Getting Started
DSH-PREDMNT and PREDMNT Solutions
1. Architecture

2. Run the application

3. Condition Monitoring with Wired Connectivity: Get started with SL-PREDMNT-E2C

4. Condition Monitoring with Wireless Connectivity: Get started with SL-PREDMNT-S2C

5. Anomaly Detection with NanoEdge AI Studio Libraries: Get started with STWIN and FP-AI-PREDMNT2
STMicroelectronics wants to enable customers to fast implement Proof Of Concept on condition monitoring and predictive maintenance from an end to end perspective.

STMicroelectronics, on top of providing evaluation tools and software libraries, allows to connect its devices on a cloud application.

Predictive Maintenance Dashboard is a Cloud application based on AWS services that allows to collect, visualize and analyze data streamed by Sensor Units tailored for Vibration, Environmental and Ultrasound condition monitoring.
Condition monitoring & Anomaly Detection edge processing enabling end-to-end

Ultrasound, vibration, environmental condition monitoring and anomaly detection

Edge

Smart Sensor Nodes

STM32

STEVAL-IDP004V2

Wi-Fi Connectivity / LTE

STEVAL-STWINKT1B

STM32

Wi-Fi Connectivity / LTE

Serial Connectivity

STEVAL-BFA001V2B

STM32

STM32MP157F-DK2

ST Connectivity SDKs

Edge Processing

Cloud Application for device management

Cloud Application

powered by AWS

AWS IoT Core

AWS Shield

AWS Lambda

AWS WAF

Amazon DynamoDB

Amazon Cognito

Amazon Simple Storage Service (S3)

Amazon API Gateway
Simplified Architecture

Data Acquisition
- Sensor
- Edge node
- AWS IoT
- GreenGrass
- Autonomous sensor
- Amazon FreeRTOS

Data Ingestion
- IoT Core

Data Processing, Storage and Services
- Kinesis
- S3
- DynamoDB
- CloudFront
- AWS Lambda
- API Gateway

Dashboard
- Users
- ST IoT Dashboard

Data Ingestion
- S3
- Kinesis
- DynamoDB
- CloudFront
- AWS Lambda
- API Gateway
Predictive Maintenance Dashboard
AWS services by class

Management and Governance
- Amazon CloudWatch
- AWS CloudFormation

Application core modules: IoT, Compute, Database and Storage
- AWS IoT Core
- AWS IoT Greengrass
- Kinesis
- AWS Lambda
- Amazon DynamoDB
- Amazon Simple Storage Service (S3)

Networking and Content Delivery
- Amazon CloudFront
- Amazon API Gateway

User identity and security
- Amazon Cognito
- AWS Shield
- AWS Identity and Access Management (IAM)
- AWS WAF
Predictive Maintenance Dashboard

How can I access?


- ST.com/DSH-Predmnt
  - dsh-predmnt.st.com

*regulated with terms of usage for free limited access
Run the application
Predictive Maintenance Dashboard
Run the Application in limited free usage

- dsh-predmnt.st.com
- Serverless deployment in customer’s account

Terms of usage:
- Max 5 devices
- Max 6 months from license agreement acceptance

When user runs out of conditions:
- user can download data
- decide whether or not open its own AWS account
- ask for additional free usage upon business case
Sign the Terms of Usage and go
Predictive Maintenance Dashboard

DSH-PREDMNT Features

- Device and AWS Greengrass Edge registration and configuration:
  - Provisioning
  - Association to assets
  - Streaming time
  - NanoEdge™ AI library

- Live data visualization
  - Add a device to live monitoring

- User login and data segregation

- Asset Health Monitoring
  - Collect data
  - Analyse Historical trends
  - Apply failure thresholds for alerts and warning

- English and Chinese

- Assets Map

- Monitor live events or check events history

- Download telemetry data sent filtering by device

- Info Panel for the user about its terms
Predictive Maintenance Dashboard
Register, add, remove and manage a device

1. Add new device

2. Compile form

3. Download device certificate and take note of IoT endpoint

Latitudes and longitudes coordinates

Download the Zip file with the files necessary to connect the device with the cloud

IoT Endpoint: a36fch9jjgpxps-ats.iot.eu-west-1.amazonaws.com
Predictive Maintenance Dashboard
Configure measures and condition monitoring thresholds

1. Select cloud dashboard side event
2. Measures domains
3. Thresholds configuration

Functional available from June 2020
Predictive Maintenance Dashboard
Set Ultrasound FFT filter

1. No filters
2. Applying filters

Set Ultrasound FFT filter

Device ID: STWm_4356932

Ultrasound Emission Analysis - FFT

Frequency MIN (kHz): 15
Frequency MAX (kHz): 85

Alerts:
- Frequency MIN: 38 kHz to 40 kHz
- Frequency MAX: 58 kHz to 62 kHz

Thresholds:
- Frequency MIN: -20 dB
- Frequency MAX: -20 dB
Predictive Maintenance Dashboard
Register and manage an AWS Greengrass Group

1. Create new group...

2. ...deploy it
The device, once connected for the first time, generates a *Hand Shaking Message* used to expose the measures (environmental, vibration, ultrasound) and Firmware Release.
The Dashboard recognizes the device, update the device shadow (that will be used for other purposes also) and adapt the visualization.

Environmental domain

Vibration (FFT) domain

Vibration Analysis: TD & FD results

Acoustic (FFT) domain
Predictive Maintenance Dashboard

Add a device to live monitoring

Select your device for live monitoring
Predictive Maintenance Dashboard

Assets Monitoring

(Please refer to the attached images for detailed content.)
Predictive Maintenance Dashboard

Geo-localization

Assets and Status

Assets Map
User can downloads the raw telemetry data for his devices
• Choose device(s) and time period
• Choose device’s domain(s)
• Download .zip package with all data in.
Predictive Maintenance Dashboard

Data Download

Devices selection

Domains selection for each device

Time period selection

Download button
Folder structure downloaded

- user-id
- device-name
- domains
- ...
- ...
- year
- month
- weeknum.json

Aggregated (by week) json file containing all data for the relative domain

```json

```

Predictive Maintenance Dashboard
Data Download

Folder structure downloaded

- user-id
- device-name
- domains
- ...
- ...
- year
- month
- weeknum.json

Aggregated (by week) json file containing all data for the relative domain

```json

```
Predictive Maintenance Dashboard

Data Download

Telemetry data (environmental)

Transmission time
User can retrieves historical events and:
- Filter by device name, date and severity using advanced panel
- Watch dynamic circular chart for global statistics
- Open event detail
Predictive Maintenance Dashboard

Events

Filters for advanced searching

Fast event identification

Paginations

Global statistics

This feature will be functional available from June 2020
Predictive Maintenance Dashboard
Send a command to NanoEdge™ AI library

1. Click on the **Configuration** tab
2. Select the () symbol of the desired STWIN board
3. Click on **Anomaly detection**

- DSH-PREDMNT allow you to configure and setup your custom NanoEdge™ AI library

<table>
<thead>
<tr>
<th>Type</th>
<th>Features</th>
<th>Firmware</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>simulated</td>
<td></td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>simulated</td>
<td></td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>simulated</td>
<td></td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>simulated</td>
<td></td>
<td>1.0</td>
<td></td>
</tr>
</tbody>
</table>
The settings tab allow to setup the sensitivity and the threshold parameters.

The commands tab allow to chose either train or detect command. The result of the train command is the training of the neai library for the time interval set in the “phase duration” form. The detect command will trigger the anomaly detection phase in the application in according with the generated library.
Predictive Maintenance Dashboard

Send a command to NanoEdge™ AI library

Use settings tab to change configuration parameters

Save parameters on the device

See the information about the last command sent
If the detect command is set, in accordance with the custom NanoEdge™ AI library, an anomaly event is sent to the dashboard and an event will be shown in the EVENTS panel of the dashboard.

For further details on how NanoEdge™ AI libraries work, read the detailed documentation of NanoEdge™ AI Studio.
CONDITION MONITORING
Get started with SL-PREDMNT-E2C
• Google Chrome
• ST Evaluation Tools and SW Packages on your hand, you can combine both approach as you may need

Quick start

End to end architecture based on wired Smart Sensor Nodes and Gateway

STM32MP157C-DK2 rev. C01
X-LINUX-PREDMNT

STEVAL-IDP004V1/V2
STSW-IDP4PREDMNT

STEVAL-BFA001V1B
STSW-BFA001V1B
Vibration and Environmental Monitoring
Quick Start with STM32MP157-DK2

In this scenario, two motors are monitored by using two STEVAL-BFA001V1B provisioned as BoothDemo1 and BoothDemo2 connected via a Master STEVAL-IDP004V1 and a Gateway STM32MP157C-DK2 rev. C01 connected over WIFI. One of the motor is unbalanced (corresponding to BoothDemo2).

1. Get STEVAL-BFA001V1, STEVAL-IDP004V1, STM32MP157C-DK2 and Download the Software
2. Deploy the X-LINUX-PREMDNT on the STM32MP157C-DK2
3. Register the Edge and the devices
4. Start the application
Vibration and Environmental Monitoring
Get the Hardware's, Download the SW

Go to www.st.com/SL-PREDMNT-E2C

<table>
<thead>
<tr>
<th>Component</th>
<th>Order code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smart Sensor Node</td>
<td>STEVAL-BFA001V2B</td>
<td>Predictive maintenance kit with sensors and IO-Link capability</td>
</tr>
<tr>
<td>Master</td>
<td>STEVAL-IDP004V1</td>
<td>IO-Link master multi-port evaluation board</td>
</tr>
<tr>
<td></td>
<td>STEVAL-IDP004V2</td>
<td></td>
</tr>
<tr>
<td>Gateway</td>
<td>STM32MP157F-DK2</td>
<td>Discovery kit with STM32MP157C MPU</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SW Layer Mission</th>
<th>Software Code</th>
<th>Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collect, Preprocess and communicate to the Master</td>
<td>STSW-BFA2PREDMNT.zip</td>
<td>Binary</td>
</tr>
<tr>
<td>Handle the communication with the Smart Sensor Node and with the gateway</td>
<td>STSW-IDP4PREMNT.zip</td>
<td>Binary</td>
</tr>
<tr>
<td>Handle the communication with the master, enable Edge processing and data injection in the Cloud</td>
<td>X-LINUX-PREDMNT</td>
<td>OpenSTLinux Expansion Pack in Source Code and with SD Card image</td>
</tr>
<tr>
<td>Visualize data</td>
<td>DSH-PREDMNT</td>
<td></td>
</tr>
</tbody>
</table>
Vibration Monitoring
deploy X-LINUX-PREDMNT

Go to
You can start the application after the configuration and deployment phases. Follow the procedure below to activate vibration and start the application on your setup with or without motors.

1. Connect the setup to the gateway via USB cable.
2. If you connect rotating motors, power on the setup.
3. Set the speed of the setup to the desired value.
4. Click “RUN APPLICATION” on the gateway GUI, or run “/home/root/start_pmp.sh” from a terminal:

Open the dashboard and log in: https://dsh-predmnt.st.com/
Click on [DASHBOARD]->[Add Device], and select the desired devices.
CONDITION MONITORING
Get started with SL-PREDMNT-S2C
Predictive Maintenance Dashboard

how to start

- ST Evaluation Tools and SW Packages on your hand, you can combine both approach as you may need
- Google Chrome, view directly in your browser the data coming thanks to DSH-PREDMNT application

Quick start

End to end architecture based on Wireless Smart Sensor Nodes (WIFI – LPWAN) – SL-PREDMNT-S2C

STEVAL-STWINWFV1

STEVAL-STWINKT1B

STMOD+ cellular add-on board coming from P-L496G-CELL02 or STEVAL-STMODLTE*

STSW-STWINCELL

STEVAL-STWINKT1B

FP-IND-PREMNT1

* Distributed only in USA
Vibration and Ultrasound Monitoring
Quick Start with WIFI expansion STEVAL-STWINWF1

In this scenario a motor is monitored by using an STEVAL-STWINKT1B as smart sensor node connected by using the WIFI expansion module (STEVAL-STWINWFV1) and the smart sensor node is provisioned.

1. Get STEVAL-STWINKT1B and STEVAL-STWINWFV1
2. Download the FP-IND-PREMNT1 and Flash it
3. Register your node at DSH-PREDMNT
4. Run the application
5. Monitor data on DSH-PREDMNT
Vibration and Ultrasound Monitoring through WIFI
Get the Hardware, Download the Software

### Buy the Hardware

<table>
<thead>
<tr>
<th>Component</th>
<th>Order code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SensorTile Wireless Industrial Node (STWIN)</td>
<td>STEVAL-STWINKT1B</td>
<td>Predictive maintenance kit with sensors</td>
</tr>
<tr>
<td>Expansion board</td>
<td>STEVAL-STWINWF1</td>
<td>WIFI Expansion</td>
</tr>
</tbody>
</table>

### Get the Software

<table>
<thead>
<tr>
<th>SW Layer Mission</th>
<th>Software Code</th>
<th>Online Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collect, Preprocess and communicate to the Cloud</td>
<td>FP-IND-PREDMNT</td>
<td>Source code available for STM32</td>
</tr>
<tr>
<td>Visualize data</td>
<td>DSH-PREDMNT</td>
<td>Web based application</td>
</tr>
</tbody>
</table>
Power ON/OFF the STWIN

• Battery only (no USB cable):
  • Power ON
    • Long-press the PWR button until the red led turns off (~1 sec)
  • Power OFF
    • Press the PWR button

• Plugged mode (USB cable)
  • Power ON
    • When USB is plugged-in, the STWIN is always on. It doesn’t matter if the battery is present or not
  • Power OFF
    • Unplug the cable and, if the battery is connected, press the PWR button.
Download FP-IND-PREDMNT1 and Flash Predictive Maintenance Cloud Application (1/5)

1. www.st.com/stm32ode-fp
2. Select FP-IND-PREDMNT1
3. Download & unpack
4. Load the pre-compiled binary using STM32 ST-LINK Utility
5. Compile/Flash and Run the project
6. Configure and Monitoring the application
   • TeraTerm (v. 4.97 or higher)
   • ST DSH-PREDMNT
Set up your network configuration
Predictive Maintenance Cloud Application (2/5)

• Connect STWIN to the PC using a micro-USB cable
• Open TeraTerm (v. 4.97 or higher)
• File-> NewConnection
  • Select the right COM port

• Setup-> Terminal
  • Set parameters as below

• Press RESET button of STWIN.
Set up your network configuration
Predictive Maintenance Cloud Application (3/5)

To change Wi-Fi network follow the instructions on the console:

- Press the STWIN USR button within 5 seconds

- Provide new Wi-Fi credentials:
  - SSID
  - Security mode
  - Password
Register your node and inject data
Predictive Maintenance Cloud Application (4/5)

1 Register and provision the device by downloading the certificates

2 Configure AWS Credentials and load the certificates

- Press the USR button within 5 seconds
- Enter the AWS IoT Core endpoint
  - a1azohj3ky8ktj-ats.iot.eu-west-1.amazonaws.com (example for Predictive Maintenance Dashboard)

- Send via terminal the certificates obtained from the dashboard when the device was created:
  - Directly drag and drop the file or copy and paste the text
Start the application

Predictive Maintenance Cloud Application (5/5)

1. Add to the dashboard

2. Experiment thresholds
Vibration, Ultrasound and Environmental Monitoring
Quick Start with STMOD+ cellular add-on of P-L496G-CELL02

In this scenario vibration, audio spectrum and environmental parameters such as temperature, humidity and pressure are monitored by using an STEVAL-STWINKT1B as smart sensor node connected by using a STMOD+ cellular add-on board based on Quectel BG96 modem, LTE Cat M1 / NB-IoT / 2G fallback, coming from P-L496G-CELL02 or STEVAL-STMODLTE

1. Get STEVAL-STWINKT1B and STMOD+ cellular add-on board based on Quectel BG96 modem
2. Setup STEVAL-STWINKT1B and add-on board
3. Download the STSW-STWINCELL and download it into STEVAL-STWINKT1B’s MCU
4. Register your node at DSH-PREDMNT
5. Set up your network configuration
6. Run the application
7. Monitor the data on DSH-PREDMNT
## Vibration, Ultrasound and Environmental Monitoring

**Get the Hardware, Download the Software**

### Buy the Hardware

<table>
<thead>
<tr>
<th>Component</th>
<th>Order code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SensorTile Wireless Industrial Node (STWIN)</td>
<td>STEVAL-STWINKT1B</td>
<td>Predictive maintenance kit with sensors</td>
</tr>
<tr>
<td>Expansion board</td>
<td>STMOD+ cellular add-on board based on Quectel BG96 modem coming from P-L496G-CELL02 or STEVAL-STMODLTE</td>
<td>Adds LTE Cat M1, NB-IoT with 2G fallback connectivity to the STWIN</td>
</tr>
</tbody>
</table>

### Get the Software

<table>
<thead>
<tr>
<th>SW Layer Mission</th>
<th>Software Code</th>
<th>Online Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collect, Preprocess and communicate to the Cloud</td>
<td>STSW-STWINCELL</td>
<td>Binary and source code available for STM32</td>
</tr>
<tr>
<td>Visualize data</td>
<td>DSH-PREDMNT</td>
<td>Web based application</td>
</tr>
</tbody>
</table>
Setup STEVAL-STWINKT1 and P-L496G-CELL2 (or STEVAL-STMODLTE)

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-STWINKT1B to a PC via the STLINK-V3MINI
6. Download STSW-STWINCELL binary file into STEVAL-STWINKT1B’s MCU
Log in to the dashboard and register the device

1. Sign Up or Sign In (myST credentials)

2. Add new device and download the zip file containing the certificates

3. Open the device’s dashboard
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

After pressing the reset button on the STEVAL-STWINKT1 … … the console will show it

```plaintext
******************************************************************************
*** STWIN - SensorTile Wireless Industrial Node
*** STM32L4R92 MCU
*** Predictive Maintenance AWS Cloud Demonstration
*** Dashboard URL is https://dash-predmnt.st.com
*** STSW-STWINCELL V1.0.0 - 13-February-2020
*** CMSIS Core(M) V5.1
*** HAL V1.10.0 RCO
*** 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 STM30D+ connector.

 MCU Unique device ID is 0x20333348334E5013002B0012

- Network Interface initialized:
  Your cellular parameters need to be entered to proceed.
  Select the SIM slot (0 - External, 1 - Internal):
Configure parameters of STSW-STWINCELL

1. Select the SIM slot to be used.
2. 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.
3. Enter the AWS IoT Endpoint: a1azohj3ky8ktj-ats.iot.eu-west-1.amazonaws.com
   - Enter the Device’s name
4. 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
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.

According the streaming time the STEVAL-STWINKT1 will publish via the STMOD+ cellular add-on board the data for each feature.
The features that will be used 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
Anomaly detection
STWIN and FP-AI-PREDMNT2
Anomaly Detection with NanoEdge AI Studio

how to start

• ST Evaluation Tools and SW Packages on your hand, you can combine both approach as you may need
• Google Chrome, view directly in your browser the data coming thanks to DSH-PREDMNT application

Quick start

End to end architecture based on Wireless Smart Sensor Nodes (WIFI – LPWAN) – FP-AI-PREDMNT2

STEVAL-STWINWFV1

STEVAL-STWINKT1B

FP-AI-PREDMNT2
Anomaly Detection with NanoEdge AI Studio
Quick Start with WIFI expansion STEVAL-STWINWF1

In this scenario a motor is monitored by using an STEVAL-STWINKT1B as smart sensor node connected by using the WIFI expansion module (STEVAL-STWINWFV1) and the smart sensor node is provisioned.

1. Get STEVAL-STWINKT1B and STEVAL-STWINWFV1
2. Generate NanoEdge AI Studio library
3. Download the FP-AI-PREDMNT2 and Flash it
4. Register your node at DSH-PREDMNT
5. Configure Wifi and DSH-PREDMNT credentials through BLE Sensor App
6. Run the application
7. Monitor data on DSH-PREDMNT
Setup a NanoEdge™ AI library into FP-AI-PREDMNT2

1. Capture data
2. Label data
3. Build NanoEdge Lib
4. Embed NanoEdge Lib
5. Process new data

Generating contextual data using FP-SNS-DATALOG1
Build library using NanoEdge™ AI Studio
Embed and use into FP-AI-PREDMNT2

Capture data: Accelerometer
Label data: Normal, Anomaly
Build NanoEdge Lib: Modeling, Results
Embed NanoEdge Lib: NanoEdge integration, NanoEdge implementation
Process new data: Real-time learning

1 2 3 4 5
Capture data and create a labelled dataset

Generating contextual data using **FP-SNS-DATALOG1**

1. **Generate data set**
   - Data log
   - SDCard
   - Serial

2. **Label Data**
   - Regular signals file.csv
   - Abnormal signals file.csv
   - normalDataFull.csv
   - abnormalDataFull.csv
Use NanoEdge AI Studio tool

Build library using NanoEdge™ AI Studio

3 Building and Export Library
file

1. Libneai.a
2. NanoEdgeAI.h
FP-AI-PREDMNT2 is not the default firmware on the STEVAL-STWINKT1B, so it needs to be downloaded on the board by the user. The easiest way is to use the pre-compiled binary provided in the package in the folder Projects\STM32L4R9ZI-STWIN\Applications\PREDMNT2\Binary.

To update the firmware:

• Connect the STWIN core system board to the STLINK-V3MINI programmer.

• Connect both the boards to a PC using micro USB cables.

• Open STM32CubeProgrammer, select the proper binary file and download the firmware.

For further details, see UM2937
1. Download & unpack

2. Select Function Pack: FP-AI-PREDMNT2

3. Configure the board through ST BLESensor app and monitor the application through the ST DSH-PREDMNT dashboard.
Integration in the FP and Running

4. Integrate Lib files into the project
   - NanoEdgeAI.h
   - Libneai.a

5. Re-compile the FP

6. NanoEdge Learn
   - NanoEdgeAI_learn()

7. Run the demo: NanoEdgeAI execute
   - NanoEdgeAI_execute()
• If the detect command is set, in according with the custom NanoEdge™ AI library, an anomaly event is sent to the dashboard and an event will be shown in the EVENTS panel of the dashboard.

• For further details on how NanoEdge™ AI libraries work, read the detailed documentation of NanoEdge™ AI Studio.
Predictive Maintenance Dashboard
Register other devices and get the Full Picture

Assets and Status
Geo localization