LEXI-R520 / SARA-R520

SpotNow

Application note

Abstract

This document describes the implementation of SpotNow positioning feature, and the techniques for hybrid positioning in u-blox LEXI-R520 and SARA-R520 modules.

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Contents

1 Introduction

1.1 Scope

This document describes the integration of GNSS functionalities in the cellular module without an additional internal or external GNSS receiver. The GNSS functionalities are obtained via SpotNow, a u-blox proprietary feature, which can be regarded as a software Assisted GPS (A-GPS).

The following sections describe:

- Overview of the SpotNow feature.
- Implementation of the aiding clients, which are software components that provide improved location performance.
- Hybrid positioning feature. This feature provides location information when the GNSS signal is weak or absent.
- Credentials and authentication: how to enable the SpotNow feature
- How different usage (aiding and hybrid positioning) impacts the cost of the service for the user.

1.2 AT commands

Table 1 lists the AT commands described in this document:

AT command	Description
Aiding feature configuration	
+UGLAASZTP	Aiding server configuration. Enables the Zero Touch Provisioning
Hybrid positioning configuration	
+ULOC	Query localization information
+ULOCIND	Localization information request status unsolicited indication
+USPOTNOWIND	SpotNow aiding validity status indication

Table 1: AT commands related with positioning and timing features

For a complete description of AT commands syntax, see the AT commands manual [1].

1.3 Aiding service

The GPS aiding service delivers satellite data and an approximate position estimation to enable and accelerate position.

An authorization token is needed to access the aiding service. To obtain the token, sign in to https://portal.thingstream.io/ and create a SpotNow "ZTP Device Profile". You can set the token in the cellular modem by the +UGLAASZTP AT command.

The credentials for the u-blox GPS aiding server authentication are provided to the cellular modem via Zero Touch Provisioning at the first interaction with the service by using the token retrieved from the Thingstream portal.

☞ With SpotNow, 8 aiding data requests per day per device are included free-of-charge on monthly base. Any request exceeding that limit are charged and mapped to the SpotNow paid plan. For more details, see Thingstream IoT Location-as-a-Service pricing [2].

2 SpotNow overview

The LEXI-R520 and SARA-R520 non-combo modules do not integrate a GNSS system, but instead support the SpotNow feature, a SW implementation of an Assisted GPS (A-GPS) receiver running on the cellular chipset.

With SpotNow feature, cellular and GPS use two dedicated antennas and have two dedicated RF paths, sharing the same internal radio receiver / transmitter engine. Inside the module, the radio resources are switched between the two inputs depending on the corresponding operating mode (cellular receiver / transmitter or GPS receiver).

☞ Using SpotNow, the visibility of at least 5 satellites is needed to perform a GPS fix.

SpotNow feature can be used either when the cellular modem is offline or registered to a serving cell. SpotNow feature relies on assistance data which are stored in the file system and kept valid for 3 hours.

Cellular and SpotNow can work together, with the GPS signals being tracked during the cellular (e)DRX paging cycle. This avoids any conflicts or possible interruptions of the cellular operations, obtaining service continuity.

☞ For further details on hardware of SARA-R520 modules, see the SARA-R52 series data sheet [3] and the SARA-R52 series system integration manual [4].

For further details on hardware of LEXI-R520 modules, see the LEXI-R520 data sheet [5] and the LEXI-R520 system integration manual [6].

3   Using aiding features

3.1   Overview

Assisted GPS (A-GPS) boosts signal acquisition by providing data such as ephemeris, almanac, accurate time, and satellite status to the GPS receiver via mobile networks or previously stored information. Aiding data enables the receiver to compute a position within seconds, even under poor signal conditions.

3.2   SpotNow and GPS aiding

SpotNow is a SW implementation of an A-GPS receiver and operates in combination with a GPS aiding service.

The GPS aiding service is the source of assistance used by SpotNow to ensure fast GPS signal acquisition and TTF. Assistance data is downloaded by the cellular module and used to predict the frequency of the signal from each GPS satellite.

☞   An active packet data connection is required to exchange data between the cellular module and dedicated u-blox server.

When the GPS aiding is requested, an HTTP data connection to the u-blox GPS aiding server is automatically triggered. The cellular module will pass the active cell information to the server, and the server will return the aiding data to SpotNow engine.

The LEXI-R520 / SARA-R520 module will contact autonomously the aiding server upon receiving the authorization token from the Thingstream portal (see section 1.3).

The GPS assistance data are stored in non-volatile memory (NVM) and are valid for up to 3 hours, and thus not to be downloaded at each location estimation request.

SpotNow can operate in two different modes:

- **Automatic aiding mode**: SpotNow automatically uses previously downloaded assistance data, if ephemeris validity time is not expired (i.e. within 3 hours). Otherwise, a new GPS aiding request is automatically triggered. Automatic mode is suggested to optimize the number of aiding download requests and to comply with the SpotNow free-of-charge plan. It can be enabled using the SpotNow sensor, e.g. AT+ULOC=2,16,… For more details, see the AT commands manual [1].
- **Manual aiding mode**: SpotNow forces the GPS aiding download from the server, even if valid assistance data are stored in NVM. This may be useful in area of poor/intermittent cellular coverage. Note that each manual request is counted and reduces the number of free-of-charge aiding requests per month. It can be enabled using the combination of SpotNow sensor and CellLocate sensor, e.g. AT+ULOC=2,18,… For more details, see the AT commands manual [1].

Use +USPOTNOWIND AT command to check the current validity status of the aiding data in NVM.

☞   The application shall configure module RTC to be aligned to UTC better than 10s. Time zone shall be updated too. Automatic update of local time with the network time information is enabled by factory default (+CTZU: 1), so after every LTE attach the time of the module is updated, if the network supports the service.
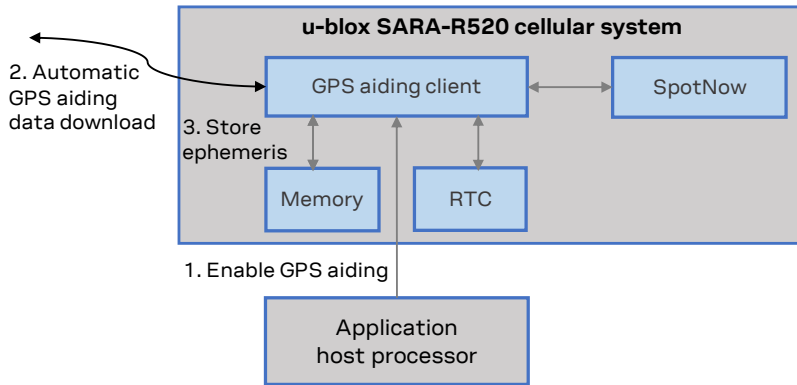
Figure 1: SpotNow and the GPS aiding service

☞ In case of no valid ephemeris and no data connection, SpotNow will use the last known ephemeris, even outside their validity interval, to attempt to get a GPS position fix.

The data payload sent from the module to the server during the GPS aiding request procedure is about 200 bytes; amount of aiding data downloaded from the server is about 2.5 kilobytes.

The `+UULOCIND: <aiding_mode>,<result>` URC provides the aiding notification. See references on the allowed aiding results in the AT commands manual [1]. The URC is disabled by default, and can be enabled via the command `AT+ULOCIND=1`.

Figure 2 and Figure 3 show the interactions between the cellular modem and the service. If enabled, a URC is sent after each step of the GPS aiding request is completed, so the indication will be returned after successful delivery of the assistance data from the server, even if the receiver cannot get a GPS fix. If an error is encountered during the GPS aiding procedure, the corresponding URC will report it. For details of the `+ULOCIND` AT command description, see the AT commands manual [1].

Figure 2 refers to SpotNow operating in automatic aiding mode, while Figure 3 refers to SpotNow operating in manual aiding mode.

Dashed lines in Figure 2 and Figure 3 refer to the cases in which the modem operates using NB-IoT technology in an area where the aiding service may require a contribution (SpotNow position fix, around 50 bytes) from the device to improve the overall performance of the assistance.
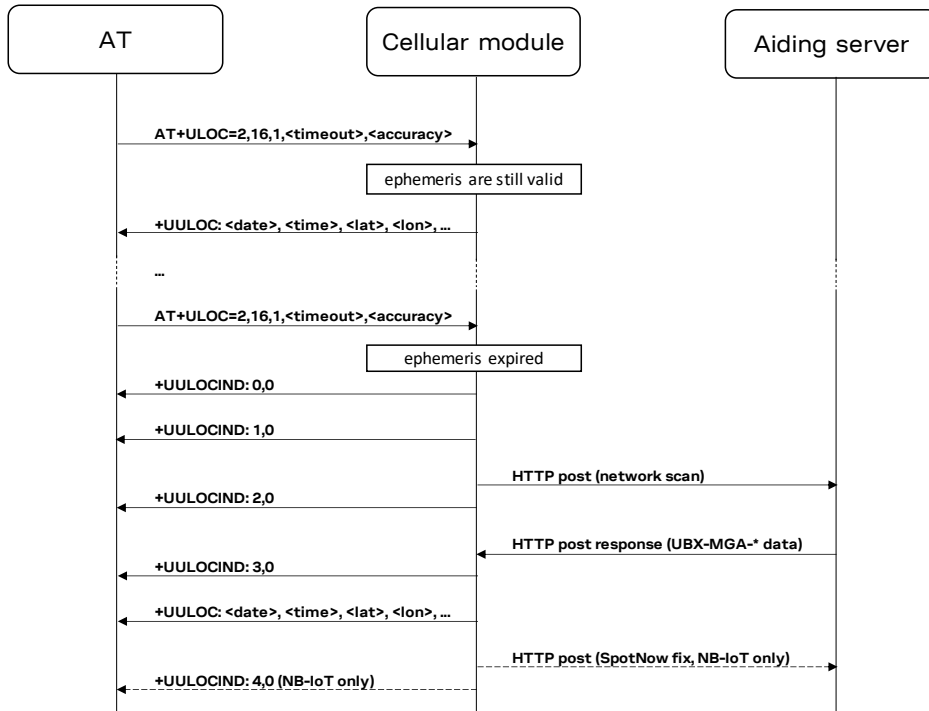
Figure 2: Interaction between the cellular module and aiding service with SpotNow set in automatic aiding mode

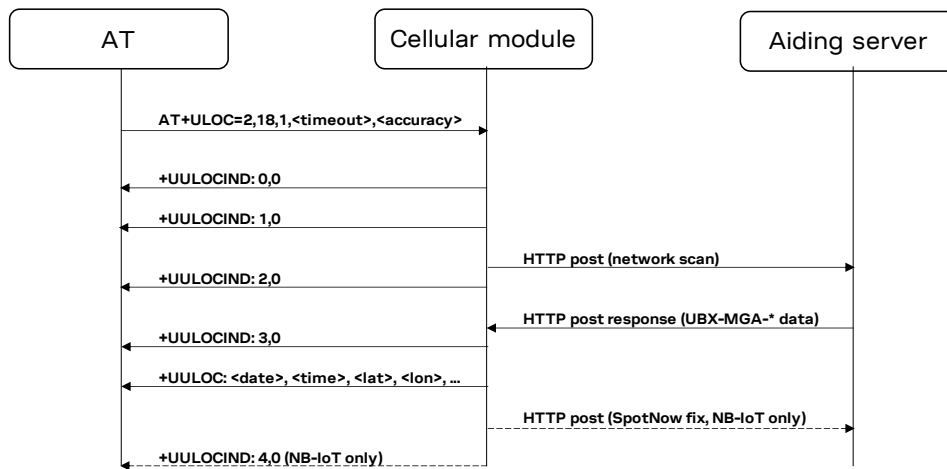**Figure 3: Interaction between the cellular module and service with SpotNow set in manual aiding mode**

Using the automatic aiding mode, the cellular module automatically checks for the validity of the stored aiding data, so no check is needed by the user application.

The stored aiding data are valid if they are not older than 3 hours and the approximate knowledge of the position is accurate within 100 km.

In case of device travelling more than linear 100km in less than 3 hours, the user application has two options:

- Trigger the SpotNow position more often (e.g.: every 30mins): the last known position is saved in the modem and used for the next signal acquisition.
- Trigger a new aiding request (position estimation and ephemeris) anytime by invoking a position estimation request using the hybrid sensor, e.g. `AT+ULOC=2,18,…` For more details, see the AT commands manual [1]. In this case both a new position estimation and new set of ephemeris will be provided by the assistance server to the device in response to the AT command.

The 1st option is preferred to reduce the power consumption, since the connection with the service is not needed and the additional position fixes required have a minimum impact on the power consumption; furthermore, this can avoid exceeding the monthly free-of-charge number of aiding requests allowance.

4 SpotNow configuration

4.1 General considerations

While operating with SpotNow:

- SpotNow sensor can be enabled by the +ULOC AT command.
- NMEA messages and UBX messages are not available in the user interface, neither as input nor output.
- A retry mechanism is exercised (e.g., with limited sky visibility) until the required accuracy is met until timeout. Therefore, the accuracy requirements will impact on the number of retries and on the overall module power consumption.
- Time and date within the cellular module can be set by the +CCLK and +CTZU commands respectively. For AT commands details, see u-blox AT commands manual [1].

4.2 Operations and messages

Table 2 shows how to input in the device the token received from the Thingstream platform, which can be performed only once, before the first use of SpotNow.

Table 3 shows an example of the configuration and the enabling of SpotNow. The data context must be configured and enabled to access the GPS aiding server. The indication status can optionally be activated.

Command	Response	Description
AT+UGLAASZTP=2,<token>,<givenName>	OK	Configure ZTP parameters to obtain access credentials to ThingStream for SpotNow service

Table 2: Example of ZTP configuration

Command	Response	Description
AT+ULOCIND=1	OK	Enable the localization information request status.
AT+USPOTNOWIND=1	OK	Enable the aiding validity status indications.
AT+ULOC=2,16,1,30,30	OK	Start SpotNow sensor with a timeout of 30 s and a desired accuracy of 30 m. The answer mode is detailed.
	+UUSPOTNOWIND: 60,0	Aiding data valid. Expire in 60 minutes.
	+UULOC: 01/01/2022,12:47:41.000, 45.7139302,13.7405056,265,25,0,0,0,16,8,0,0	Output when the desired accuracy is reached, or timeout is expired. If aiding data are still valid, then GPS aiding service is not queried and no +UULOCIND indications are received.

Command	Response	Description
AT+ULOC=2,18,1,30,30	OK	Start hybrid solution (SpotNow and CellLocate sensors) with a timeout of 30 s and a desired accuracy of 30 m. The answer mode is detailed.
	+UULOCIND: 0,0	Network scan started.
	+UULOCIND: 1,0	Network scan finished.
	+UULOCIND: 2,0	Requesting data to the server.
	+UULOCIND: 3,0	Received data from the server.
	+UUSPOTNOWIND: 180,0	Aiding updated. Expire in 180 minutes.
	+UULOC: 01/01/2022,12:47:41.000, 45.7139302,13.7405056,265,25,0,0 ,0,16,8,0,0	Output when the desired accuracy is reached or timeout is expired.

Table 3: Example of SpotNow configuration and enabling

5   SpotNow use cases

Different use cases may trigger SpotNow execution from different module status. Depending on the module status, a different set of commands shall be used, resulting in different processing times.

Possible statuses are:

- Power-off mode
- Airplane mode
- Registered, equivalent to the airplane mode, but without network registration phases
- Deep-sleep mode

Aiding data are saved in the module file system, therefore are persistent even when passing through operational states (e.g., deep-sleep mode) when RAM memory is released.

5.1   Time to fix from power-off mode

Time to fix (TTF) on a LEXI-R520 / SARA-R520 have been measured in two possible scenarios:

- Aiding data must be downloaded.
- Aiding data are still valid.

Figure 4 and Figure 5 show the different phases of the SpotNow use depending on the mode.

When the aiding is requested, a connection must be established and, by invoking the use of SpotNow (via `AT+ULOC=2,16,…`), the aiding will be automatically downloaded from the GPS aiding service. The module then automatically releases its connection with the network and performs the measurements needed to collect the fix.

Once the data context is active, the TTF will take about 5 s (depending also on network settings, as shown in Figure 4.

When using aiding data previously acquired, the module shall only perform the measurements and compute the fix in less than 2 s, as shown in Figure 5.

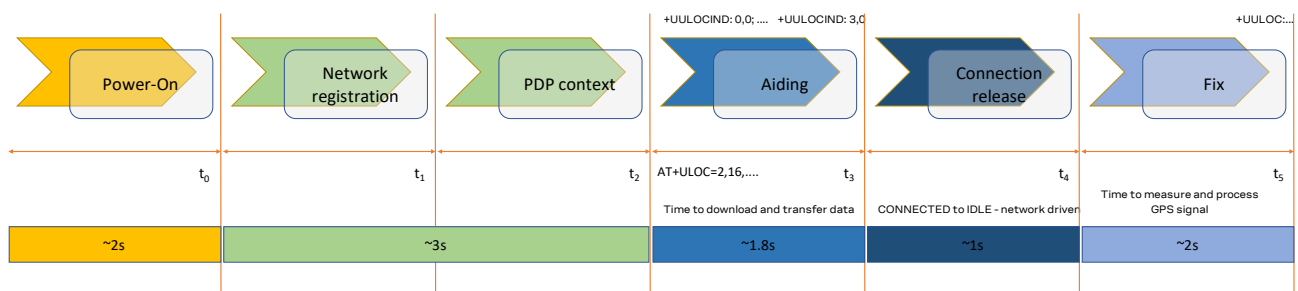These timings represent the TTF in good satellite visibility conditions.

Figure 4: The different phases in a LEXI-R520 / SARA-R520 module with GPS aiding
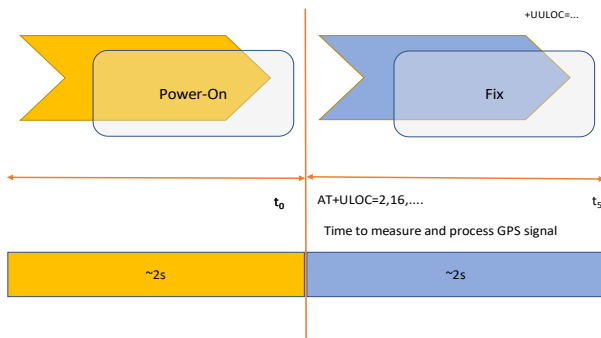
Figure 5: The different phases in a LEXI-R520 / SARA-R520 module when aiding data are still valid

Table 4 shows the AT commands to get the GPS fix by SpotNow starting from power-off mode. For details of the AT commands involved, see AT commands manual [1].

AT command / action	Notes
AT+ULOCIND=1	Enables the localization information request status (optional)
AT+ULOC=2,16,1,30,30	Starts SpotNow sensor

Table 4: Activating SpotNow sensor from power-off mode

5.2   Time to fix from airplane mode status

The actions required by the user application when the module is in airplane mode are different depending on the need of assistance from the GPS aiding service.

When the aiding data are already available and valid (downloaded less than 3 hours earlier, can be checked with +USPOTNOWIND AT command), there is no need to exit from the offline mode and to activate the data context, as shown in Figure 6.
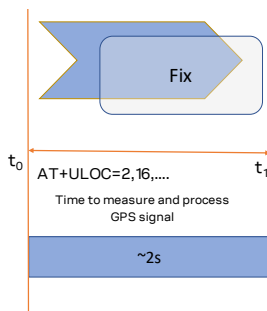

Figure 6: SpotNow operations when offline and with valid aiding

Table 5 shows the AT commands to pass from airplane mode status to the GPS fix by SpotNow.

AT command / action	Notes
AT+ULOCIND=1	Enable the localization information request status (optional)
AT+ULOC=2,16,1,30,30	Starts SpotNow sensor

Table 5: AT commands to activate SpotNow sensor when the module is offline and the aiding data are available

When the GPS aiding service shall be called for assistance (e.g.: aiding data expired, can be checked with +USPOTNOWIND AT command), the module must exit from offline mode and enable data context, as shown in Figure 7.
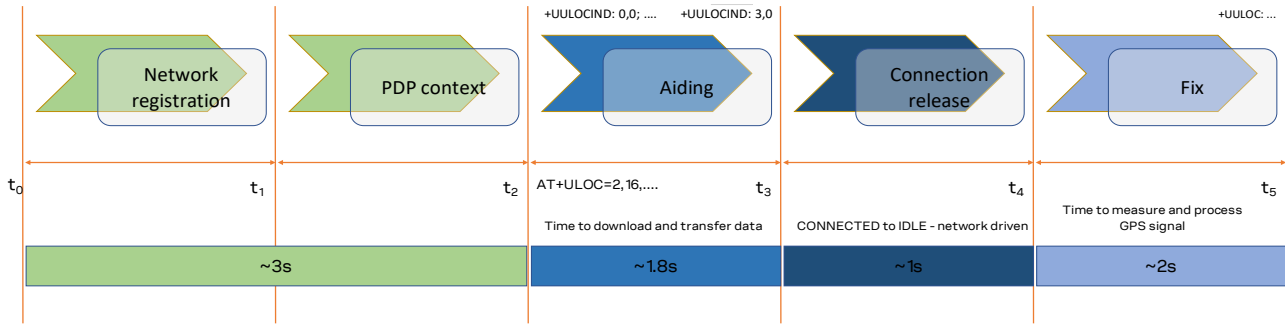
Figure 7: SpotNow operations when offline and the GPS aiding service shall be called

Table 6 shows the AT commands to pass from airplane mode status to the GPS fix by SpotNow.

AT command / action	Notes
+UUSPOTNOWIND: 0,1	**URC** to notify expired aiding data
AT+CFUN=1	Set the module to full functionality
AT+ULOCIND=1	Enable the localization information request status (optional)
AT+ULOC=2,16,1,30,30	Start SpotNow sensor

Table 6: Activating SpotNow sensor from airplane mode if aiding required

5.3   Time to fix from deep-sleep mode (with valid aiding)

Table 7 shows the AT commands to pass from deep-sleep mode to the GPS fix by SpotNow, assuming aiding data are already available and valid (downloaded less than 3 hours earlier).

When the aiding data are already available and valid, there is no need to activate the data context, see Figure 6.

AT command / action	Notes
Exit from the deep-sleep mode by means of PWR_ON input pin	Early wake-up
AT+ULOCIND=1	Enables the localization information request status (optional)
AT+ULOC=2,16,1,30,30	Starts SpotNow sensor

Table 7: Activate SpotNow sensor in early wake-up from deep-sleep mode (with aiding not expired).

Depending on the bit 4 setting on +UPSMVER command, the module may return automatically to deep-sleep mode (if the module does not make any network interactions for the subsequent 6 s) or can be forced to return to deep-sleep mode by issuing the +USLEEP AT command. For more details on the commands, see the AT commands manual [1].

Appendix

A Glossary

Abbreviation	Definition
AT	AT Command Interpreter Software Subsystem, or attention
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HTTP	HyperText Transfer Protocol
NMEA	National Marine Electronics Association
PDP	Packet Data Protocol
PSM	Power Saving Mode
RAM	Random Access Memory
RF	Radio Frequency
RRC	Radio Resource Control
RTC	Real Time Clock
TTF	Time To Fix
UART	Universal Asynchronous Receiver-Transmitter
URC	Unsolicited Result Code
UTC	Coordinated Universal Time
ZTP	Zero Touch Provisioning

Related documentation

[1]   u-blox LEXI-R520 / SARA-R5 series AT commands manual, UBX-19047455
[2]   Thingstream IoT Location-as-a-Service pricing, https://portal.thingstream.io/pricing/laas
[3]   u-blox SARA-R52 series data sheet, UBX-22038918
[4]   u-blox SARA-R52 series system integration manual, UBX-23004806
[5]   u-blox LEXI-R520 data sheet, UBX-22020070
[6]   u-blox LEXI-R520 system integration manual, UBX-23008006

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Revision history

Revision	Date	Name	Comments
R01	16-Mar-2022	anda	Initial release
R02	03-Jul-2023	anda / fvid	Updated for SARA-R520
R03	29-Mar-2024	vbon / anda / fvid	Extended applicability to LEXI-R520. Added +USPOTNOWIND. Updated authentication process. Improved description of aiding modes.

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