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## Getting started with the STM32Cube function pack for GNSS and cellular connectivity enabling Assisted-GNSS applications

### Introduction

The **FP-SNS-AGNSS1** function pack for **STM32Cube** lets you connect your IoT node to a cellular network and enable Assisted-GNSS applications.

Assisted-GNSS provides ephemeris assistance from an external source (RxNetworks online service), thus considerably reducing the time to obtain a FIX, especially in critical environments when the ephemeris download time could be very long.

The software runs on **STM32L496AG** MCUs and it is easily portable across different MCU families thanks to **STM32Cube**.

The package contains a sample implementation for **32L496GDISCOVERY** board equipped with the **X-NUCLEO-GNSS1A1** expansion board (featuring a GNSS receiver based on **Teseo-LIV3F** module), and the LTE IoT expansion board featuring a Quectel BG96 module.

The cellular expansion board included in the **P-L496G-CELL02** package is connected directly to the STMod+ connector of the **32L496GDISCOVERY** board.

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### RELATED LINKS

*Visit the [STM32Cube ecosystem web page on www.st.com](http://www.st.com) for further information*

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# 1 FP-SNS-AGNSS1 software expansion for STM32Cube

## 1.1 Overview

The **FP-SNS-AGNSS1** is an **STM32 ODE** function pack and expands **STM32Cube** functionality.

The software package shows how to enable Assisted-GNSS mechanism (both Predictive and RealTime types) supported by the **Teseo-LIV3F** device through the partnership with RxNetworks.

The package key features are:

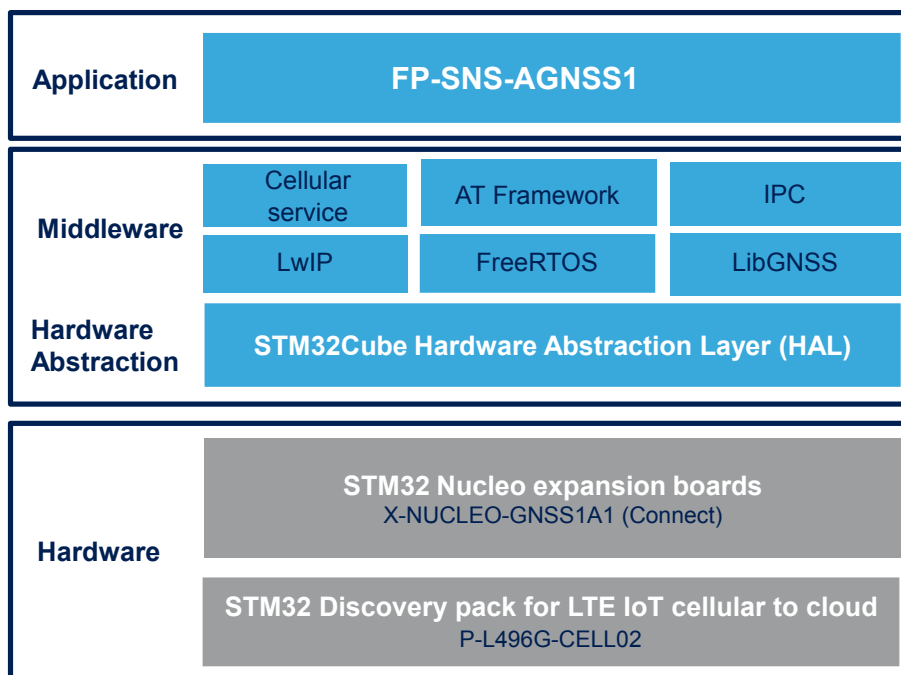
- Complete firmware to connect an IoT node with GNSS module to an LTE IoT cellular network
- Support for Assisted-GNSS through RxNetworks online services
- Middleware libraries with support for FreeRTOS, GNSS, NMEA and JSON parsing functionalities
- Sample implementation available for the **X-NUCLEO-GNSS1A1**, and the LTE IoT cellular expansion boards, when connected to a **32L496GDISCOVERY** board
- Easy portability across different MCU families, thanks to **STM32Cube**
- Free, user-friendly license terms

## 1.2 Architecture

The application software accesses the **X-NUCLEO-GNSS1A1** and cellular expansion boards through the following software layers:

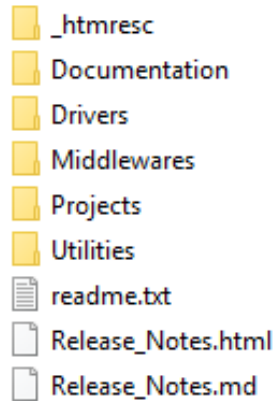
- the **STM32Cube HAL layer**, which provides a simple, generic, multi-instance set of application programming interfaces (APIs) to interact with the upper application, library and stack layers. It has generic and extension APIs and is directly built around a generic architecture and allows successive layers like the middleware layer to implement functions without requiring specific hardware configurations for a given microcontroller unit (MCU). This structure improves library code reusability and guarantees an easy portability on other devices.
- the **board support package (BSP)** layer supports all the peripherals on the **STM32 Nucleo** except the MCU. This limited set of APIs provides a programming interface for certain board-specific peripherals like the LED, the user button, etc. This interface also helps in identifying the specific board version.

Figure 1. FP-SNS-AGNSS1 software architecture



## 1.3 Folder structure

Figure 2. FP-SNS-AGNSS1 package folder structure



The following folders are included in the software package:

- **Documentation:** contains a compiled HTML file generated from the source code which details the software components and APIs.
- **Drivers:** contains the HAL drivers and the board-specific drivers for each supported board or hardware platform, including the on-board components and the CMSIS vendor-independent hardware abstraction layer for ARM Cortex-M processor series.
- **Middlewares:** contains libraries and protocols related to FreeRTOS, GNSS, NMEA, JSON parsing, and the cellular framework.
- **Projects:** contains a sample application used to perform the Assisted GNSS. This application is provided for [P-L496G-CELL02](#) platform with three development environments: IAR Embedded Workbench for ARM, RealView Microcontroller Development Kit ([MDK-ARM-STR](#)) and [STM32CubeIDE](#).
- **Utilities:** contains some complementary project files.

## 1.4 APIs

Detailed technical information with full user API function and parameter description are in a compiled HTML file in the "Documentation" folder.

## 1.5 Sample application description

A sample application is provided in the Projects folder, using the [X-NUCLEO-GNSS1A1](#) and LTE IoT cellular expansion boards with [P-L496G-CELL02](#).

Ready-to-build projects are available for multiple IDEs.

The user interface is provided via serial port and must be configured with the settings shown below.

Figure 3. Terminal settings

Tera Term: Serial port setup

Port: COM7

Baud rate: 115200

Data: 8 bit

Parity: none

Stop: 1 bit

Flow control: none

Transmit delay

10 msec/char 10 msec/line

OK

Cancel

Help

**Step 1.** Wait for the modem to be successfully initialized and in active state.

Note:

*If the modem fails initializing, push the reset button on the discovery board.*

**Step 2.** Press enter to start the A-GNSS Application when the related message appears to notify the A-GNSS task is ready.

**Step 3.** Select a command from the A-GNSS main menu.

**Figure 4. A-GNSS application main menu**

```
COM7 - Tera Term VT
File Edit Setup Control Window Help
AT+CGATT?<CR>
<CR><LF>
+CGATT: 1<CR><LF>
<CR><LF>
OK<CR><LF>
***** CST_attach_modem_mngt OK *****
-----> State : CST_MODEM_REGISTERED_STATE <-----
ATParser:*** SEND (size=14) ***
AT+CGEREP=1,0<CR>
<CR><LF>
OK<CR><LF>
ATParser:*** SEND (size=10) ***
AT+QIAC?<CR>
<CR><LF>
OK<CR><LF>
UC96:user cid = 1, modem cid = 1
ATParser:*** SEND (size=11) ***
AT+QIAC?<CR>
<CR><LF>
OK<CR><LF>
ATParser:*** SEND (size=10) ***
AT+QIAC?<CR>
<CR><LF>
+QIAC: 1.1.1,"10.193.184.27"<CR><LF>
<CR><LF>
OK<CR><LF>
-----> State : CST_MODEM_PDN_ACTIVATE_STATE <-----
***** CST_cellular_service_task : auton_event = no event
ATParser:*** SEND (size=10) ***
AT+QIAC?<CR>
<CR><LF>
+QIAC: 1.1.1,"10.193.184.27"<CR><LF>
<CR><LF>
OK<CR><LF>
-----> State : CST_MODEM_DATA_READY_STATE <-----
Press enter to start the A-GNSS Application!
Select a command:
1 - agnss
2 - help
3 - ext-help
> 1
Type "GENPASS" to get password
Type "DOWNLOAD-PR-DATA,x" - x constellation flag:
G or g: only GPS
R or r: only GLO
E or e: only GAL
C or c: only BEI
A or a: FULL constellation GPS + GLO + GAL
Type "DOWNLOAD-RT-DATA,x" - x constellation flag:
G or g: only GPS
R or r: only GLO
E or e: only GAL
C or c: only BEI
Type "GETAGPSSTATUS" to get A-GNSS status
>
```

- Step 4.** To access the RxNetworks servers, provide a set of parameters to generate the HTTP request. Predictive A-GNSS and RealTime A-GNSS use the same password generator and the same NMEA commands. GENPASS is the command used to make the [Teseo-LIV3F](#) generate a password to access the RxNetworks server.

Figure 5. Password generation

```
COM7 - Tera Term VT
File Edit Setup Control Window Help
>
UG96: SOCKET PROMPT RECEIVED
      ATParser:*** SEND (size=37) ***
0x48 0x45 0x41 0x44 0x20 0x2f 0x20 0x48 0x54 0x50 0x2f 0x31 0x2e 0x31 0x0d
0x0a 0x48 0x6f 0x73 0x74 0x3a 0x20 0x77 0x77 0x2e 0x73 0x74 0x2e 0x63 0x6f
<CR><LF>
      SEND OK<CR><LF>
COM: snd data ok
HTTP: socket send data OK
      ATParser:*** SEND (size=12) ***
AT+QIRD=1,0<CR>
<CR><LF>
      +QIRD: 0,0,0<CR><LF>
UG96: +QIRD: total_receive_length = 0
UG96: +QIRD: have_read_length = 0
UG96: +QIRD: unread_length = 0
<CR><LF>
      OK<CR><LF>
CS:Size of data received on the socket= 0 bytes
<CR><LF>
      +QIURC: "recv".1<CR><LF>
COM: ch socket 0 data ready called: waiting rsp
      ATParser:*** SEND (size=12) ***
AT+QIRD=1,195<CR>
<CR><LF>
      +QIRD: 195,0,195<CR><LF>
UG96: +QIRD: total_receive_length = 195
UG96: +QIRD: have_read_length = 0
UG96: +QIRD: unread_length = 195
<CR><LF>
      OK<CR><LF>
      ATParser:*** SEND (size=14) ***
AT+QIRD=1,195<CR>
<CR><LF>
      +QIRD: 195<CR><LF>
UG96: +QIRD: received data size = 195
UG96: +QIRD: remote IP address =
      ATParser: Big frame (display deactivated)
<CR><LF>
      OK<CR><LF>
CS:Size of data received on the socket= 195 bytes
COM: rev data exit with data
HTTP: Update date and time
Configuring the RTC from Date: Thu, 19 Dec 2019 15:45:20 GMT
HTTP: Update date and time OK
HTTP: HEAD response OK
Today's time : 15:45:20
GPS time [sec] : 1260005520
Password Generation: [ PASS GEN OK ]
Device Id: [ 00513730363331341900AF97 ]
Password: [ jCkIng1h16S19H+M16v7NwR5hDDz0qgnmHahq2HPoC4= ]
>
```

**Step 5.** To download the assistance data called “seed” for the Predictive A-GNSS mechanism, invoke the command `DOWNLOAD-PR-DATA, x`, where `x` is the flag for one of the following constellations:

- GPS
- Glonass
- Galileo
- BeiDou

When the message “SEED PROPAGATION OK” is displayed, the transmission is complete.

**Figure 6. Predictive A-GNSS seed transmission**

```

COM7 - Tera Term VT
File Edit Setup Control Window Help
UG96:~QIRD: unread_length = 1001
<CR><LF>
OK<CR><LF>
ATParser:*** SEND (size=15) ***
AT+QIRD=1,1001<CR>
<CR><LF>
+QIRD: 1001<CR><LF>
UG96:~QIRD: received data size = 1001
UG96:~QIRD: remote IP address =
ATParser: Big frame (display deactivated)
<CR><LF>
OK<CR><LF>
CS:Size of data received on the socket= 1001 bytes
COM: rcv data exit data available or err low level
ATParser:*** SEND (size=13) ***
AT+QICLOSE=1<CR>
<CR><LF>
OK<CR><LF>
CS:socket deallocateHandle 0
COM: close socket ok
HTTP: socket close OK
HTTP: POST response OK
curr_secs(18), next_gps_time(0) next_secs(19)
Seed (seed_size 5120, base64 - len 4672):

*****nun_sats_gps = 30

*****seed_info.nsat = 0

*****seed_info.max_satid = 30
Send $PSTMSIAGPSSEEDBEGIN command
SEED BEGIN OK
>Send $PSTMSIAGPSBLKTYPE command
BLOCK TYPE OK
>Send $PSTMSIAGPSSEEDPKT commands
Sending PKT 0
SEED PKT OK
>Sending PKT 1
SEED PKT OK
>Sending PKT 2
SEED PKT OK
>Sending PKT 3
SEED PKT OK
>Sending PKT 4
SEED PKT OK
>Sending PKT 5
  
```

**Step 6.** To download the assistance data called “seed” for the RealTime AGNSS mechanism, invoke the command `DOWNLOAD-RT-DATA, x`, where x is the flag for one of the following constellations:

- GPS
- Glonass
- Galileo
- BeiDou

**Figure 7. RealTime A-GNSS seed transmission**

```
COM7 - Tera Term VT
File Edit Setup Control Window Help
[GPS EPH] SAT ID: 14
[GPS EPH] SAT ID: 15
[GPS EPH] SAT ID: 16
[GPS EPH] SAT ID: 17
[GPS EPH] SAT ID: 19
[GPS EPH] SAT ID: 20
[GPS EPH] SAT ID: 21
[GPS EPH] SAT ID: 22
[GPS EPH] SAT ID: 23
[GPS EPH] SAT ID: 24
[GPS EPH] SAT ID: 25
[GPS EPH] SAT ID: 26
[GPS EPH] SAT ID: 27
[GPS EPH] SAT ID: 28
[GPS EPH] SAT ID: 29
[GPS EPH] SAT ID: 30
[GPS EPH] SAT ID: 31
[GPS EPH] SAT ID: 32
Alm Seed (base64 - bytes written 964):
[GPS ALM] (num_sats=31):
[GPS ALM] SAT ID: 1
[GPS ALM] SAT ID: 2
[GPS ALM] SAT ID: 3
[GPS ALM] SAT ID: 4
[GPS ALM] SAT ID: 5
[GPS ALM] SAT ID: 6
[GPS ALM] SAT ID: 7
[GPS ALM] SAT ID: 8
[GPS ALM] SAT ID: 9
[GPS ALM] SAT ID: 10
[GPS ALM] SAT ID: 11
[GPS ALM] SAT ID: 12
[GPS ALM] SAT ID: 13
[GPS ALM] SAT ID: 14
[GPS ALM] SAT ID: 15
[GPS ALM] SAT ID: 16
[GPS ALM] SAT ID: 17
[GPS ALM] SAT ID: 19
[GPS ALM] SAT ID: 20
[GPS ALM] SAT ID: 21
[GPS ALM] SAT ID: 22
[GPS ALM] SAT ID: 23
[GPS ALM] SAT ID: 24
[GPS ALM] SAT ID: 25
[GPS ALM] SAT ID: 26
[GPS ALM] SAT ID: 27
[GPS ALM] SAT ID: 28
[GPS ALM] SAT ID: 29
[GPS ALM] SAT ID: 30
[GPS ALM] SAT ID: 31
[GPS ALM] SAT ID: 32
Send $PSTIMEPHEN command...
[GPS EPH] SAT ID: 1
[GPS EPH] SAT ID: 2
[GPS EPH] SAT ID: 3
```

## RELATED LINKS

For more details about Assisted-GNSS, see [AN5160: "RxNetworks Assisted-GNSS Server Interface Specification"](#) and [UM2399: "ST Teseo III binary image"](#)



## 2 System setup guide

### 2.1 Hardware description

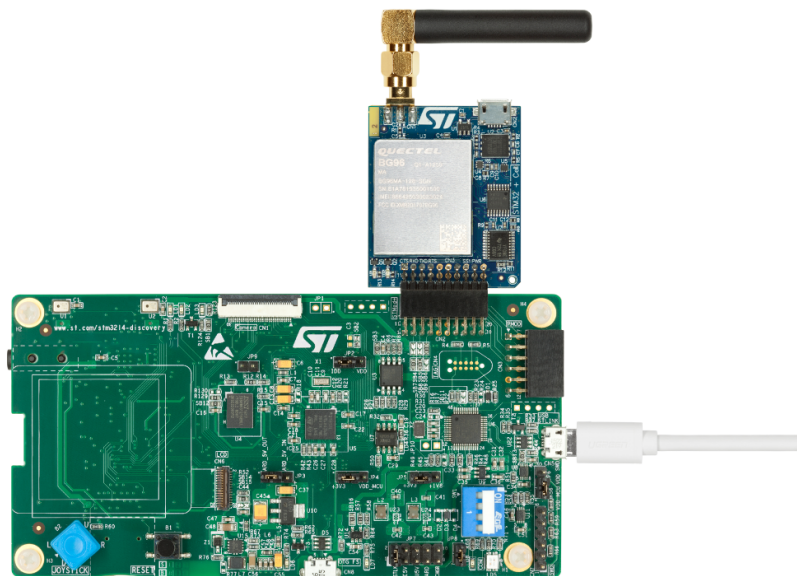
#### 2.1.1 P-L496G-CELL02 discovery pack

The [P-L496G-CELL02](#) STM32 discovery pack for LTE IoT cellular to cloud (STM32-C2C/LTE IoT) is a turnkey development platform for cellular and cloud technology-based solutions.

The discovery pack consists of the following boards:

1. An [STM32L496AGI6](#)-based low-power discovery motherboard with preloaded firmware ([32L496GDISCOVERY](#)). The microcontroller has 1 Mbyte of Flash memory and 320 Kbytes of RAM in a UFBGA169 package.
2. An STMod+ cellular expansion board with antenna. The expansion board features a Quectel BG96 worldwide cellular modem LTE Cat M1/Cat NB1/EGPRS module 300 kbps downlink, 375 kbps uplink.

**Figure 8. P-L496G-CELL02 LTE cellular to cloud pack**



#### 2.1.2 X-NUCLEO-GNSS1A1 expansion board

The [X-NUCLEO-GNSS1A1](#) expansion board is based on the Teseo-LIV3F tiny GNSS module.

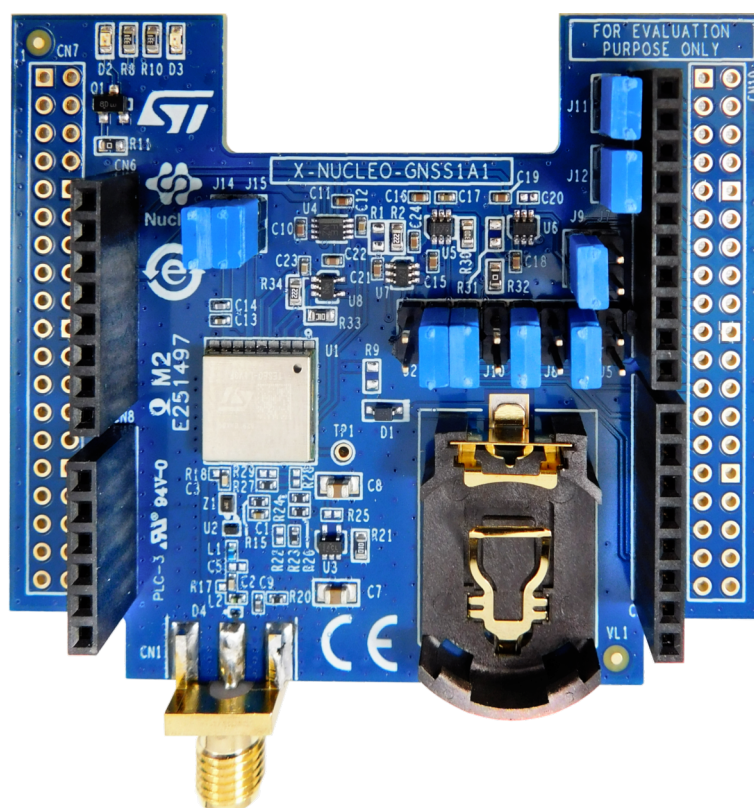
It represents an affordable, easy-to-use, global navigation satellite system (GNSS) module, embedding a TeseoIII single die standalone positioning receiver IC, usable in different configurations in your [STM32 Nucleo](#) project.

The Teseo-LIV3F is a compact (9.7x10.1 mm) module that provides superior accuracy thanks to the on-board 26 MHz temperature compensated crystal oscillator (TCXO) and a reduced time-to-first fix (TTFF) with its dedicated 32 KHz real-time clock (RTC) oscillator.

The Teseo-LIV3F module runs the GNSS firmware (X-CUBE-GNSS1) to perform all GNSS operations including acquisition, tracking, navigation and data output without external memory support.

The X-NUCLEO-GNSS1A1 expansion board is compatible with the Arduino™ UNO R3 connector and the ST morpho connector, so it can be plugged to the STM32 Nucleo development board and stacked with additional STM32 Nucleo expansion boards.

Figure 9. X-NUCLEO-GNSS1A1 expansion board



## 2.2 Hardware setup

The following hardware components are needed:

1. One STM32 discovery pack for cellular to cloud (STM32-C2C) development platform (order code: [P-L496G-CELL02](#) for LTE IoT) with an STM32-C2C LTE IoT cellular expansion boards (provided in the [P-L496G-CELL02](#) pack)
2. One [Teseo-LIV3F](#) expansion board (order code: [X-NUCLEO-GNSS1A1](#))
3. One USB type A to Mini USB Type B cable to connect the STM32 discovery board to the PC

## 2.3 Software setup

The following software components are required for the setup of a suitable development environment to create applications for the [32L496GDISCOVERY](#) board equipped with the [X-NUCLEO-GNSS1A1](#), and the LTE IoT cellular expansion boards:

- [FP-SNS-AGNSS1](#) firmware and related documentation available on [www.st.com](#)
- Development tool-chain and Compiler. The [STM32Cube](#) expansion software supports the three following environments to select from:
  - IAR Embedded Workbench for ARM® (EWARM) toolchain + ST-LINK
  - RealView Microcontroller Development Kit ([MDK-ARM-STR](#)) toolchain + ST-LINK
  - [STM32CubeIDE](#) + ST-LINK

## 2.4 System setup

The [32L496GDISCOVERY](#) board integrates the ST-LINK/V2-1 debugger/programmer. The developer can download the relevant version of the ST-LINK/V2-1 USB driver by searching STSW-LINK008 or [STSW-LINK009](#) on [www.st.com](#) (depending on your Windows version).

The [X-NUCLEO-GNSS1A1](#) expansion board can be easily connected to the [32L496GDISCOVERY](#) board through the Arduino UNO R3 extension connector.

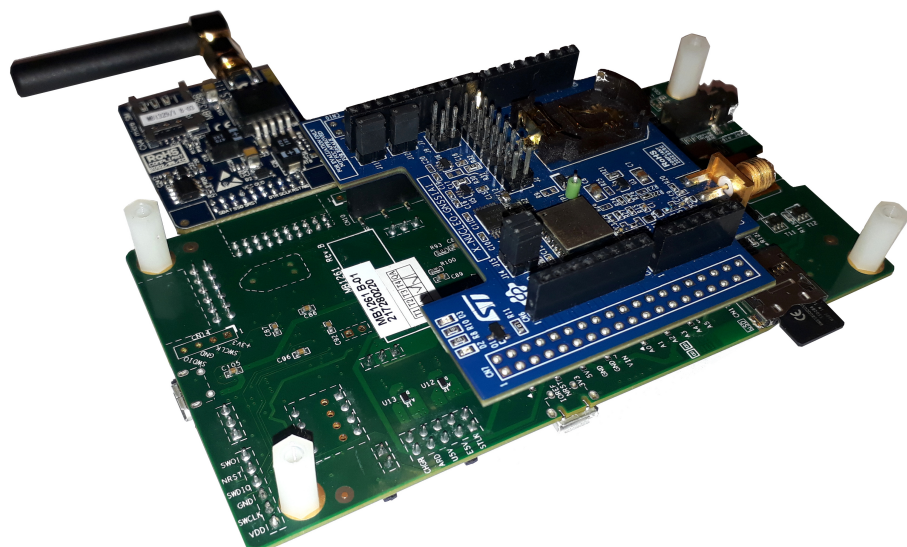
Before connecting the boards, on the [X-NUCLEO-GNSS1A1](#) expansion board:

- open J3, J4, J6, J7, J8, J10 jumpers
- close J2, J5, J9, J11, J12, J13, J14, J15 jumpers

The board interfaces with the external STM32 microcontroller on the [32L496GDISCOVERY](#) board using inter-integrated circuit (I<sup>2</sup>C) transport layer.

The Quectel BG96 modem expansion board can be directly connected to the [32L496GDISCOVERY](#) board through the STMod+ port.

**Figure 10. P-L496G-CELL02 plus X-NUCLEO-GNSS1A1**



## Revision history

**Table 1. Document revision history**

Date	Version	Changes
14-Jan-2020	1	Initial release.
11-Feb-2020	2	Updated Introduction, <a href="#">Section 1.1 Overview</a> , <a href="#">Figure 1. FP-SNS-AGNSS1 software architecture</a> , <a href="#">Section 1.5 Sample application description</a> , <a href="#">Section 2.2 Hardware setup</a> . Added <a href="#">Section 2.1.1 P-L496G-CELL02 discovery pack</a> . Added P-L496G-CELL02 compatibility information.

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