



life.augmented

FlightSense ST time-of-flight ranging sensors Smart Presence Detection

STMicroelectronics

남경태 부장



Agenda

1

About dTOF

- Intro ST TOF
- TOF family
- VL53L7CX demo GUI

2

Smart Presence Detection (SPD)

- Introduction
- SPD package content

3

SPD Demo

- Running SPD GUI for your demo
- Running SPD in terminal

4

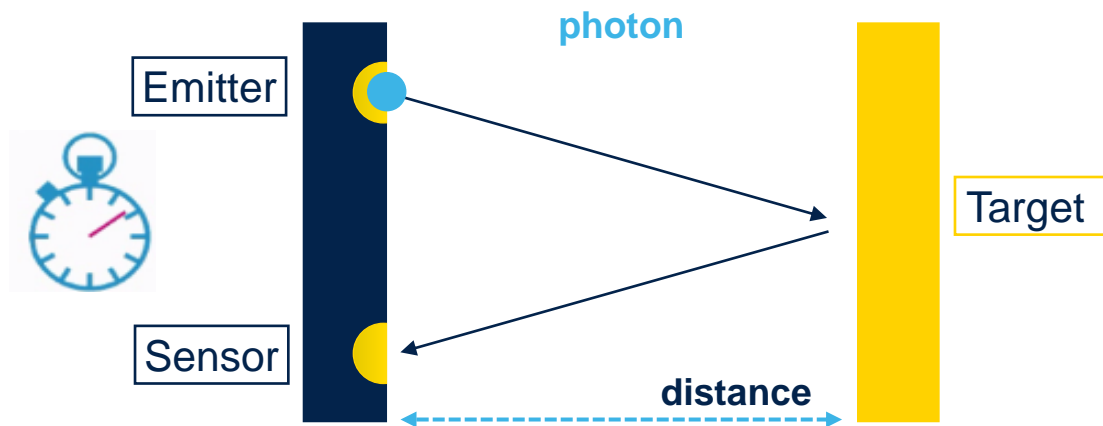
SPD in details

- SPD in details
- SPD Programming Guide



FlightSense* ... Making Light work

Time-of-Flight Principle



$$\text{Measured distance} = \text{Photon travel time} / 2 \times \text{Speed of light}$$

1cm round-trip takes 67ps

ST proprietary FlightSense technology

True distance measurement

Independent of target size, color & reflectance

Fast and low power

Truly invisible 940nm illumination



FlightSense typical module overview

All-in-One (illumination & sensor) Time of Flight System
→ Optimized Size/ Perf/ Cost mix

Advanced optics with
integrated IR filter

State-of-art assembly & testing
manufacturing ST line in SHZ



Monolithic ToF SoC, SPAD Array, RAM/ROM
& powerful Class1 VCSEL driver

High power VCSEL
Full Class 1 safety

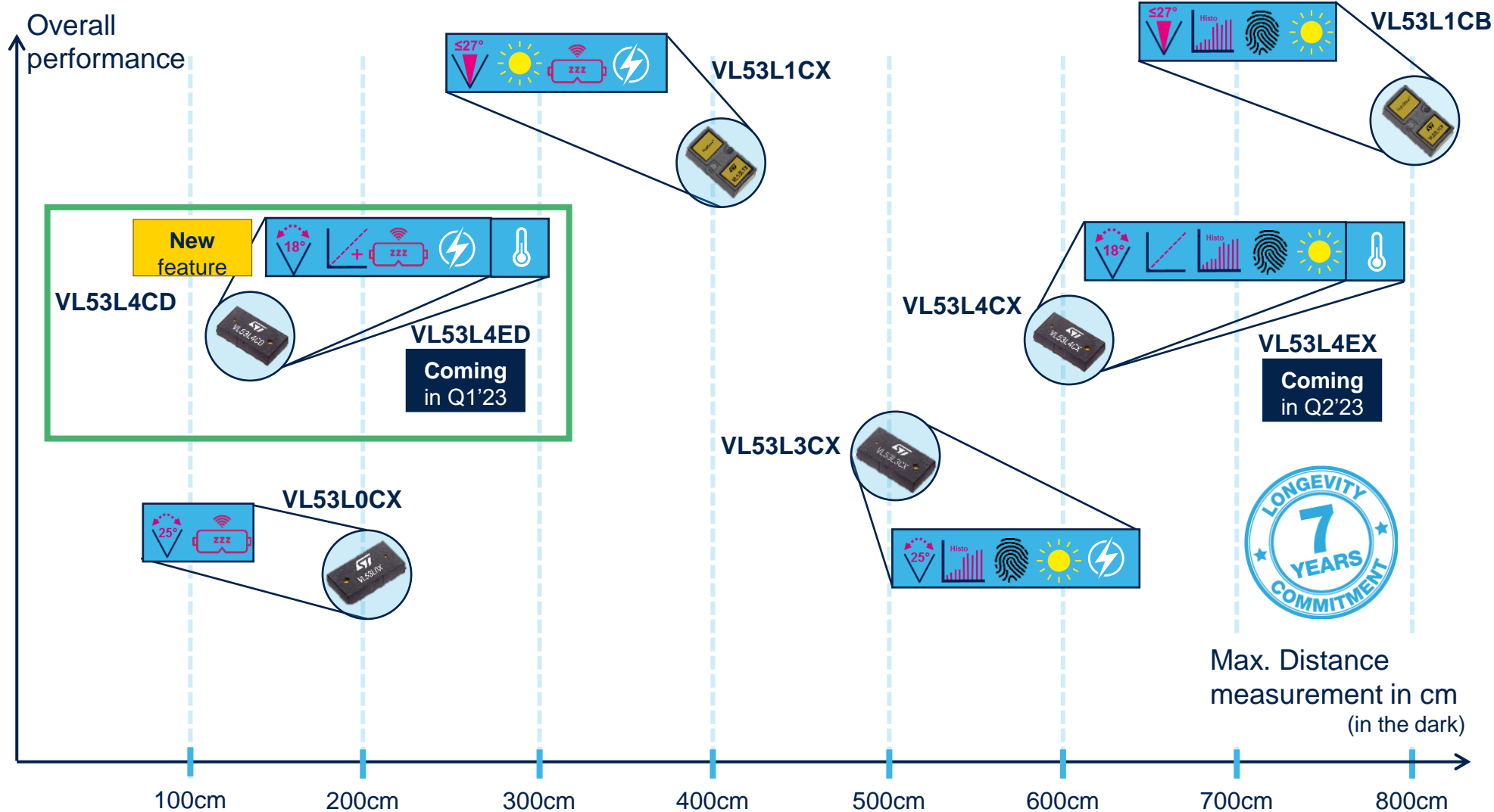
FlightSense ST time-of-flight ranging sensors / mass-market roadmap





FlightSense™ Single-Zone portfolio

- XX° FoV
SXX° Programmable FoV
- Histogram
MultiObject detection
- Smudge correction
- Perf. Under Ambient (>100cm)
- Autonomous mode
- Ultralow Power Mode
- Close distance Linearity
+ : High Perf in short distance
- Extended Temperature range
- Ambient Light Sensing





FlightSense™ Single-Zone portfolio

VL6180V1 Proximity sensor with low power consumption	VL53L4CD Proximity sensor with high accuracy	VL53L0CX Ranging sensor	VL53L1CX Ranging sensor programmable FoV	VL53L3CX Ranging and multi-target sensor	VL53L4CX Short to long ranging, multi-target sensor	VL53L1CB Long Distance and multi-target sensor
--------------------------------------------------------------------	------------------------------------------------------------	---------------------------------------	--------------------------------------------------------	--------------------------------------------------------	-------------------------------------------------------------------	--------------------------------------------------------------

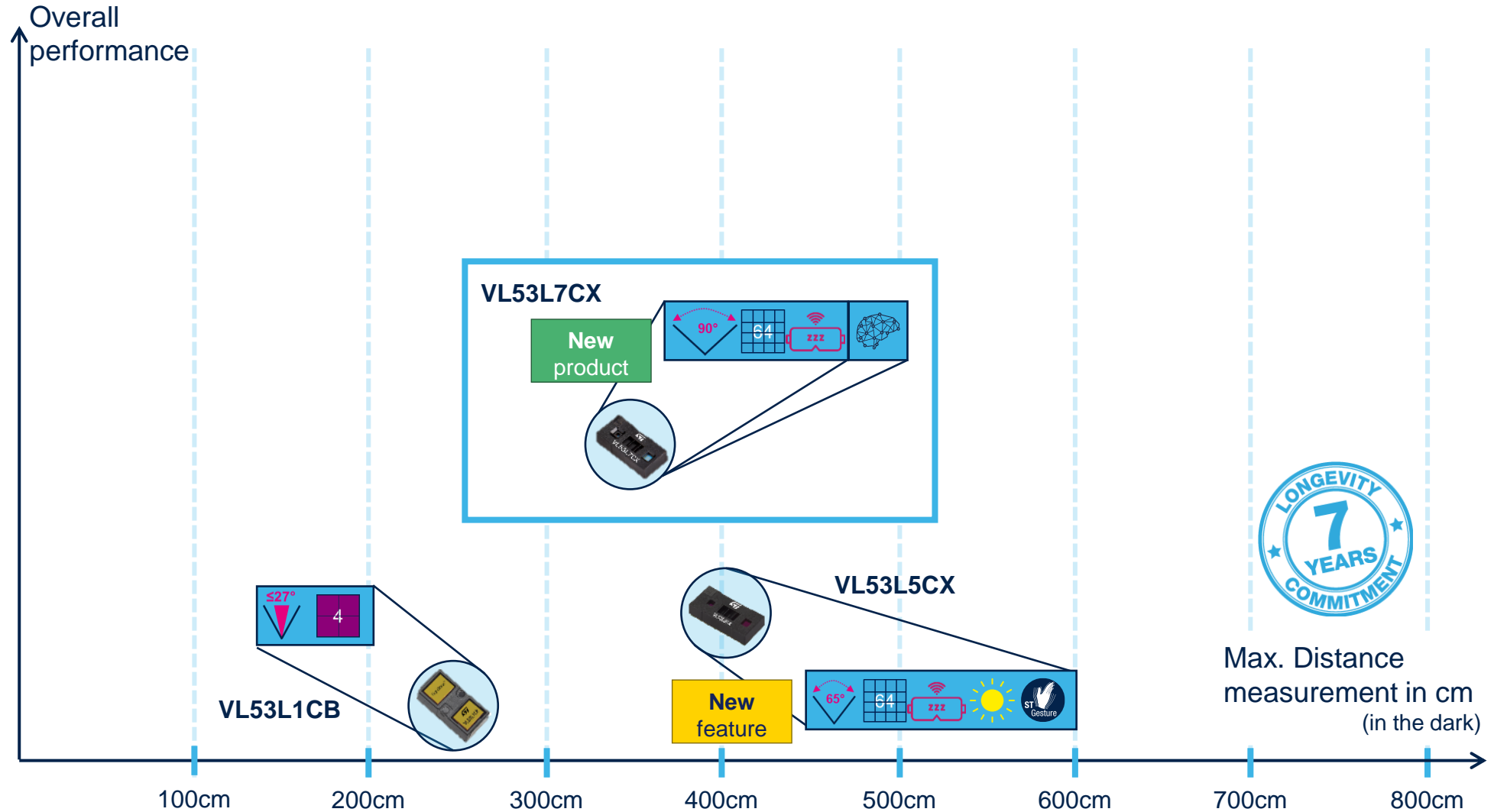
Max distance measurement	60 cm	130 cm	200 cm	400 cm	500 cm	600 cm	800 cm
Field-of-View	25° No Lens	18° No Lens	25° No Lens	27° (SW config) Lens on Rx	25° No Lens	18° No Lens	27° (SW config) Lens on Rx
Perf. under ambient light (along windows with strong outside light)	10cm	60cm	80cm	++ (135cm)	++ (140cm)	++++ (180cm)	+++ (160cm)
Close distance linearity	+++ >1.0cm	+++++ >0.1cm	++ >2.5cm	+ >2.5cm	++ >2.5cm	+++ >1.0cm	++ >2.5cm
Min. distance detection	0cm	0cm	<1.5cm	1.0cm	1.0cm	0cm	1.0cm
Multi-target detection (Histogram)	No	No	No	No	Yes	Yes	Yes
Crosstalk / Smudge immunity	Crosstalk compensation	Crosstalk compensation	Crosstalk compensation	Crosstalk compensation	Immunity >80cm <80cm: Smudge comp.	Immunity >80cm <80cm: Smudge comp.	Immunity >80cm <80cm: Smudge comp.
Power conso	Typical (act. ranging)	1.7mA	22mA	19mA	16mA	16mA	19mA
	Autonomous mode (1Hz)	170µA	240µA	340µA	395µA	-	-
	ULP (Ultra Low Power)	-	55µA	-	65µA	55µA	-
Memory footprint	ROM 4.5kB RAM 0.44kB	ROM 2.7kB RAM >0.1kB	ROM 23.4kB RAM 1.2kB	ROM 3.3kB RAM 0.03kB	ROM 36kB RAM 11.2kB	ROM 36kB RAM 11.2kB	ROM 47.6kB RAM 9.8kB
Product variants Same HW, different features	VL6180X ambient light sensing	VL53L4ED extended temp. range (-40°/+105°)	-	-	-	VL53L4EX extended temp. range (-40°/+105°)	-
All-in-one module size	4.8 x 2.8 x 1.0 mm	4.4 x 2.4 x 1.0 mm	4.4 x 2.4 x 1.0 mm	4.9 x 2.5 x 1.56 mm	4.4 x 2.4 x 1.0 mm	4.4 x 2.4 x 1.0 mm	4.9 x 2.5 x 1.56 mm



FlightSense™ Multi-Zones portfolio

- XX° FoV
- Number of zones
* In sequential mode
- Perf. Under Ambient (>100cm)
- Autonomous mode
- Ultralow Power Mode
- Gesture recognition
- Suitable for AI

- Common Features**
- Histogram
 - MultiObject detection





FlightSense™ Multi-Zone portfolio



Resolution	Max zones	Up to 4 zones	Up to 64 zones	Up to 64 zones
	Modes	-	8x8 & 4x4	8x8 & 4x4
Max distance measurement		250cm	400cm	350cm
Field-of-View		27° (SW config) Lens on Rx	45° x 45° (Ø65°) Lens on Rx + Tx	60° x 60° (Ø90°) Lens on Rx + Tx
Perf. under ambient light (along windows with strong outside light)		tbc	+++ (170cm)	+ (65cm)
Close distance linearity		+ >2.5cm	++ >2.0cm	++ >2.0cm
Min. distance detection		1.0cm	1.0cm	1.0cm
Multi-target detection (Histogram)		Yes	Yes	Yes
Crosstalk / Smudge immunity		Immunity >80cm <80cm: Smudge comp.	Immunity >60cm <60cm: Crosstalk comp.	Immunity >60cm <60cm: Crosstalk comp.
Power conso	Typical (act. ranging)	16mA	216mW	216mW
	Autonomous mode (1Hz)	-	2.8mW / 8mW	2.8mW / 8mW
Memory footprint		ROM 47.6kB RAM 9.8kB	ROM 103.372KB RAM 4.096KB	ROM 103.372KB RAM 4.096KB
All-in-one module size		4.9 x 2.5 x 1.56 mm	6.4 x 3.0 x 1.5 mm	6.4 x 3.0 x 1.6 mm



VL53L7CX at a glance

First Multi-zone (64 zones) Time-of-Flight ranging sensor

Highlights

- Parallel multizone ranging output:
 - 4x4 or 8x8 zones separate regions of interest
- Ultra-wide FoV: 60° x 60° (90° diagonal)
- Up to 350 cm ranging
- Multi-target detection and distance measurement in each zone
- Motion indicator indicating if the target has moved
- 60 Hz (4x4 zones) frame rate capability
- Immunity to cover glass cross-talk beyond 60cm
- Pin-to-pin and driver compatible with VL53L5CX



Package size : 6.4 x 3.0 x 1.6 mm
 Square FoV : 60° x 60° (90° diagonal)
 Multi-zone (8x8)



Max Distance measurement	3.5 meters
Close distance linearity	>2cm
Performance under ambient light (5klux)	65cm
Multi-target detection (Histogram)	Yes, in each zone
Crosstalk / Smudge immunity	Immunity >60cm <60cm: Smudge compensation
Power Consumption	95mA (continuous ranging) 1.3mA in Low power mode



VL53L7CX GUI demo

VL53L7CX

Mini Depth-Map Calibration Data Log About

R:77	R:80	R:90	R:156	R:1675	R:1670	R:1707	R:1708
R:85	R:88	R:174	R:1674	R:1676	R:1651	R:1679	R:1677
R:174	R:1652	R:183	R:1666	R:1635	R:1675	R:1667	R:1669
R:1651	R:1638	R:1653	R:1658	R:1638	R:1650	R:1666	R:1674
R:1641	R:1635	R:1649	R:1642	R:1648	R:1646	R:1658	R:1650
R:1628	R:1631	R:1636	R:1643	R:1642	R:1640	R:1636	R:1661
R:1622	R:1608	R:1621	R:1831	R:1630	R:1638	R:1646	R:1673
R:1625	R:1603	R:1616	R:1608	R:1620	R:1632	R:1649	R:1676

Device Control

Zone Mode: 8x8
Power Mode: Continuous
Ranging Rate(Hz): 15
Integration Time: 5
Sharpener(%): 3
CoverGlass On:
Rotation: None
Sensor: Centre
Save Above Settings: Save
Rate from Device(Hz): 15.53

Start Stop

Display Control

Range Gradient Min(mm): 10
Range Gradient Max(mm): 2000
Median Range(mm):
Peak Signal Rate(kcps/spad)
Ambient Signal Rate(kcps/spad)
Target Status
Zone Number

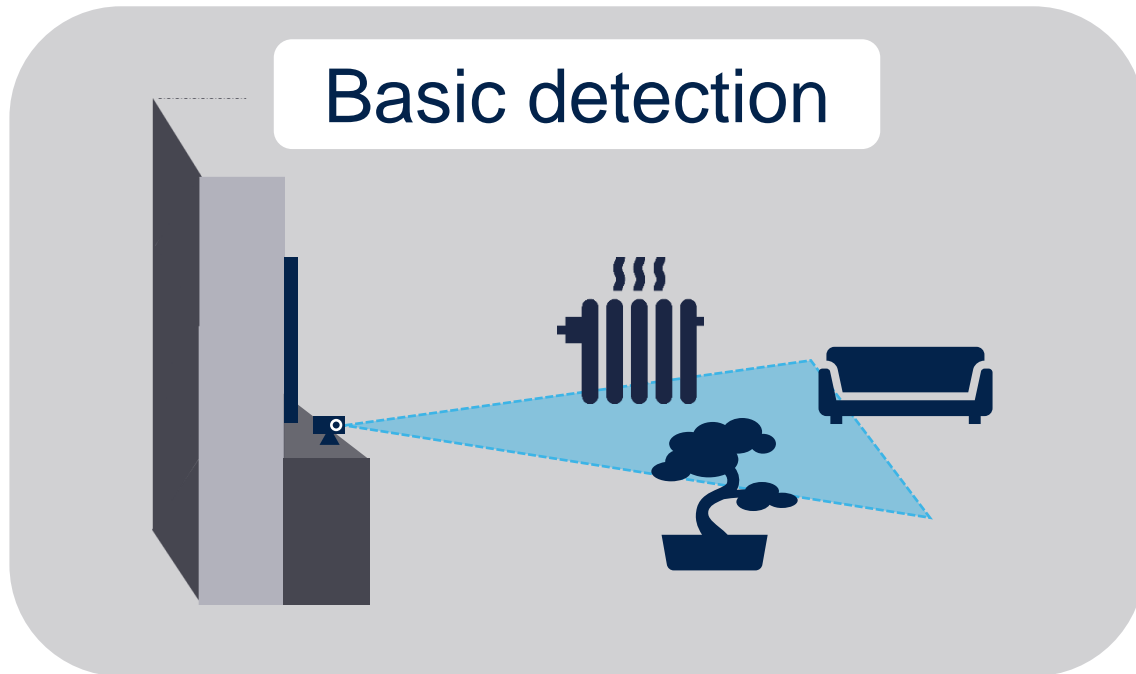
Smart Presence Detection



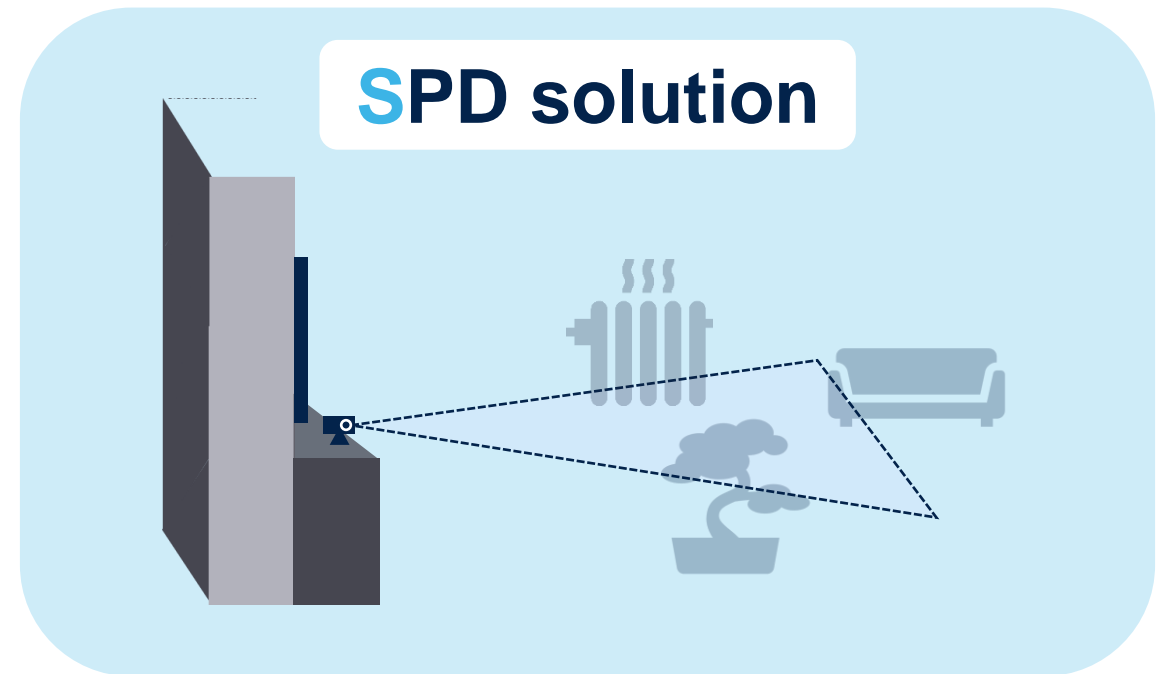


Why Smart Presence Detection?

1 Immune to the environment : Wall / Plants / Furniture / Temperature



- Something Detected
- Presence = True

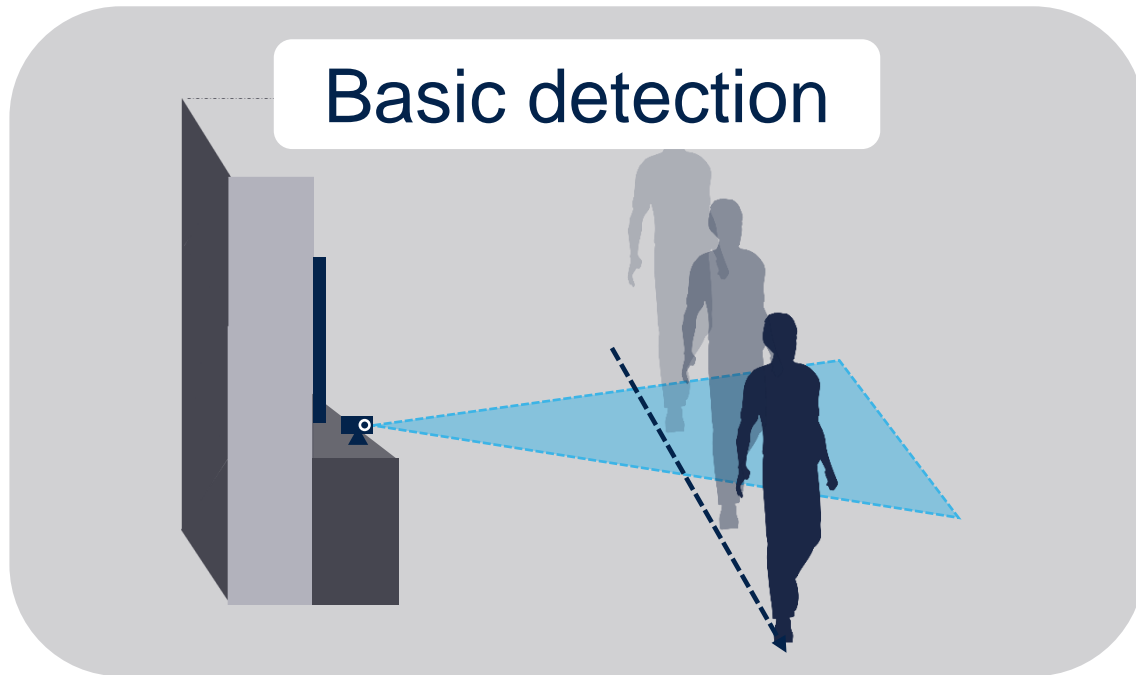


- Object Detected
- Presence = False

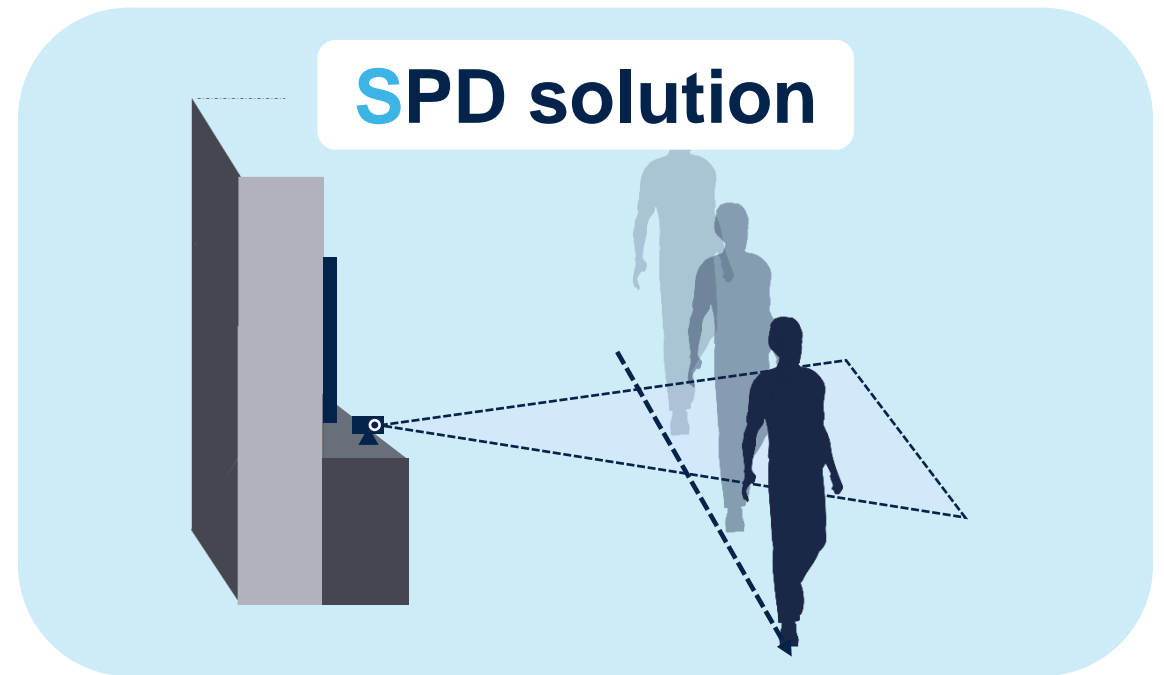


Why Smart Presence Detection?

2 Filters Passing-By Users : Corridor / Lobby / Kitchen



- User entering the FoV
- Presence = True

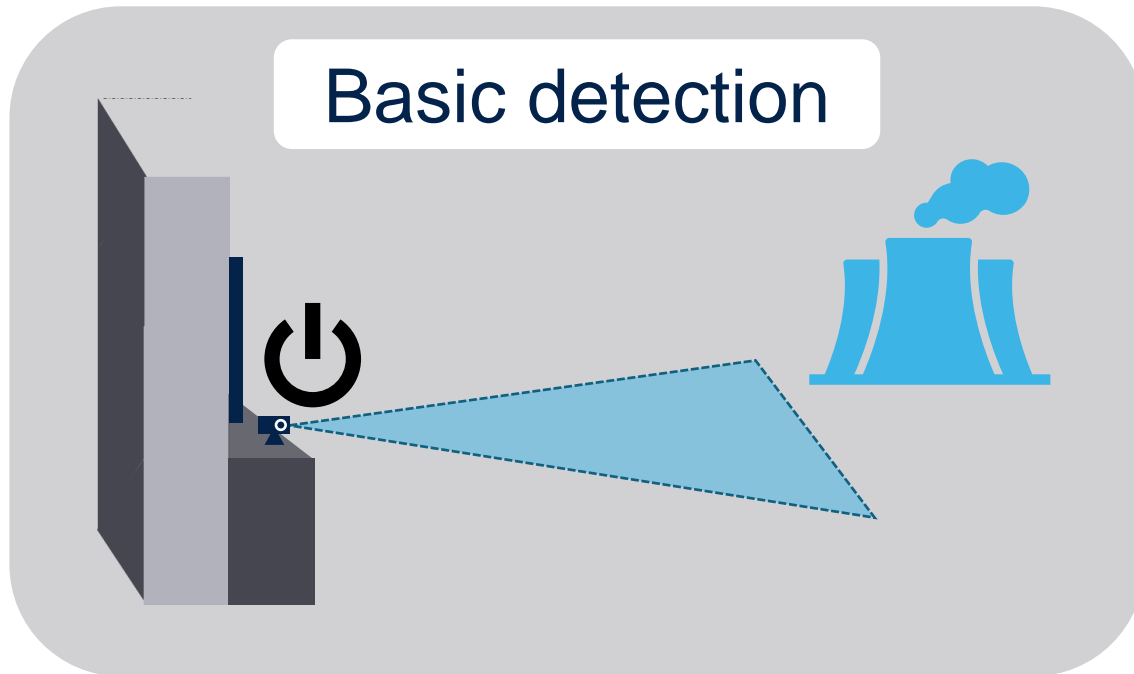


- User crossing the FoV
- Presence = False

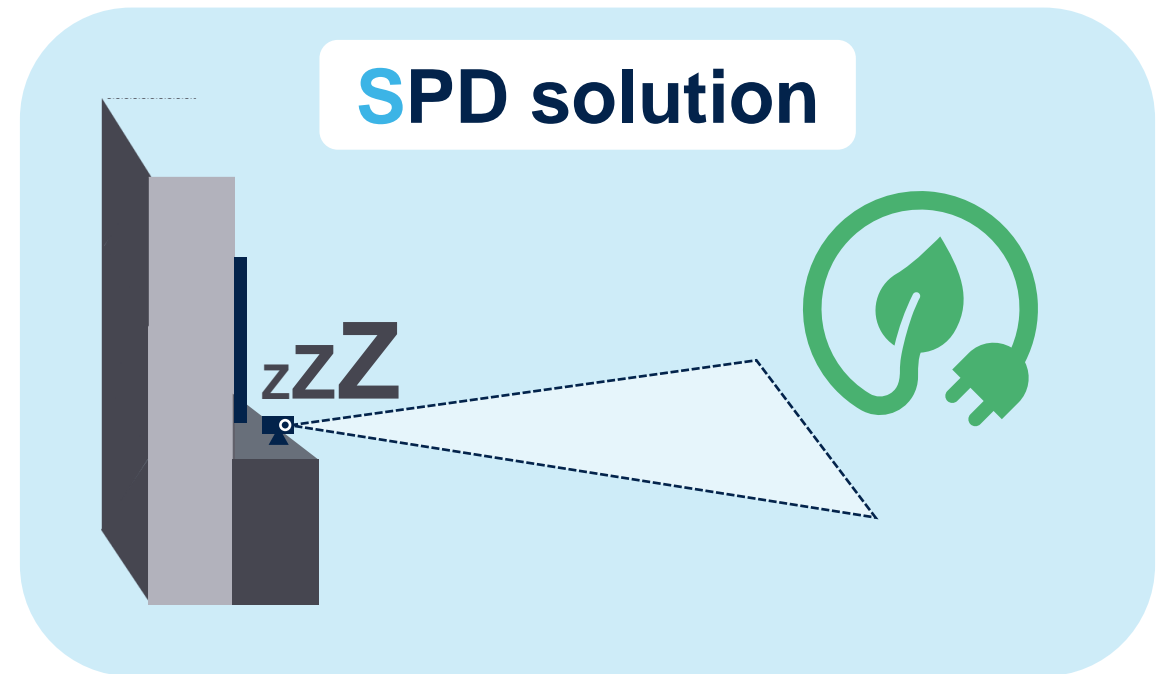


Why Smart Presence Detection?

3 Runs in Low Power Autonomous Mode: System going to sleep mode...



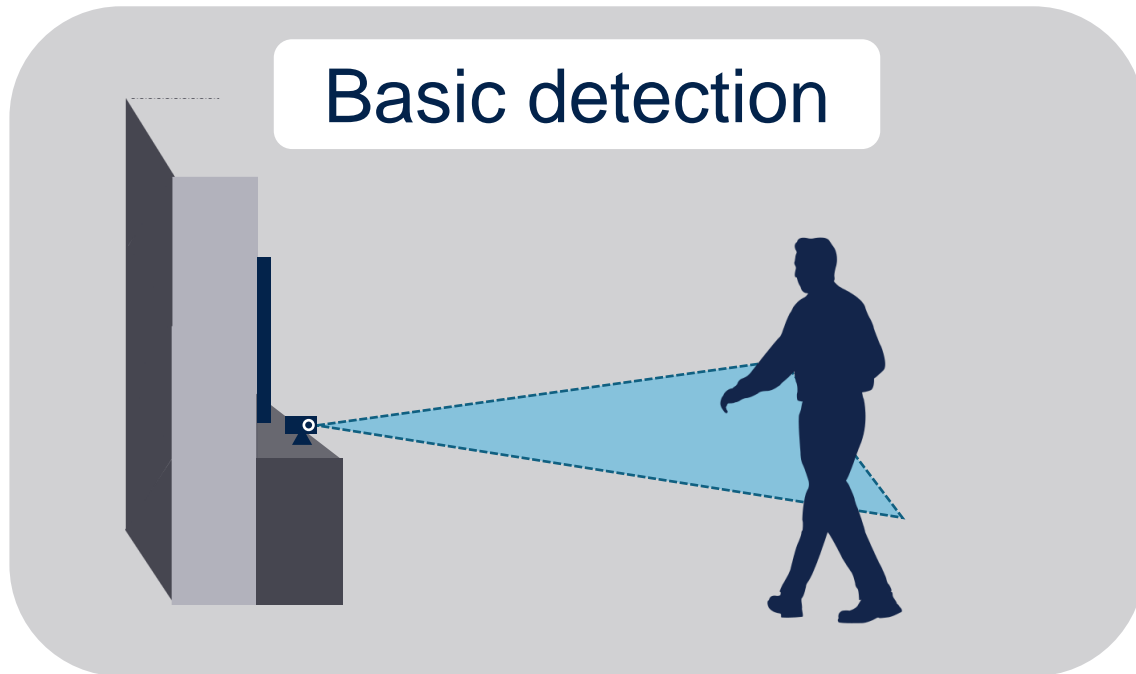
- Sensor Continuous Scanning
- MCU running



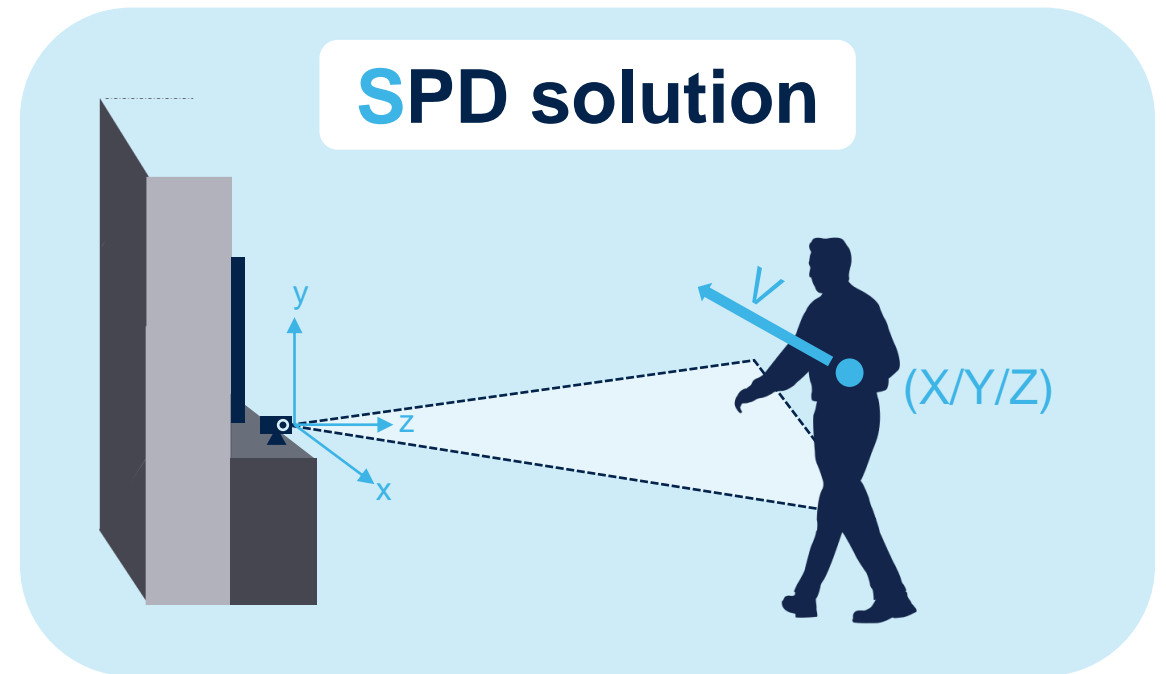
- Sensor in Autonomous Mode
- MCU sleeping
- Below 1mW

Why Smart Presence Detection?

4 Tracks users : position and speed



➤ A user entering the FoV



➤ A user is entering the FoV at the position $X/Y/Z$ and moving at V km/h



Why **Smart** Presence Detection ? No camera / No image

1

Immune to the environment

2

Runs in Low Power Autonomous Mode

5

Identifies the number of users



100% Privacy

3

Filters Passing-By Users

4

Tracks users

SPD package content



SPD is a
all-in-one package

A screenshot of the ST.com website showing the product page for STSW-IMG035. The page features a navigation bar with links for Careers, Sample & buy, and Support & community. Below the navigation is the ST logo and a search bar. The main content area displays the product name "STSW-IMG035" with an "ACTIVE" status, followed by a description: "Turnkey gesture recognition solution based on VL53L5CX, VL53L7CX and VL53L8CX multizone Time-of-Flight ranging sensors". Two buttons are visible: "Get Software" and "Download databrief". At the bottom, there are tabs for "Overview", "Documentation", and "Tools & Software".

st.com/en/embedded-software/stsw-img035.html

ST

Careers Sample & buy Support & community 日本語

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Products Tools & software Applications Solutions STM32 Developer Zone About us

Embedded software > Imaging Software > STSW-IMG035 >

STSW-IMG035 ACTIVE Save to MyS

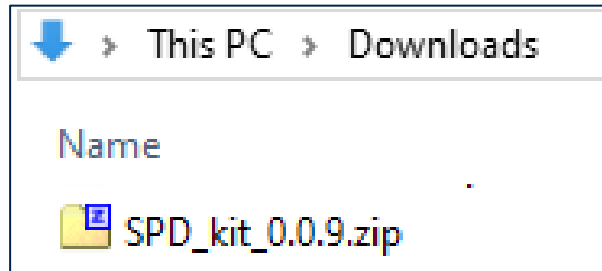
Turnkey gesture recognition solution based on VL53L5CX, VL53L7CX and VL53L8CX multizone Time-of-Flight ranging sensors

Get Software Download databrief

Overview Documentation Tools & Software

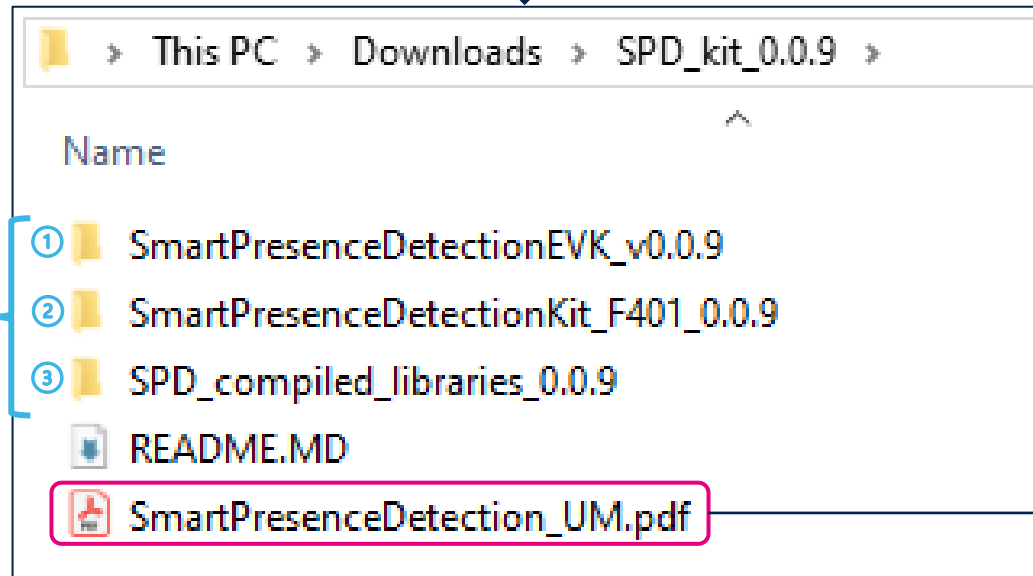


Package content

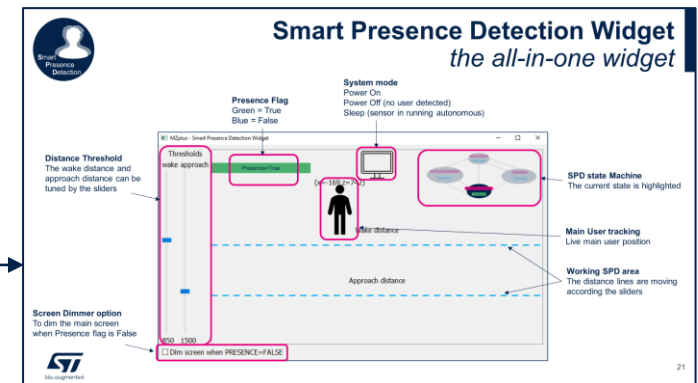


SPD is a **all-in-one package**

Unzip it



3 deliveries

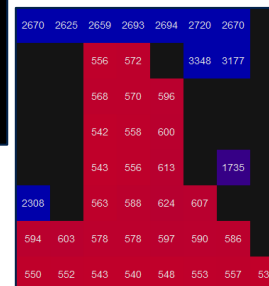
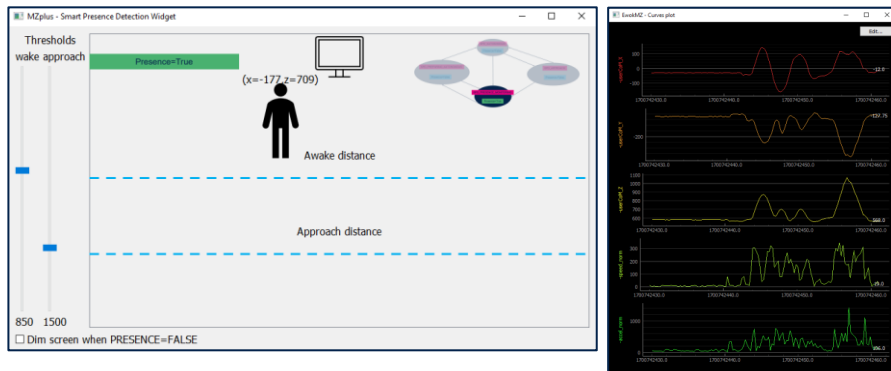
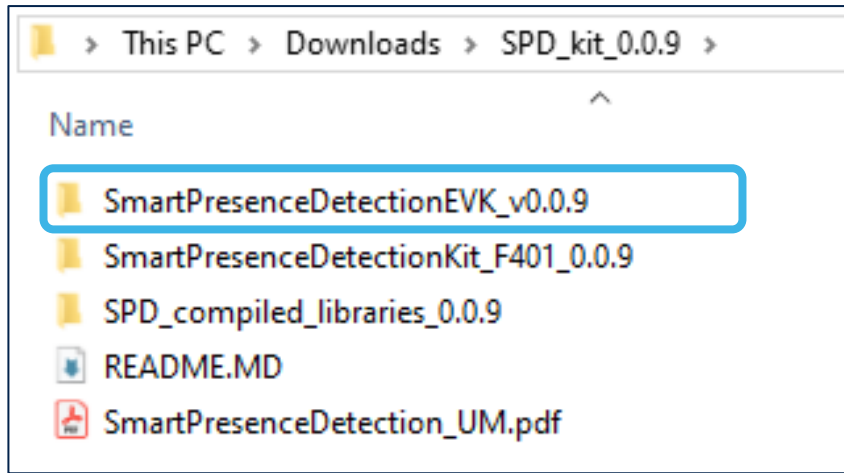




Package content

1

SmartPresenceDetection EVK GUI



- Software User Interface for SPD
- Sensor data visualization
- SPD algo output monitoring
- SPD applicative demo
- Powerful datalogger

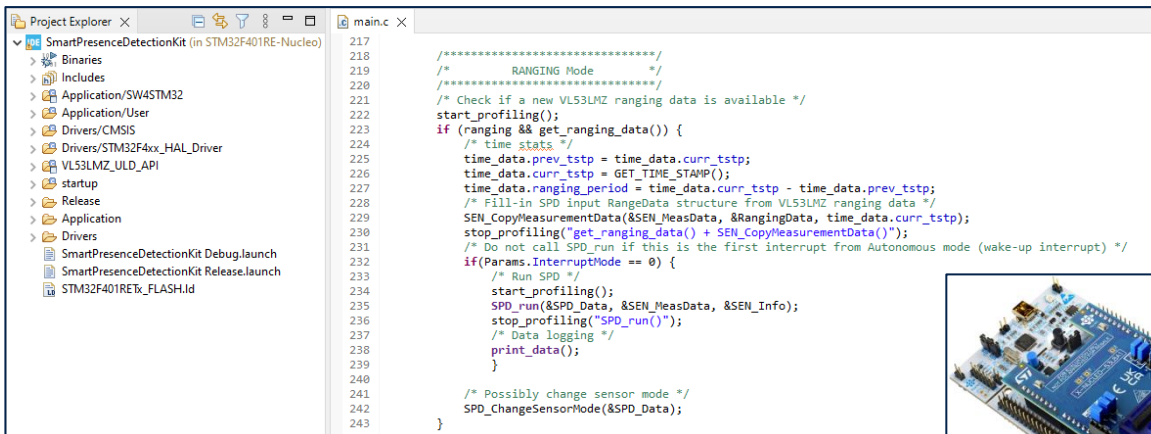
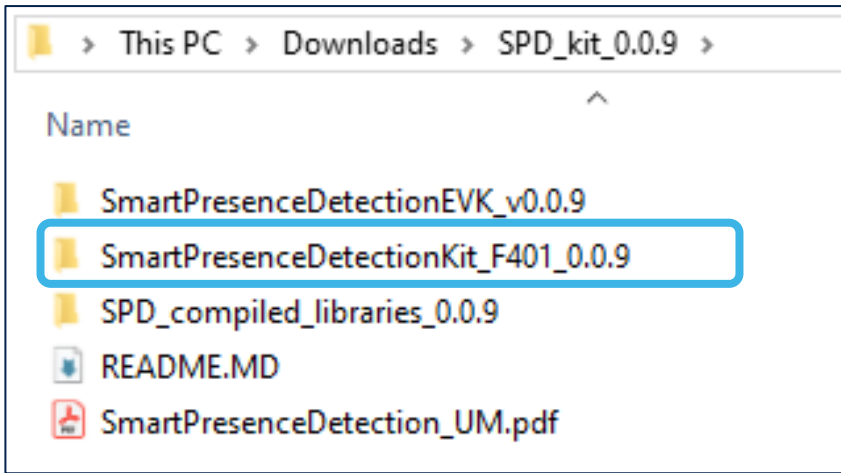
↳ User Manual: “Running in the EVK GUI”



Package content

2

SmartPresenceDetection Kit F401



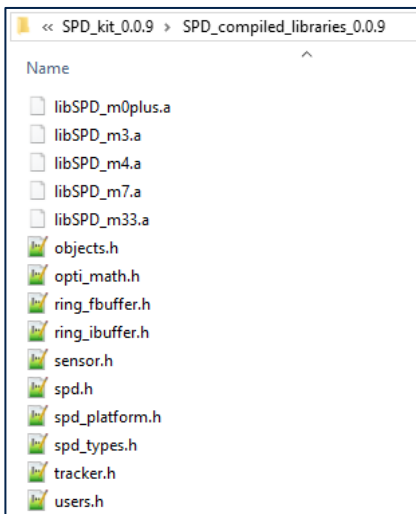
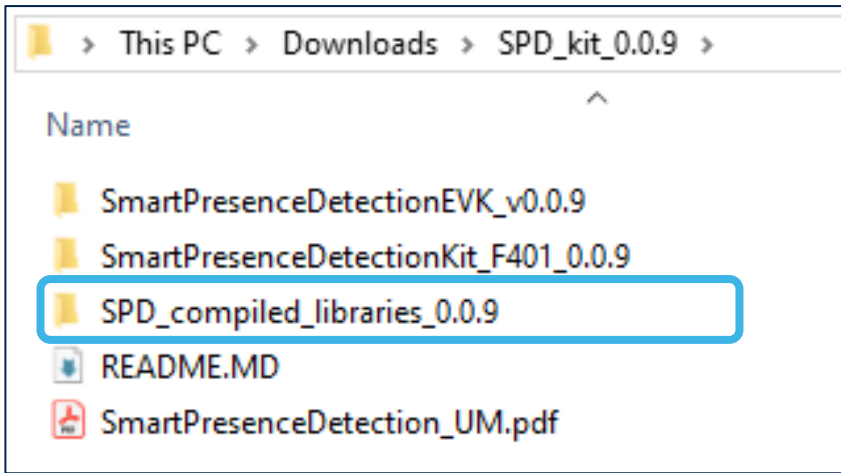
- Complete C project example
- P-NUCLEO-53L7/8A1 - STM32F401RE
- ST ToF MZ generic ULD
- SPD algo integration
- Sensor configuration

↔ User Manual: “SPD Library: Programming Guide”



3

SPD compiled libraries



arm
CORTEX-M

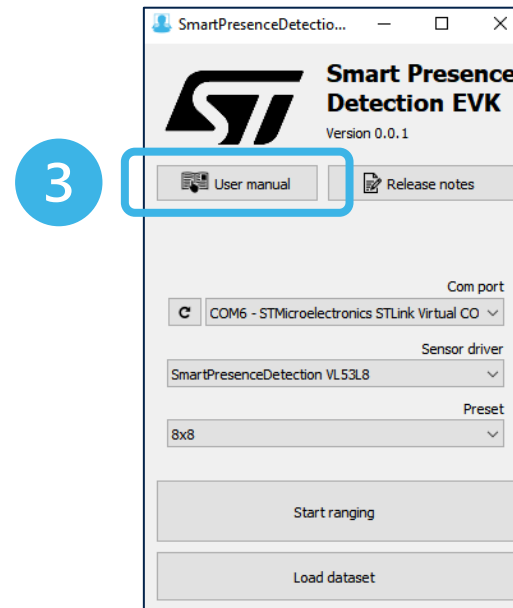
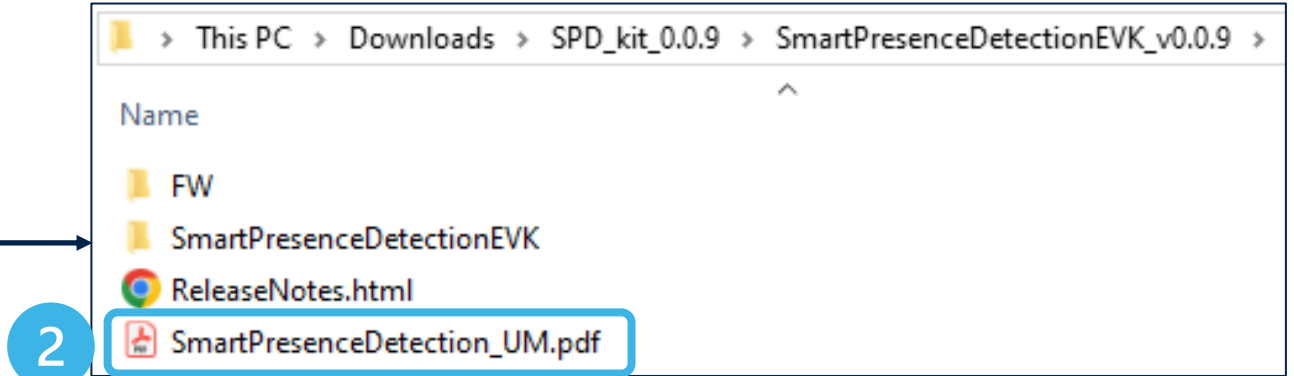
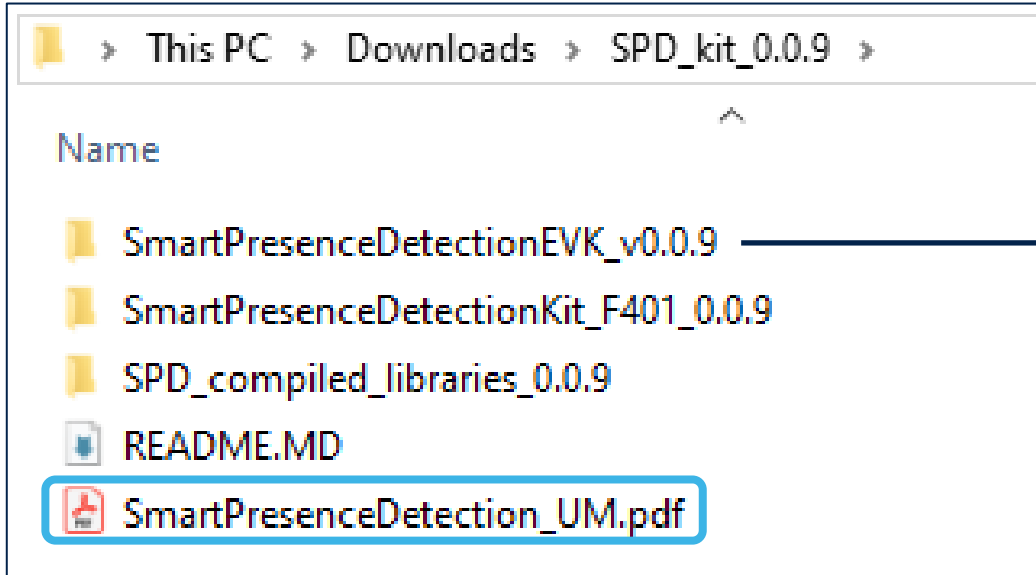


- ARM Cortex-M4
- ARM Cortex-M33
- ARM Cortex-M0+
- ARM Cortex-M7
- ARM Cortex-M3



Where to find the User Manual

User Manual ➔ User Guide



Running SPD GUI for your demo



User Guide: EVK Getting Started Running in the EVK GUI

Step 1: Hardware setup

Connect the board to the PC via a USB to Micro-USB cable

Compatible operating system:

- Windows

Compatible boards:

- P-NUCLEO-53L7A1 Expansion pack (NUCLEO-F401RE, X-NUCLEO-53L7A1)
- P-NUCLEO-53L8A1 Expansion pack (NUCLEO-F401RE, X-NUCLEO-53L8A1)

Board example

ST logo

Step 2: Firmware loading

Open the .FW folder in the Smart Presence Detection EVK repository to find the firmware compatible with VL53L5CX, VL53L7CX and VL53L8CX sensors

Drag and drop the .bin file to flash the board

ST logo

Main window

Press stop to end the ranging

Record data

Select file format of data to log

Retract right part of the display

Open a new widget

Help locate the selected window

Save and retrieve widgets layout configuration

Configure how information are displayed in the above window. Details on next page

Display variables from the algorithm

ST logo

Smart Presence Detection Widget the all-in-one widget

System mode

- Power On (no user detected)
- Power Off (no user detected)
- Sleep (sensor in running autonomous)

Presence Flag

- Green = True
- Blue = False

Distance Threshold

The wake distance and approach distance can be tuned by the sliders

SPD state Machine

The current state is highlighted

Main User tracking

Live main user position

Working SPD area

The distance lines are moving according to the sliders

Screen Dimmer option

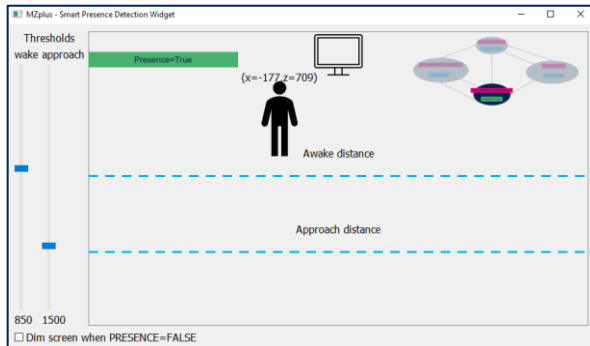
To dim the main screen when Presence flag is False

Dim screen when PRESENCE=FALSE

ST logo

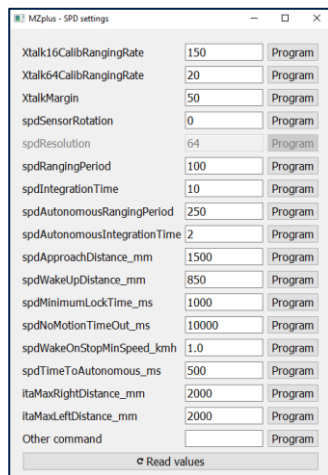


Smart System Detection Widgets



SPD widget

- All in one widget:
- User tracking
 - Distance thresholds tuning
 - Presence Monitoring
 - State Machine
 - Screen dimmer

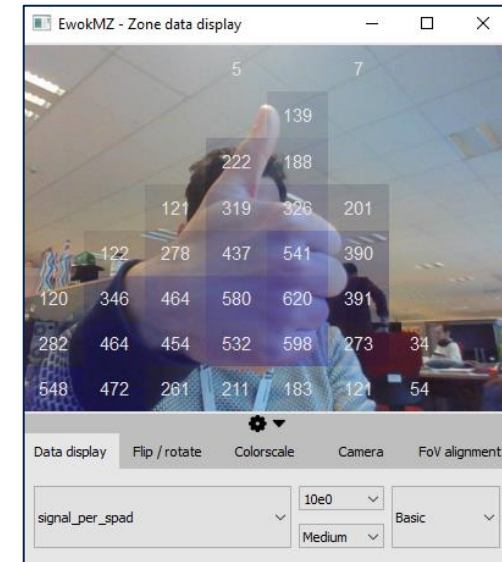


SPD settings

Live SPD parameters tuning

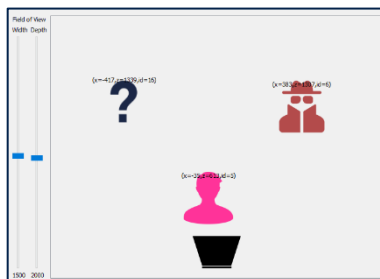
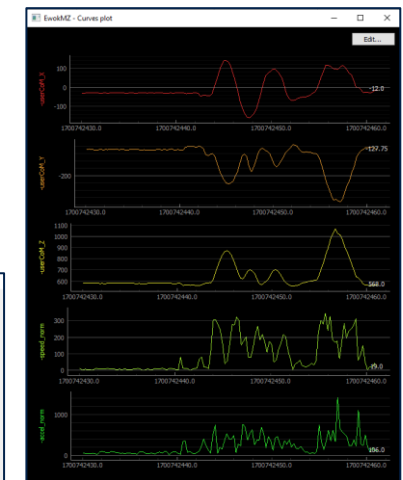
Zones display data

Open a display window (similar to the main one), connected to the same sensor. This is useful to display other data types in parallel



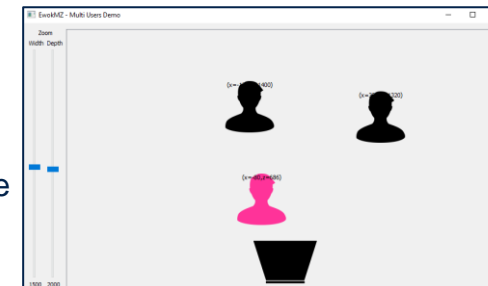
Curves plot

Complete tool to plot curves among all the data outputted by the device.



User Analysis

Allows to detect multiple objects and identify if they are intruders



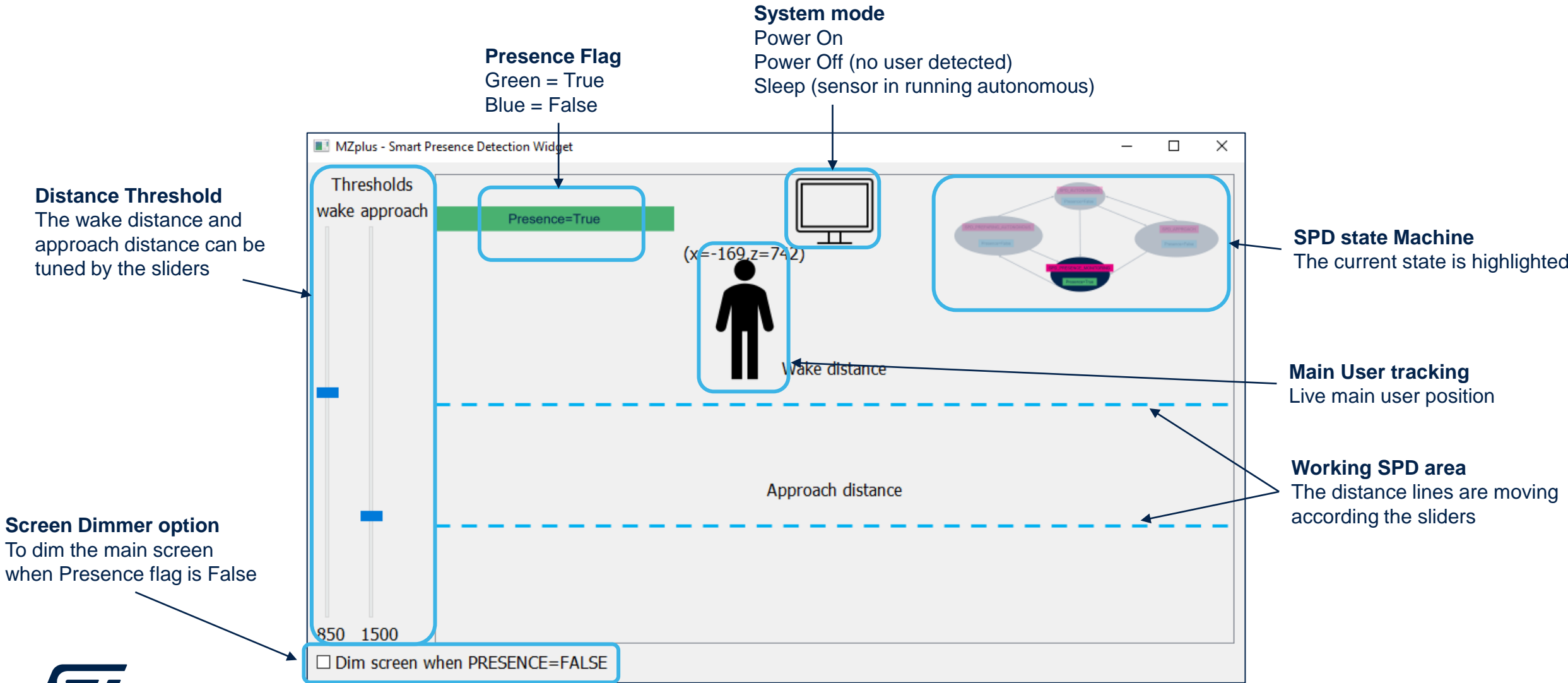
Multi Users Demo

Allows to detect multiple humans and track their positions



Smart Presence Detection Widget

the all-in-one widget





How to Showcase the SPD features

Wake-on Approach

Human VS Object

Passing-By Filter

Wake-on Stop

Walk-away Lock

The screenshot displays two windows from the MZplus application. The left window, titled "MZplus - Zone data display", shows a camera view of a room with a blue overlay containing a grid of numerical zone IDs. The right window, titled "MZplus - Smart Presence Detection Widget", shows configuration options for a monitor labeled "ZZZ".

Zone ID	Zone ID	Zone ID	Zone ID	Zone ID	Zone ID	Zone ID	Zone ID
2759	2583	2604	2545	2634			
3022	3028	3046	3075	3068	3078	3138	
2983	2988	3014	2985	3067	3064	3096	3072
	2935		3006	2941	2942		
	2815		2918	2887	2854		
	2788	2797	2807	2808	2799		
	2693	2699	2731	2732	2730		
	2637	2650	2671	2700	2654		

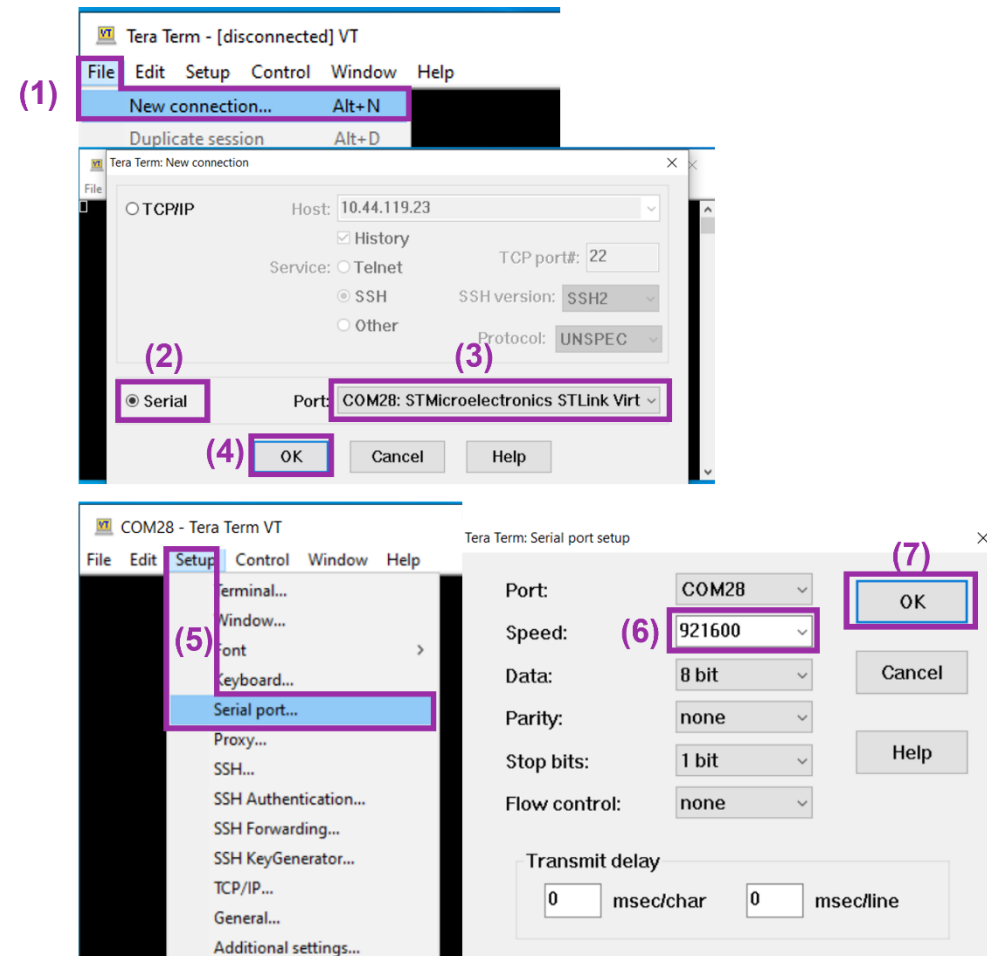
The "MZplus - Smart Presence Detection Widget" window includes the following elements:

- Thresholds:** A vertical slider for "wake approach" with values 600 and 1500.
- Presence Status:** A blue bar labeled "Presence=False".
- Wake distance:** A horizontal dashed blue line.
- Approach distance:** A horizontal dashed blue line.
- Monitor:** An icon of a monitor displaying "ZZZ".
- Diagram:** A network diagram showing a central node connected to three peripheral nodes.
- Checkbox:** "Dim screen when PRESENCE=FALSE" (unchecked).

Running SPD in terminal

Running in a serial terminal (1/3)

- To connect the serial port please follow the steps shown in the figure below:



(1) File Edit Setup Control Window Help
New connection... Alt+N
Duplicate session Alt+D

(2) Tera Term: New connection
Host: 10.44.119.23
History
Service: Telnet TCP port#: 22
SSH SSH version: SSH2
Other Protocol: UNSPEC

(3) Serial Port: COM28: STMicroelectronics STLink Virt

(4) OK Cancel Help

(5) File Edit Setup Control Window Help
Terminal...
Window...
Font
Keyboard...
Serial port...
Proxy...
SSH...
SSH Authentication...
SSH Forwarding...
SSH KeyGenerator...
TCP/IP...
General...
Additional settings...

(6) Tera Term: Serial port setup
Port: COM28
Speed: 921600
Data: 8 bit
Parity: none
Stop bits: 1 bit
Flow control: none
Transmit delay: 0 msec/char 0 msec/line

(7) OK Cancel Help



Running in a serial terminal (2/3)

- To run the application, use the command line “enable” and press enter:

A screenshot of a serial terminal window titled "COM6 - Tera Term VT". The window has a menu bar with "File", "Edit", "Setup", "Control", "Window", and "Help". The terminal output shows the following text:

```
SPD ULD SW Kit version 0.0.9  
Module type = UL53L8CX  
Module ID : 0000000000000000_UL53L8CBV0GC/1$2  
FW Version : 1.7.0.0  
ULD Driver UL53LMZ_2.0.10
```

* For more information about the available commands, see the chapter: [command manager](#)



Running in a serial terminal (3/3)

- The serial terminal shows the output of the ST SPD solution:

```
COM6 - Tera Term VT
File Edit Setup Control Window Help
Presence:1
Main User position: X=-125 mm, Y=-106 mm, Z=557 mm
SPD state = SPD_PRESENCE_MONITORING

[ASCII art of a person]

Nb users:2, Intruder Alert:1
Other User #1, X:53, Y:-161, Z:1141
```

- SPD metrics:
 - Presence flag
 - Main User position
 - Number of Users

- State Machine
- Multi human detection viewer
- Users' information

```
COM6 - Tera Term VT
File Edit Setup Control Window Help
Presence:0
Main User position: X=0 mm, Y=0 mm, Z=0 mm
SPD state = SPD_AUTONOMOUS

[ASCII art of three Z's]

Nb users:0, Intruder Alert:0
```



Command manager

- All the commands are available in the help:

```
COM6 - Tera Term VT
File Edit Setup Control Window Help
SPD ULD SW Kit version 0.0.9
Module type = UL53L8CX
Module ID : 0000000000000000_UL53L8CBU0GC/1$2
FW Version : 1.7.0.0
ULD Driver UL53LMZ_2.0.10
help
```



```
COM6 - Tera Term VT
File Edit Setup Control Window Help
SPD ULD SW Kit version 0.0.9
Module type = UL53L8CX
Module ID : 0000000000000000_UL53L8CBU0GC/1$2
FW Version : 1.7.0.0
ULD Driver UL53LMZ_2.0.10
help
name Give f/w name
version Give f/w version
module Give module type
spdver give SPD algo version
apiver Give UL53LMZ API (Bare Driver) version.
fwver Give UL53LMZ FW version.
enable Enable sensor ranging.
Syntax: 'enable'
Example: 'enable' => Enable sensor ranging
disable Disable sensor ranging.
Syntax: 'disable'
Example: 'disable' => Disable sensor ranging
off Set sensor in ULP mode (Ultra Low Power).
Syntax: 'off'
Example: 'off' => Disable sensor
get_calstatus Gets Calibration status
Syntax: 'get_calstatus'
params Show all input parameters
Syntax: 'params'
Example: 'params' => Show all input parameters
set Set a parameter. See params command to know available parameters and current values.
Syntax: 'set param_name=value'
Example: 'set RangingPeriod=1'
log Enable/Disable spd data logging and set logging level.
Syntax: 'log spd x'
Example: 'log spd 2' => Enable range logging on zone 1
help Displays this help
```

- The principal commands:
 - help
 - enable
 - disable
 - params
 - set

SPD in details





SPD key outputs

SPD outputs:

- **Presence Flag**
- Main User X/Y/Z positions
- Main User moving speed
- SPD state

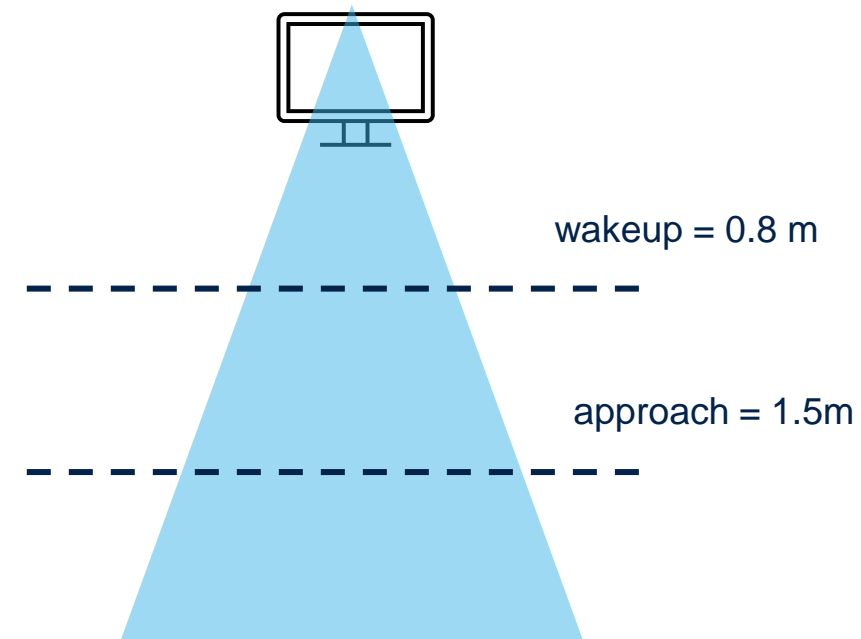
Multi-Human tracking outputs:

- **Number of Users**
- Each user X/Y/Z positions and speed



Key distance parameters

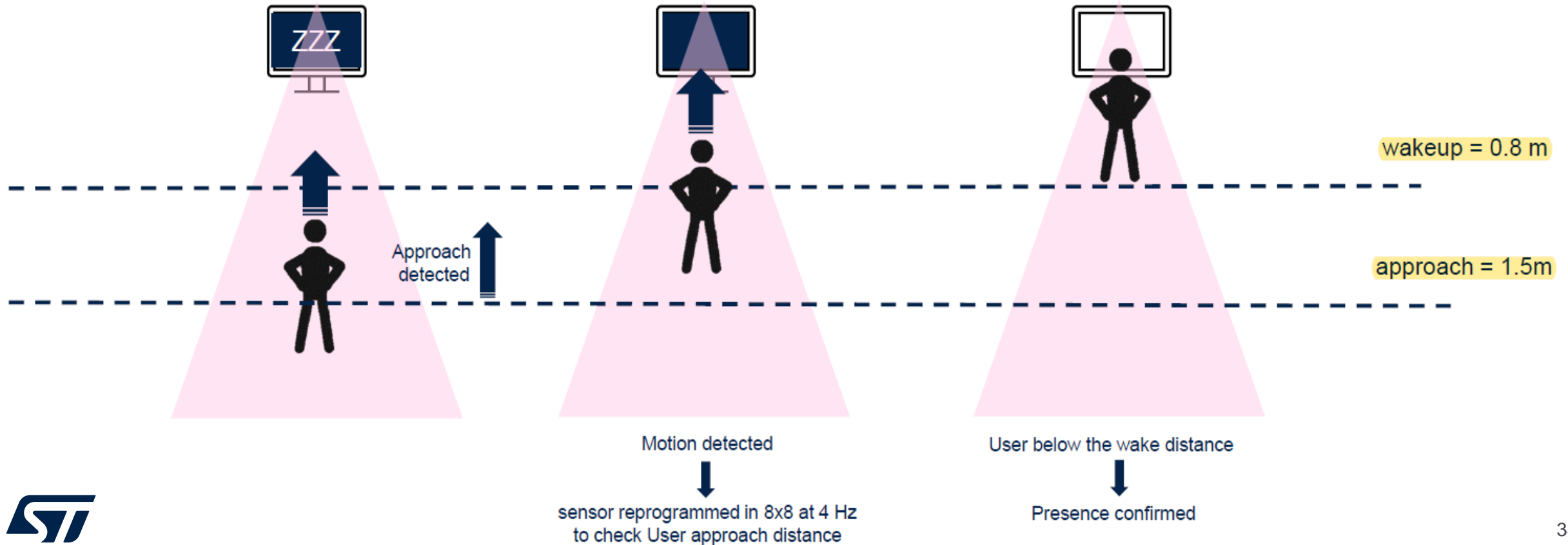
- **WAKEUP:**
 - the **Presence Flag** is always **True** when a User is detected inside this area
- **APPROACH:**
 - The SPD algorithm is tracking the identified User and try to determine if:
 - Passing-By: the user is just crossing the sensor FoV and doesn't have interest in the application
 - Presence flag = False
 - Wake-On Stop: the user stops his movement in front of the application and potentially he is interested by
 - Presence flag = True





Wake On Approach

FSM	SPD_AUTONOMOUS	SPD_APPROACH	SPD_PRESENCE_MONITORING
Sensor	Sleep, 4x4, 1 Hz	Ranging, 8x8, 4 Hz	Ranging, 8x8, 4 Hz
Presence	False	False	True





SPD ranging mode

Autonomous mode

Sensor is ranging autonomously and wake the host up only if a motion is detected

Example

Sensor configuration 1:

- Ranging Frequency = 1 Hz
- Integration Time = 2 ms

Example

Sensor configuration 2:

- Ranging Frequency = 4 Hz
- Integration Time = 2 ms

Default SPD settings

Low Power Consumption



Tracking mode

Sensor is ranging continuously and sends the ranging data to the host and the SPD algorithm

Example

Sensor configuration 1:

- Ranging Frequency = 4 Hz
- Integration Time = 5 ms

Example

Sensor configuration 2:

- Ranging Frequency = 10 Hz
- Integration Time = 10 ms

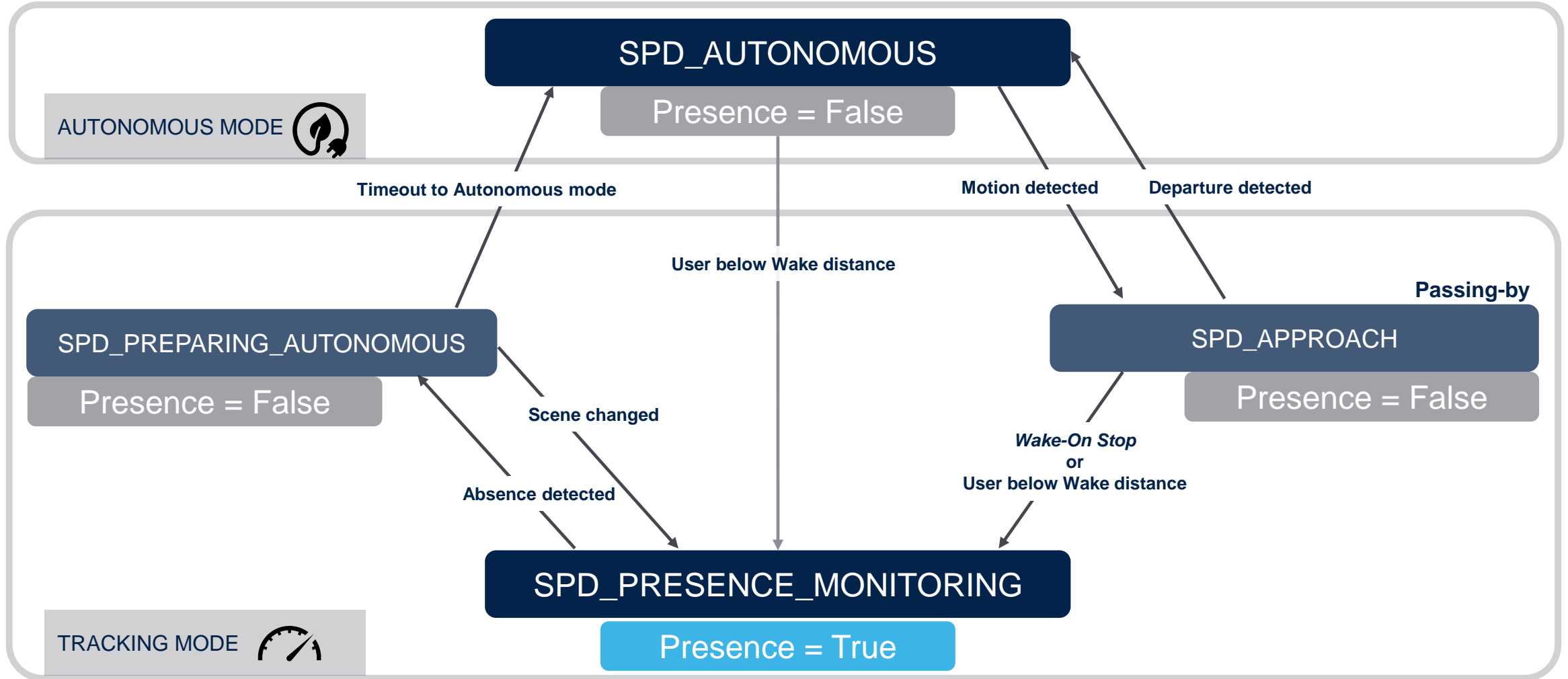
Default SPD settings

Full performances





SPD State Machine





SPD Params

Parameters	Default value	Value range	Description
spdSensorRotation	0		Change the sensor orientation used in the application and adapt the data indexes
spdRangingPeriod (ms)	100	50 – 1000 (20Hz – 1Hz)(*)	Sensor ranging period when the sensor is in tracking mode (SPD_APPROACH / SPD_PRESENCE_MONITORING / SPD_PREPARING_AUTONOMOUS)
spdIntegrationTime (ms)	10	1 – 20	Sensor integration time when the sensor is in tracking mode (SPD_APPROACH / SPD_PRESENCE_MONITORING / SPD_PREPARING_AUTONOMOUS)
spdAutonomousRangingPeriod (ms)		(20Hz – 1Hz)	Sensor ranging period when the sensor is in autonomous mode (SPD_AUTONOMOUS)
spdAutonomousIntegrationTime (ms)	5	1 – 20	Sensor integration time when the sensor is in autonomous mode (SPD_AUTONOMOUS)
spdWakeUpDistance_mm (mm)	850	0 – 2000	“Wake Up distance” threshold -> Key distance parameters
spdApproachDistance_mm (mm)			“Approach distance” threshold -> Key distance parameters It has to be higher than the “Wake Up distance”
spdMinimumLockTime_ms (ms)	1000	0 – 2147483647 (**)	Timeout after departure detection: FSM: SPD_PRESENCE_MONITORING -> SPD_PREPARING_AUTONOMOUS
spdNoMotionTimeOut_ms (ms)			Timeout if no motion detected in the scene: FSM: SPD_PRESENCE_MONITORING -> SPD_PREPARING_AUTONOMOUS
spdTimeToAutonomous_ms (ms)	500	0 – 2147483647	Time to switch to autonomous mode when the Presence Flag if False FSM: SPD_PREPARING_AUTONOMOUS -> SPD_AUTONOMOUS
spdWakeOnStopMinSpeed_kmh (km/h)	1	0.2 – 10 (***)	Threshold speed to detect the user stopped FSM: SPD_APPROACH -> SPD_PRESENCE_MONITORING

Sensor Settings

Distances

Timings

spdRangingPeriod	100
spdIntegrationTime	10
spdAutonomousRangingPeriod	250
spdAutonomousIntegrationTime	2
spdApproachDistance_mm	1500
spdWakeUpDistance_mm	850
spdMinimumLockTime_ms	1000
spdNoMotionTimeOut_ms	10000
spdTimeToAutonomous_ms	500
spdWakeOnStopMinSpeed_kmh	1.0
itaMaxRightDistance_mm	2000
itaMaxLeftDistance_mm	2000

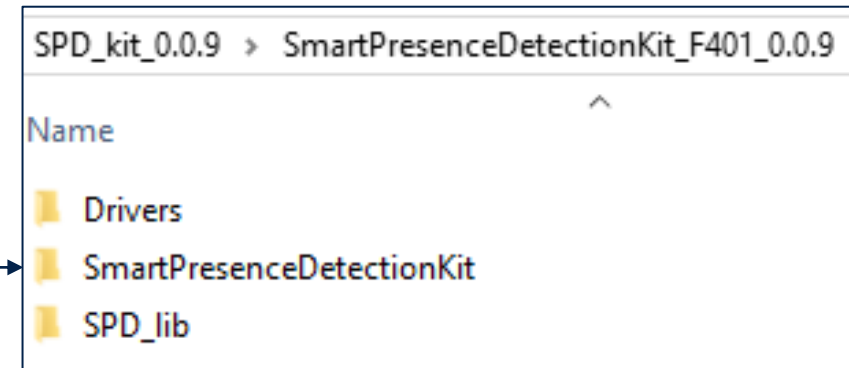
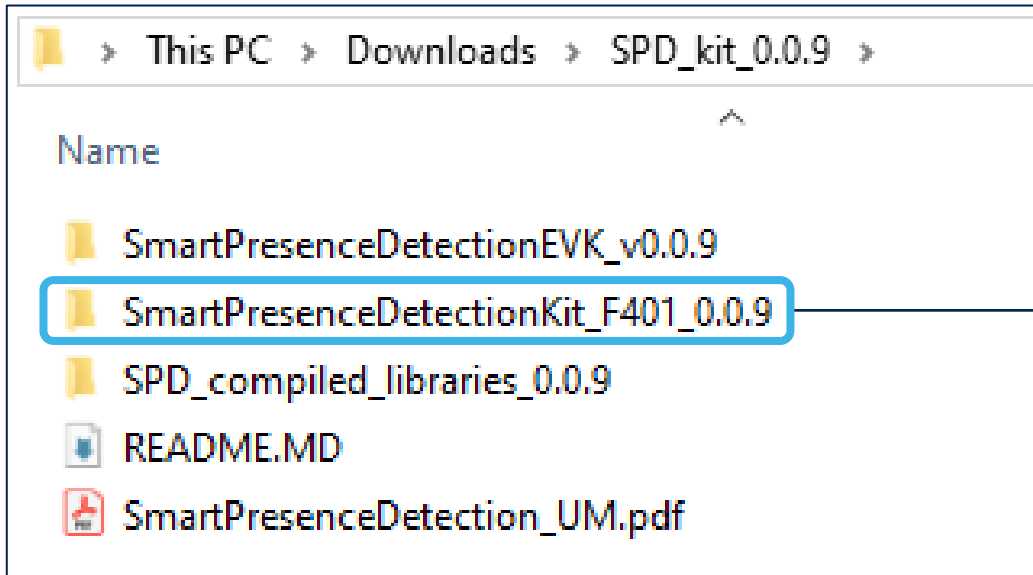
SPD Settings widget

(*) The max ranging frequency @20Hz can only be reached with the maxI2C baudrate 1MHz
 (**) 2147483647 is the max value supported by the algo variable, but has probably no application interest
 (***) The algo can support more than the max value but 10Km/h is already more than the average walking human speed

SPD Programming Guide



Project architecture



Drivers: STM32F401 libraries

SmartPresenceDetectionKit: Application code

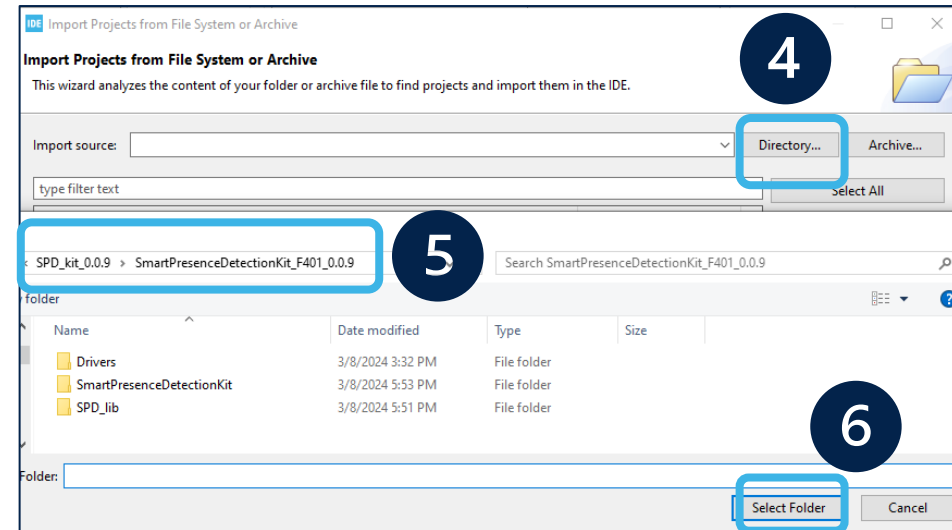
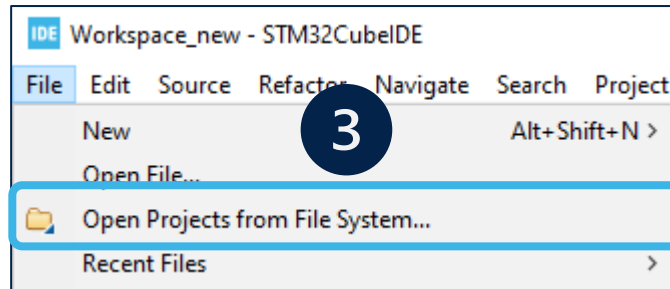
SPD_lib: SPD library + header files



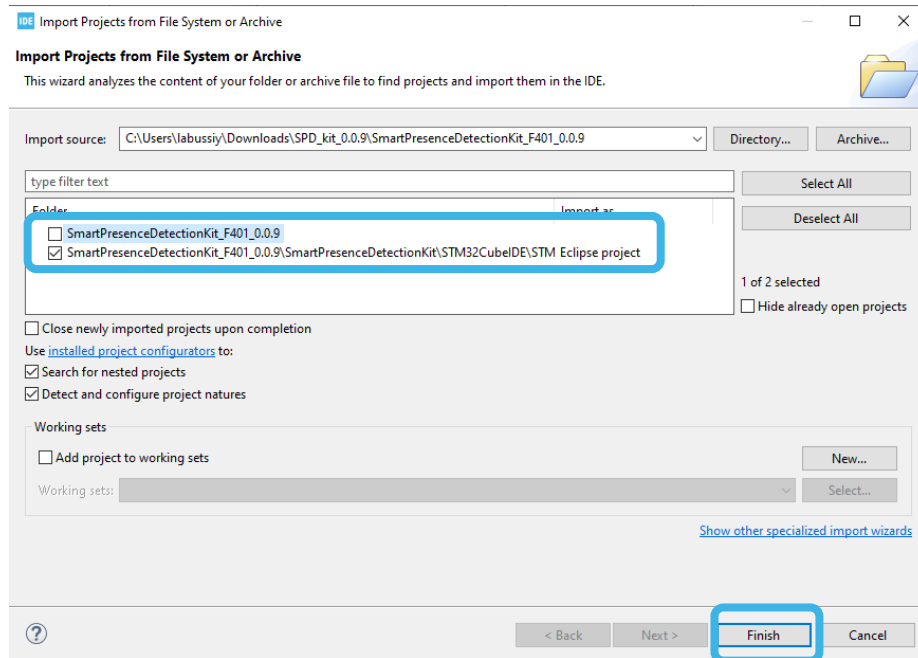
Open the project in CubeIDE

1 Open CubeIDE

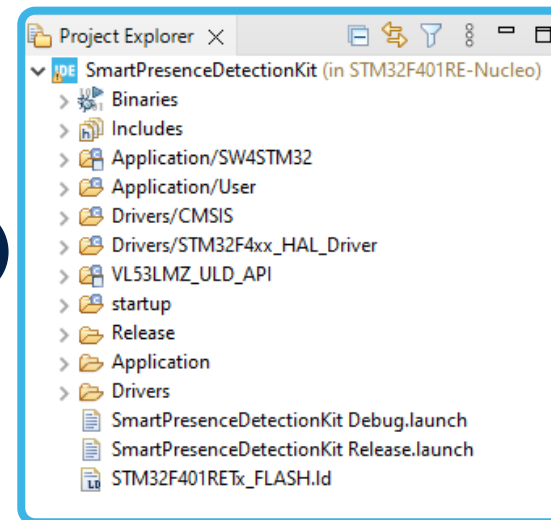
2 New workspace



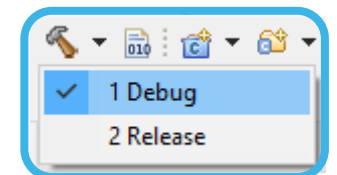
7



9



10



Build Finished. 0 errors, 3 warnings.



Implementation flow

Open main.c

1. Peripheral init
2. ToF sensor Init
3. SPD algo Init
4. Set Params in Tracking Mode
5. Configure the sensor
6. Start the Ranging & get frame

```
1 /* Reset of all peripherals, Initializes the HAL_Init();  
/* Configure the system clock */  
SystemClock_Config();  
/* Initialize all configured peripherals */  
MX_GPIO_Init();  
MX_DMA_Init();  
MX_USART2_UART_Init();  
MX_I2C1_Init();  
UartComm_Start();
```

```
2 /* Initialize VL53LMZ I2C address */  
LMZDev.platform.address = 0x52;  
/* Initialize sensor */  
status = init_vl53lmz_sensor();
```

```
3 /* Initialize SPD algo */  
SPD_Init(1);
```

```
4 // Reset sensor settings in Tracking mode (after SPD init)  
SPD_SetParamsForTracking();  
sci_motion_map_stored = 0;
```

```
5 // Configure VL53LMZ  
status = vl53lmz_Configure();
```

```
6 // Start ranging  
status = vl53lmz_start_ranging(&LMZDev);  
get_ranging_data()
```

SPD Loop

7. SPD algo Run
8. Change Sensor Mode according SPD FSM

```
7 /* Run SPD */  
SPD_run(&SPD_Data, &SEN_MeasData, &SEN_Info);
```

```
8 /* Possibly change sensor mode */  
SPD_ChangeSensorMode(&SPD_Data);
```



What is SPD_ChangeSensorMode doing?

- This function changes the sensor mode according the SPD FSM.
- There are 2 FSM transitions requiring to change the sensor mode

- Going to SPD_AUTONOMOUS
 - **SEN_SetParamsForAutonomous()**
 - Resolution = 4x4 (mandatory)
 - spdAutonomousRangingPeriod
 - spdAutonomousIntegrationTime
 - disablePipe
 - sciDetectionThreshold
 - auto_stop enabled

- Leaving SPD_AUTONOMOUS
 - **SEN_SetParamsForTracking()**
 - Resolution = spdResolution
 - spdRangingPeriod
 - spdIntegrationTime
 - enablePipe
 - sciDetectionThreshold
 - auto_stop disabled



Algo Data structures

* only useful variables are described

- Data structure:

- **SPD_Data_t** (spd.h)

- `state` : SPD FSM current state
 - `presence` : User Presence detection flag
 - `userID` : User # of the main user
 - `TRK_Data.tkd_Obj[SPD_Data.userID].CoM_pos.x / y / z` : Main User x/y/z position
 - `TRK_Data.tkd_Obj[SPD_Data.userID].speed_norm` : Main User x/y/z motion speed
 - `Nb users`
 - `positions`

- Measurement structure:

- **SEN_Measurement_Data_t** (sensor.h)

- Data sensor formatted for the SPD algo
 - `timestamp_ms / RangeMilliMeter / SignalRatePerSpad / ...`

- Sensor info structure

- **SEN_Info_t** (sensor.h)

- General information about the sensor settings to tune the SPD algo
 - `nb_zones` : Sensor resolution
 - `Freq` : Sensor ranging frequency

- Input parameters

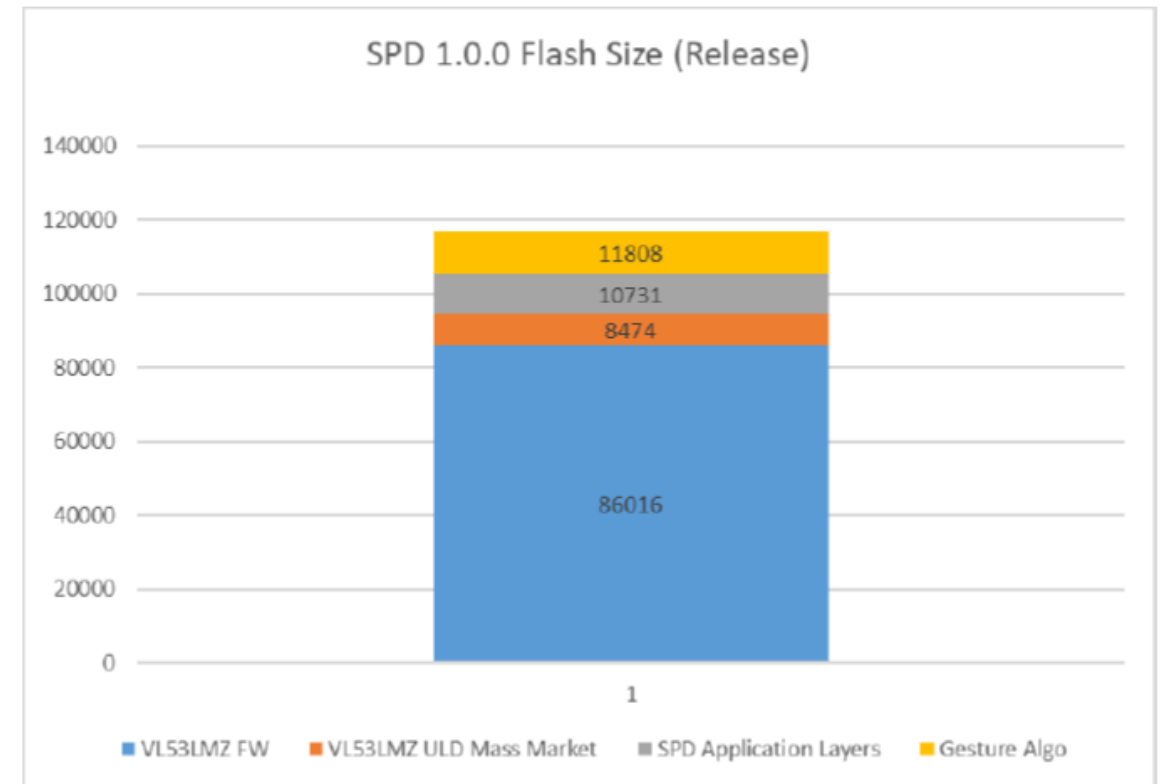
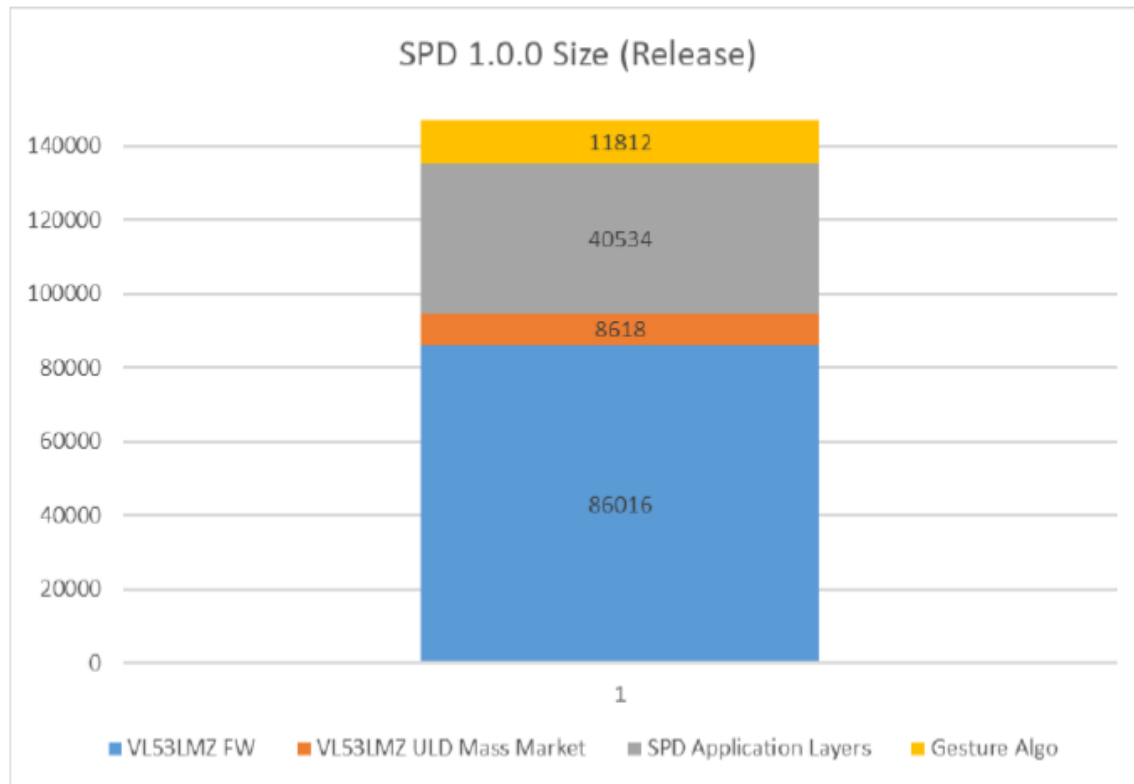
- **Params_t** (sensor_command.h)

- Main parameters described in [SPD Params](#)



Memory Footprint

SmartPresenceDetectionKit_1.0.0 (spd v1.0.0)			
	FLASH	RAM	memory
VL53LMZ FW	86016	0	86016
VL53LMZ ULD Mass Market	8474	144	8618
SPD Application Layers	10731	29803	40534
Gesture Algo	11808	4	11812
TOTAL	117029	29951	146980





SPD algo profiling

Algo Rev	I2C @ 400KHz get_ranging_data() + SEN_CopyMeasurementData()		I2C @ 1MHz get_ranging_data() + SEN_CopyMeasurementData()		SPD Init execution time SPD_init()		Maximum SPD execution time SPD_run()	
	CPU cycles	ms	CPU cycles	ms	CPU cycles	ms	CPU cycles	ms
V1.0.0	2676450	3.2	118890	1.4	131398	1.5	470000	5.6

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