STSW-STWINCELL
Quick Start Guide

Version V1.0 (April, 2020)

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Introduction

Cellular low power wide area network (**LPWAN**) technologies are highly applicable in Industrial Internet of Things (IIoT) scenarios, especially those involving battery-powered sensor nodes that require wireless, low power and long-range connectivity. Condition monitoring and predictive maintenance applications are excellent candidates for leveraging LPWAN protocols such as **NB-IoT** and **LTE-M** to deliver affordable cloud monitoring solutions for industrial equipment when wired connectivity is not viable.

Narrow band Internet of Things (NB-IoT) is a standards-based, LPWAN technology that offers a wide range of services associated with connected objects. It can significantly reduce power consumption in user devices and still provide the necessary coverage for application control and data transmission services, including security and privacy support for user identity confidentiality, entity authentication, confidentiality, data integrity, and mobile equipment identification.

Long-term evolution machine type communication (LTE-M) offers better performance and can therefore complement NB-IoT when high data transmission speeds and terminal mobility are required, while the superior radioelectric coverage, lower costs and longer battery life offered by NB-IoT should be preferred when these services are not necessary.

The STSW-STWINCELL software package lets you test and develop a cloud condition monitoring environment implementing safe and low-consumption machine-to-machine (M2M) cellular communication using the SensorTile Wireless Industrial Node (STEVAL-STWINKT1) along with the STMod+ cellular expansion board with BG96 modem from Quectel (included in the P-L496G-CELL02 Discovery pack), which is able to connect to LTE Cat M1 (LTE-M), LTE Cat NB1 (NB-IoT) and EGPRS cellular networks.

This cellular connectivity allows the STSW-STWINCELL firmware to publish smart, preprocessed data from STEVAL-STWINKT1 sensor nodes on the ST Predictive Maintenance Dashboard (DSH-PREDMNT) cloud application based on Amazon Web Services (AWS), from which you can gather, monitor and analyze critical vibration, ultrasound and environmental data on specific industrial equipment.

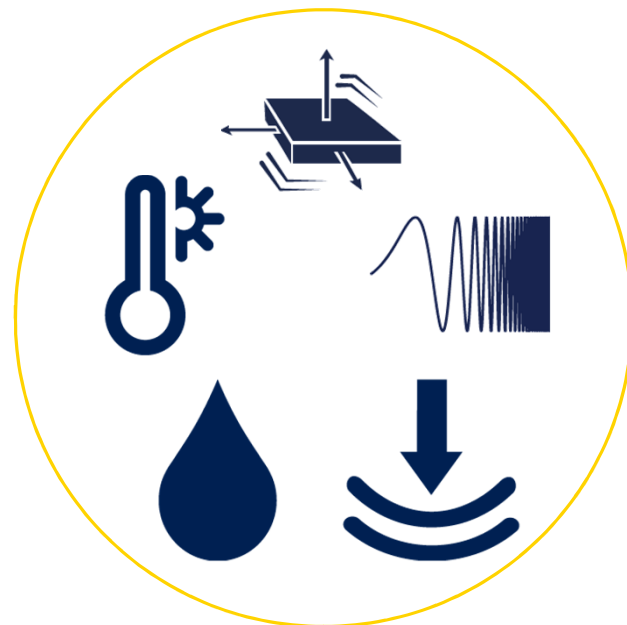# Contents

LPWAN cellular connectivity on STEVAL-STWINKT1
## Cloud condition-based monitoring applications

STSW-STWINCELL is a software package enabling users to connect a condition monitoring industrial smart sensors node to a cloud application based on Amazon Web Services (AWS), to share preprocessed sensor data, over the innovative Low Power Wide Area Network(LPWAN) cellular technology such as NB-IoT and LTE-M.

1. Get STEVAL-STWINKT1 and STMOD+ cellular add-on board based on Quectel BG96 modem
2. Download the STSW-STWINCELL and download it into STEVAL-STWINKT1's MCU
3. Register your node at DSH-PREDMNT
4. Set up your network configuration
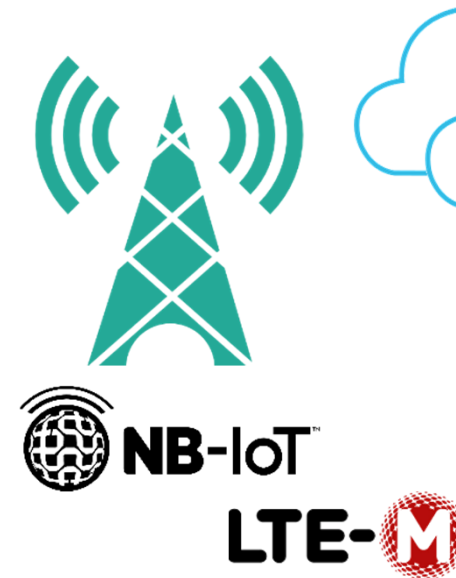5. Run the application
6. Monitor the data on DSH-PREDMNT

STEVAL-STWINKT1

STSW-STWINCELL
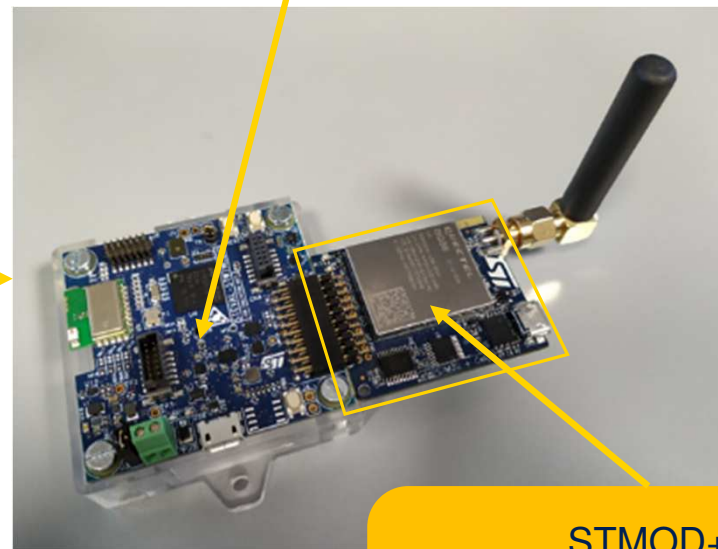
STMOD+
cellular add-on board
e.g. Quectel BG96 modem
(LTE Cat M1/NB/2G fallback)

NB-IoT

LTE-M

aws

Hardware Prerequisities

- **STEVAL-STWINKT1**
  - SensorTile Wireless Industrial Node development kit

- **Cellular STMod+ expansion board** with Quectel BG96 worldwide cellular modem (LTE Cat M1/Cat NB1/EGPRS module)
  - *The expansion board is not available separately and can only be ordered as part of the P-L496G-CELL02*
  - *STM32 Discovery pack, which includes a Discovery MCU board that you can use to optimize the scanning and connection times of the BG96 modem on the cellular expansion board.*

- **Micro-SIM** (3FF) with M2M/NB-IoT profile

- **Windows PC/laptop**

- **Micro USB cable**

STEVAL-STWINKT1

STMOD+
cellular add-on board
e.g. Quectel BG96 modem (LTE Cat M1 / NB-IoT / 2G fallback) coming from P-L496G-CELL02
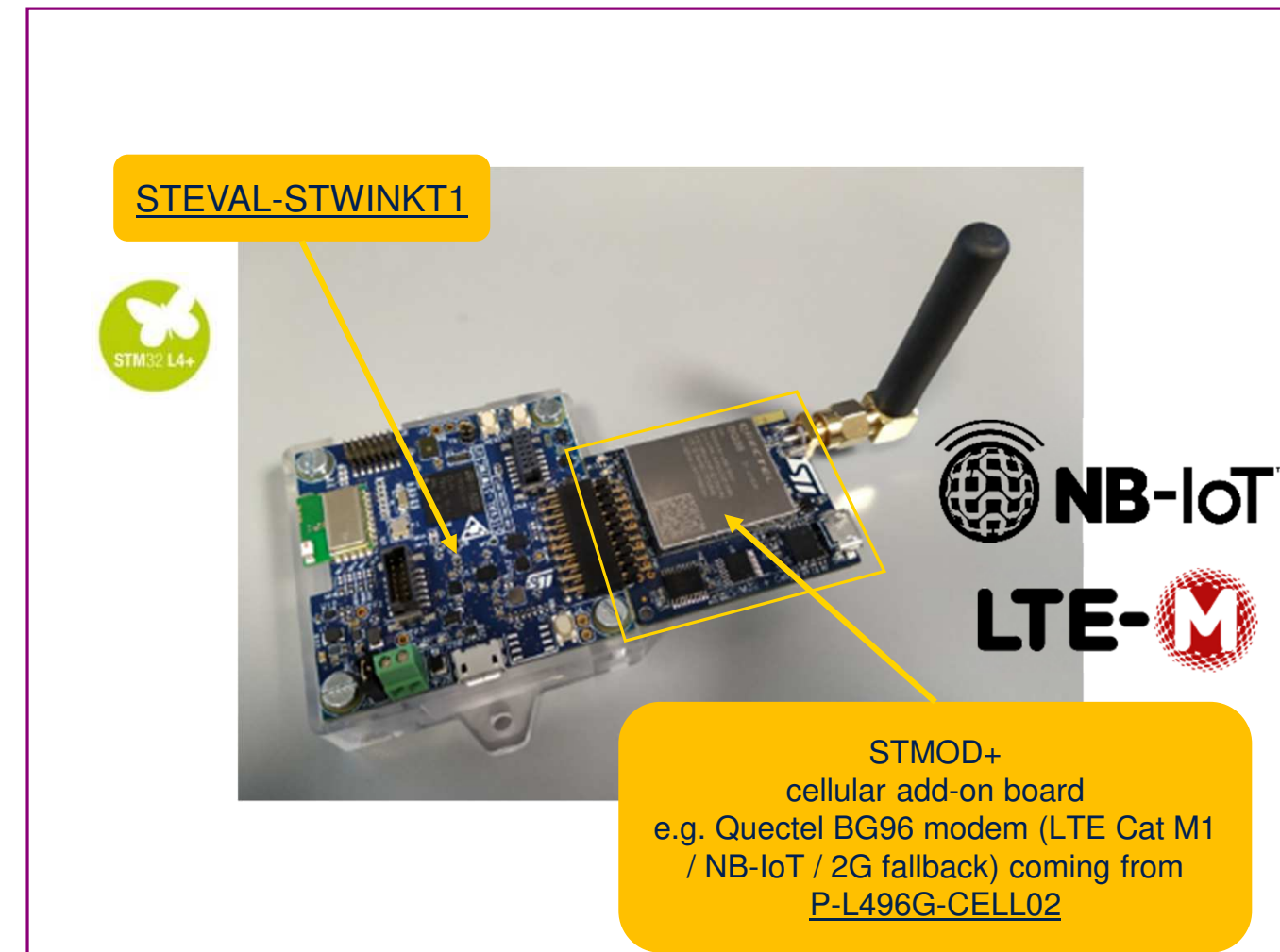
Software Prerequisities

- **STSW-STWINCELL**

  - cellular to cloud connectivity software package

- **X-CUBE-CELLULAR** cellular connectivity software expansion for STM32Cube

  Note: This software is optional and can be used to optimize the scanning and connection times of the BG96 modem

  on the cellular expansion board.

- Quectel LTE&5G Windows USB Driver

  - This software is optional and offers an alternative way to optimize the BG96 module scanning and connection times

- **STM32CubeProg**

  an all-in-one multi-OS software tool for programming STM32 products, to erase and program the flash memory of the microcontroller

- Common freely **Serial line terminal** (e.g. Tera Term)

- **DSH-PREDMNT**

  - Predictive Maintenance Dashboard AWS cloud application

Setup and Programming
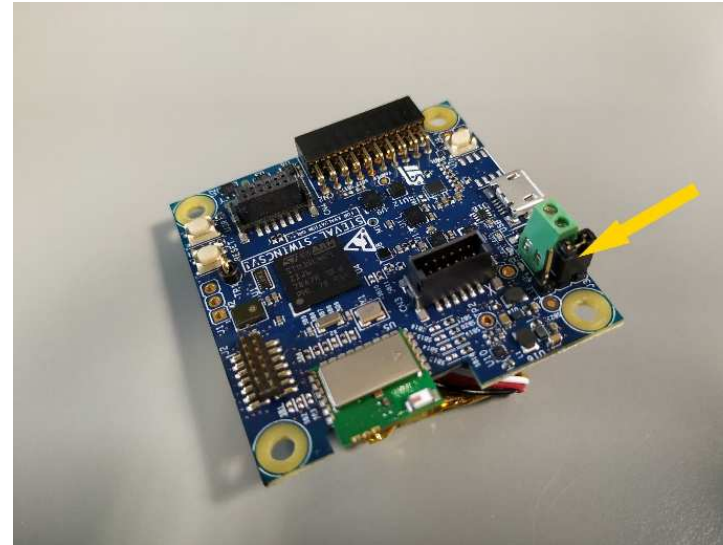
Setup STEVAL-STWINKT1 with Cellular add-on board

1 Connect the battery.

2 Route the right voltage to the power supply pin of the STMOD+ connector.
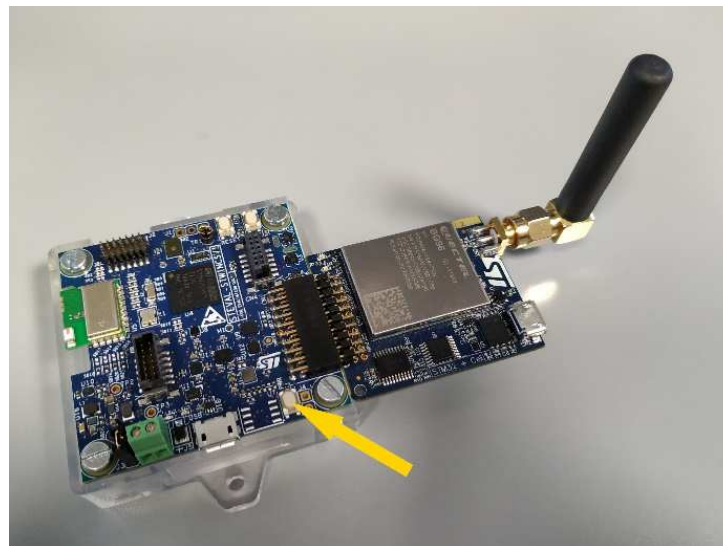

3 Insert the SIM card into the related socket of the STMOD+ cellular add-on board.
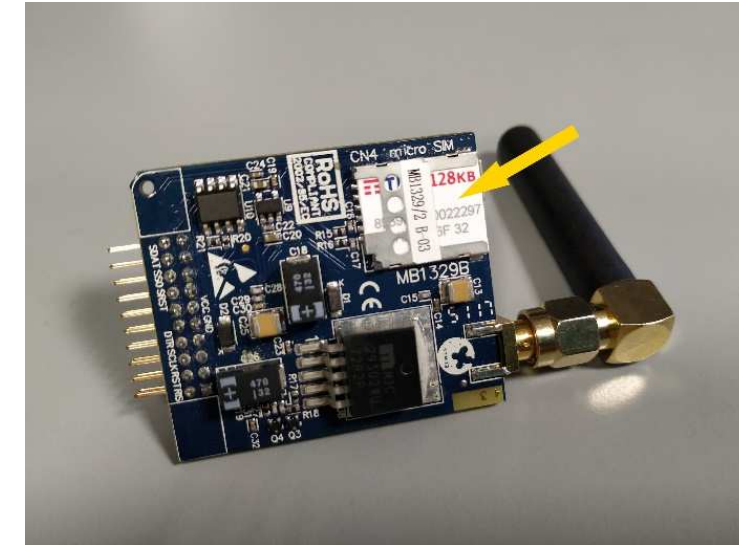
4 Assembly the main board with the plastic box and connect the cellular add-on board.

5 Power via USB receptacle and connect the STEVAL-STWINKT1 to a PC via the STLINK-V3MINI

6 Download STSW-STWINCELL binary file into STEVAL-STWINKT1's MCU

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Turn on and off the STEVAL-STWINKT1

- **Battery supply (no USB cable):**

  - Power ON

    - Press the PWR button for more than 2 s.

  - Power OFF

    - Holding down the PWR button for more than 4 s.

- **USB supply (no battery)**

  - Power ON

    - just connect a micro USB cable between the micro USB socket of the STEVAL-STWINKT1 and a USB port with at least 1 A of current capability.

  - Power OFF

    - Unplug the micro USB cable.
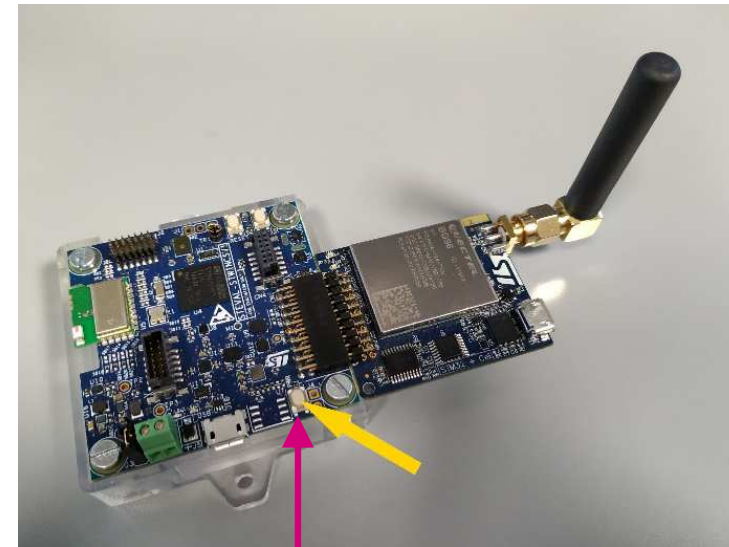
PWR button

USB cable
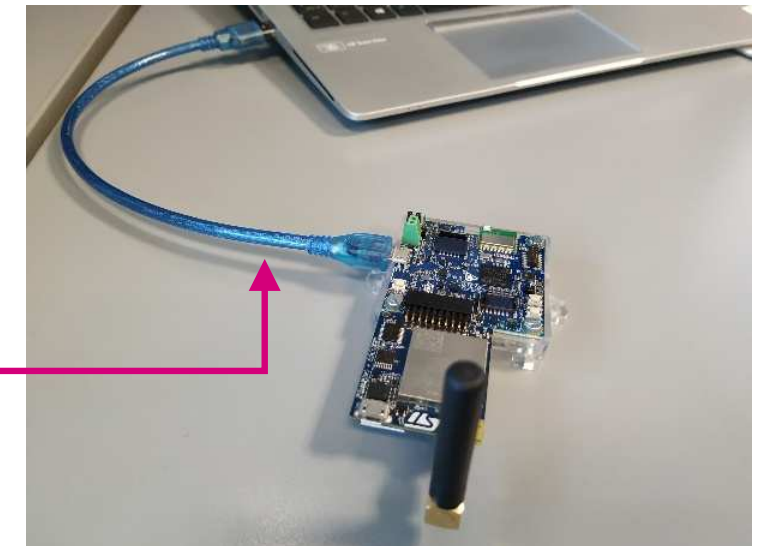
Remark: *The STMOD+ cellular add-on board is not optimized to be only powered by Li-Po battery. See AN5472 for more details.*

Download STSW-STWINCELL into STEVAL-STWINKT1

- **Connect** board as reported in picture

- **Download and unpack** the **STSW-STWINCELL** firmware (please take in account the path length issue so it is suggested to unpack into the root)
- Run the **STM32CubeProgrammer**
- Click on 'Connect'
- Click on 'Erasing & Programming'

Now …
- Choose the right (refer to the cellular module name) pre-built binary located into the folder 'STSW-STWINCELL\Projects\Demonstrations\C2C\AWS\Binary\'.
- Check 'Verify programming'
- Check 'Run after programming'
- Check 'Download file'
- Click on 'Start Programming'.

Then …
- Close all pop-up message windows.
- Click on 'Disconnect'.
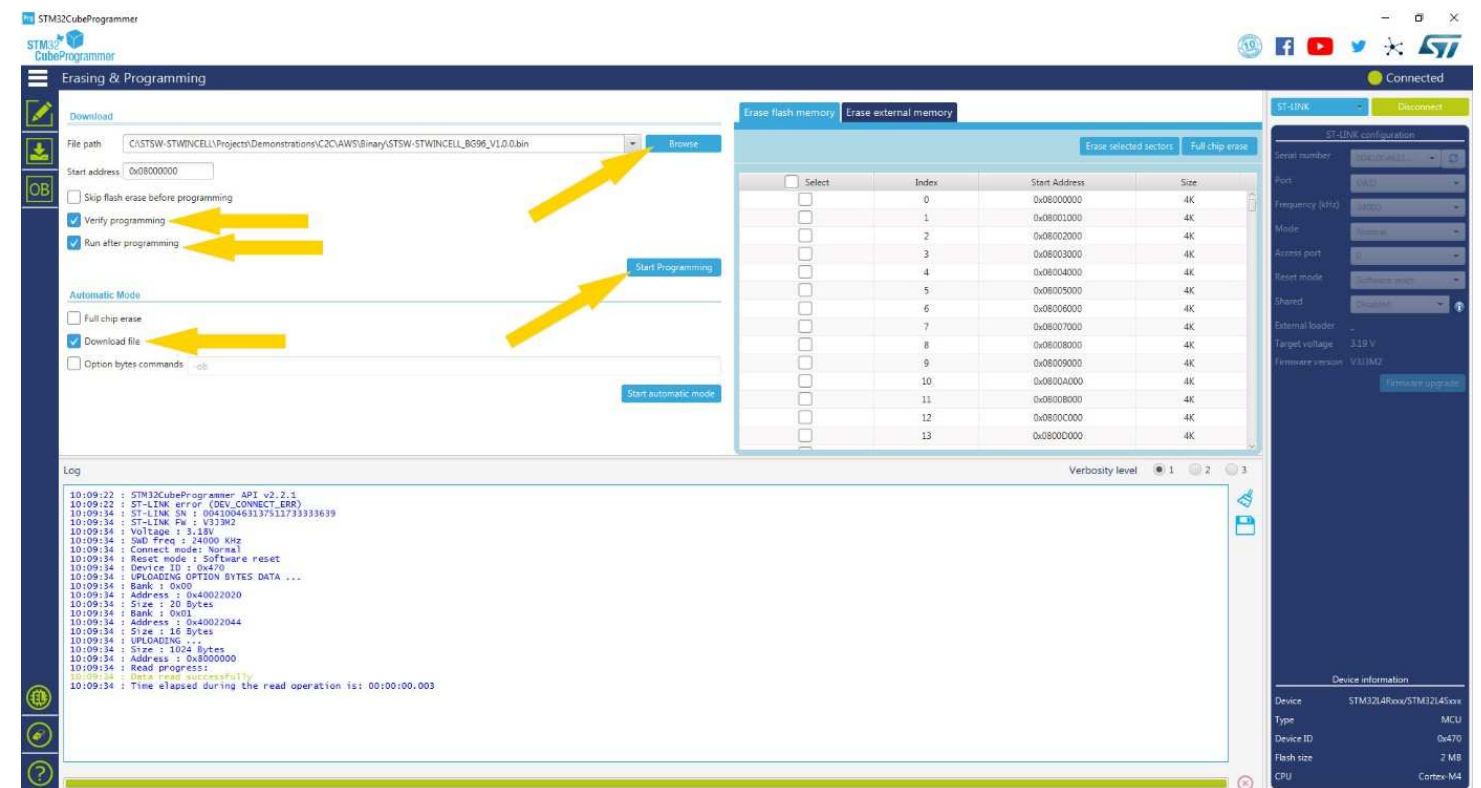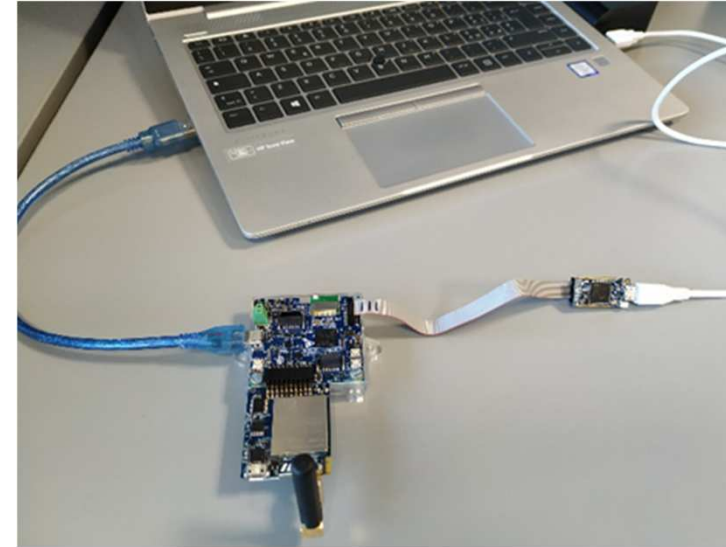
Dashboard Configuration

Get the ST Predictive Maintenance Dashboard

1 **Get the DSH-PREDMNT**

Please, use Google Chrome as web browser

Get Software

Part Number	Software Version	Marketing Status	Supplier	Download
DSH-PREDMNT		Active	ST	Go to site

2 https://dsh-predmnt.st.com/SignIn

Terms of Usage
- Free trial
- 5 node max
- 6 month from license agreement acceptance

4

3

Login with the myST credentials.
If you don't have them, create an account.

The Predictive Maintenance Dashboard is a cloud application based on AWS services.

The cloud package can receive and process data streamed directly from compatible ST sensor nodes with real-time data pre-processing capabilities such as Fast Fourier Transforms (FFT).

As the dashboard runs on a third party cloud storage service provider, the number of ST IoT sensor nodes you can connect on a free trial basis is limited to 5, for a maximum duration of 6 months.

Add and Configure a New Device

Select **CONFIGURATION** tab

1
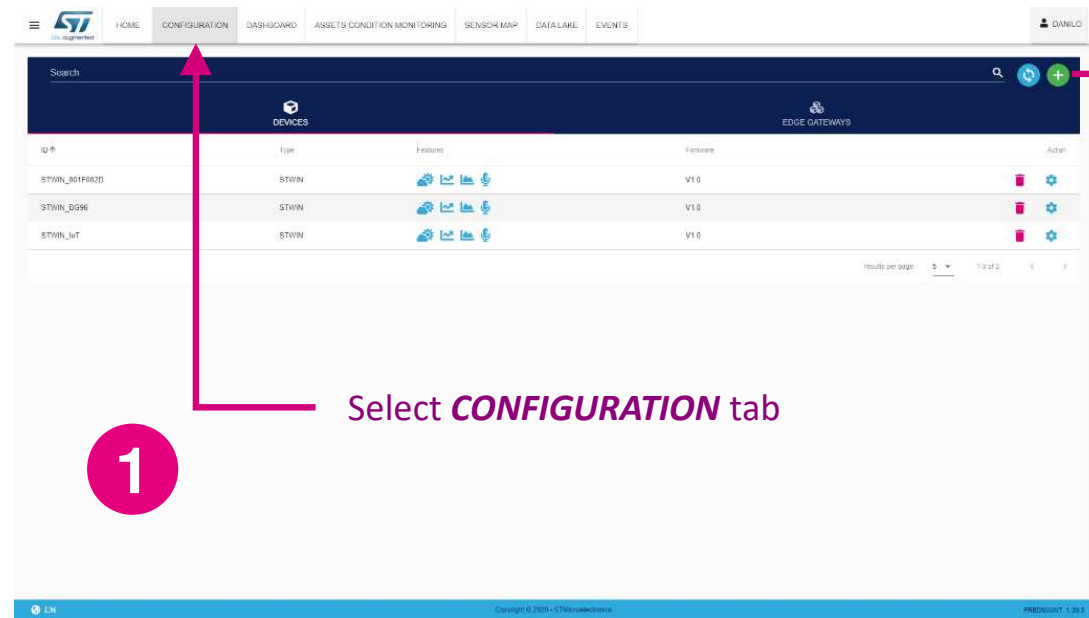
Click on **Add Device**

2
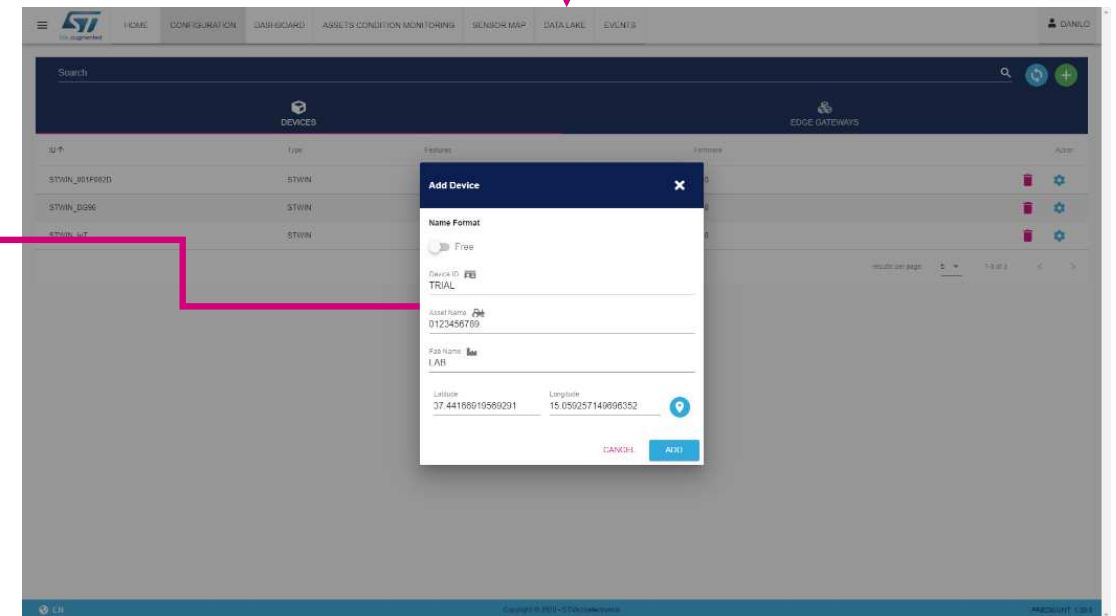
- Fill the pop-up form
- Click on **ADD**

3

The new device is now listed
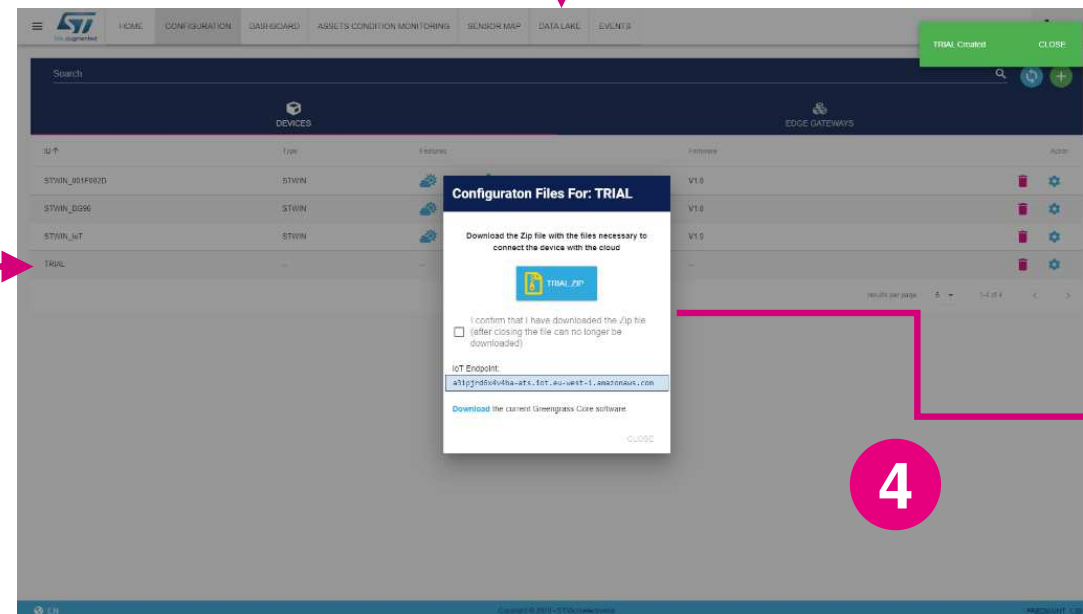
4

- Download the zip file that contains:
  - Root **Certificate Authority** (CA)
  - Device certificate
  - Device private key
- Take note of the IoT Endpoint
- Select **CONFIRM** check box
- Click on **CLOSE**

root.ca.pem
TRIAL.cert.pem
TRIAL.private.key

13

Set Streaming Time
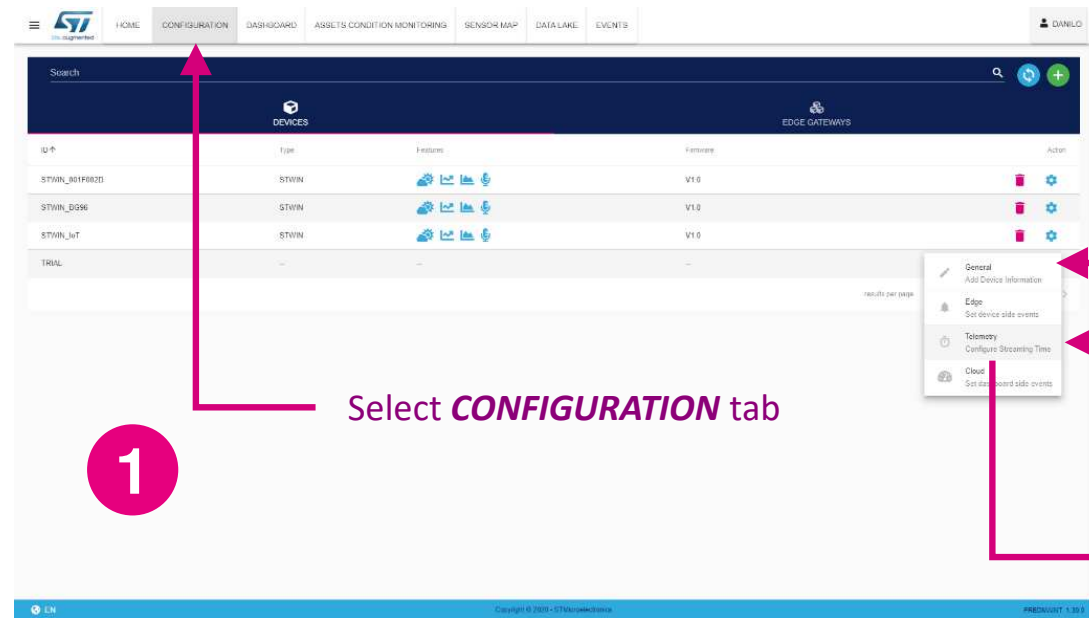
Click on the device's gear wheel

Click on **Telemetry** of the pop-up menu

Select **CONFIGURATION** tab

1

2
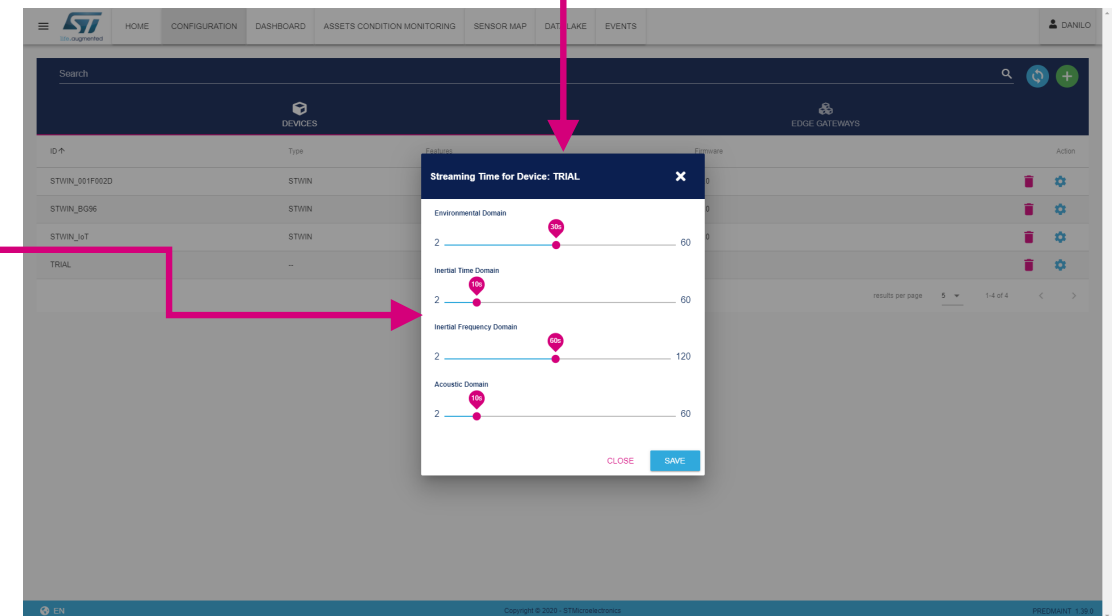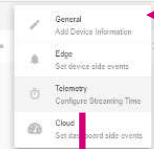
For each feature
set the streaming time
moving the related
drag balloon

3

Dashboard

Since the device has been created it must be added into the dashboard to be monitored.

Select **DASHBOARD** tab

Select **Add device**

Select the device to add

1
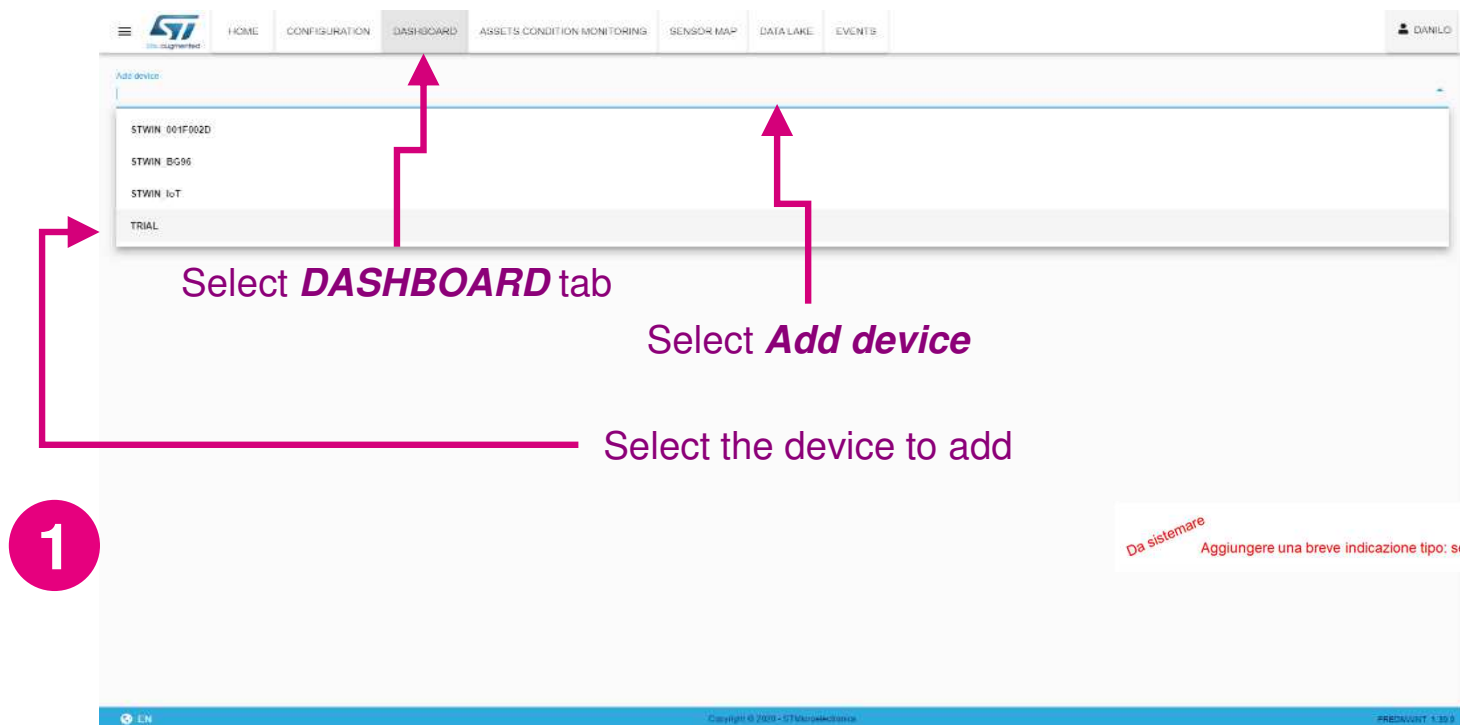
Da sistemare
Aggiungere una breve indicazione tipo: seguire questa procedura per connettere il dispositivo..

The dashboard is waiting for first connection

2
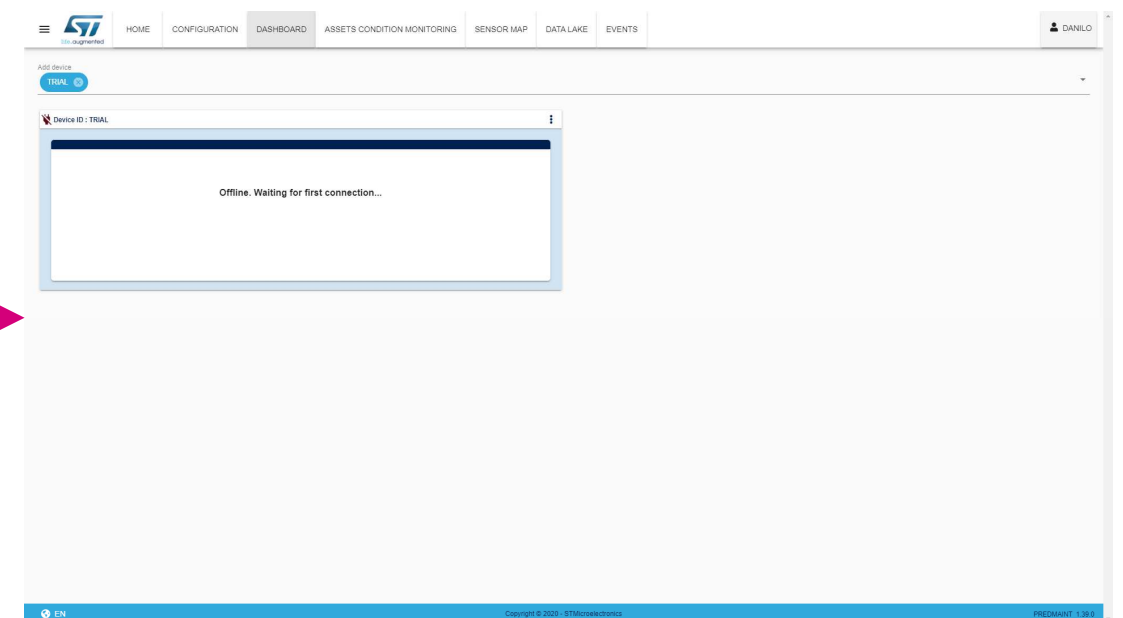
Work with the demonstration application
Setup

Before running demo application, user must know configuration parameters for network and cloud to be entered during FW customization (SIM, APN, cloud API keys).

1 Arrange the system <u>as already explained</u>

2 Start a terminal emulator software and set the parameters as follow:

- Terminal
  - [New line]
    - [Receive]: AUTO
    - [Transmit]: LF
    - [Local Echo] selected

- Serial
  - [Port]: *as the port assigned to ST-LINK debugger by OS*
  - [Baud rate]: 115200
  - [Data]: 8 bit
  - [Parity]: none
  - [Stop]: 1 bit
  - [Flow control]: none
  - [Transmit delay]: 10 ms each

3 Press the reset button on the STEVAL-STWINKT1, the console will show it.

```
*********************************************************
***    STWIN - SensorTile Wireless Industrial Node
***        STM32L4R9Z MCU
***    Predictive Maintenance AWS Cloud Demonstration
***    Dashboard URL is https://dsh-predmnt.st.com
***    STSW-STWINCELL V1.0.0 - 13-February-2020
***    CMSIS Core(M) V5.1
***    HAL V1.10.0 RC0
***    Compiled Feb 13 2020 18:39:08 (IAR)
*********************************************************

*** Board personalization ***

    A cellular expansion board, MB1329B, provided with the BG96 module
    have to be plugged into the STMOD+ connector.

    MCU Unique device ID is 0x2033334B334E5013002B0012

- Network Interface initialized:
Your Cellular parameters need to be entered to proceed.
Select the SIM slot (0 - External, 1 - Internal):
```

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Work with the demonstration application
Configure parameters of STSW-STWINCELL

```
- Network Interface initialized:
Your Cellular parameters need to be entered to proceed.
Select the SIM slot (0 - External, 1 - Internal): 0
You have selected the external SIM.

Enter Sim Operator Access Point Code (e.g. EM or ESEYE1 etc): nbiot.tids.tim.it

You have entered <nbiot.tids.tim.it> as the Sim Operator Access Point Code.

Enter the username (it can be NULL) (max 16 char):

You have entered <> as the username.

Enter the password (it can be NULL) (max 16 char):

You have entered <> as the password.

- Network Interface starting:

*** C2C connection ***

Initializing the cellular module

- Network Interface connecting:
Trying to connect with the external SIM

Waiting for BG96 modem running
Signal not known or not detectable yet (be patient)
.................................................
Signal Level: -77 dBm
........
C2C module registered

Registration done in 60025 msseconds

Retrieving the cellular operator: "I TIM"

Module initialized successfully: Quectel

ProductID: BG96

FW version: BG96MAR02A09M1G

SIM Id (IccID): 89390100002229786797

- Network Interface started:
   - Device Name : Quectel.
   - Device ID : BG96.
   - Device Version : BG96MAR02A09M1G.
- Network Interface connected:
   - IP address :  10.18.44.41.

Enter server address: (example: xxx.iot.region.amazonaws.com)
```

```
Enter server address: (example: xxx.iot.region.amazonaws.com)
a31pjrd6x4v4ba-ats.iot.eu-west-1.amazonaws.com
read: --->
a31pjrd6x4v4ba-ats.iot.eu-west-1.amazonaws.com
<---

Enter device name: (example: mything1)
STWIN_BG96
read: --->
STWIN_BG96
<---

Updating TLS security credentials.

Enter the x509 certificates or keys as per the following format:
-----BEGIN CERTIFICATE-----
YMPGn8u67GB9t+aEMr5P+1gmIqNb1LTV+/Xjli5wwOQuvfwu7uJBVcAOLn0kcmnL
R7EUQIN9Z/SG9jGr8XmksrUuEvmEF/Bibyc+E1ixVAOhmnM3oTDPb5Lc9un8rNsu
........
-----END CERTIFICATE-----
-----BEGIN CERTIFICATE-----
YMPGn8u67GB9t+aEMr5P+1gmIqNb1LTV+/Xjli5wwOQuvfwu7uJBVcAOLn0kcmnL
........
-----END CERTIFICATE-----

........

Enter your root CA:
```

```
Enter your root CA:
-----BEGIN CERTIFICATE-----
MKKDQTCCAimgAwKBAgKTBmyfz5m/jAo54vB4ikPmljZbyjANBgkphkiG9w0BAQsF
ADA5MQswCQYDVQQGEwWVUzEPMAOGA1UEChMGQW1hem9uMRkwFwYDVQQDExBBbWF6
b24gUm9vbCBDQSAxMB4XDTE1MDUyNjAwMDAwMFoXDTM4MDExNzAwMDAwMFowOTEL
MAkGA1UEBhMCVVMxDzANBgNVBAoTBkFtYXpvbjEZMBcGA1UEAxMQQW1hem9uKFWv
b3QgQ0EgMTCCASKwDQYWKoZKhvcNAQEBBQADggEPADCCAQoCggEBALW4gHHKeNXj
```

```
Enter your device certificate:
-----BEGIN CERTIFICATE-----
MKKDWjCCAkKgAwKBAgKVAKPWpBtX6wziOY4z0pX19T7aU5owMA0GCSpGSKb3DQEB
CwUAME0xSzBWBgNVBAsMQkFtYXpvbiBXZWKgU2VybmljZXMqTz1BbWF6b24uY29t
KEluYy4qTD1TZWF0bGx1KFNUPVbhc2hpbmb0b24qQz1VUzAeFw0yMDAxMDqxNTU5
NDZaFwO0OTEyMzEyMzU5NTlaMB4xHDAaBgNVBAMME0FXUyBWb1QgQ2VybG1maWNh
bGUwggEiMA0GCSpGSKb3DQEBAQUAA4KBDwAwggEKAoKBAQClM1MNC651mpVE58v0
```

```
Enter your device key:
-----BEGIN RSA PRIVATE KEY-----
MKKEowKBAAKCAQEApTNTDQuubZpVROfL9DS+BNQY91P7shGzzzaDicSDaW4pQcBl
jgz1ALsaGwhBpLW4K0hHfR1DZyWK5pnfAp/lg9F233fUyaS5ZmBL8CMWryLsFNO0
Cy7X/0g3pup/QGnURxX3Abpvx6TWWF2EjNut6Zt9WWMWYOnTPrzADizfDpuBCVi9
plbFkp/71ZpK1WFEokfHWgsMvN4uvikp6ZQ+U5tjyZgHEFyb7fkhaNTzBt/Sn0FW
jKOP5h2SvMLtcgz0ukK+bOBSstEfb6kvUS9PpkrnpF2bmKPL3xf0234YhsbbMlRA
```

1
- Select the SIM slot to be used.
- Enter the APN for the cellular network operator you are going to use and the optional credential as well.
- Wait for the cellular module initialization and its network registration.

2
- Enter the AWS IoT Endpoint: **a1azohj3ky8ktj-ats.iot.eu-west-1.amazonaws.com**
- Enter the Device's name

3
- Enter the certificates for the AWS IoT device (you can find it inside the downloaded zip file):
  - Root certificate authority (CA)
  - Device certificate
  - Device private key

1

Since the needed parameters have been successfully entered …

- The on board components are going to be initialized.
- The MQTT connection is going to be established.

```
Setting the RTC from the network time.
Connecting to www.gandi.net at ipaddress: 151.101.193.103
20001410 => X:\STSW-STWINCELL\Middlewares\Third_Party\mbedTLS\library\ssl_tls.c:4643:
x509_verify_cert() returned -9984 (-0x2700)

Signal Level: -71 dBm

Configuring the RTC from Date: Tue, 18 Feb 2020 08:46:46 GMT

Initializing the Environmental Sensors ...
- Humidity sensor is ready.
- Pressure sensor is ready.
- Temperature sensor is ready.


Initializing the Inertial Sensor ...
- Accelero sensor is ready.


Initializing the Audio Sensor ...
- Audio sensor is ready.


Shadow Init ...

Shadow Connect ...

MQTT connection in progress:    Attempt 1/3 J..

Signal Level: -77 dBm


Signal Level: -71 dBm


Connected to a31pjrd6x4v4ba-ats.iot.eu-west-1.amazonaws.com:8883
```

2

The cloud shadow will be updated with the features to be monitored.

The streaming time already set on dashboard will be passed to the application running into the STM32.

```
Update Shadow: {"state":{"reported":{"Device_Type":"STWIN","Features":["Environmental",
"Inertial_TDM", "Inertial_FDM",
"Acoustic"],"Firmware":"V1.0","Env_Time":50,"Ine_Time_TDM":50,"Ine_Time_FDM":50,"Aco_Time":50}},
"clientToken":"STWIN_BG96-0"}

Delta - EnvStreamingTime changed to 60

Delta - IneTdmStreamingTime changed to 10

Delta - IneFdmStreamingTime changed to 30

Delta - AcoStreamingTime changed to 10

Update Accepted!

Update Shadow: {"state":{"reported":{"Device_Type":"STWIN","Features":["Environmental",
"Inertial_TDM", "Inertial_FDM",
"Acoustic"],"Firmware":"V1.0","Env_Time":60,"Ine_Time_TDM":10,"Ine_Time_FDM":30,"Aco_Time":10}},
"clientToken":"STWIN_BG96-5"}

Update Accepted!
```

3

According the streaming time the STEVAL-STWINKT1 will publish via the STMOD+ cellular add-on board the data for each feature.

```
Published to topic pm/STWIN_BG96/sense/environmental:
{"Humidity": 34.37, "Pressure": 1028.54, "Temperature": 30.28}

Published to topic pm/STWIN_BG96/sense/acoustic:
{"Aco_FFT":[-72.86,-72.4,-74.61,-75.94,-73.730000000000009,-72.53,-73.92,-76.33,-79.17,-78.39,-
76.7,-77.540000000000009,-81.15,-83.790000000000009,-83.069999999999991,-81.340000000000009,-
80.68000000000009,-81.61,-83.65999999999991,-84.65,-82.51999999999991,-79.94,-80.86,-84.02,-
86.13,-84.57,-82.090000000000009,-81.87,-83.81,-85.91,-85.98,-83.569999999999991,-
83.18000000000009,-84.05,-86.38,-87.84,-85.6,-84.04,-83.94,-86.05,-88.58,-86.1,-84.4,-84.39,-
86.07,-88.99,-88.49,-87.03,-86.13,-86.75,-90.33,-91.59,-88.65,-86.77,-87.42,-89.51,-91.94,-89.95,-
```

```
Published to topic pm/STWIN_BG96/sense/inertial_tdm:
{"RMS_Speed": [0.42,0.41,0.11], "Peak_Acceleration": [2.57,3.30,8.12]}

Published to topic pm/STWIN_BG96/sense/inertial_fdm:
{"Ine_FFT":
[[0.00,0.00,0.00,0.00],[25.96,0.00,0.00,0.01],[51.91,0.01,0.00,0.01],[77.87,0.01,0.00,0.01],[103.83,
0.01,0.01,0.01],[129.79,0.01,0.01,0.01],[155.74,0.01,0.01,0.01],[181.70,0.01,0.01,0.01],[207.66,0.01
,0.01,0.01],[233.61,0.01,0.01,0.01],[259.57,0.01,0.01,0.01],[285.53,0.01,0.01,0.01],[311.48,0.01,0.0
1,0.01],[337.44,0.01,0.01,0.01],[363.40,0.01,0.01,0.01],[389.36,0.01,0.01,0.01],[415.31,0.01,0.01,0.
01],[441.27,0.01,0.01,0.01],[467.23,0.01,0.01,0.01],[493.18,0.01,0.01,0.01],[519.14,0.01,0.01,0.01],
```
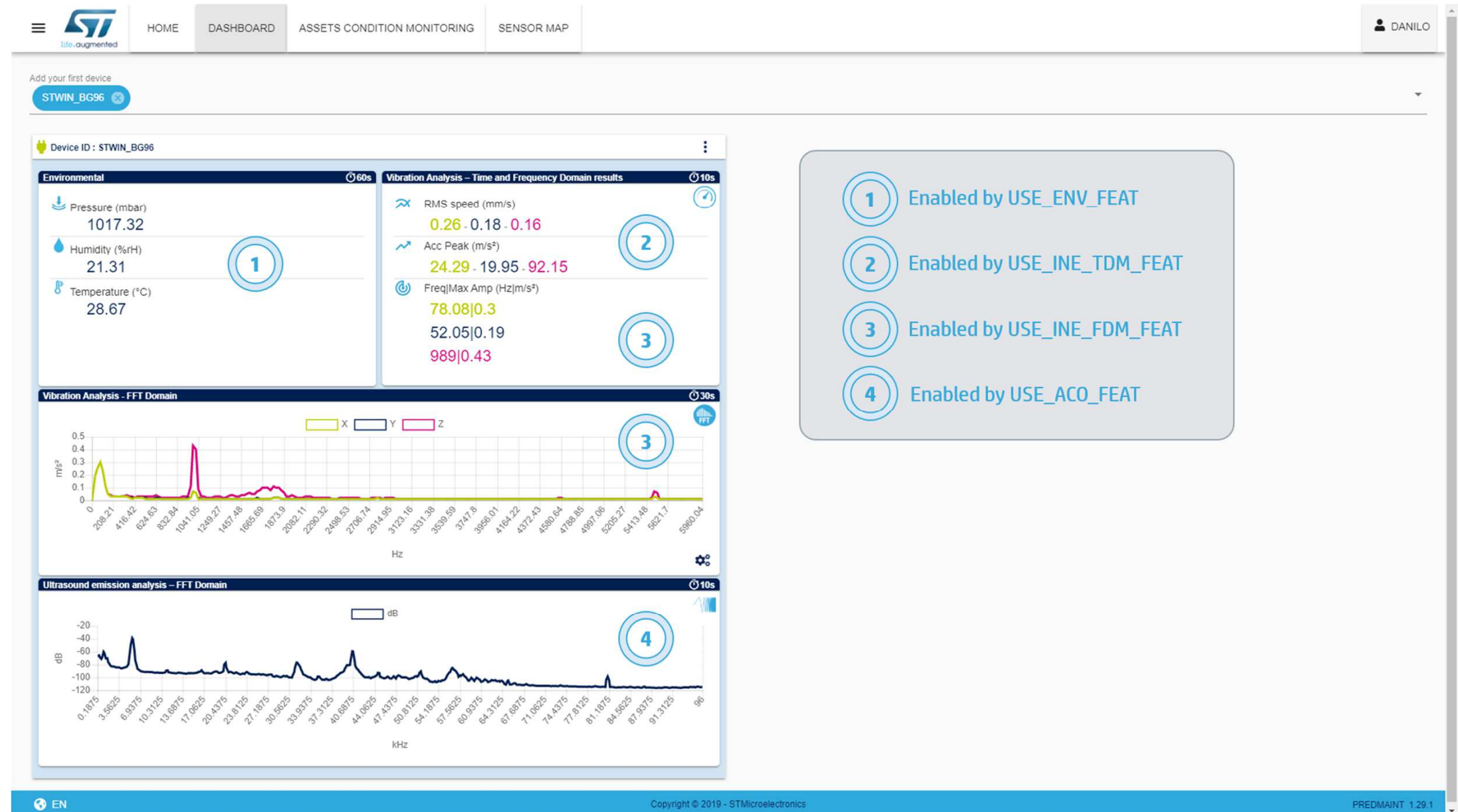
Remote data monitoring

Populated ST Predictive Maintenance Dashboard while running STSW-STWINCELL

The features that will be plotted can be selected during FW compiling.

The user can choose from one up to all four features acting on the values of the following key words inside the file 'aws_iot_config.h':

- USE_ENV_FEAT
- USE_INE_TDM_FEAT
- USE_INE_FDM_FEAT
- USE_ACO_FEAT

Thank you

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