LoRaWAN Range Testing

RM1xx Series

Application Note *v1.0*

Introduction

The RM1xx series from Laird offers a powerful, convenient solution for long-range Enterprise IoT (EIoT) deployments using the LoRaWAN specification. Laird innovatively also combines Bluetooth® v4.0 with LoRaWAN™, the emerging standard in Low Power Wide Area Networks (LPWAN), into one module.

LoRaWAN claims to support a long range capability where a single gateway can cover a whole town and many square kilometers; but just what sort of range can you expect from a LoRaWAN module such as the Laird RM1xx series? Ten miles or 15 kilometers is the often-quoted range; but is that achievable?

The goal of this document is to demonstrate the following:

- To determine if a 15 kilometer line-of-sight range is possible with the RM1xx series. For our testing we used the RM186 version (a CE approved version for the 868 MHz frequency band for European operation).
- To show what settings are required to achieve the 15 kilometer range.

Overview

To test for a 15 kilometer line-of-sight range, it's first necessary to find a location that offers the ability to maintain line-of-sight over such a long distance. This is obviously not possible in a city. Also, height is everything when looking for range; for our test, we located the required LoRaWAN gateway on a hill but, in the real world, locating the gateway antenna on a mast or tall building achieves similar results.

Out test plan required the following:

- One vehicle fitted with a Multitech Conduit gateway and an externally-mounted antenna. This vehicle remained stationary on the hill.
- A second vehicle fitted with a DVK-RM186 development board and an externally-mounted antenna. This vehicle drove to various locations known to have a line-of-sight with hill and the stationary vehicle.
- At each location, one or more LoRaWAN packets sent from the RM186, received by the gateway, and retransmitted back to the RM186 via a loopback in Node Red running on the Conduit gateway.

Test Setup

The following hardware/software was used for the test:

- DVK-RM186-SM development kit
- Laird Phantom antenna (Laird part # TRA6927M3NB-001) with SMA to U.FL pigtail
- UWTerminalX Terminal Program
- **lora.rftest.sb** *smart*BASIC sample program available from the RM1xx Github page
- Multitech Conduit AEP Gateway
- Multitech MTAC-LORA-868 card required for the Conduit

- RP-SMA adapter to allow the Laird Phantom antenna supplied with an SMA to be used with the Conduit gateway.

We chose a viewpoint/carpark near Priddy, Somerset, UK, on the southern flank of the Mendip Hills. This location overlooks the Somerset levels and provided plenty of scope for achieving a 15 kilometer line-of-sight range tests. A link to the location on Google maps can be found here: https://goo.gl/maps/GECv2KG4Cm32.

The Somerset levels extend south and south west from this location. The weather conditions for the test were heavy rain and low clouds.

Gateway Setup

We used a Multitech Conduit gateway fitted with an MTAC-LORA-868 card. It was configured in network server mode and was running the Node Red application. This allowed a self-contained test without requiring an onward TCP/IP network connection. We configured Node Red to output received packets from the RM186 to its debug tab as well as loop back the packet to the RM186. We used a Laird mobile antenna (part number TRA6927M3NB-001) attached to the vehicle with a Laird magnetic mount (part number G8SMI). This antenna is rated at 0 dBi for 698-960 MHz with a 90% efficiency (Figure 1 and Figure 2).

Figure 1: Gateway setup

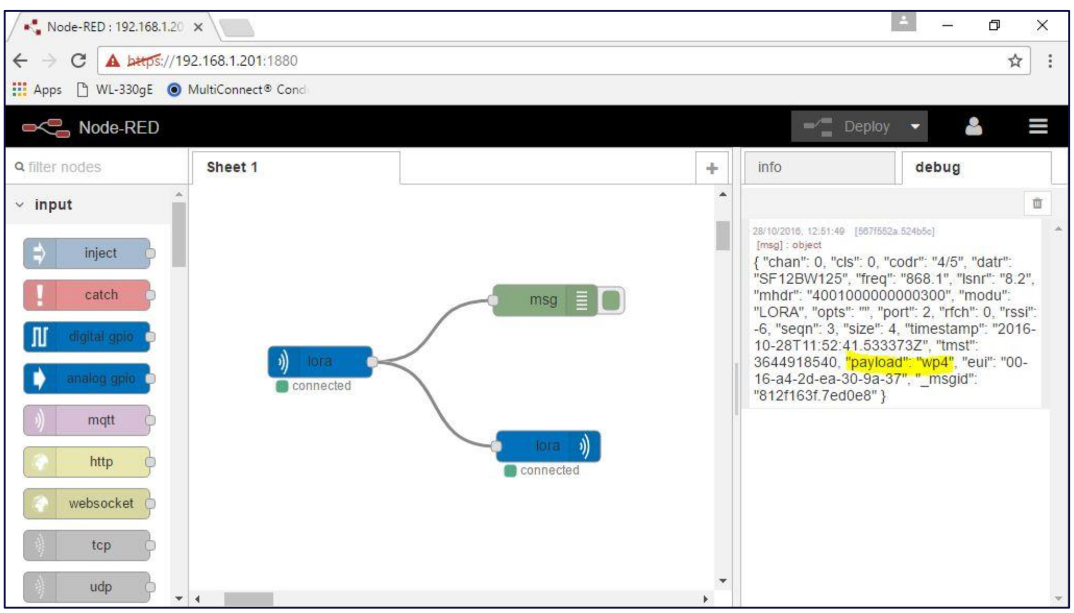

Figure 2 Node Red setup

For further information on setting up the Multitech Conduit, refer to the RM1xx setup guides. Links are available in the Resources section of this document.

RM186 Development Board Setup

For our test, the RM186 development board was located in the second (mobile) vehicle with the same Laird mobile antenna as used with the gateway. The development board's antenna was disconnected and the external antenna connected to the board's U.FL connector via an SMA to U.FL pigtail (Figure 3).

Figure 3: RM186 development board setup including antenna mounted on car roof

The RM186 was loaded with the RFTest *smart*BASIC program. This program configured the module to send packets at the maximum Tx power supported on the RM186 (14 dBm) and using the highest spreading factor (SF12/DR 0) for maximum range with adaptive data rate (ADR) switched off. At each of 20 locations, a packet indicating the location was sent. For example, the payload WP2 indicated test location number two. A message coming back from the gateway was confirmed by the Tx sequence complete message along with the received RSSI and SNR. A handheld GPS was used to record each test location.

Note: RM1xx sample applications are available from the following link: https://github.com/LairdCP/RM1xx-Applications.

Note: **It is very important to have ADR off when range testing.** Because ADR allows the gateway to change the spreading factor and transmit power the RM186 uses based on the signal quality of the received packets. If you start range testing near the gateway with ADR on, the gateway sees a good signal from the RM186 and may decide to instruct the RM186 to change its spreading factor or transmit power. If you then move the RM186 further away from the gateway, it may no longer be able to contact the gateway, leading you to believe the range is poor. The RFTest sample application used in this test has ADR set to off.

This also might apply to any LoRa application that makes use of a mobile node. Because of this, we recommend that ADR be switched off for an application that is mobile in nature.

Figure 4: Logging data from the RM186 development board and noting the location on a GPS

With the RFTest.sb *smart*BASIC program loaded, we ran it by sending the following from our UWTerminalX terminal program.

lora	To run the *smart*BASIC program
lora join 1	To initiate a join to the LoRaWAN network using OTAA

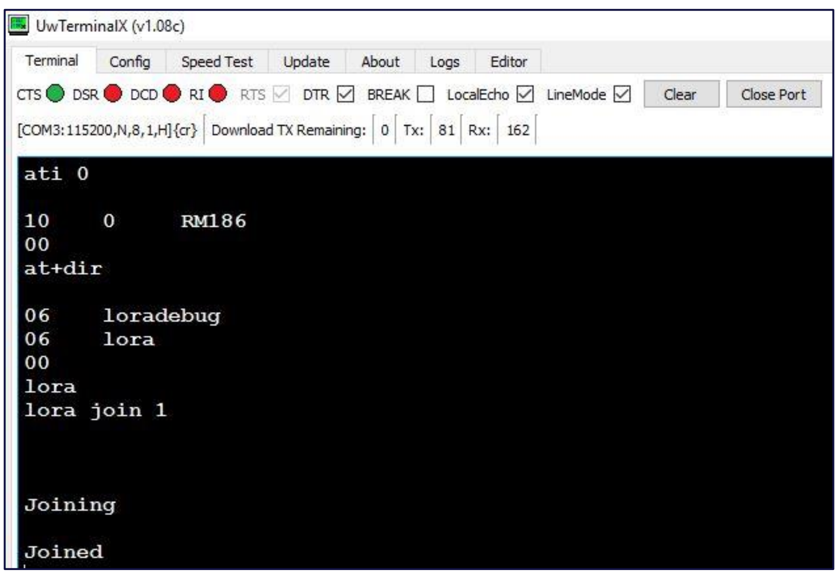

Figure 5: Joining the network

Once joined to the network a packet was sent using the command below:

```
lora send wp1 0
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Where wp1 is the packet payload and represented the location under test as recorded by the handheld GPS.

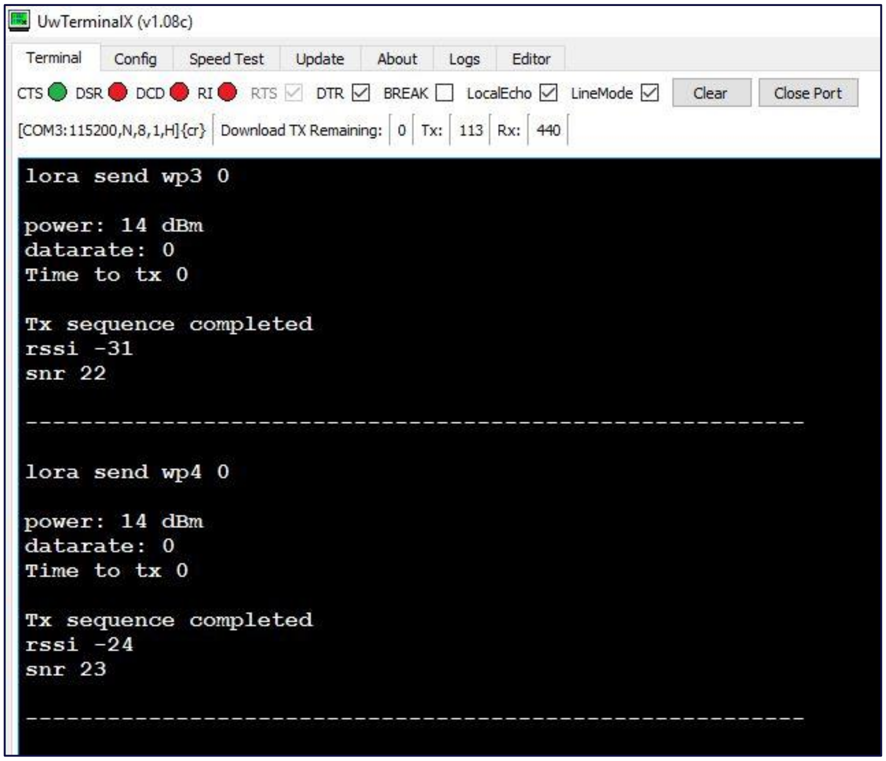

Figure 6: Sending packets from the RM186 development board

The transmit power and LoRaWAN data rate are confirmed and the RSSI and SNR of the returning packet from the gateway displayed when the transmission sequence has been completed.

Results

The following figures are samples of the successful test locations, each having seen a successful packet exchange. You can see that, given a good line-of-sight, the RM186 LoRaWAN module is capable of sending data at least 15 kilometers (Figure 7, Figure 8, and Figure 9).

It may be possible to achieve a greater range, especially with a higher gain gateway antenna but this test was limited by the terrain.

With each test location marked by the GPS and the packet exchange confirmed, we were then able to plot the range and elevation using the free online RF Line of Sight Tool at http://pathrf.com/.

For best range performance, line-of-sight or near line-of-sight is desirable. Elevating the gateway antenna (for example, on a building or a mast) is recommended along with a site survey to determine the best location to site the gateway antenna.

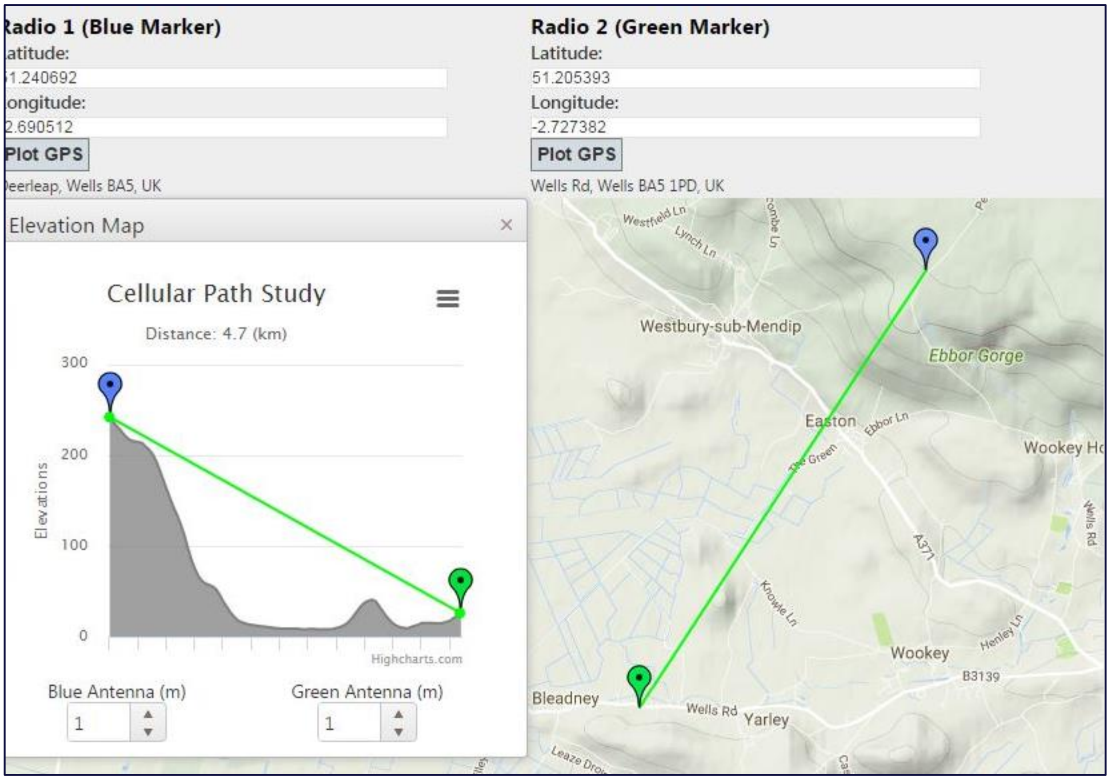

Figure 7: 4.7 km successful test

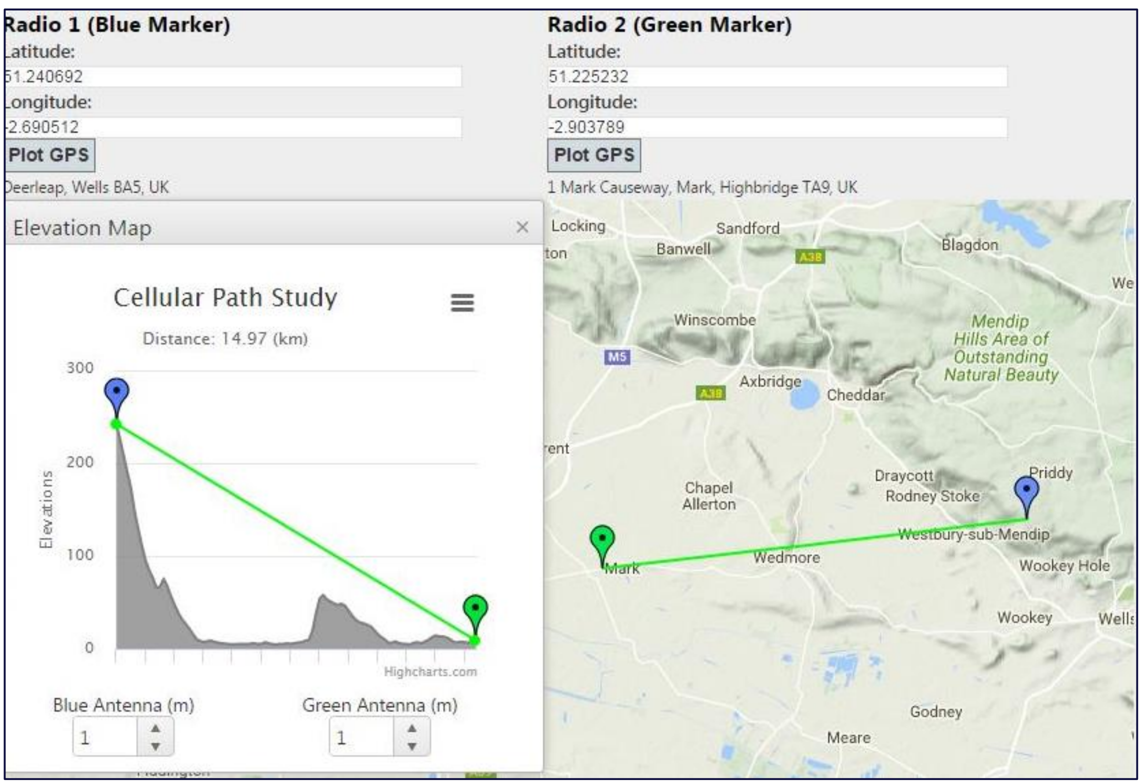

Figure 8: 14.97 km successful test

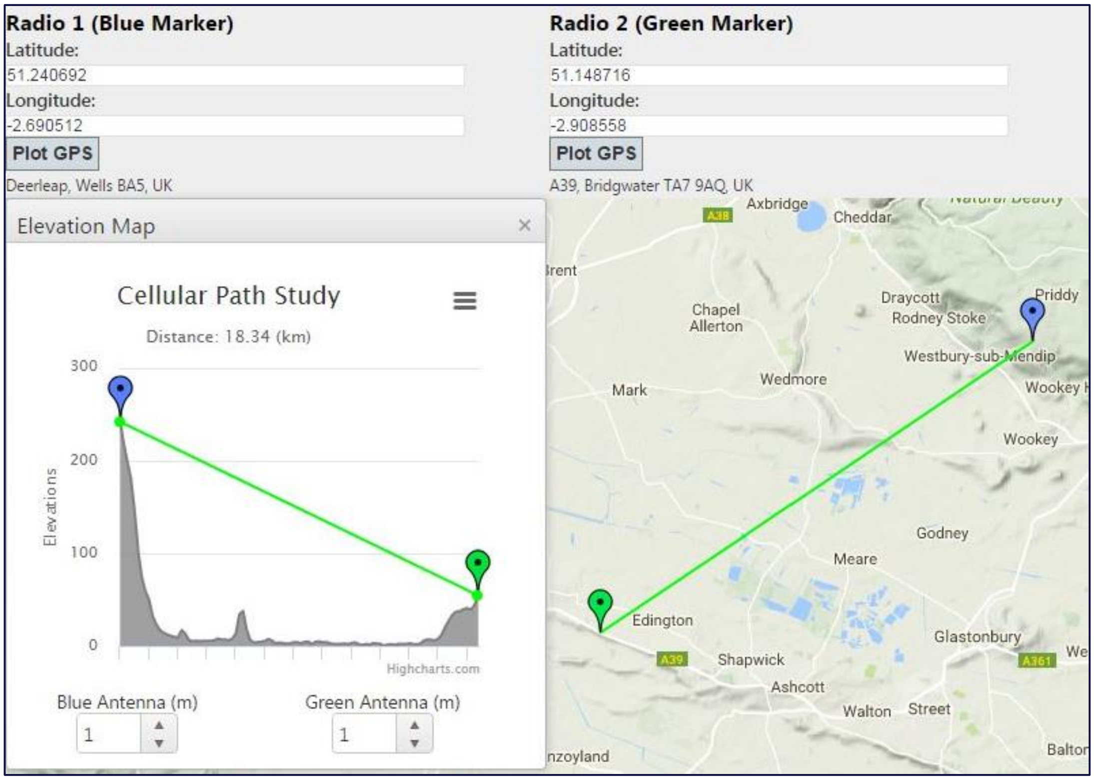

Figure 9: 18.34 km successful test

It should be noted that hills effectively block the signal and are the main limiter of range.

Range within an urban environment was beyond the scope of this test but 1-2 kilometers (depending on the environment) should be possible in an urban environment with some degree of building penetration.

Resources

RM1xx LoRaWAN Module and Development Kits – http://www.lairdtech.com/products/rm1xx-lora-modules

Line of Sight Calculator – http://pathrf.com/

Multitech Conduit Gateway – http://www.multitech.co.uk/brands/multiconnect-conduit

RM1xx Sample Applications – https://github.com/LairdCP/RM1xx-Applications

Laird Mobile Antenna – http://www.lairdtech.com/products/tra6927m3nb-001

RM1xx Setup Guides – http://www.lairdtech.com/products/rm1xx-lora-modules#documentation-tab

Revision History

Version	Date	Notes	Approver
1.0	19 Dec 2016	Initial Release	Mark Duncombe