavors is in the application that collects, analyzes and presents the information in a meaningful way to the users.

Geo-Fencing

Geo-fencing is the concept of controlling a device's operation based on where it is located. One use may be to only allow a device to operate if it is located in an area it is authorized to be.

For example, if an ISR inside a store, kiosk or ATM was taken to a location other than where it should be, the ISR could disable itself. Or if the device is programmed to send (or polled) for its location, and the cloud/host application finds it outside the authorized area, the application may stop allowing communications to the devices behind the ISR.

Asset Tracking

Asset tracking is the concept of knowing where equipment or devices are currently, and their condition/operation. The condition/operation can be gleaned by cloud/host applications, or by network management tools. The location of the specific device/equipment however can be important to an organization's operations.

For example, a transportation enterprise may need to know the location of each of its trucks, train cars and ships in order to coordinate the on-time shipment and delivery of cargo. This may allow for the best selection of transport means and specific vehicles for a particular expedited shipment.

Travel Tracking

Travel tracking is the concept of knowing the location, path, travel time, and stop time for a vehicle (train, bus, truck, trailer, or car). The efficiency and route for a particular vehicle, along with analysis of routes across an organization can allow for increased efficiency and productivity.

For example, an organization can learn which routes, or vehicles, or drivers provide efficient routes, how long stops are, if the routes change, traffic patterns, time lapse and average speed on particular portions of a route. Another example is tracking the location of emergency vehicles such as ambulances for improved emergency patient preparations.

Movement Tracking

Movement tracking is similar to travel tracking but in a more limited area. This is leveraged in warehousing, manufacturing, mining, construction, defense, etc. This combines asset and travel tracking to determine where on a work site heavy equipment is currently located, where it has been, and its movement over time.

For example for oil and gas exploration, the location and movement of large/expensive/specialized heaving equipment can be analyzed to provide efficient operations.

Time Synchronization

Accurate time on an ISR can be important, for having exact time stamps of logs, or for accurate execution of tasks via automated/scheduled ISR functions.

There may be times that the ISR requires synchronization of its internal clock with a highly accurate time source. Inability to sync the time may occur with deployments in vehicles or movable installations that are out of signal range for long periods, or where the deployment used a connection to an isolated private network with no NTP server.

In those instances the GPS signal's accurate time reference can be used to synchronize the ISR clock. Although this is not currently a function configurable with native IOS command, it is easily accomplished using the powerful IOS Embedded Event Manager (EEM) automation function available on ISRs.

Guidelines for GPS Antenna Installation and Placement

On the ISR EHWIC-4G-LTE-V, C819G-4G-V, and CGR2010 with GRWIC-4G-LTE-V, the GPS antenna is separate from the LTE antennas, and has a separate connector, as shown in the diagrams below. On the Cisco LTE enabled platforms, the connector is SMA. Some cisco.com documentation may denote the GPS antenna as “active”, however all the platforms support active satellite GPS. Although non-Cisco GPS antennas with SMA connector may function with ISRs and CGRs, the only Cisco-supported antenna is the Cisco GPS antenna part number GPS-ACT-ANTM-SMA= (GPDS outdoor antenna) and 4G-LTE-ANTM-O-3= (combination LTE/GPS outdoor antenna)

The installation of satellite GPS is related to the physical location of the ISR/CGR, similarly to the installation of LTE antennas with ISR/CGR as outlined in

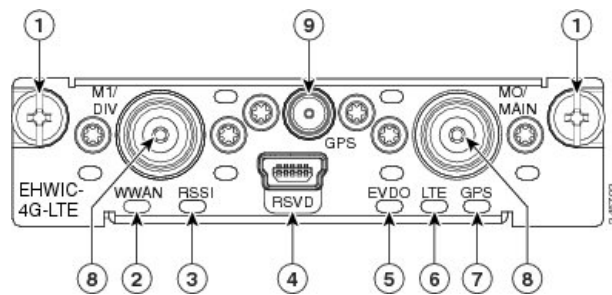
www.cisco.com/en/US/docs/routers/access/interfaces/software/deployment/guide/guide_100413.pdf

The main issue is connecting the GPS antenna to the ISR/CGR while providing direct line-of-sight to the sky for the antenna. The GPS-ACT-ANTM-SMA is an indoor-only antenna. Placement must be indoors and immediately next to or attached to a window. This antenna has an attached 17 foot cable with SMA male connector. If this length is insufficient to allow the GPS antenna placement near/on a window, then a low loss extension cable (SMA male/female ends) could be used. Cisco currently only supports direct connection of the GPS antenna to the GPS connector of the ISR, however on-site testing may provide confidence that an extension cable will provide consistent coordinates. The other option is to place the ISR closer to a window and connect back to the local network via Ethernet cable.

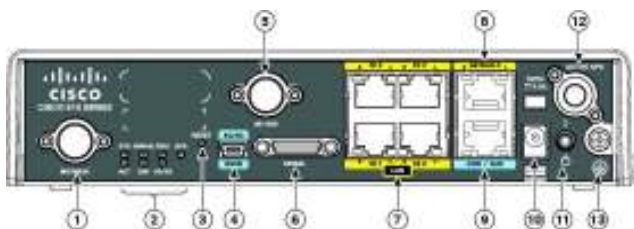
Information and installation instructions for the Cisco GPS antenna can be found here:

www.cisco.com/en/US/partner/docs/routers/access/wireless/hardware/notes/gps_ant.html and www.cisco.com/c/en/us/td/docs/routers/access/wireless/hardware/guide/antenna/4glteantmo3.html

After following the above guide, IOS configuration is needed in order to test operation of receiving GPS coordinates.



1	Mounting Screws	2	LED—WWAN
3	LED—RSSI ¹	4	RSVD (reserved) port, USB 2.0 mini type B
5	LED—EVDO ²	6	LED—LTE
7	LED—GPS ³	8	Antenna Connectors—M1/DIV, M0/MAIN
9	Antenna Connector—GPS		



1	4G Antenna connector—M0/MAIN	8	GE WAN port
2	LEDs	9	Console/Aux port
3	Reset button	10	Power input
4	4G/3G port	11	Power switch
5	4G Antenna connector—M1/DIV	12	Active GPS antenna connector
6	Serial port	13	Ground
7	FE ports		

ISR LTE GPS Configuration and Use

The details of IOS configuration for satellite GPS can be found here:

www.cisco.com/en/US/docs/routers/access/interfaces/software/feature/guide/EHWIC-4G-LTESW.html#wp1282783

www.cisco.com/en/US/docs/routers/access/interfaces/software/feature/guide/EHWIC-4G-LTESW.html#wp1283763

An example configuration for a C819G-4G-V is below.

```
!
controller Cellular 0
  lte gps mode standalone
  lte gps nmea ip          (note that for ISRs using eHWIC/GRWIC, the "ip" variable is omitted)
!
```

An example of the output from “show cellular 0/x/0|0 GPS” follows, also from a C819G-4G-V is below:

C819H2#**sh cell 0 gps**

GPS Info

```
GPS Feature: enabled
GPS Port Selected: Dedicated GPS port
GPS State: GPS enabled
GPS Mode Configured: standalone
Last Location Fix Error: Offline [0x0]
GPS Error Count: 31
Latitude: 40 Deg 6 Min 7 Sec North
Longitude: 75 Deg 7 Min 20 Sec West
Timestamp (GMT): Fri Nov 1 12:47:48 2013
```

Fix type index: 0, Height: 90 m

Satellite Info

```
Satellite #2, elevation 45, azimuth 265, SNR 34 *
Satellite #4, elevation 75, azimuth 352, SNR 37 *
Satellite #5, elevation 8, azimuth 202, SNR 36 *
Satellite #10, elevation 53, azimuth 167, SNR 47 *
Satellite #12, elevation 32, azimuth 309, SNR 32
Satellite #13, elevation 7, azimuth 104, SNR 32 *
Satellite #20, elevation 14, azimuth 43, SNR 30 *
Satellite #24, elevation 4, azimuth 261, SNR 0 *
Satellite #28, elevation 6, azimuth 161, SNR 0 *
```

There are multiple formats for GPS coordinates, shown below:

- WGS84: A fully decimal format popular with GIS systems and used in higher-end GPS equipment. Positive values occur north of the equator and east of the prime meridian to the International Date Line, while negative values occur south of the equator and west of the prime meridian.
 - Example: 30.29128 -97.73858
- Degrees/Minutes/Seconds: The standard minutes/seconds translation of latitude/longitude; many GPS units support this traditional format.
 - Example: 30° 17' 28" -97° 44' 18"
- GPS: A mixed minutes/decimal format which is becoming the standard for GPS equipment. All values are positive; the hemisphere is indicated by N and W. Minutes are attached to the degrees of the coordinates, while seconds are expressed in decimal format with the minutes.
 - Example: N30 17.477 W97 44.315
- Cisco IOS format: A format based on degrees/minutes/seconds, with `deg min sec` inserted versus `° ' "` and North South East West ending each coordinate versus a negative degree value if south of the equator or west of the prime meridian.
 - Example: 40 Deg 17 Min 29 Sec North 97 Deg 44 Min 18 Sec West

The example coordinates and some descriptions above are from www.utexas.edu/parking/maps/gps.html

There may be tools or applications that prefer a specific format. Below are techniques to convert the Cisco IOS GPS coordinate format to other formats, which can be automated; there are also existing conversion applications available.

Conversion of IOS current format to deg/min/sec format:

Remove "North/South" If South, make 1st value negative. Swap Deg Min Sec for `° ' "`

Remove "East/West" If West, make 1st value negative. Swap Deg Min Sec for `° ' "` (e.g. -97° 44' 18")

Conversion of IOS format to "GPS" format:

Remove "North" "South" "East" or "West" and insert N S E or W before the first number (degrees)

Remove Deg Min Sec. Divide seconds by 60 and add to minutes (e.g. W97 44.315)

Conversion of IOS format to WGS84 (decimal degree) format:

Remove North South East West. If South or West, make the degrees negative

Remove Deg Min Sec. Divide seconds by 60 and add to minutes (e.g. -97 44.315)

Divide 2nd number (minutes in decimal) by 60 and take to 6 decimal places (e.g. 44.315 / 60 = 0.73858)

Place the result of the above "minutes & seconds turned into a partial degree" to the right of the decimal point of the degrees (e.g. -97.73858)

Sample Configuration for Collecting GPS Coordinates and Radio Statistics for an ISR

Cisco IOS powers the ISRs and CGRs. When an ISR/CGR has an LTE interface, detailed information is available for the status of the LTE modem, SIM, connection, radio signal, and GPS. These are seen via SNMP polling, command line interface (via system logs, console, telnet, SSH, HTTP, and SMS). Some of these methods can be automated via IOS Embedded Event Manager, in order to provide automatic GPS tracking, alerting, or responding.

EEM is an IOS feature available on ISR and CGR routers that allows for automation, self-recovery and communication to management systems or applications. The automation can be triggered in various ways, such as ISR log message, specific/recurring date/time, status change of an interface or available route, a probe failure, etc.

Below is a configuration example of leveraging both GPS coordinate and radio signal strength quality, by logging values for both to a text file on the ISR every minute. This simple example could be expanded to send the results every hour to an application via FTP, email, etc. with the results from multiple locations aggregated and reported. Please note that Cisco currently does not support ISR LTE GPS on-the-move. This will be supported in the future.

```
event manager applet GPS-TRACK-BASIC
event timer cron cron-entry "*" * * * *
action 010 cli command "enable"
action 020 cli command "sh cell 0 gps | i Lat|Lon|Tim"
action 030 file open GPSLOG.TXT flash:GPSLOG.TXT a+
action 040 file write GPSLOG.TXT "$_cli_result"
action 050 cli command "sh cell 0 rad | i Band|RSSI|SNR"
action 060 file write GPSLOG.TXT "$_cli_result"
action 070 file close GPSLOG.TXT
```

Below is sample output from the file GPSLOG.TXT:

```
C819H2#Current Band = LTE
Current RSSI = -64 dBm
Current SNR = 9.0 dB
C819H2#Latitude: 40 Deg 9 Min 53 Sec North
Longitude: 75 Deg 7 Min 25 Sec West
Timestamp (GMT): Fri Oct 11 17:29:32 2013
C819H2#Current Band = LTE
Current RSSI = -51 dBm
Current SNR = 8.8 dB
C819H2#Latitude: 40 Deg 9 Min 26 Sec North
Longitude: 75 Deg 7 Min 20 Sec West
Timestamp (GMT): Fri Oct 11 17:30:54 2013
C819H2#Current Band = LTE
Current RSSI = -57 dBm
Current SNR = 12.2 dB
C819H2#Latitude: 40 Deg 9 Min 22 Sec North
Longitude: 75 Deg 7 Min 19 Sec West
Timestamp (GMT): Fri Oct 11 17:31:55 2013
C819H2#Current Band = LTE
Current RSSI = -59 dBm
Current SNR = 11.0 dB
C819H2#Latitude: 40 Deg 9 Min 3 Sec North
Longitude: 75 Deg 7 Min 14 Sec West
Timestamp (GMT): Fri Oct 11 17:32:53 2013
```

Sample Application for synchronizing the ISR clock via GPS time information

Cisco IOS powers the ISRs and CGRs, and offers multiple options for time and date setting/synchronization. NTP can be used, and the accuracy of the NTP server(s) will determine the clock accuracy on the ISR. GPS can be used instead, and offers an accurate time reference (stratum 1). A clock source should be used with an ISR where more accurate time stamps and system clock is required, as the ISR backplane and system clock is stratum 4E.

This example provides a way to set an ISR's system clock once per day by synchronization with GPS time reference, and for that ISR to be an NTP time server for other devices (e.g. for a closed network without access to a public or private time source). Although there is no single IOS command to set the clock via GPS reference, IOS EEM can be used to accomplish this, and a sample script has been made available to do so. The following steps are required:

- Install and configure an ISR G2 with active LTE connection
- Configure the GPS function in IOS and install the GPS antenna with direct line of sight to the sky
- Check that GPS coordinates are obtained successfully
- Install the `gps_time.tcl` script (from <https://supportforums.cisco.com/document/12013976/gpstimezip>) onto the ISR flash
- Configure the ISR to disable NTP client, enable NTP server, and enable the `gps_time.tcl` script
- Check for successful time change messages in the ISR log.

Below are the details for these steps:

Install and configure an ISR G2 with active LTE connection:

Planning and configuration guides are available at www.cisco.com/go/4g under [Configuration and Deployment Guides](#)

Configure the GPS function in IOS and install the GPS antenna with direct line of sight to the sky:

Follow the steps listed under section "ISR LTE GPS configuration and use", specifically:

```
conf t
controller Cellular 0
lte gps mode standalone
lte gps nmea ip          (note that for ISRs using eHWIC/GRWIC, the "ip" variable is omitted)
end
```

Check that GPS coordinates are obtained successfully:

Attach the antenna, place near a window, wait 1 minute, and use the following command to ensure coordinates have been calculated: `show cellular x gps` (where x is the interface number of the LTE interface (from "`show ip int brief`" command)). If a few minutes after initially attaching the GPS antenna the coordinates still show as zeroes, power-cycle the LTE modem (note this will disrupt the LTE data connection for 30 seconds):

```
conf t
service internal
end
test cellu 0 modem-power-cycle
```

Configure the ISR to disable NTP client, enable NTP server, and enable the `gps_time.tcl` script

```
show run | | ntp server      (display all NTP server definitions)
conf t
no ntp server <ip address> (remove each NTP server definition from previous display)
ntp master 3                (digit is for stratum level, NTP clients with multiple servers can determine best source)
event manager directory user policy "flash:/"
event manager applet gps_time.tcl type user
end
wr
```

Below is an ISR console log of the process:

```
C819H2#conf t
Enter configuration commands, one per line. End with CNTL/Z.
C819H2(config)#controller cell 0
(config-controller)# lte gps mode standalone
C819H2(config-controller)# lte gps nmea ip
```

```

C819H2(config-controller)#end
Nov 18 09:47:06: %SYS-5-CONFIG_I: Configured from console by console
C819H2#
C819H2#sh cell 0 gps

GPS Info
-----
GPS Feature: enabled
GPS Port Selected: Dedicated GPS port
GPS State: GPS enabled
GPS Mode Configured: standalone
Last Location Fix Error: Offline [0x0]
GPS Error Count: 8
Latitude: 40 Deg 6 Min 8 Sec North
Longitude: 75 Deg 7 Min 20 Sec West
Timestamp (GMT): Mon Nov 18 09:51:17 2013

Fix type index: 0, Height: 68 m
Satellite Info
-----
Satellite #1, elevation 0, azimuth 0, SNR 26
Satellite #2, elevation 28, azimuth 247, SNR 31
Satellite #10, elevation 30, azimuth 174, SNR 45
Satellite #20, elevation 29, azimuth 53, SNR 38
Satellite #24, elevation 14, azimuth 279, SNR 33
Satellite #28, elevation 28, azimuth 158, SNR 50
Satellite #32, elevation 3, azimuth 33, SNR 30
Satellite #23, elevation 3, azimuth 91, SNR 0
C819H2#
C819H2#conf t
Enter configuration commands, one per line. End with CNTL/Z.
C819H2(config)#no ntp server 66.228.35.252
C819H2(config)#ntp master 3
C819H2(config)#end
Nov 18 09:52:53: %SYS-5-CONFIG_I: Configured from console by console
C819H2#
C819H2#copy tftp flash
Address or name of remote host []? 10.239.249.4
Source filename []? gps_time.tcl
Destination filename [gps_time.tcl]?
Accessing tftp://10.239.249.4/gps_time.tcl...
Loading gps_time.tcl from 10.239.249.4 (via Vlan1): !
[OK - 2811 bytes]

2811 bytes copied in 0.520 secs (5406 bytes/sec)

C819H2#sh clock
09:55:24.209 est Mon Nov 18 2013
C819H2#
C819H2#conf t
Enter configuration commands, one per line. End with CNTL/Z.
C819H2(config)#event manager directory user policy "flash:/"
C819H2(config)#event manager policy gps_time.tcl type user
C819H2(config)#end
  
```

```
C819H2#
Nov 18 09:55:59: %SYS-5-CONFIG_I: Configured from console by console
Nov 18 14:56:01.213: %HA_EM-6-LOG: gps_time.tcl: INT = Cellular 0
Nov 18 14:56:01.337: %HA_EM-6-LOG: gps_time.tcl: regx = Nov 18 09:59:43 2013
.Nov 18 09:59:43: %SYS-6-CLOCKUPDATE: System clock has been updated from 09:56:01 est Mon Nov 18 2013 to 09:59:43 est Mon Nov 18 2013, configured from console by on vty0 (EEM:gps_time.tcl).
```

```
C819H2#
C819H2#sh clock
09:59:53.667 est Mon Nov 18 2013 <<command issued about 10 sec later>>
C819H2#
C819H2#sh cell 0 gps
```

GPS Info

```
-----
GPS Feature: enabled
GPS Port Selected: Dedicated GPS port
GPS State: GPS enabled
GPS Mode Configured: standalone
Last Location Fix Error: Offline [0x0]
GPS Error Count: 8
Latitude: 40 Deg 6 Min 8 Sec North
Longitude: 75 Deg 7 Min 20 Sec West
Timestamp (GMT): Mon Nov 18 09:59:43 2013
```

Fix type index: 0, Height: 101 m

Satellite Info

```
-----
Satellite #4, elevation 72, azimuth 277, SNR 34 *
Satellite #10, elevation 34, azimuth 174, SNR 53 *
Satellite #12, elevation 19, azimuth 317, SNR 35 *
Satellite #17, elevation 63, azimuth 70, SNR 38 *
Satellite #20, elevation 27, azimuth 50, SNR 37 *
Satellite #23, elevation 4, azimuth 88, SNR 35 *
Satellite #28, elevation 24, azimuth 160, SNR 44 *
Satellite #32, elevation 0, azimuth 30, SNR 0
```

```
C819H2#
C819H2#sh ntp status
Clock is synchronized, stratum 3, reference is 127.127.1.1
nominal freq is 250.0000 Hz, actual freq is 250.0000 Hz, precision is 2**20
ntp uptime is 59447500 (1/100 of seconds), resolution is 4000
reference time is D634A9EF.F3BA8A5A (09:59:59.952 est Mon Nov 18 2013)
clock offset is 0.0000 msec, root delay is 0.00 msec
root dispersion is 3937.72 msec, peer dispersion is 3937.56 msec
loopfilter state is 'CTRL' (Normal Controlled Loop), drift is 0.000000000 s/s
system poll interval is 16, last update was 12 sec ago.
```

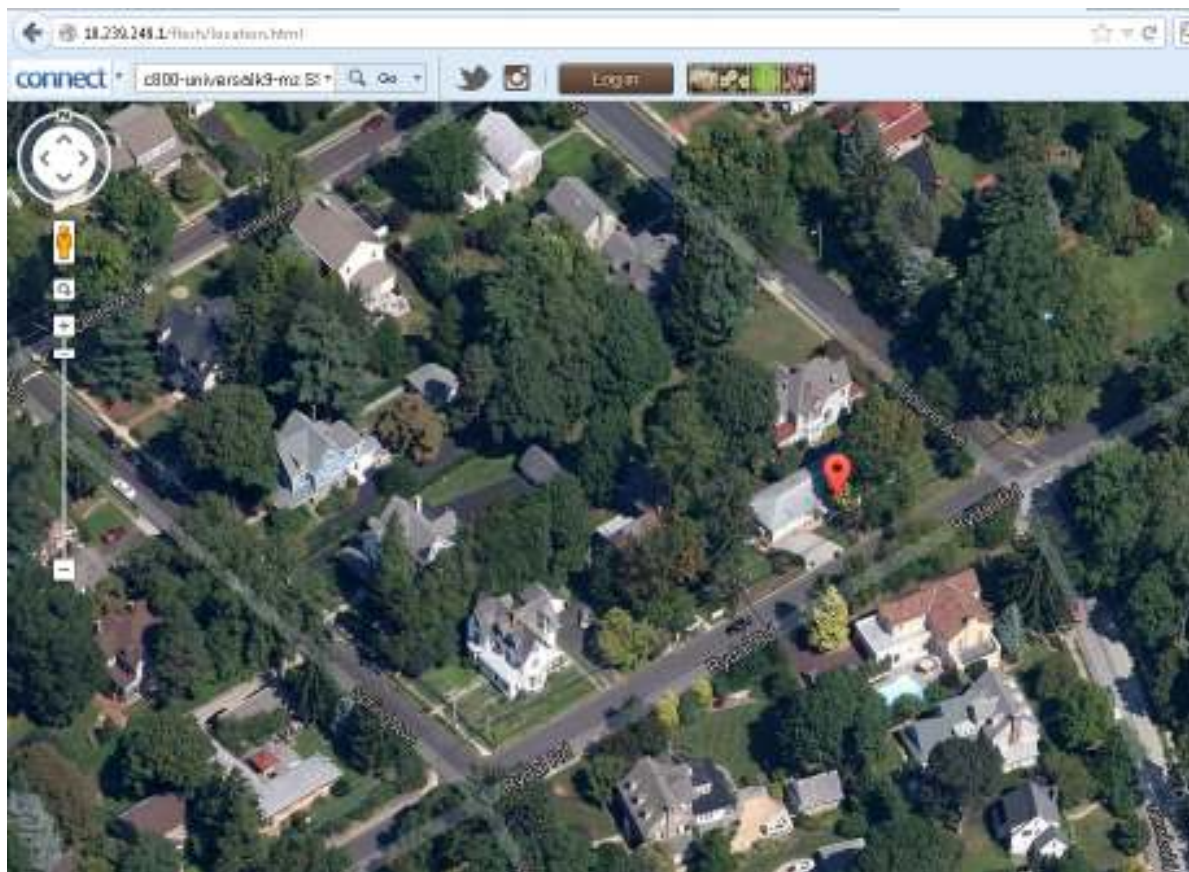
```
C819H2#
C819H2#sh run | s clock
clock timezone est -5 0
clock summer-time edt recurring
C819H2#
C819H2#sh run | i timestamps
service timestamps debug datetime msec
service timestamps log datetime localtime
```

Sample Application to Display the Geographical Location of an ISR via Web Browser

As seen in the previous two samples the Cisco ISR can be programmed to perform many functions. Determining the location of an ISR provides the ability to provide the basis for applications listed earlier (geo-fencing, asset tracking, etc.). This example provides a way to see the location of an ISR (and thus the vehicle, kiosk, etc.) displayed on a map from a web browser. The sample highlights other possibilities, such as displaying the path traveled on a map.

The method leverages a publicly available tcl script on the ISR that uses a Google Maps[®] API. When an html page is accessed via a simple URL from a Web browser, a map from google.com is displayed, with the location of the ISR shown. In this example, an administrator points their web browser to a URL consisting of the IP address (or DNS name) of the ISR followed by the location and name of the html page.

Access to the web page can be protected via username/password and only allowed from specific addresses or networks (for example only within the private network). However, for the graphical mapping to function, the ISR itself must be able to reach the Internet (to communicate with Google Maps[®]). Below is a display from this example:



Google and the Google logo are registered trademarks of Google Inc., used with permission.

The following steps are required:

- Install and configure an ISR G2 with active LTE connection
- Configure the GPS function in IOS and install the GPS antenna with direct line of sight to the sky
- Check that GPS coordinates are obtained successfully
- Download the script and complete the tasks outlined <https://supportforums.cisco.com/document/12018071/findmyrouterzip> (registering with Google[®] to use the API, editing one line of the tcl script).
- Install the edited findmyrouter.tcl script onto the ISR flash
- Configure the ISR to execute the tcl script
- Access the ISR's location on the map via Web browser

As the first 3 steps are shown in the previous example, below are the details for the remaining steps:

Download the script and complete the tasks outlined (registering to use the API, editing the tcl script)

The zip file contains both the tcl script and a document detailing how to register in order to use the map API, then what line to edit in the tcl script (and how to edit it). <https://supportforums.cisco.com/document/12018071/findmyrouterzip>

Install the edited findmyrouter.tcl script onto the ISR flash:

Copy the edited tcl file onto ISR flash (via USB drive, TFTP, FTP, etc.), similar to copying an IOS image to flash.

C819H2#copy tftp flash:

```
Address or name of remote host []? 10.239.249.2
Source filename []? findmyrouter.tcl
Destination filename [findmyrouter.tcl]? <hit enter>
Accessing tftp://10.239.249.2/findmyrouter.tcl...
Loading findmyrouter.tcl from 10.239.249.2 (via Vlan1): !
[OK - 4930 bytes]
```

Configure the ISR to execute the tcl script then use access the ISR's location on the map via Web browser

From the IOS command line interface:

```
conf t
event manager directory user policy "flash:/"
event manager policy findmyrouter.tcl type user
end
```

Check that the tcl script is running:

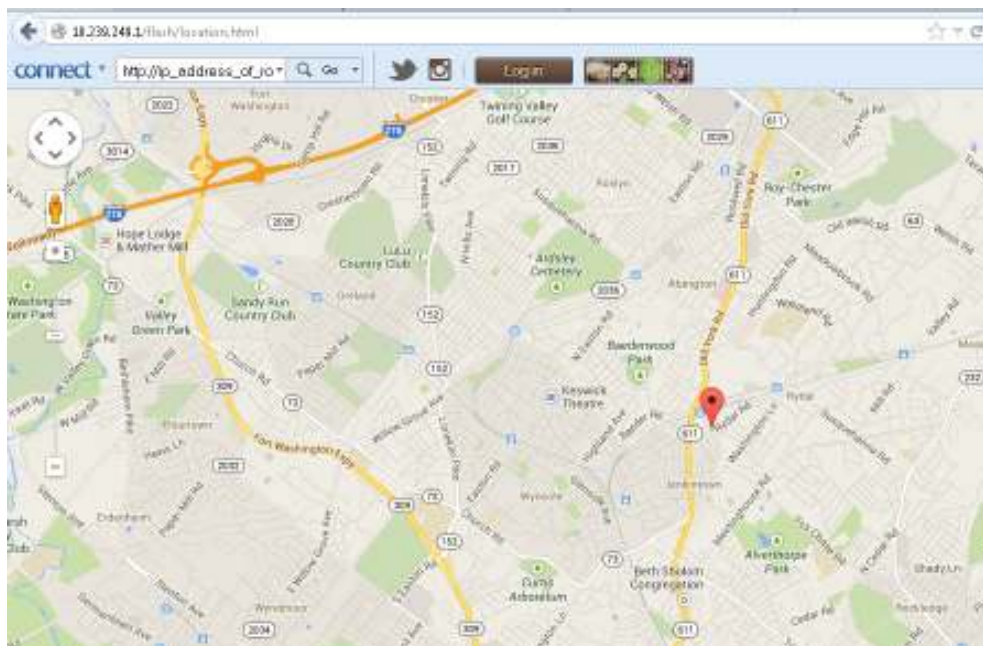
```
C819H2#sh event man pol reg
No. Class Type Event Type Trap Time Registered Name
...
2 script user timer cron Off Tue Dec 10 10:21:39 2013 findmyrouter.tcl
name {findmyrouter.tcl} cron entry {0 * * * *}
nice 0 queue-priority normal maxrun 55.000 scheduler rp_primary Secu none
```

The tcl script will create a file on flash called "location.html"

```
C819H2#dir flash: | i location
248 -rw- 1048 Jan 3 2014 20:00:00 -05:00 location.html
```

Access the ISR's location on the map via Web browser

A userID and password should be set on the ISR for this, and the web page will prompt for this. The URL is the IP address (or domain name) of an interface on the ISR, followed by /flash/location.html: 10.239.249.1/flash/location.html



Sample Application for GPS-based Geo-Fencing

This ISR app will periodically monitor the GPS location of the ISR. If it is more than a specified distance from the ISR's expected location (e.g. home base) it will perform one or more of the following actions:

- Default: Log a message (syslog, console, etc. based on logging definition) including
 - o ISR hostname, timestamp, "out-of-bounds" text, and current GPS location
- Optional: Send a text message with the same information to a defined phone number
- Optional: Disable the LTE interface (via the "shut" command)
 - o This is included for example, and not necessarily recommended for field use

The full documentation and app itself are available at <https://supportforums.cisco.com/document/12150821/geo-fence>

Operations: When the app is enabled (tcl script loaded and configured to run) the following occurs every 10 minutes:

- The first period: Check to see if the home latitude/longitude coordinates are defined.
 - o If so, set these as the home location (will survive reboot, power off/on)
 - o If not, use the current GPS coordinates (will survive reboot, power off/on)
- Subsequent periods: Check if lat or lon are => X seconds from home lat/long
 - o X = 4, unless the `_boundary` variable is defined, then that value is used
 - o If not, do nothing (device at same location or within acceptable distance)
 - o If so, perform the actions as configured (devices is out of bounds)
 - Log a message with ISR hostname, timestamp, "out-of-bounds" text, and current GPS location (the default action, always done)
 - Send a text message with the above information to the phone number as configured (optional)
 - Disable the LTE interface (optional, via IOS "shutdown" interface)

Considerations:

- The app will handle no GPS coordinates (e.g. GPS antenna not connected); lat/lon appear as 0 0 0 in that case. Unless the ISR's home location is in the Gulf of Guinea (Atlantic Ocean), this will cause an "out of bounds" situation.
- The optional LTE interface disablement should be carefully considered. If there is no alternate access, a visit to the ISR location to re-enable (via ISR command) may be needed. However, the ISR can still accept SMS; there is another app that allows ISR configuration via text message. These can be used together on the same ISR.
- The app runs every 10 minutes. It can be set to a lesser or greater value (testing etc.). Example, to change frequency from 10 to 1 minute, modify the tcl script 1st line from `cron_entry "0,10,20,30,40,50 * * * * *` to `cron_entry " * * * * *`

Requirements

1. ISR G2 with an LTE eHWIC or an 819 series ISR with embedded LTE
2. A minimum IOS level of 15.3(3)M2
3. An active SIM inserted with appropriate IOS configuration, and (optionally) knowledge of the phone number where text messages are to be sent
4. An external GPS antenna connected to the ISR, with line-of-sight to the sky.
5. `gps_geofence.tcl` script loaded onto ISR and properly configured

Installation

- 1) Insert an external GPS antenna connected to the ISR. An 819-4G is shown below.



- 2) Enable GPS
 From IOS configuration mode:

```

controller Cellular <number> ("number" from running config or "show ip int brief")
lte gps mode standalone
lte gps nmea ip
      
```

 (note that for ISRs using eHWIC/GRWIC, the "ip" variable is omitted)
- 3) Download the `gps_geofence.tcl` script from <https://supportforums.cisco.com/document/12150821/geo-fence>
- 4) Copy `gps_geofence.tcl` script onto the ISR flash via USB drive, TFTP, FTP, etc.
- 5) (optional) Configure the following variables as needed:
 - `_homelongitude x y z east|west` (x y z coordinates are degrees minutes seconds and either east or west, as found via the ISR "show cell x gps" command output)
 - `_homelatitude x y z north|south` (x y z coordinates are degrees minutes seconds and either north or south, as found via the ISR "show cell x gps" command output)

Both of the above should be included, or neither included. If included, this will be the "home location". If not included, the script will set the "home location" as the location seen the first (or next) period the script runs. If the lines are present then removed, the next time the script runs it will reset the "home location" and keep this value. To reset it, reinsert the definitions.

- **_boundary x** (x is the threshold, the number of GPS seconds from the “home location” for either latitude or longitude. If reached for either, action (as defined) is taken. If not defined, the default is 4 (a range of 300-450 feet in the continental U.S.)
- **_cellinterface cellular 0|0/x/0** (0 for 819, 0/x/0 for LTE eHWIC, where x is the slot number (from output of IOS command “sh ip int brief | i Cell”, e.g. 0/0/0). Note that there must be a space between “cellular” and the port address here!)
 - o This optional value is set if a text message is to be sent when “out of bounds”, and if the option to shut down the LTE interface is desired.
- **_onenumber xxxyyyzzzz** (xxxxyyyzzzz is the phone number that will receive the text the “out-of-bounds” alert text.)
- **_shutdown** (this optional variable has no additional value/parameter. By simply defining it, the app will shut down the LTE interface if the ISR is “out of bounds”. This option should be carefully considered before being enabled.

6) Define the default location and the tcl script itself
event manager directory user policy "flash:/"

event man pol gps_geofence.tcl type user

7) An example of a complete configuration

```
event manager environment _cellinterface cellular 0
event manager environment _onenumber 5551234567
event manager environment _shutdown
event manager environment _homelatitude 40 7 19 north
event manager environment _homelongitude 74 58 48 west
event manager directory user policy "flash:/"
event manager policy gps_geofence.tcl type user
```

Below are screen shots of the text messages received by a smartphone, sent by the ISR. The 1 minute out-of-bounds frequency is due to the script being modified for testing. The out-of-bound message frequency defaults to 10 minutes.



Sample Application for Streaming GPS NMEA Information via IP to a Location Service

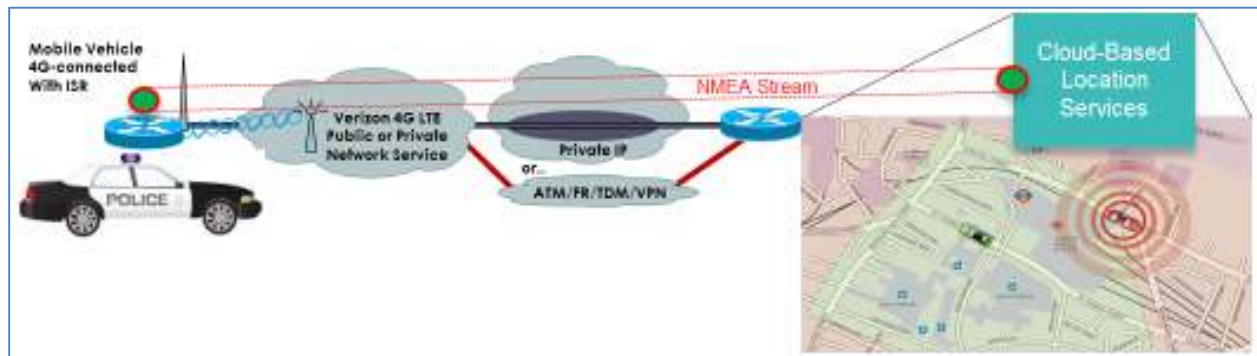
NMEA (National Marine Electronics Association) has developed a data format standard for PVT (position, velocity, time) location-based reporting. The information is formatted as a single ascii text line, which is sent once every reporting period. This standard has become popular for real-time location-based reporting and is also commonly used for land-based systems.

This ISR app sends location information with timestamp in NMEA format once per second. The information is sent in a UDP packet to an IP address and port number that are configured via two required variables. The app is triggered by the ISR cellular interface coming up (active), and then it continuously sends the location information to the server. To use the app, install the small tcl file, enable GPS NMEA, and enable the EEM application in the ISR configuration (shown in a subsequent section below).

The following is an example of the data sent:

```
09:51:23.303475260 108.16.125.2 60646: 65 $GPRMC,134858.0,A,4006.152961,N,07507.354396,W,0.0,,180614,,A*5A
```

Below is a diagram depicting a vehicle use case.



The full documentation and application are available at

<https://supportforums.cisco.com/document/12239371/gps-nmea-streaming-over-udp>

Considerations:

- Existing systems integrators offer services or products to receive NMEA streams and provide mapping, reporting and analytics. The app should allow an ISR with LTE eHWIC or 819 with LTE to work with these products and services.
- As the location information is acquired from GPS, a supported GPS antenna with direct line of sight to the sky needs to be connected to the ISR.
- If line of sight to the sky is lost, or the GPS antenna is disconnected, the ISR will continue to send location data to the server. NMEA packets will still be received with latitude/longitude GPS coordinates of 0,0,0 (degrees, minutes, seconds).

Requirements

1. ISR G2 with an LTE eHWIC, or an 819 series ISR with embedded LTE and a minimum IOS level of 15.3(3)M2
2. An active SIM inserted with appropriate IOS configuration, and (optionally) knowledge of the phone number where text messages are to be sent
3. The NMEA Streaming tcl script loaded onto ISR flash and configured (as shown below), and the EEM applet defined in the IOS configuration.
4. Both main and diversity LTE antennas appropriately connected.
5. A GPS antenna connected to the ISR GPS port, with line-of-sight to the sky. This can be the dedicated Cisco GPS antenna (GPS-ACT-ANTM-SMA) or the Cisco single outdoor LTE/GPS antenna (SKU to be available summer 2014).

Installation

- 1) Ensure that the ISR is operational (enabled SIM installed, appropriate IOS version, configured, LTE antennas installed with at least one extension cable, and GPS antenna installed).
 - a. Guidance for the above is available via the documents located here:
www.cisco.com/c/en/us/support/interfaces-modules/high-speed-wan-interface-cards/products-installation-and-configuration-guides-list.html
- 2) Enable NMEA GPS function on ISR (IOS configuration mode).


```
controller cellular 0/X    (where X is the LTE eHWIC slot number, or cellular 0 for 819)
lte gps mode standalone
lte gps nmea                (note that for 819s, "ip" is added to the end of the line)
```
- 3) Enable AAA on ISR to allow the NMEA app access to ISR enable commands (IOS configuration mode).


```
aaa new-model
aaa authentication login nologin none
aaa authorization exec nologin none
```
- 4) Download the stream_NMEA2.tcl script from
<https://supportforums.cisco.com/document/12239371/gps-nmea-streaming-over-udp>
- 5) Copy **stream_NMEA2.tcl** script onto the ISR flash via USB drive, TFTP, FTP, etc. (IOS enable mode)
- 6) Define the destination IP address & port number, default tcl location, and tcl script (IOS configuration mode).


```
event manager environment server "a.b.c.d" (with quotes where a.b.c.d is an IPv4 address)
event manager environment port "X" (with quotes where X is an integer, not a well-known port)
event manager directory user policy "flash:/"
event manager policy stream_NMEA2.tcl type user
```

- 7) Define the EEM applet that calls the tcl script above (IOS configuration mode).


```

event manager applet NMEA
event syslog pattern "LINEPROTO-5-UPDOWN: Line protocol on Interface Cellular[0-9V]+, changed state to up" maxrun 31536000
action 010 cli command "enable"
action 020 syslog msg "NMEA streaming starting now"
action 030 cli command "tclsh flash:stream_NMEA2.tcl $server $udp_port"
      
```
- 8) Reset the LTE interface via configuration shut/no shut, LTE modem power cycle, or ISR reload during planned maintenance (IOS configuration mode).
 - a. IOS commands from enable mode: `configure terminal`, `interface cell 0/x/0` (where x is the ISR slot number for 1900/2900/3900, or cell 0 for 819), `shut` (wait 5 seconds), `no shut`, `end`. (Operational in a few seconds)
 - i. Requires ISR terminal access other than through the LTE interface
 - b. IOS commands from enable mode: `configure terminal`, `service internal`, `end`, `test cellular 0/x/0 modem-power-cycle` (where x is the ISR slot number for 1900/2900/3900, or cell 0 for 819) (IOS configuration and enable modes)
 - i. Can be done over LTE, but takes 1 minute to return to operation

Example: shut/no shut the ISR LTE interface to initiate the script:

```

C1921_pod4#conf t
Enter configuration commands, one per line. End with CNTL/Z.
C1921_pod4(config)#int cell 0/0/0
C1921_pod4(config-if)#shut
C1921_pod4(config-if)#
*Jun 18 13:27:37.989: %LINK-5-CHANGED: Interface Cellular0/0/0, changed state to administratively down
*Jun 18 13:27:38.989: %LINEPROTO-5-UPDOWN: Line protocol on Interface Cellular0/0/0, changed state to down
C1921_pod4(config-if)#no shut
C1921_pod4(config-if)#end
C1921_pod4#
*Jun 18 13:27:45.001: %SYS-5-CONFIG_I: Configured from console by cisco on console
C1921_pod4#
*Jun 18 13:27:46.329: %LINK-3-UPDOWN: Interface Cellular0/0/0, changed state to up
*Jun 18 13:27:47.329: %LINEPROTO-5-UPDOWN: Line protocol on Interface Cellular0/0/0, changed state to up
*Jun 18 13:27:47.349: %HA_EM-6-LOG: NMEA: NMEA streaming starting now
*Jun 18 13:27:47.405: %LINEPROTO-5-UPDOWN: Line protocol on Interface Tunnel0, changed state to up
*Jun 18 13:27:47.417: %SYS-5-CONFIG_I: Configured from console by on vty1
*Jun 18 13:27:47.529: %SYS-5-CONFIG_I: Configured from console by on vty1
*Jun 18 13:27:47.533: %SYS-5-CONFIG_I: Configured from console by on vty1
*Jun 18 13:27:48.365: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback7, changed state to up
C1921_pod4#
      
```

Sample NMEA information posted to the server from the NMEA app on this ISR: (IP address of ISR hidden, first 2 octets replaced with X and Y)

```

09:51:03.322475941 X.Y.125.2 60646: 65 $GPRMC,134838.0,A,4006.152992,N,07507.354367,W,0.0,,180614,,,A*5E
09:51:04.303889374 X.Y.125.2 60646: 65 $GPRMC,134839.0,A,4006.152990,N,07507.354370,W,0.0,,180614,,,A*5B
09:51:05.297133729 X.Y.125.2 60646: 65 $GPRMC,134840.0,A,4006.152991,N,07507.354374,W,0.0,,180614,,,A*50
09:51:06.297635238 X.Y.125.2 60646: 65 $GPRMC,134841.0,A,4006.152987,N,07507.354378,W,0.0,,180614,,,A*5A
09:51:07.313955173 X.Y.125.2 60646: 65 GPRMC,134842.0,A,4006.152983,N,07507.354383,W,0.0,,180614,,,A*59C
      
```

LTE GPS Frequently Asked Questions

Q) I installed the Web browser location app, but it did not generate the location.html file. Why?

A) The findmyrouter.tcl script creates or updates location.html at the top of each hour. When first installed and configured, it will wait until the top of the next hour to create the location.html file. The tcl file can be edited to execute more frequently by changing the first line. For example to execute every minute, edit the portion `cron_entry "0 * * * *` to `cron_entry "* * * * *`

Q) When will GPS be supported on ISRs with LTE?

A) Official support will coincide with ISR GPS antenna general availability, December 2013

Q) How do I order the GPS antenna?

A) Via CCW on cisco.com as a spare part (GPS-ACT-ANTM-SMA=)

Q) Does Cisco sell a combination LTE/GPS antenna?

A) Not currently, but may in the future. One consideration is that the best placement for the LTE antenna may not be where the GPS antennas has direct line of sight to the sky

Q) Can non-Cisco LTE/GPS antennas be used with the ISR G2 and CGR 2010 devices?

A) The antenna may physically connect and function, but it is not support by Cisco TAC.

Q) What are standalone GPS and assisted GPS?

A) Assisted GPS is where the coordinates are calculated more quickly and potentially more accurately by two-way communications with a service providing GPS coordinate processing. Standalone GPS is where the GPS device calculates its location/coordinates itself (based on the multiple received satellite information).

Q) What is active GPS?

A) Active GPS is where GPS signal is amplified and/or processed to provide a cleaner more powerful signal. This is done within the device itself, so still a standalone GPS function.

Q) Is the ISR LTE GPS antenna providing standalone GPS or assisted GPS?

A) The ISR GPS antenna supports active GPS, which is standalone GPS along with amplifying the received signal; location is calculated by the ISR itself, based on the coordinates from multiple satellites.

Q) Can the ISR LTE GPS function be used with Verizon Mobile Private Network (MPN)?

A) Yes, the active GPS function is internal to the ISR, and the results can be accessed or provided from the ISR via a network with IP reachability. MPN provided IP reachability as if the ISR were directly attached to a private network.




Americas Headquarters
Cisco Systems, Inc.
San Jose, CA

Asia Pacific Headquarters
Cisco Systems (USA) Pte. Ltd.
Singapore

Europe Headquarters
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