# User Manual

For the

## PM-L

## LTE CAT 1/3G Wireless Tracking Device

August 2018



**R1.0**

The information presented in this document is strictly confidential and contains trade secrets and other confidential information that are the exclusive property of M-Labs Technologies

| Author | Revision | Changes | Date |
|--------|----------|---------|------|

| | 1.0 | Initial version | 2018 Aug 3 |
|---|---|---|---|
| | 1.1 | Updated start up banner and edits | 2018 Aug 7 |
| | | | |
| | | | |

# Contents

# 1   Introduction

The PM-L is a self-contained LTE CAT1/3G wireless tracking device targeting trailers. The device combines GPS location with LTE/GSM/GPRS/WCDMA connectivity. It is primarily a location reporting device that responds to requests (user, server) and events generated by timers, geofences, sensors, etc. Data reports consist of a single record that contains all location data and system status.

The device comes pre-configured and ready to use from the factory. The PM-L appears to a user or a server application as a single endpoint device. It can be queried, updated and configured either through a serial connection, or an over the air LTE or WCDMA IP connection, or through SMS messaging. The PM-L presents itself over these connections as an enhanced cellular modem with attached functional elements. These elements include:

- GPS location engine
- 2 General Purpose Bidirectional I/O (GPIO) pins
- 1 Tamper
- 1 1-Wire Bus Interface
- 3.3V Power out for Peripheral Sensors
- Serial UART port
- Input voltages and Battery Voltage monitor
- Timers
- Watchdog lockup protection
- Motion detection
- Power Management

Access to these elements and general-purpose interfaces is done through an extended AT command set. Configuration parameters are stored to flash memory and are automatically used on the next power up event. For more details, please reference the AT Command document.

This device is designed based on the Quectel EC21-A (4G LTE CAT 1/3G fallback,) baseband module. Antennas for cellular and GPS are internal to the device.
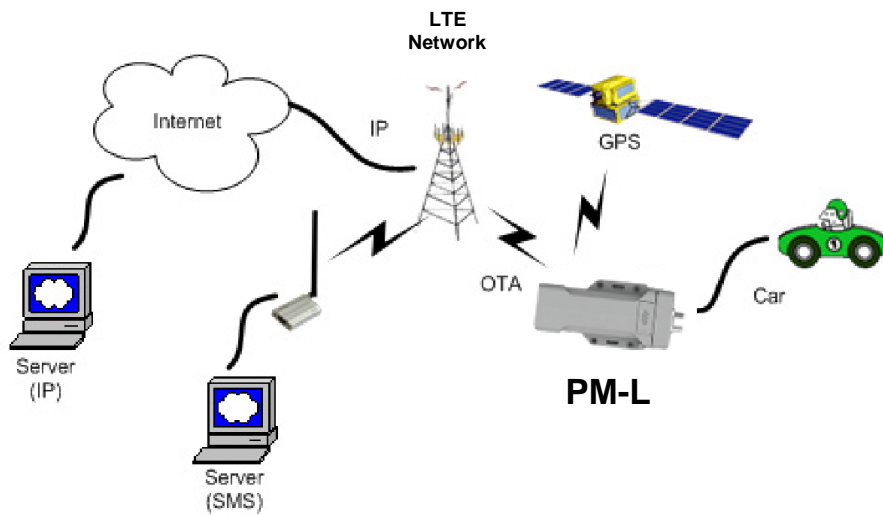
LTE
Network

Internet

IP

GPS

OTA

Car

PM-L

Server
(IP)

Server
(SMS)

*Figure 1*

## 2  Hardware Design

### 2.1 Basic Hardware

| Items | Requirement |
|---|---|
| Baseband Module | Based on Quectel EC21-A baseband module |
| Air Interface | Support for LTE B12, B4, B2 WCDMA B2, B4, B5 |
| Frequency | B2(MHZ):TX(1850-1910)    RX(1930-1990)<br>B4(MHZ): TX(1710-1755)    RX(2110-2155)<br>B12(MHZ): TX(699-716)       RX(729-746)<br>B5 (MHZ): TX (824-849)      RX (869-894) |
| Antenna | Internal single antenna |
| UIM requirement | Support: 3FF SIM interrupt mode<br>No Support: Hot plug/unplug |
| GPS Antenna | Dedicate high performance ceramic antenna |
| Power Inputs | 12V DC Input（1.2A max current）<br>Main/Aux/Solar inputs |
| Interface<br>Voltage/Battery Monitor<br>Build in battery manager<br>Dedicate Timers | UART TX/RX<br>GPIO1 and GPIO2<br>1-Wire Bus Interface<br>3.3V Power out<br>Internal analog input scaled |
| Watchdog | Supported |

| Motion Detect | GPS/G-Sensor |
|---|---|
| **LED** | 3 LED's (Red, Green, Orange) |
| **Battery** | Built in battery（4400mAh Lion） |
| **Working Time** | > 40 hours (Continuously On)<br>> 250 days Standby |
| **Power switch** | No |
| **Power Cable color** | 12 colors |
| **Power Cable connector type** | 12 pin |
| **Power Consumption** | < 5Watts |

The PM-L provides support for specialized hardware features through extended AT commands. The features supported include the following.

## GPS

GPS location functionality is provided by the device GPS receiver. NMEA GPS records can be extracted in real time from the unit via the UART connection using special debug commands that are outside the scope of this document.

## GPIO

The GPIO pin, is presented to the external environment on the main connector. It is a general purpose bidirectional line capable of providing system interrupts to generate a report or drive logic levels to external devices. This line is 3.3V logic level input or output with transient voltage protection and internal pull-up resistor. GP1 is intended to use for a Door open sensor.

## LED's

Three LED status indicators are provided to verify correct installation and operation. The status LEDs are color coded and directly convey the status of the cellular and GPS subsystems as described in the table below. Their valid operation also indicates operational status and power.

| LED | Function | Status |
|---|---|---|
| Red | GPS | **On: GPS satellites acquired and Locked**<br>**Flash Slow**: GPS satellite search is in progress<br>**Off: No power or GPS subsystem fault** |
| Green | GSM/GPRS Connection | **On: Indicates GPRS connection is made**<br>**Flash Slow**: GPRS subsystem initialized but no connection<br>**Flash Fast**: GPRS initialization in process<br>**Off: No power or GSM   subsystem fault** |
| Orange | battery charging | **Orange LED is Flashing to indicate charging** |

The PM-L provides user control allowing the LEDs to be extinguished once installation is verified. This feature reduces power and further conceals the PM-L from untrained parties

wishing to defeat its operation.

### UART

A UART is provided for AT command and data interaction and optionally for connection to peripheral sensors

### Relay Driver

A 500mA sink capable output pin is provided. This pin is meant to drive a relay coil indented to operate a door opening device.

### 1-Wire Bus Interface

The 1-Wire bus interface can be connected to sensors that support the 1-wire serial protocol such as Temperature sensors or driver identification.

### 3.3V Power Out

3.3V Power output is available to power peripheral sensors such a cargo sensor. The power is turned on only when the peripheral sensor is being read to save power.

### Input Voltage and Battery Voltage Monitor

The Input Voltage monitors and battery voltage monitor are internal analog inputs scaled such that the DC value of the voltage input pin to the PM-L system and internal battery voltage is measured. This value is scaled to span the most significant 8 bits of the A/D and consequently covers a scale from 0 to 32V for Input Voltage and 0 to 9V for internal battery voltage

### Timers

Timers resident on the baseband chip generate periodic interrupts for power down wakeup, watchdog support, report generation and other timer related functions. Report timers are supported by related AT command and cause generation of periodic reports.

### Watchdog

The Quectel EC21-A chipset provides internal software Watchdog. Also the PM-L includes an MCU that acts as a failsafe external watchdog.

### Motion Detect

Configurable through AT commands the unit can go to a low power mode when the main power is removed until motion is detected. Upon wakening, a report can then be generated, and the GPS enabled to detect drive events.

批注 [GE2]: To be updated…but do we really need this detail? Can we delete this section?

## *2.2 Certification and Safety*

| Items | Requirement |
|---|---|
| Drop Design | 1.2meter 6 direction standard drop test |
| Temperature Range | -20 to 65C Operation |
|  | -40 to +85 °C Storage |

| Humidity: | 20% to 90% Operation<br>10% to 95% Storage |
|---|---|
| Altitude: | -500 to +18,000m |
| Vehicle ISO Test | ISO 7637-2-2004; ISO 7637-3-2007; ISO 10605-2008; ISO 16750-2-2010 |
| FCC Certification | FCC 47 CFR Part 15 ,Part 2, Part 22, Part 24, Part 27 |
| Others Operator Requirement | Industry Canada/ PTCRB |
| ESD Requirement | 10KV non-Conductive |

批注 [GE3]: To be updated.

# 3  Software Features

## 3.1 Basic Software

| Items | Requirement |
|---|---|
| Network Interface | CAT 1 LTE: B2, B4, B12, WCDMA: B2, B4, B5 |
| IP Stack | Ipv4/IPV6 |
| Upgrade Method | Remote update / PC tool |
| Remote Update | Supported |
| Power Modes | Supported |
| AT Command | Supported |
| Report | Supported；3000 records |
| Driver | GPIO，LED，GPS，UART，3.3V out |
| GPIO | Interrupt for Door Open Detect |
| LEDs | GPS Status, Cellular Status, Power State |
| Watch Dog | Supported |
| Reset | Soft reset |
| Startup Banner | Supported |

## 3.2 Remote Update

The PM-L supports OTA field upgrades of the resident application. An over the air TFTP (Trivial File Transfer Protocol) connection is made over an IP connection. A replacement file is then transferred from a server to the PM-L and that file replaces the previous application image.

## 3.3 Auto Execute

The Auto Execute Utility copies the contents of file system.exf into system executable RAM and executes it from there. This file is the factory default application. Another file named custom.exf can be loaded into the file system.

Auto Execute will look first for a file named update.exf and load and execute that in place of custom.exf if it exists. If update.exf executes successfully, the previous copy of custom.exf is deleted from the file system and update.exf is renamed to custom.exf.

## 3.4 Power Modes

The PM-L device supports several power modes that are set by the power mode command. In full power mode the GPS is active and the cellular subsystem will maintain a persistent cellular connection whenever service is available. IP connection is maintained according to the configuration of the device.

The device can be put into several levels of low power mode whenever it runs on the internal backup battery, or if the external input voltage is low or if it is not moving depending on how the unit is configured through AT commands.

| Power Mode | Cellular | GPS |
|---|---|---|
| Full Power (Track) | On | On |
| Listen | On | Off |
| Stealth | Off | Off |

The device would return to full power whenever an event occurs that triggers a report. Those events include:

- Report timer
- GPIO change
- IP change
- Battery threshold
- Heartbeat
- Watchdog
- Power-up
- Motion Detected

Any hardware or software reset will return the device to full power mode.

## 3.5  Report

The PM-L captures data and forms a report record with that data. A report is a data structure containing all of the sensory and other typically useful data on the device. Reports are generated in response to specified events, such as periodic timeout, speed threshold, geo-fence crossing, etc., or in response to a Report Now command.

### Report Queuing

If a report trigger occurs while UDP connection is unavailable, it will be queued until connection becomes available and transmitted at such time. The only way report(s) can be lost is if too many reports are queued and the report-queue is overflowing. In such case the earliest report(s) will be discarded. The size of the queue can be configured via the Report Queue command.

### Ack'ed Mode

UDP is not a 100% reliable connection and occasional reports or command/responses may be lost. Since all commands have responses, the server can repeat any command to which there is no response. In order to assure reliable reception of reports, Arsenal devices can be configured either in Normal or Ack'ed mode to send the reports. In the Normal mode the reports are simply sent "as is" with no acknowledgment from the server. In the Ack'ed mode every report sent is expected to be acknowledged by the server by sending back an ACK message back. If acknowledgement is not received within the specified timeout, the report is re-sent. If the report is not acknowledged after the specified number of attempts, it is queued. If acknowledgement is received after the report is queued (i.e. past timeout of the last attempt), it is ignored.

Report is not considered "complete" until its acknowledgement is received. Thus, if report X is sent and report X+1 is triggered while waiting for acknowledgement of X, report X+1 will be queued until such acknowledgement is received and only then sent. The Arrow will attempt to re-send queued report(s) every time a new report is triggered. If there is more than one report queued, the reports will attempt to be sent in the order of triggering and only once the report is acknowledged, the next report is attempted. This assures that reports are sent and received in order.

Ack'ed mode assures that all reports are received, but adds overhead in time and data. Report that is not acknowledged is sent again and eventually will be queued and sent again. The number and frequency of re-tries is configurable via the Report Acknowledgement command.

### Event Report Format

Reports can be generated in either an ASCII representation of hex or as actual binary encoded hex. The reporting format is selected via Report Format command. Note that while the logical content of the report is the same in both representations, the size for an ASCII report is twice the size of actual numbers of bytes compared to binary representation.

## 3.6 Reset

There are a number of resets available on the device. Soft reset resets the baseband only by using an internal watchdog, while hard reset power cycles the whole device. There is also an option to reset the GPS sub-system only.

### Context Preservation

When a reset is caused by the Network Watchdog or by the Reset command (modes 0,1), the context of the system is being preserved and is restored after the reset. The context includes all the periodic timers, the report queue, the odometer, etc. This allows to reset the unit as a troubleshooting measure either periodically or due to Network Watchdog without losing reports that are already in the queue or are pending on running timers. Note that the reset process may cause 1-2min of inaccuracy in the timers and should not be considered as very precise.

## 3.7 Startup Banner

After a reset a startup banner is printed through the UART only. The format and content of the banner shown below:

```
PROD:  PUMA-L
IMEI:  353782069100085
ICCID: 89014103279453385701
MDL:   3025R01
BIN:   EC21AFAR05A04M4G
APP:   3.3.9
IO:    1.1.11
CFG:   0025 Puma/Jaguar-LTE/3G-ATT
IP:    "54.186.180.122",15030
LPORT: 17006
APN:   11583.mcs
SIM:   READY
```

# 4   Test Method

## 4.1 Hardware

| Test Item | Description |
|-----------|-------------|
| **Baseband Function Test** | • Power Input Test<br>• Power Consumption and Current Test<br>• Heat Dissipation Test<br>• UART Stability Test<br>• GPIO Level Test<br>• LED Stability Test<br>• Drop Down Test<br>• ESD Test<br>• High/Low Temperature Test<br>• Humidity Test |
| **RF Test** | • RF Performance Test<br>• GPS Performance Test<br>• Antenna Performance Test |

## 4.2 Software Test

**Test Environment Construct**

➢ Message Test environment
   1. USB dongle and PC as message server
   2. Send message to PM-L

➢ UDP Test environment
   1. Connect dongle to PC and create dialup as ip server
   2.  PM-L create IP connection to server

➢ UART Test environment
  1. Connect PM-L to pc with com serial cable
  2. Open Terminal tool and send at command
  3. Response can be shown at terminal window
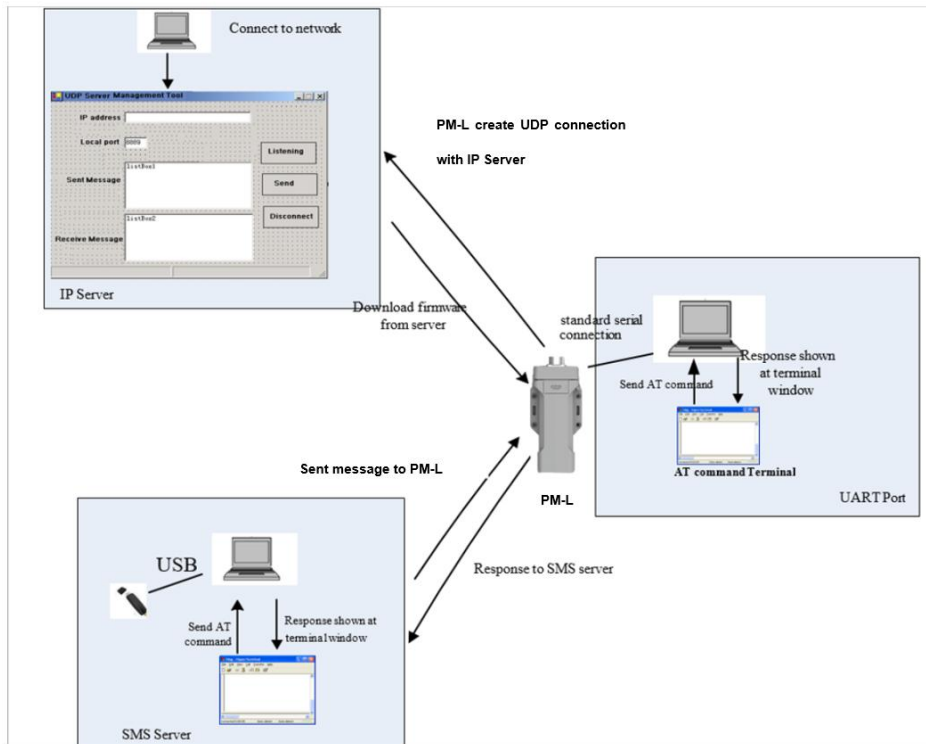
## 5 Mechanical Structure(mm) To be Updated
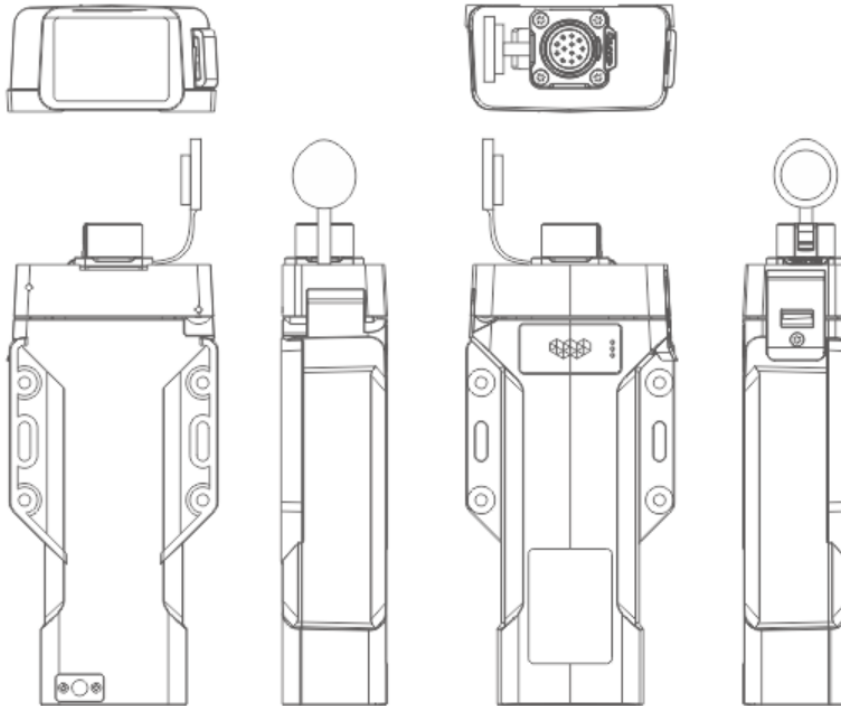


## 6 FCC Statement

## RF Exposure Warning Statements:

The antenna(s) used for this transmitter must be installed to provide a separation distance of at least 20 cm from all persons and must not be co-located or operating in conjunction with any other antenna or transmitter.

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:
-- Reorient or relocate the receiving antenna.

-- Increase the separation between the equipment and receiver.

-- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.

-- Consult the dealer or an experienced radio/TV technician for help.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

# 7  IC STATEMENT

This device complies with Industry Canada licence-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes : (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

In order to avoid the possibility of exceeding the IC radio frequency exposure limits, human proximity to the antenna shall not be less than 20cm (8 inches) during normal operation.

Afin d'éviter la possibilité de dépasser les limites d'exposition aux fréquences radio de la IC CNR102, la proximité humaine à l'antenne ne doit pas être inférieure à 20 cm (8 pouces) pendant le fonctionnement normal.