GPS

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GPS

GPS - Introduction

Messages transmitted by the satellites include

time the message was transmitted
ephemeris or the information about the orbit
almanac or the health and rough orbits of all the satellites.

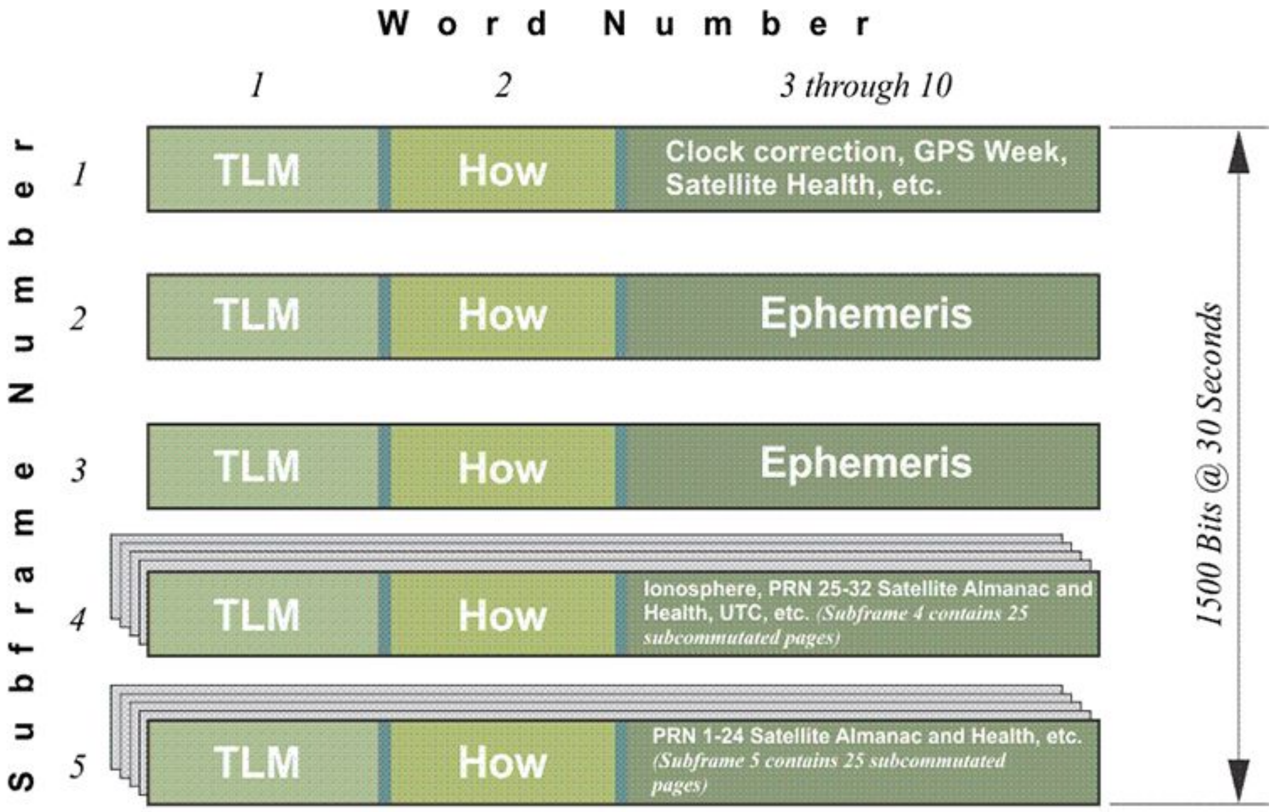
GPS receivers use these signals by calculating the time at which the signals were sent by the satellites and time at which they were received on Earth.

It may take 3 sec to a couple of minutes to get the signal depending upon the location and amount of interference

Interferences may be because of the terrain or number of buildings, foliage, atmospheric inconsistencies etc.

GPS - Introduction

Each word = *30 bits*
Each subframe = *10 words = 300 bits*
Each frame = *5 subframes = 1500 bits*
Navigation message = *25 frames = 37,500 bits*

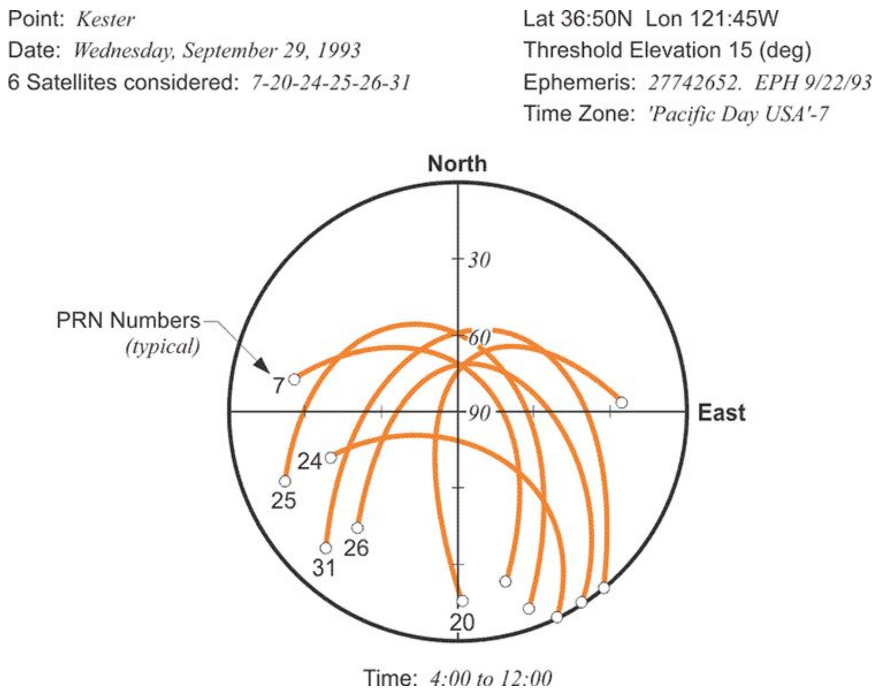


GPS - Almanac

The almanac contains Satellite Vehicle (SV) orbit information and allows the GPS receiver to predict which satellites are overhead, shortening acquisition time.

The almanacs are much smaller than the ephemerides but they are still accurate enough to generate a list of visible satellites at power-up.

The receiver must have a continuous fix for approximately 15 minutes to receive a complete almanac from the satellites. Once downloaded it is stored in nonvolatile memory.



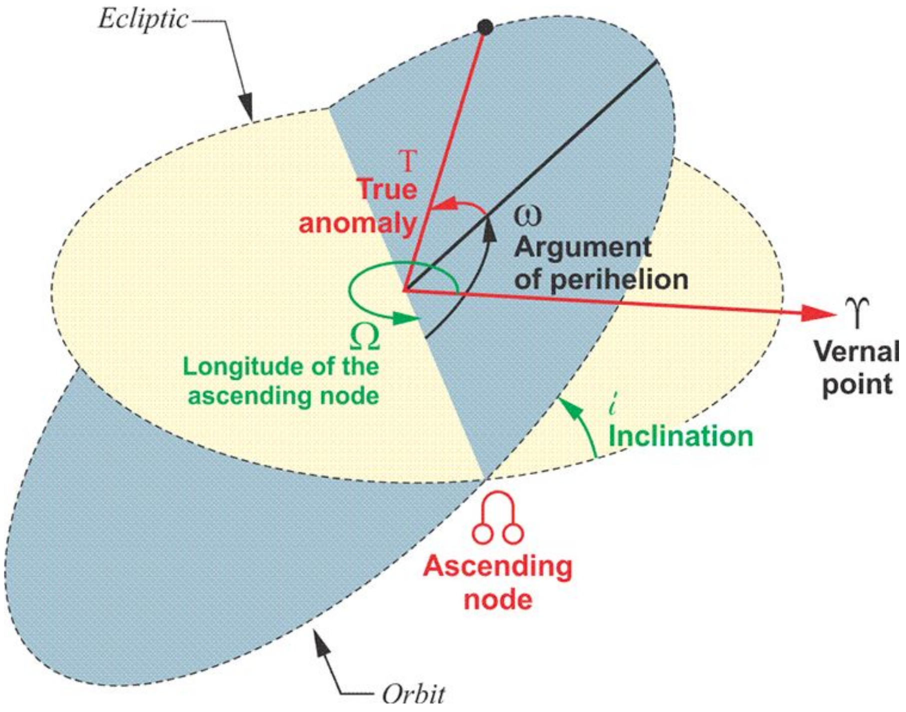
GPS - Ephemeris

Ephemeris data contains information about the position of the satellite, with respect to time.

Functions as precision corrections to the almanac data and is required for accurate positioning.

The ephemeris that each satellite broadcasts to the receivers provides information about its position relative to the earth

It is continuously updated and so Ephemeris data within a deactivated GPS receiver will become stale after 3-6 hours.



GPS - Stored Position and Time Data

When a GPS receiver has established a fix and is deactivated the last valid position and time data are stored.

When the unit is powered up again it will attempt to use this stored information with the internal almanac to predict which satellite vehicles are overhead.

If the unit has moved too far or the internal clock powers down the stored data cannot be used to predict satellite vehicle location.

GPS - TTFF and startup modes

The GPS receiver can boot up in one of three modes: Hot Start, Warm Start(Normal Start) or Cold Start.

The Time-To-First-Fix (TTFF) is the time required to acquire satellite signals and navigation data, and calculate a position solution (called a fix). It depends on the startup mode (with cold starts taking the longest TTFF because it is the start mode with less previous information)

Factors affecting boot mode include:

- Whether or not the GPS has valid almanac and ephemeris data
- Incoming signal levels
- The unit is far from the location of previous fix
- Length of time since previous fix.

Estimating how long each type of start will actually take is difficult; overhead obstructions interrupting the signal from the satellites, the GPS signals reflecting from nearby structures, etc., can delay the loading of the ephemeris necessary to lock onto the satellite's signals.

GPS - Cold Start Mode

The GPS starts up in this mode when:

• It is manually reset.
• Receiver has moved more than 100Km from the location of the previous fix.
• Current time is inaccurate or unknown.
• Incoming signal levels are marginal. The predicted satellites are physically overhead but the receiver cannot see them, for example due to tall buildings, foliage etc.

Any of these situations means that the receiver cannot predict and/or verify which satellite vehicles are overhead.

The receiver then works through an internal list of all satellites, trying to acquire each one in turn.

The TTFF for a cold start can be from 2, or even 1, to 4 minutes, since discovery of the overhead satellite vehicles has a random element.

GPS - Warm Start Mode

The GPS starts up in this mode when:

- It has a valid Almanac.
- The current location is within 100Km of the last fix location.
- The current time is known (the GPS has been active in the last three days).
- No Ephemeris data has been stored or it has become stale.
- 4 or more satellites with HDOP(degree of horizontal error in the position solution due to the satellite geometry) < 6 and good signal strength (ie the satellites have good geometry and there is an uninterrupted view of the sky) are visible and above the mask angle.

The receiver can predict which satellites are overhead but needs to download current Ephemeris data.

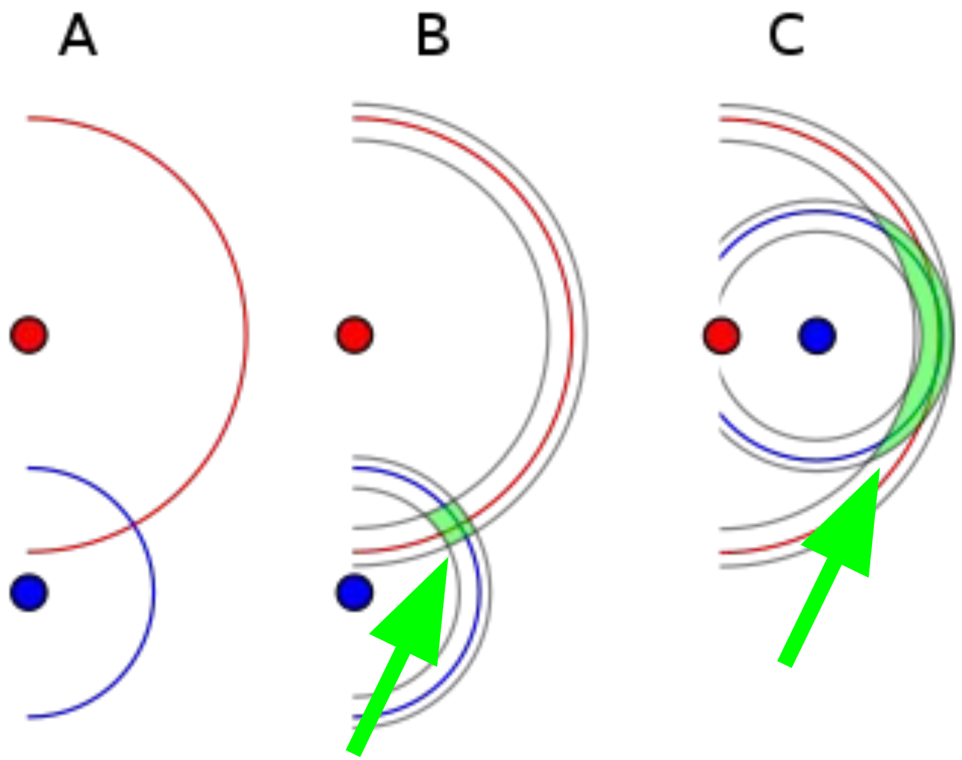
TTFF for this start mode could be up to 2 seconds according with some datasheets.

HDOP

A someone has measured the distance to two landmarks, and plotted their point as the intersection of two circles with the measured radius.

In B the measurement has some error bounds, and their true location will lie anywhere in the green area.

In C the measurement error is the same, but the error on their position has grown considerably due to the arrangement of the landmarks.



GPS - Hot Start Mode

The GPS starts up in this mode when the ‘Warm Start’ conditions are met and:

• A fix has been established within the last 2 hours.
• The GPS has valid Ephemeris data for at least 5 satellites.

In this mode the receiver rapidly tracks the overhead satellites and needs to download a minimum of data to establish a position.

TTFF for a hot start could be a 2 seconds or less.

A-GPS Technology

GPS - A-GPS Assisted Global Positioning System

While it works on the same principles as a GPS the difference is that it gets the information from the satellites by **using network resources** also called assistant servers.

Since these servers are continually **sending and receiving information** there is no delay in knowing the exact orbit and time location of the satellites or in other words the time to fix is a lot faster

Also these servers have good computation power so they can analyze the fragmentary signals received from the GPS receiver and those received directly from the satellite and thus correct the error. It will then inform the receiver its exact location.

A-GPS Technology Example

ublox

CellLocate®

AssistNow

A-GPS Technology Example

Downloading GPS data through network

ublox

AssistNow

Assisted GNSS (A-GNSS)

Fast Time-To-First-Fix, even under poor signal conditions

- End-to-end service for OEMs and end-users
- Global coverage and network operator independent
- Easy to install; no additional hardware required
- Seamless implementation with u-blox cellular modules that have an embedded AssistNow client
- **Free of charge service**
- Premium service with guaranteed QoS option
- Available for **all u-blox GNSS** products
- Low CPU load

Assisted GNSS (A-GNSS)

Accelerates calculation of position by delivering satellite data such as:

Ephemeris

Almanac

Accurate time

Accurate satellite status

to the GNSS receiver via wireless networks or the internet.

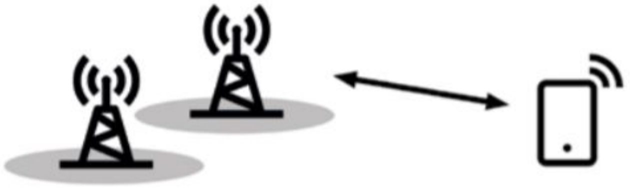
Assisted GNSS (A-GNSS)

AssistNow Online

Downloads assistance data from Online Service **at system start-up**

Ephemeris data is only sent for those satellites currently visible to the device minimizing the amount of data transferred.

No special arrangements with mobile network operators are needed to enable AssistNow Online, making this solution network operator independent and globally available



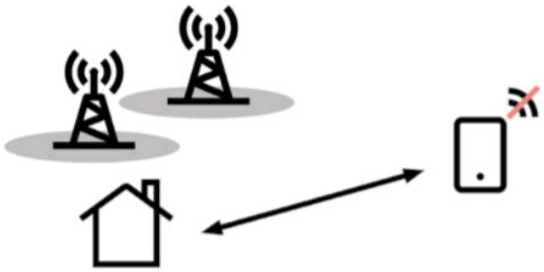
Assisted GNSS (A-GNSS)

AssistNow Offline

Users download u-blox’ Differential Almanac Correction Data from the internet at their convenience.

The correction data is then transferred to the mobile terminal via TCP/IP, serial port, memory card, etc, and can either be stored in the GNSS receiver’s Flash EPROM (if available) or in the memory of the application processor.

The service requires no connectivity at system start-up



Enables a position fix within seconds, even when no network is available.

u-blox provides correction data valid from **1 to 35 days.**

The size vary from **3 kB to 125 kB**.

Positioning accuracy decreases with the length of the correction data duration, with 1–3 day data providing relatively high accuracy and 10– 35 day data progressively less accuracy.

Assisted GNSS (A-GNSS)

AssistNow Autonomous

Is an embedded feature available free-of-charge that accelerates GNSS positioning by capitalizing on the **periodic nature of GNSS satellite orbits**.

GNSS orbit predictions are directly calculated by the receiver and **no external aiding** data or connectivity is required.

AssistNow Autonomous can be used alone, or together with AssistNow Online or AssistNow Offline for increased positioning speed and accuracy.

Assisted GNSS (A-GNSS)

Free and premium service options

AssistNow data is collected by u-blox's global array of satellite receivers, and maintained in real-time on u-blox AssistNow servers accessible via the internet.

For **best-effort applications**, u-blox provides AssistNow **free-of-charge** to its customers.

For applications requiring a guaranteed minimum **Quality of Service (QoS)**, u-blox provides AssistNow **Premium** which provides **guaranteed availability** based on a service level agreement and 24/7 support.

A-GPS Technology Example

Only with network data

CellLocate

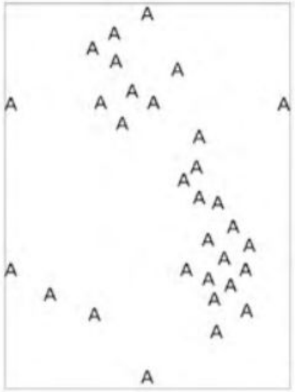
Position available even in areas of poor or no GNSS

- **Network operator independent**
- Supported by u-blox GSM/GPRS, HSPA/UMTS, LTE Cat 1, LTE-M, and **NB-IoT** modules
- Easy to integrate into end applications
- No additional hardware required
- **Free** best-effort service

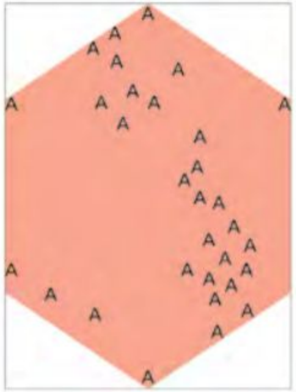
CellLocate

The proprietary CellLocate feature allows u-blox **cellular modules** to **report** to the CellLocate server those **cells which are visible at any specific location**.

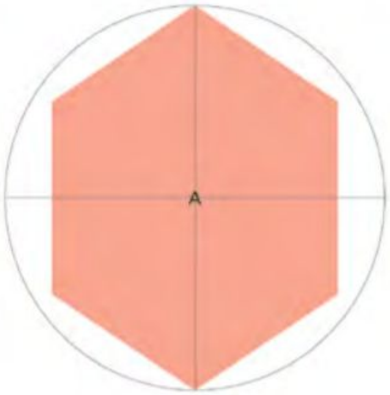
This enables the server to estimate an approximate position on the basis of previous **observations from other modules** reporting the same cell visibility pattern, and this position is reported back to the module. The estimated position is then output by the module to the host processor via its serial port.



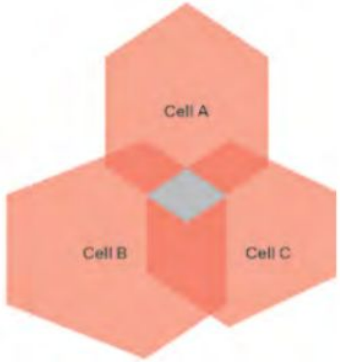
CellLocate database contains historic observations of cell A reported by several devices



CellLocate server defines area of cell visibility



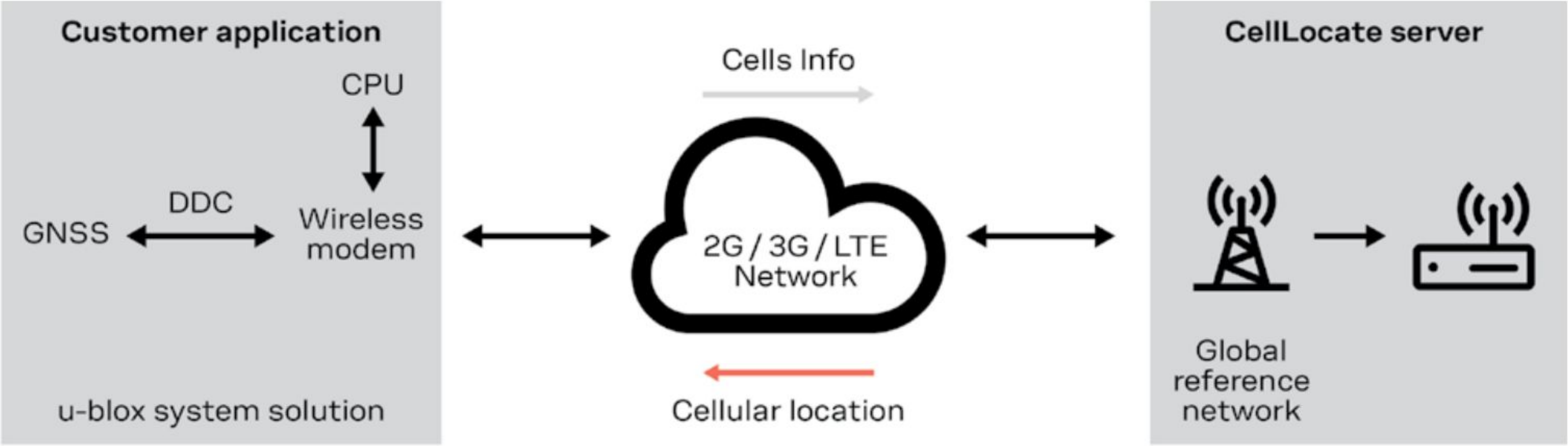
New device observes cell A, position is estimated from the previous observations



Visibility of multiple cells provides even better coverage and accuracy

CellLocate

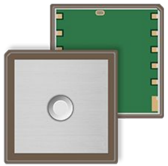
While stand-alone CellLocate is able to estimate position even when the GNSS signal is completely absent, **hybrid positioning** technology provides even better performance by using a combination of complementary positioning methods.



Assisted GNSS (A-GNSS)

	AssistNow Online	AssistNow Offline	AssistNow Autonomous
Data			
Data download frequency	At every startup	Once every X days	Never
Data retrieval at start-up	Data downloaded from server	Pre-downloaded from local memory	Retrived from local memory
Aiding data type	Ephemeris, almanac, time, health	Differential almanac correction	Automatically generated
Data validity period	2 - 4 hours	35 days	Up to 6 days
Size of downloaded data	1 - 3 kB	10 kB (1 day) ... 125 kB (35 days)	N.A.
Acquisition (TTFF) performance	As low as 1 second	As low as 5 seconds	As low as 10 seconds
GNSS			
Satellite systems supported	GPS, Galileo, GLONASS, BeiDou	GPS, GLONASS	GPS, Galileo, GLONASS, BeiDou
Service options			
Free service	Best-effort	Best effort	N.A.
Premium service	Guaranteed availability based on service level agreement	Guaranteed availability based on service level agreement	N.A.

GPS modem reviews



Kolmostar

QUECTEL®
Build a Smarter World

GPS modem reviews

GPS modem with lowest consumption
Kolmostar JEDI 200

Kolmostar

Kolmostar - JEDI 200

Ultra-low-power GNSS module

Designed for IoT applications

Optimized for integration with LPWAN technologies such as LoRaWAN®/NB-IoT

120x reduced energy to get one position fix compared with traditional GNSS sensors

Kolmostar - JEDI 200

Ultra Low Energy Consumption

25 mJ/position
(measured in real environment)
(~4 years with 1000mAh battery)

Fast time to fix

1 second TTFF (time to first fix)

Accurate position fix

5.0m CEP Probable.—Circular Error Probable
(estimate of horizontal accuracy. Radius of a circle in the horizontal plane that will contain at least 50% of the GPS 2D positional solutions)

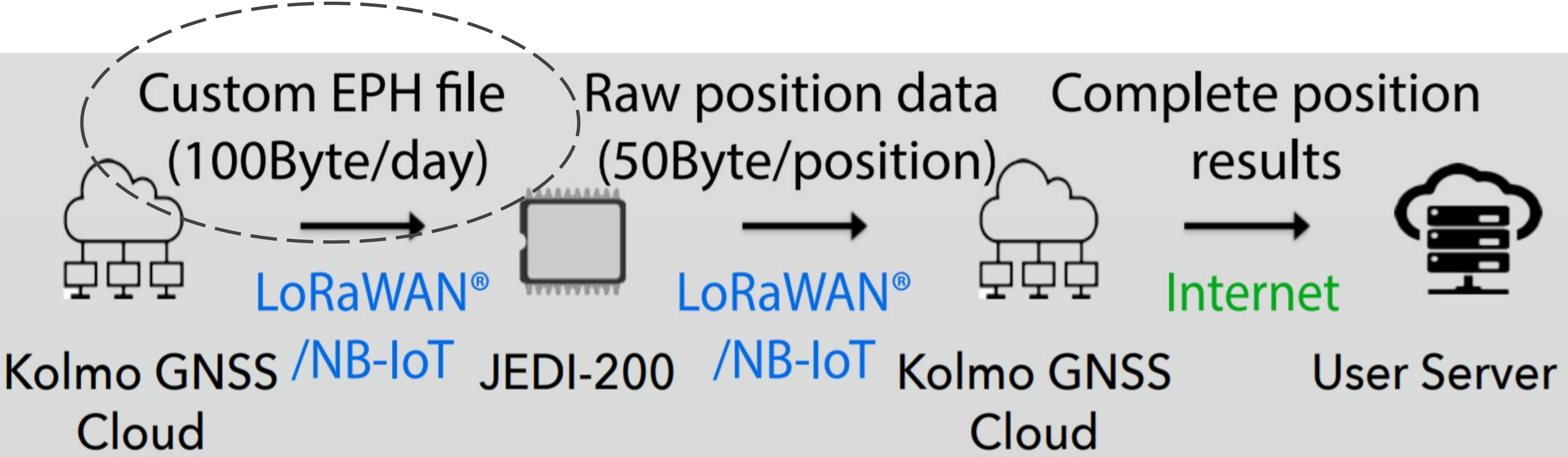
Kolmostar - JEDI 200

A-GPS via LPWAN

Download

Ephemeris file from 15KB to 50 Byte compressed ephemeris file for speedy download & only **1 refresh every 12 hours** needed

Traditionally it is downloaded from satellites during +30s consuming energy

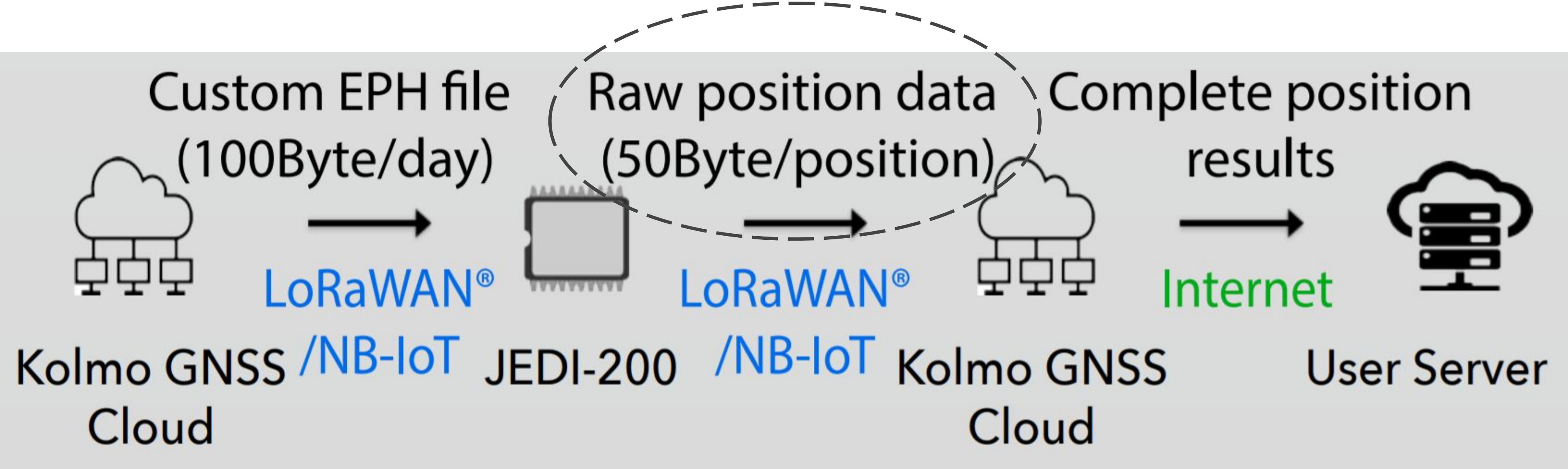


Kolmostar - JEDI 200

A-GPS via LPWAN

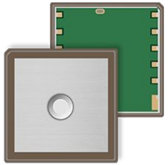
Upload

50 Byte **raw position data** (Beta Release: up to 100 Byte) for efficient narrow-band upload and auxiliary high-performance cloud computing



Quectel L86

GPS modem available of laboratory



QUECTEL
Build a Smarter World

Quectel - GNSS L86

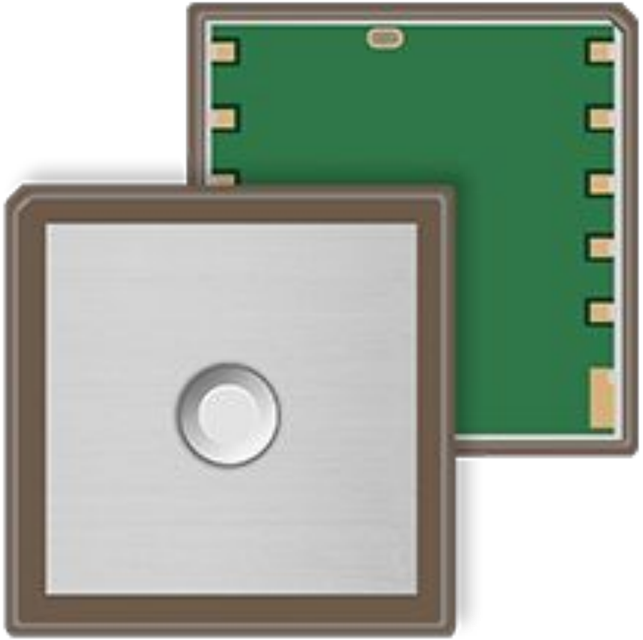
QUECTEL®
Build a Smarter World

Ultra-compact GNSS POT (Patch on Top) module

Embedded 18.4mm × 18.4mm × 4.0mm patch antenna

Automatic antenna switching function keeping positioning

MediaTek new generation GNSS chipset MT3333



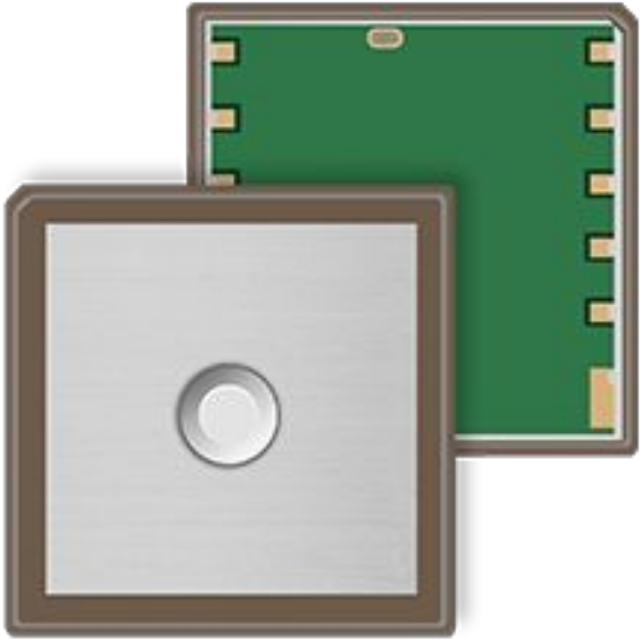
Quectel - GNSS L86

Advanced A-GPS called EASY™ (Embedded Assist System)

Allows to calculate and predict orbits automatically using the ephemeris data (up to 3 days) stored in internal RAM memory

AlwaysLocate™ technology

Adjust the on/off time to achieve balance between positioning accuracy and power consumption according to the environmental and motion conditions.



Quectel - GNSS L86

TTFF with EASY™:

Cold Start: <15s

Warm Start: <5s

Hot Start: <1s

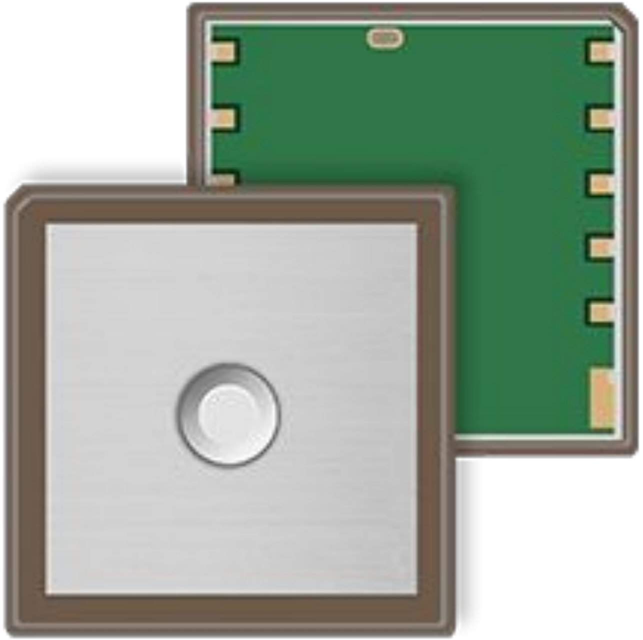
TTFF without EASY™:

Cold Start: <35s

Warm Start: <30s

Hot Start: <1s

@-130dBm



GPS modem comparison

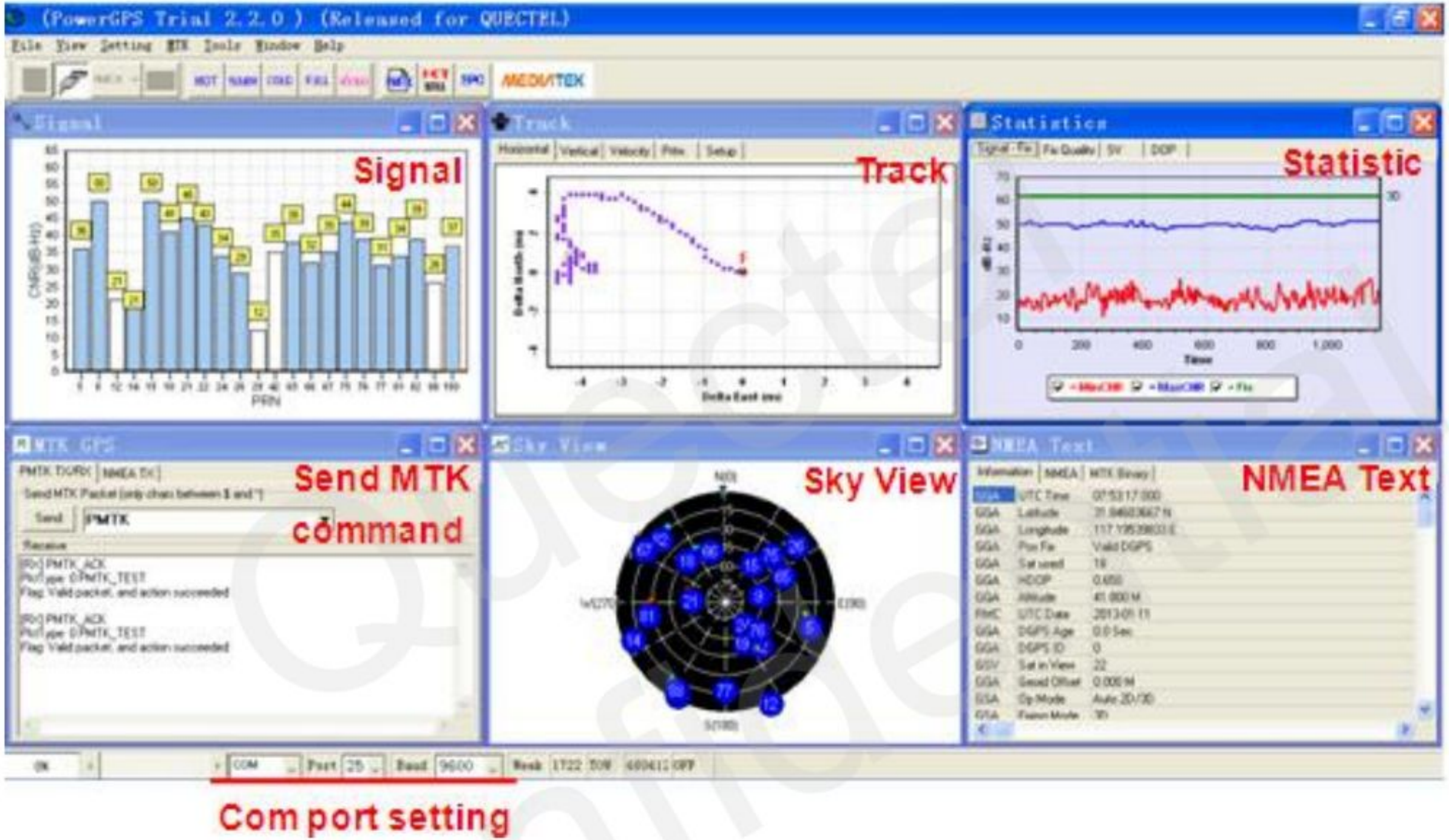
Currently available GPS modem
Quectel L86

Consumption comparison

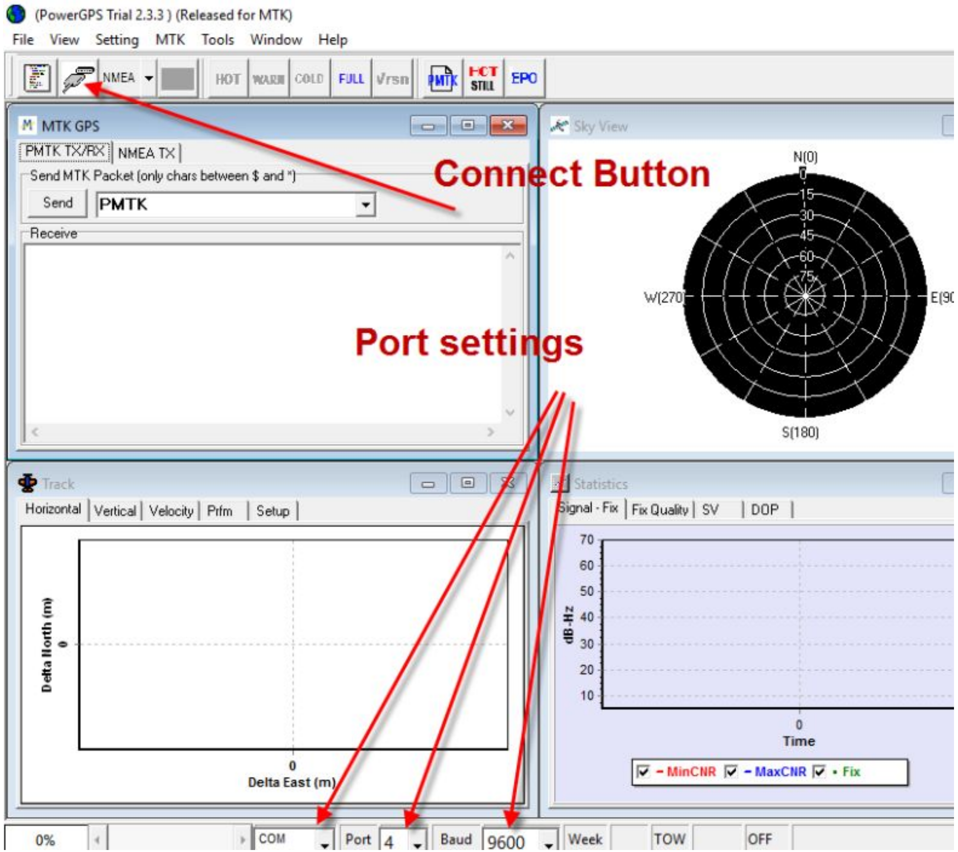
	Kolmostar	QUECTEL Build a Smarter World	QUECTEL Build a Smarter World	Linx	ublox	SIMCom
	JEDI 200	L86	L96	FM Series	UBX-M9140	SIM28
Consumption acquisition [mA]	-	30	22	14	23	24
TTFF Warm Start[s]	-	5	2	15	2	1.5
Energy per measurement [mJ/position]	25	495	145	743	12	7.4

Lab part 1

Power GPS


(PowerGPS Trial 2.2.0) (Released for QUECTEL)
Signal
Track
Statistic
Send MTK command
Sky View
NMEA Text
Com port setting

Power GPS


(PowerGPS Trial 2.3.3) (Released for MTK)
File View Setting MTK Tools Window Help
NMEA
HOT WARM COLD FULL Vrsn
PMTK
FCT STILL
EPO
MTK GPS
PMTK TX/RX
NMEA TX
Send MTK Packet (only chars between $ and *)
Send
PMTK
Receive
Connect Button
Port settings
Sky View
N(0)
W(270)
S(180)
Track
Horizontal Vertical Velocity Prfm Setup
Delta North (m)
Delta East (m)
Statistics
Signal - Fix Fix Quality SV DOP
dB-Hz
Time
MinCNR
MaxCNR
Fix
0%
COM
Port 4
Baud 9600
Week
TOW
OFF

Lab part 2

Lab example and library

To download the material for the second part of the library enter or clone the github repository

https://github.com/JuanPabloBeco/Laboratorio-NB-IoT-GPS

There you will find the gps example in the home folder and inside the GNSS folder the functions to retrieve the messages from the GPS modem

NMEA 0183

National Marine
Electronics Association

NMEA 0183

It is a combined electrical and data specification for communication between marine electronic devices, such as echo sounder, depth sounder, anemometer, gyrocompass, autopilot, GPS receivers, and many other types of instruments.

Because early GPS sensors were designed to be compatible with these systems, GPS reporting protocols are often a small subset of NMEA 0183 or a mutation of that subset.

NMEA 0183

This protocol is issued by the National Marine Electronics Association (NMEA) for use in ship control and navigation systems.

It is proprietary and sells for at least $2,000 as of September 2020. However, much of it has been reverse engineered from public sources.

NMEA 0183

$GPGGA,000313.000,3454.4898,S,05610.5785,W,1,7,1.39,40.1,M,10.8,M,,*64\r\n

The NMEA 0183 standard uses a simple ASCII serial communications protocol that defines how data is transmitted in a "sentence".

NMEA 0183

```
b'$GPGGA,000313.000,3454.4898,S,05610.5785,W,1,7,1.39,40.1,M,10.8,M,,*64\r\n'

b'$GNGSA,A,3,20,30,13,08,05,,,,,,,,1.66,1.39,0.90,1*0C\r\n'
b'$GNGSA,A,3,76,66,,,,,,,,,,,1.66,1.39,0.90,2*00\r\n'

b'$GPGSV,3,1,11,30,68,186,28,14,55,351,14,07,50,137,17,20,43,271,35,0*6E\r\n'
b'$GPGSV,3,2,11,09,36,066,,05,31,236,27,13,18,233,26,08,17,113,13,0*6F\r\n'
b'$GPGSV,3,3,11,04,03,061,,27,03,142,,43,,,,0*63\r\n'
b'$GLGSV,2,1,06,65,86,049,17,76,48,296,17,72,33,035,,66,30,211,26,1*7B\r\n'
b'$GLGSV,2,2,06,74,13,142,,77,02,312,,1*7A\r\n'
b'$GNGLL,3454.4898,S,05610.5785,W,000313.000,A,A*4F\r\n'
b'$GPTXT,01,01,02,ANTSTATUS=OPEN*2B\r\n'
b'$GNRMC,000314.000,A,3454.4900,S,05610.5784,W,0.00,276.23,020322,,,A,V*07\r\n'
b'$GPVTG,276.23,T,,M,0.00,N,0.00,K,A*3F\r\n'
```