Application Note

Using RAB4-RTK and RSS application to receive high precision localisation

Versions

Version	Date	Rationale
1.0	January 22, 2023	First release. Autors: ROJ, KOA
1.1	November 25, 2025	PSOC 64 disclaimer added. Author: KOA

Legal Disclaimer

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Introduction

RTK positioning

GPS receivers utilize Global Navigation Satellite System (GNSS) satellites to determine locations worldwide. Currently, the following GNSS systems are in operation: GPS, GLONASS, BeiDou, and Galileo.

In this document, we will use the GPS abbreviation in its literal sense, referring to the global positioning system, rather than as the name of the USA navigation system.

To define a navigation quality (i.e. its accuracy), a concept of quality indicator is used. There are four main quality indicators:

- Quality 1: GPS fix - utilizes signals from satellites only (~15 meters precision).
- Quality 2: differential GPS (DGPS) - relies on signals from satellites and a network of fixed ground stations providing a value correction (up to few meters precision).
- Quality 4: real time kinematic (RTK) fix – upgraded version of DGPS; gathers position data from satellites and static base stations, employing advanced data protocol and algorithms (centimeter precision - the best)!
- Quality 5: RTK float – a variant of RTK navigation with reduced satellite and synchronization requirements between base and rover stations (decimeter precision).

In basic positioning (quality 1), satellites transmit signals containing information about their positions to a GPS receiver, also called sensor, antenna, or rover. The rover calculates the distance to each satellite based on the received signal, using signals from at least four satellites. The more satellites are used to define the position, the more precise the result is.

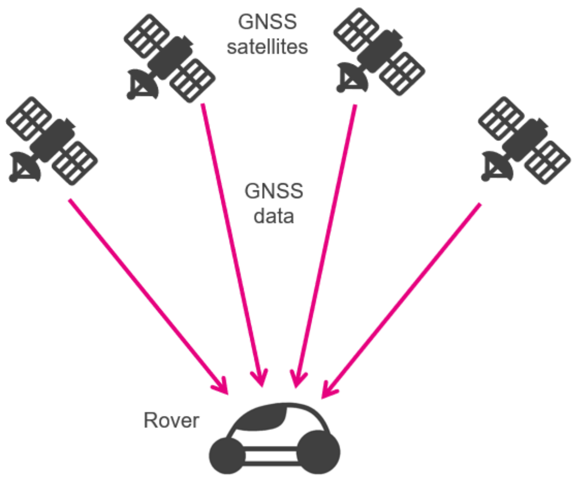


Figure 1. Basic navigation

When the distances between a rover and all satellites in sight are defined, the rover position is computed by using triangulation method.

However, numerous factors impact positioning accuracy throughout the process. As the satellite moves in orbit, deviations may occur. Atmospheric phenomena, such as clouds or wind, can slow down the signal speed, and the signal will reach the receiver later than on fair weather. These microseconds of slowdown give the difference of few meters on the ground. The clock on the rover records the moment the signal arrives from the satellite, which requires micro and nanosecond accuracy that is not easy to achieve. Plus, synchronization between rover and satellite clocks is essential to avoid errors in signal flight time calculation.

Let’s take a look at the Figure 2 to see the accuracy of GPS positioning on a real example. These are the screenshots from RSS application, that show the position of GPS antenna connected to RAB4-RTK board. The screenshots differ only in a map scale.

Figure 2. Navigation without correction data (quality 1)

The blue curve here consists of points, each of which represents the position of antenna at the different moment of time. 28 satellites were used to define the position. The antenna did not move during measurement time, but because of GPS measurement errors we receive a spread of location data within ± 2 meters.

RTK technology enhances positioning precision by employing static ground-based base stations. These stations compute correction data broadcasted in RTCM packets.

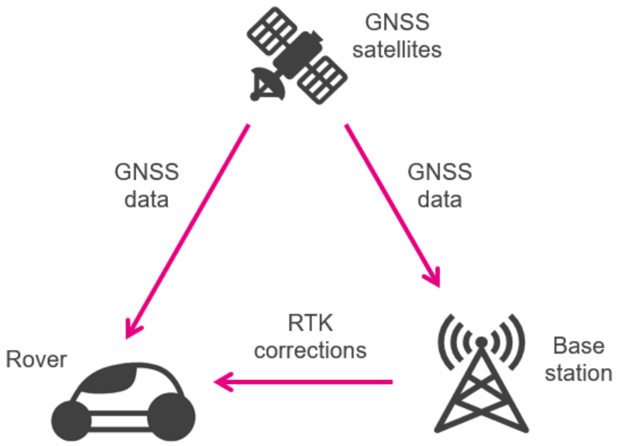


Figure 3. RTK navigation principle with direct connection between base and rover

In RAB4-RTK, a Unicore UM980 module gets correction data and uses it to define the position of the rover. We created our own base station using another RDK3 and RAB4-RTK boards kit, you'll find the code example here.

There are several requirements for RTK navigation:

1. The distance between rover and base station should not exceed 10 km;
2. There should be 8 common satellites from which both rover and base receive signals;
3. The rover and base station should be equipped with dual band antennas.
4. The rover can move, but the base station must remain static.

Alternatively, you have the option to utilize base stations provided by other companies. In such instances, the exchange of correction data occurs through the internet. Rutronik developed an NTRIP Client software to test this solution, check this document for details.

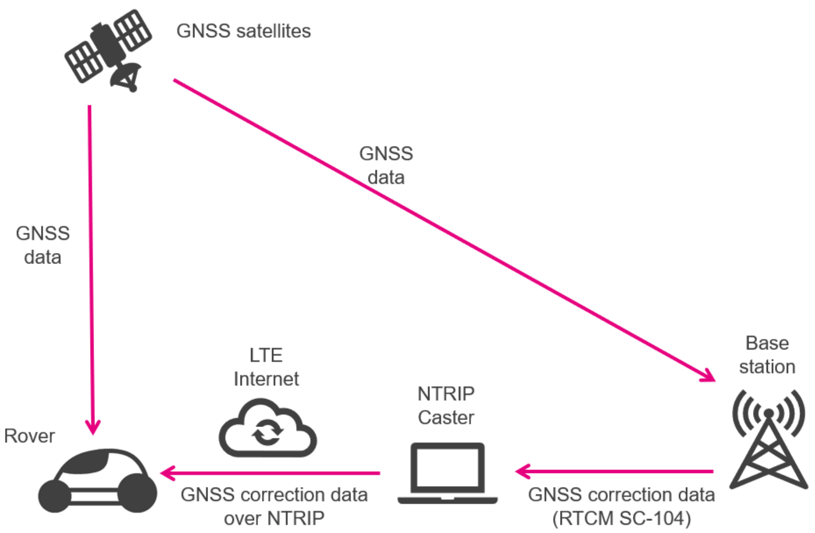


Figure 4. RTK navigation with NTRIP caster (using Internet)

Figure 5 shows the result of rover positioning when using RTK navigation. The rover was stationary during the entire measurement time. The variation of its position is about ±2 cm.

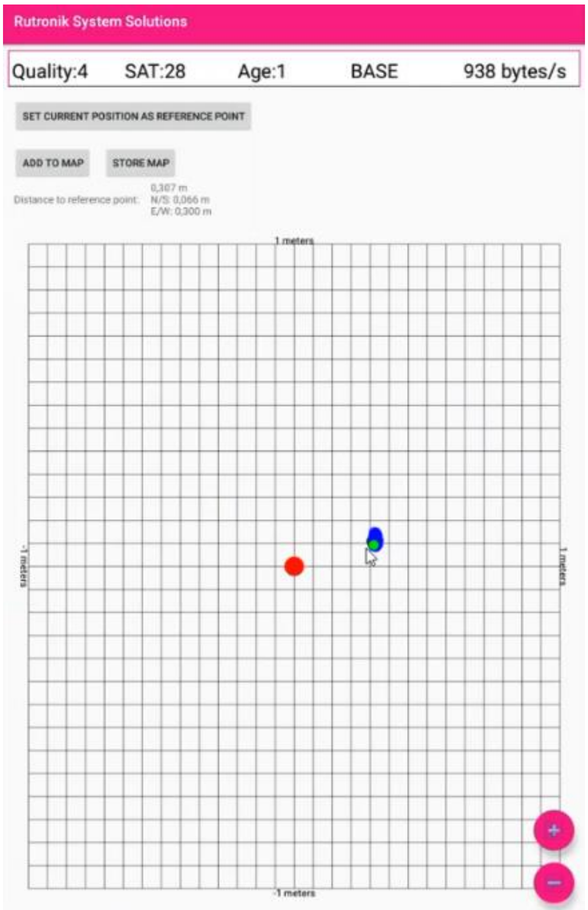


Figure 5. Navigation with correction data (quality 4)

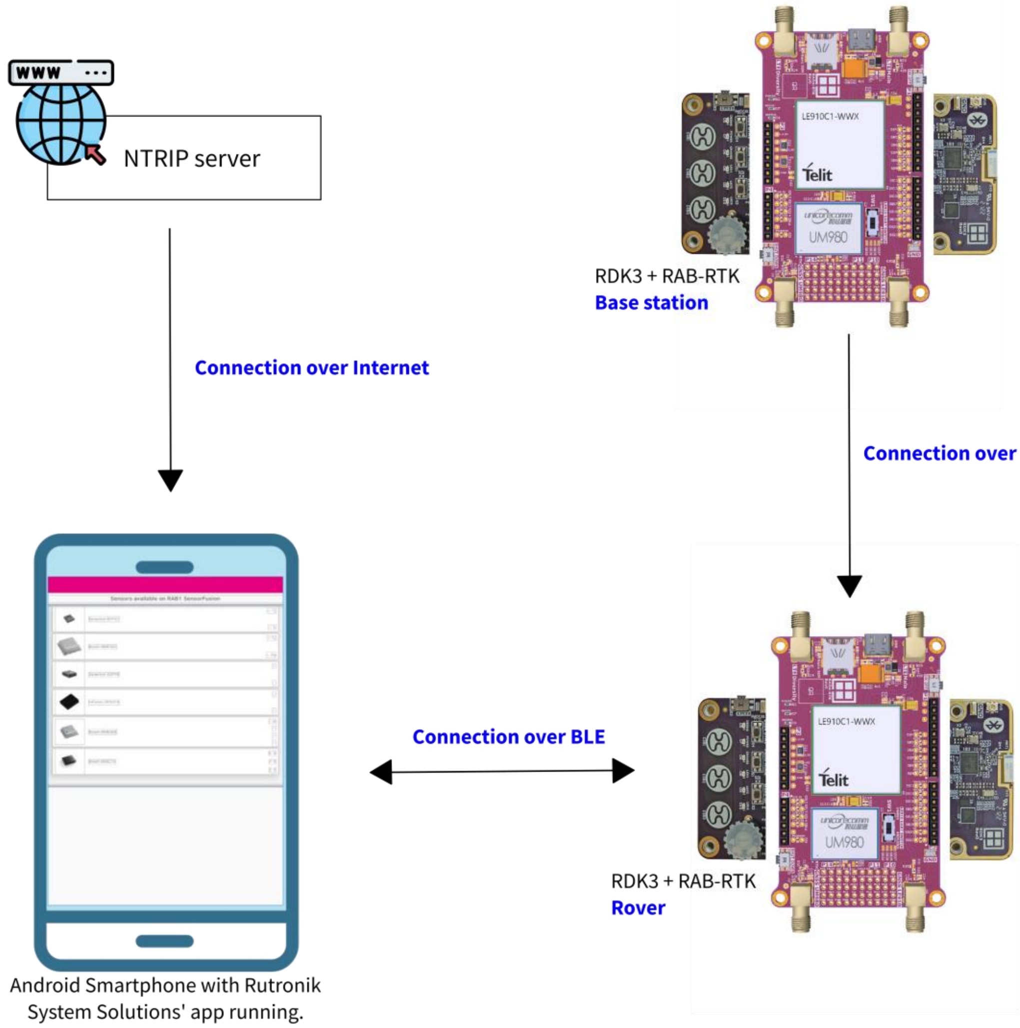
To initiate RTK correction, a synchronization period (e.g., 10 minutes) is necessary. This synchronization has a complex mathematics on the background and considers a lot of different factors. Once the system is successfully synchronized, it works in the high precision mode within the whole session. If synchronization fails, switch to quality 5 and then attempt to return to quality 4.

Presentation of solution

As displayed below, the solution enables to evaluate multiple configurations for testing the accuracy of the measured localisation depending on the chosen correction solution.

You can test following configurations:

- Rover mode only (without correction).
- Rover / Base station mode: The base station sends correction data over BLE to the rover.
- Using external NTRIP server (Internet connection mandatory): Android app collects correction data from an NTRIP server on the Internet and sends the correction data to the rover over BLE.



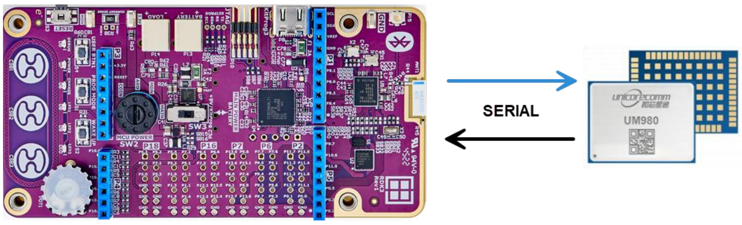
Overview of RAB4-RTK board

The RAB-RTK board includes two major components:

- UM980 from Unicore Communication: a high precision RTK positioning module;
- Telit LE910C1-WWXD: an LTE module enabling connectivity. Telit module will not be used in that application note.

Presentation of UM980 module

The UM980 module communicates with the microcontroller on the RDK3 using UART communication.



The workflow is the following one:

- The RDK3 configures the UM980 by sending commands over UART (see the document ***N4 Products Commands and Logs Reference Book*** for more information).
  Example of commands:
  “unlog”: stop generation of positioning/correction data.
  “mode base time 60”: set the UM980 in base mode.

- The RDK3 configures how the UM980 should generate the positioning/correction data
  Example of command:
  “gpgga 1”: start generation of positioning data. The UM980 will send its position to the RDK3 one time per second.
  “RTCM1006 10”: start generation of 1006 RTCM correction data. The data will be sent every 10 seconds.

- The configuration of the UM980 is now completed. The UM980 will send periodic data to the RDK3 over the serial connection.

- If the RDK3 has available RTCM correction data from another source (from NTRIP server or from another base station) it will write directly the correction data (RTCM) to the UM980 using the serial connection.

How to use the solution

Required hardware

- Android smartphone/tablet with **Rutronik System Solution** app running on it. The smartphone/tablet needs at least BLE. If possible (to receive correction data from an NTRIP caster) Internet connection.
- For the rover:
    - RDK3 board
    - RAB-RTK board
    - GNSS Antenna
    - Battery or USB power Bank to power the RDK3 board
    - If possible a water-proof box in order to make test outdoor
- For the base station:
    - RDK3 board
    - RAB-RTK board
    - GNSS Antenna
    - Battery or USB power Bank to power the RDK3 board
    - If possible a water-proof box in order to make test outdoor

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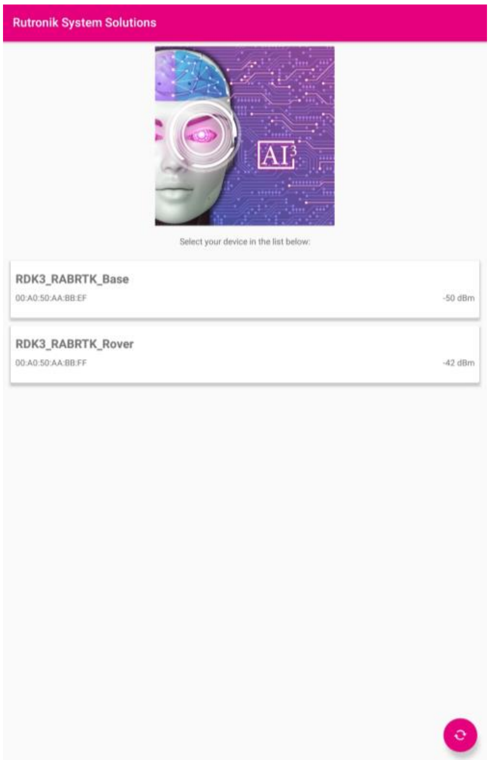
Infineon has discontinued the PSOC™ 64 Secured MCU product line. As a result, the CYB06447BZI-BLD53 MCU used in the RDK3 is not recommended for new designs. The Infineon CY8C6347BZI-BLD53 MCU may be considered a suitable alternative.

Required software

- Android application software can be found here: https://github.com/RutronikSystemSolutions/RDK3_Android_App
- Base and rover station BSP can be found here: https://github.com/RutronikSystemSolutions/RDK3_UM980_Rover_Base

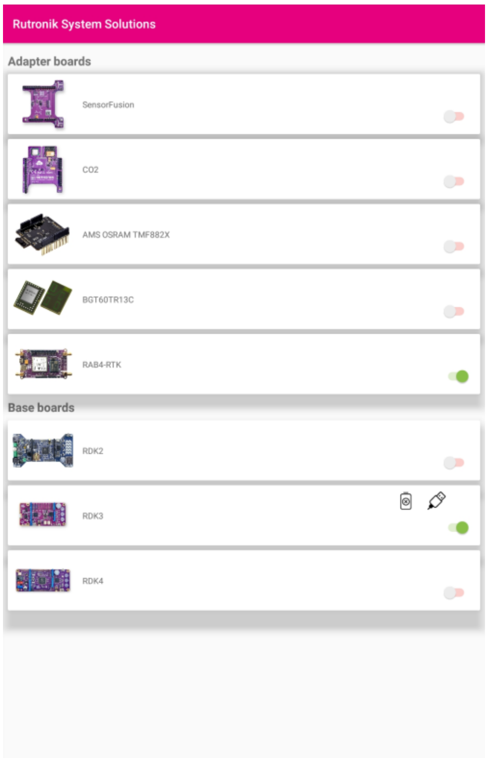
Step by step workflow

Step 1 – Start Android application and connect to “Rover” RDK3



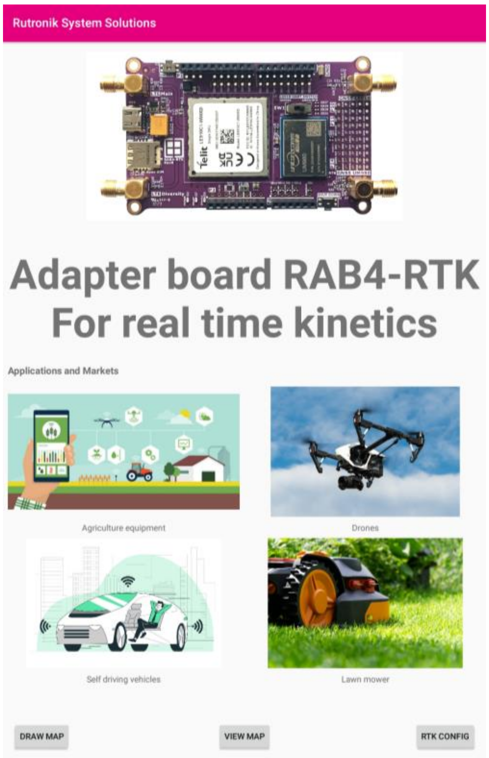
Press on **RDK3_RABRTK_Rover** button (not on the base one!)

Step 2 – You will see the list of available devices



Select **RAB4-RTK**.

Step 3 – You will see a quick-overview of RAB4-RTK board



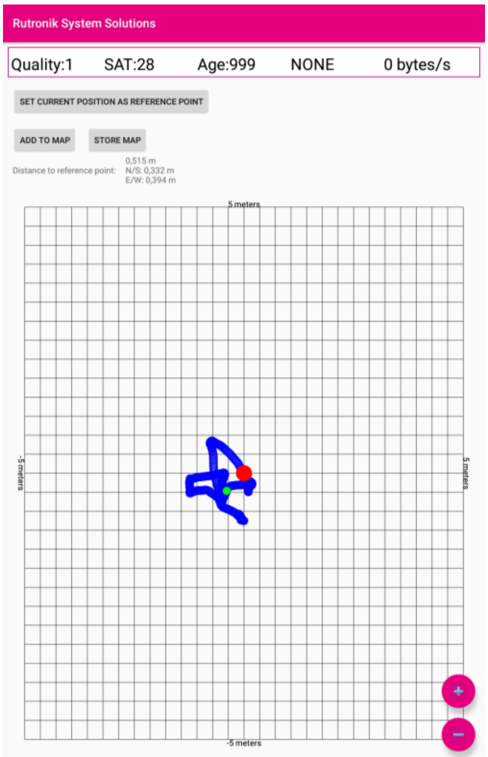
You now have three options:

- Press on **Draw map** to open the screen enabling to draw a map using the current localization and see how the position is changing.

- Press on **View map** to open a screen enabling to visualize the current position on an open view map (downloaded from the Internet).

- Press on **RTK Config** to see the raw values coming from the sensor and configure the correction data reception (from NTRIP caster or from a base station).

Draw map



Draw map displays all the position measured by the UM980 on a virtual grid map.

The banner on the top of the screen gives an overview of the quality of the signal (described below).

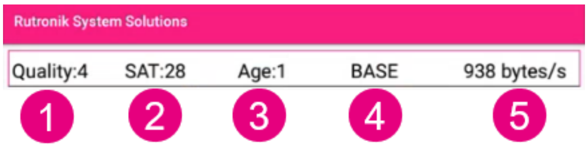
There are buttons that you can use to add some special points to the map:

- **Set current position as reference point**: use the last known position as a center of the screen (the red point).
- **Add to map**: add the current position to the map.
- **Store map**: store the map (points saved using **Add to map** to a CSV file).

(+) and **(-)** buttons enable to zoom the map in an out.

The green point on the map is the last known position. The blue points are the previous positions of the sensor (so you can track how the sensor is moving).

The banner on the top of the screen gives an overview of the signal quality.



(1) Quality: quality indicator of the positioning, check here for details.

(2) SAT: indicates the number of satellites that are used to compute the position.

(3) Age: indicates the age (in seconds) of the last received correction packet (RTCM).

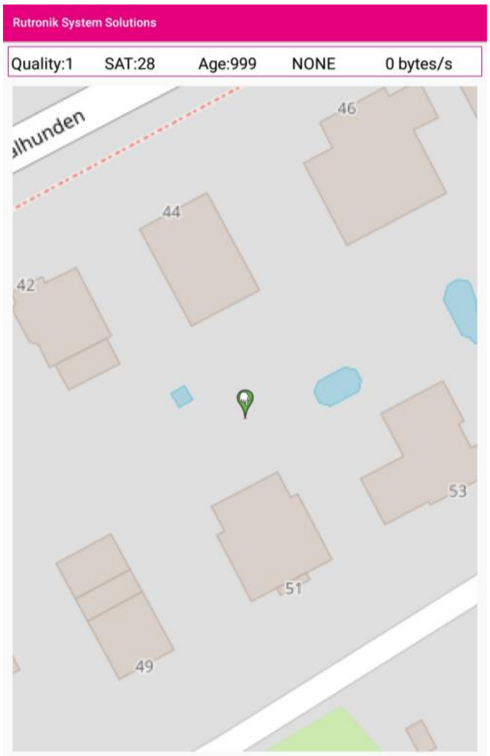
(4) Correction source: indicates the source of the correction packets.

It can have following values:

- NONE: no correction data source configured.
- NTRIP: receiving correction data from an NTRIP caster (over Internet).
- BASE: receiving correction data from a base station based on RDK3 (over BLE)

(5) Data speed: data speed of the correction data.

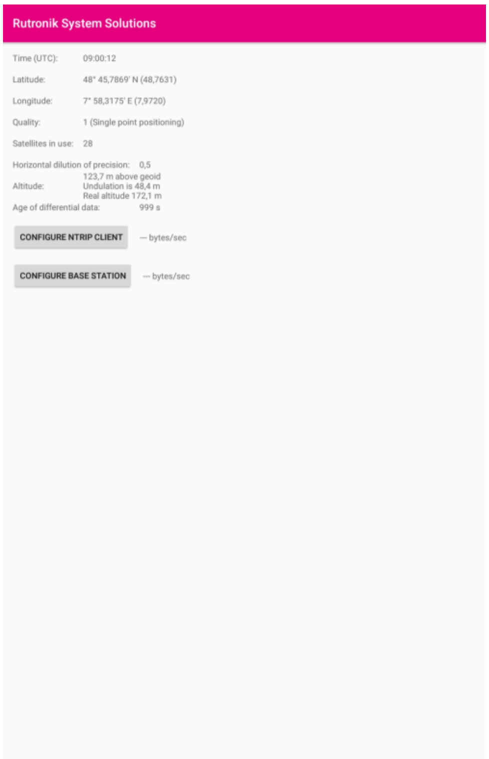
View map



View map displays all the values measured by the UM980 on an open street map below.

Remark: by clicking on the map, you can scroll and zoom.

RTK config

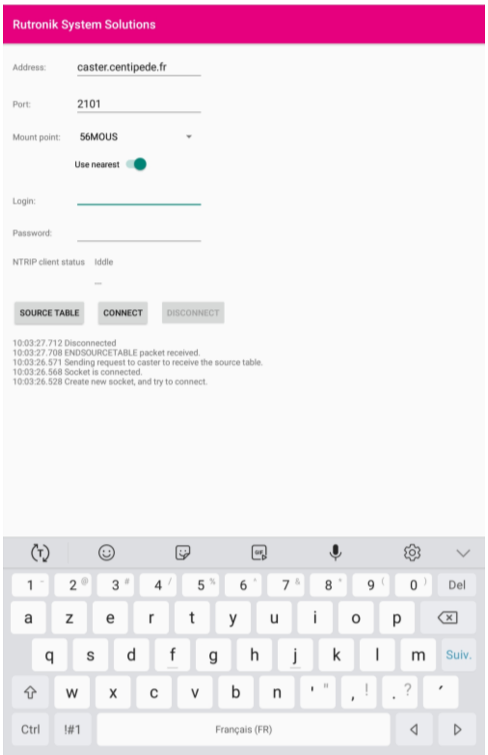


RTK config displays the raw values coming from the UM980 sensor. You can also configure the source for the correction packet.

Configure NTRIP client: enables to connect to an NTRIP server to receive RTCM packets over Internet.

Configure base station: enables to connect to a base station around (over BLE). The base station is implemented using an RDK3 and should have the same antenna for best performances.

Configure NTRIP client



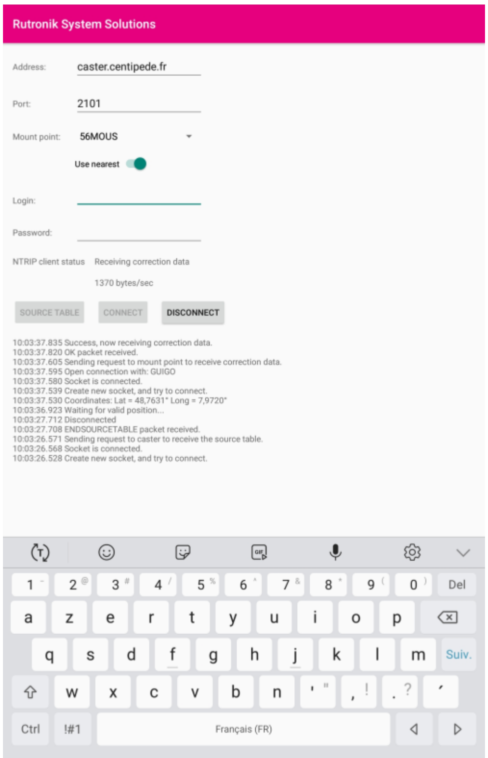
Enables to open a connection with an NTRIP caster. Tested with caster.centipede.fr, euref-ip.net and LitPos (195.182.72.152 or 193.219.10.2) servers. A list of correction data providers can be found here.

Firstly, click on the button **Source table** (after entering address, port and login/password if necessary). A connection will be opened to retrieve a list of the available stations.

If the connection is successfully established, you will see a message similar to the one in the picture on the left (*ENDSOURCETABLE packet received*).

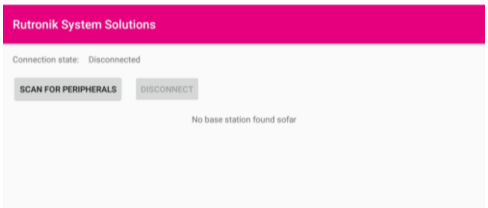
You can then choose the station (**Mount point**) you want to connect to, or activate **Use nearest** to use the nearest station.

Then press on **Connect**.

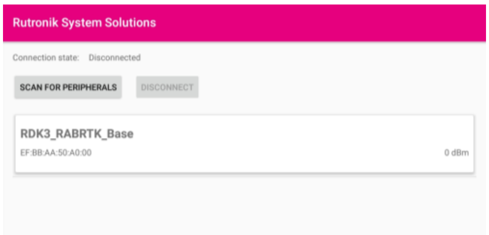


If the connection is successfull, you will see a log similar to the one in the picture on the left.

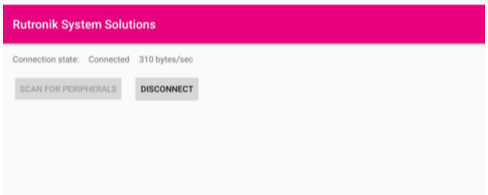
Configure base station



First, click on **Scan for peripherals**. The rover (RDK3) – and not the app – will scan for available peripherals around.



If a base station has been found, it will be listed (see RDK3_RABRTK_Base). Click on the item to open the connection.



If the connection is successful, you will see a **Connected** status. The rover station measures the speed of the correction data.