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# FlightSense ST time-of-flight ranging sensors

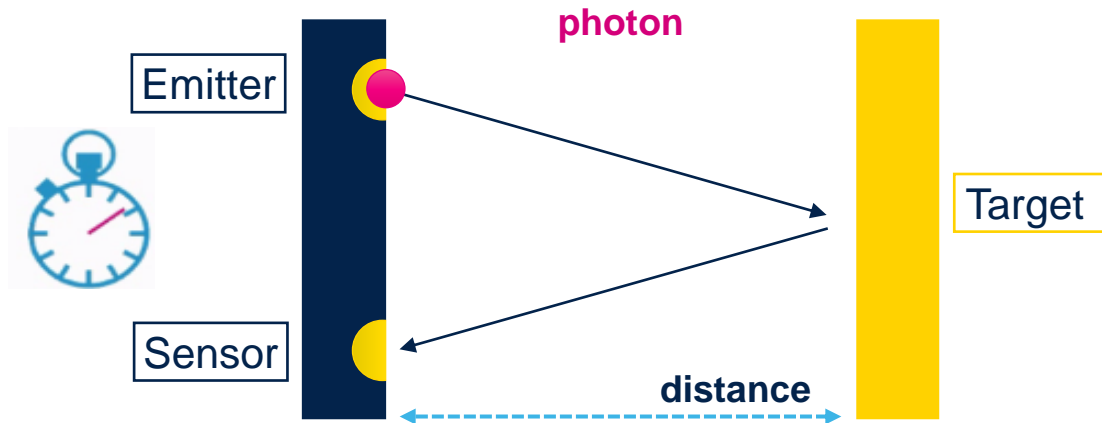
ST Imaging Division

남경태 부장



# 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

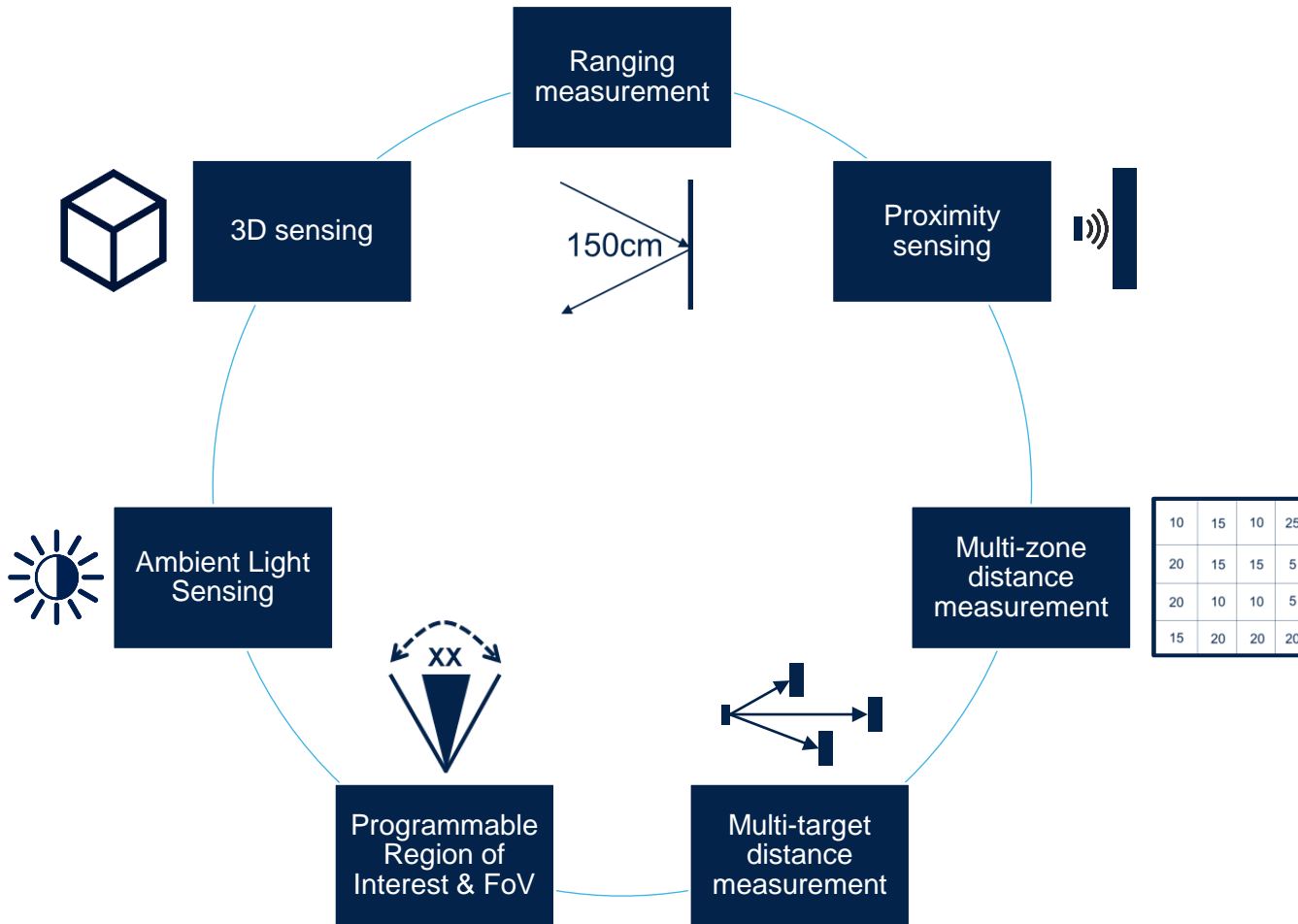


Monolithic ToF SoC, SPAD Array, RAM/ROM  
& powerful Class1 VCSEL driver

High power VCSEL  
Full Class 1 safety



# FlightSense sensors main functions



## Enabling multiple Use-Cases :












- Touchless Button
- System Activation
- Eye Protection
- Occupancy Detection
- Power Saving (Presence)
- Auto Display Brightness
- Crop/plant/food health
- Inventory Management
- Autofocus
- Biometric/User Distance Assist (Auto Intensity Adjustment)
- Content Level Monitoring
- Liquid Level Monitoring
- People Counting
- Keystone Correction
- Obstacle Avoidance
- Wall Tracking
- Cliff Detection
- Ceiling Detection
- Floor Mapping
- Floor Material Detection
- Bar Code Reading
- Gesture Control
- Face Identification
- Posture Control

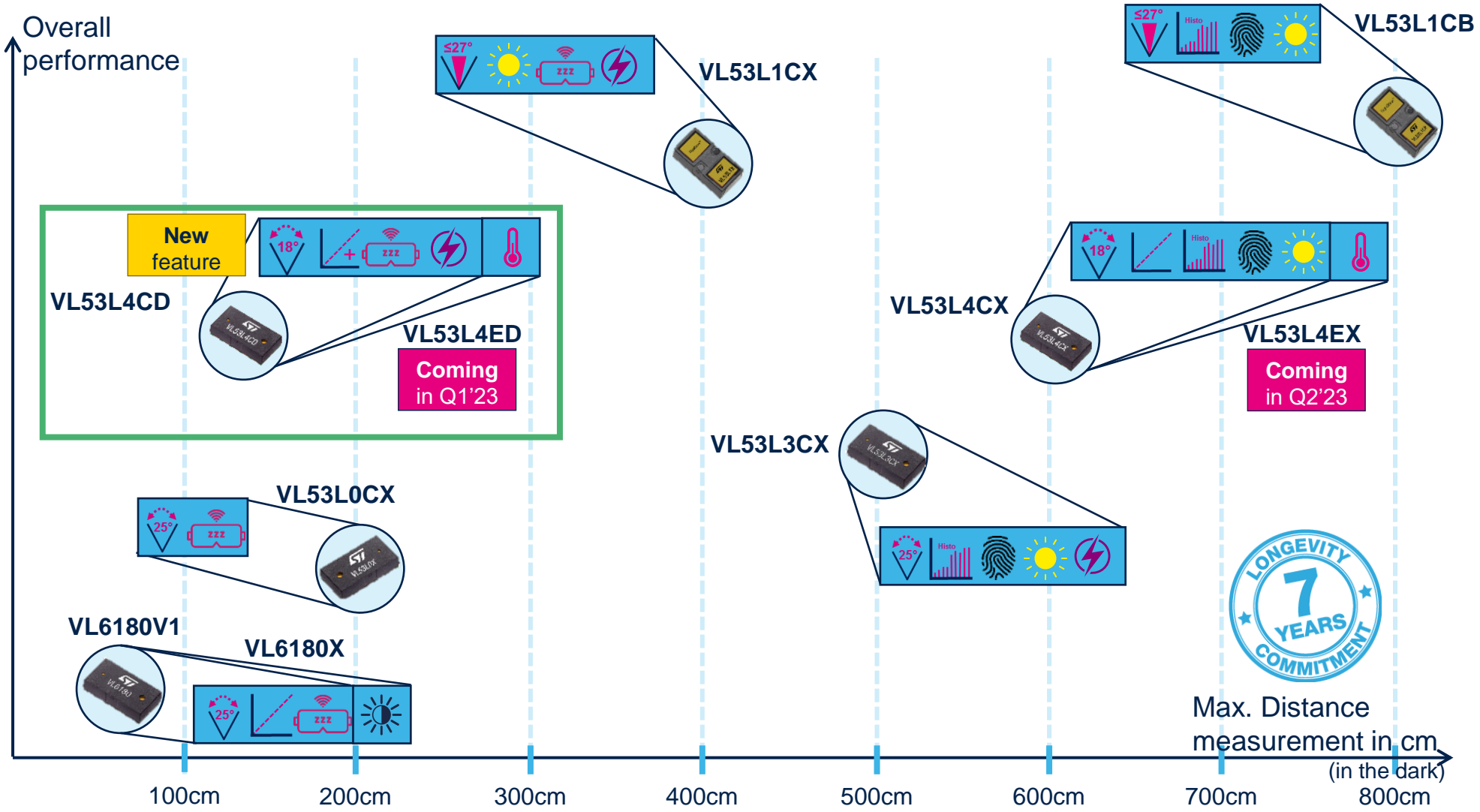
## To develop unlimited Markets...

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



# FlightSense™ Single-Zone portfolio

-  XX° FoV
-  SX° 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



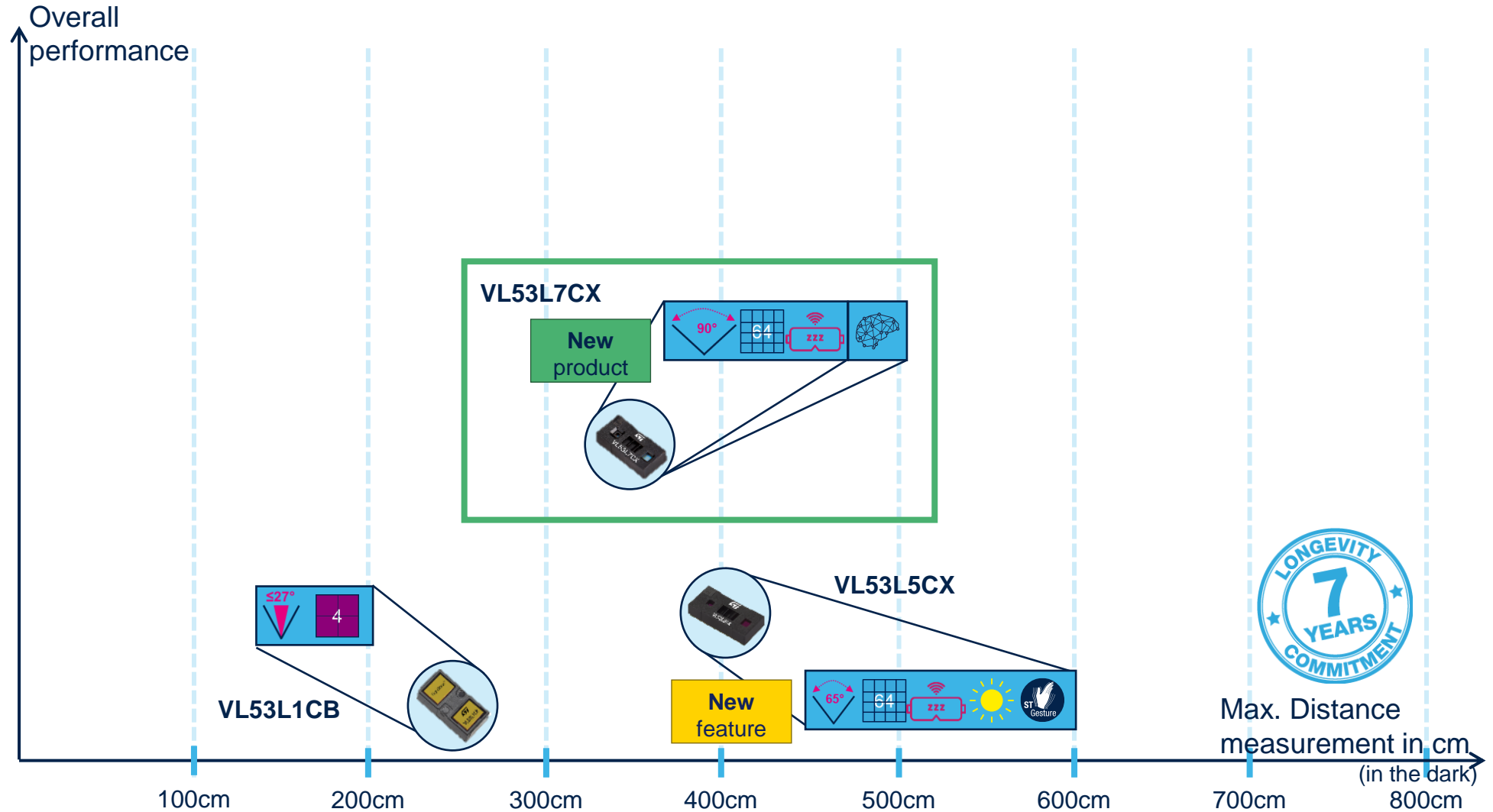
	VL6180V1	VL53L4CD	VL53L0CX	VL53L1CX	VL53L3CX	VL53L4CX	VL53L1CB
<b>Max distance measurement</b>	<b>60 cm</b>	<b>130 cm</b>	<b>200 cm</b>	<b>400 cm</b>	<b>500 cm</b>	<b>600 cm</b>	<b>800 cm</b>
Field-of-View	25° No Lens	18° No Lens	25° No Lens	27° (SW config) Lens on Rx	25° No Lens	18° No Lens	27° (SW 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	<b>0cm</b>	<b>0cm</b>	<1.5cm	<b>1.0cm</b>	<b>1.0cm</b>	<b>0cm</b>	<b>1.0cm</b>
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)	-	<b>55µA</b>	-	<b>65µA</b>	<b>55µA</b>	-
Memory footprint	<b>ROM 4.5kB</b> <b>RAM 0.44kB</b>	<b>ROM 2.7kB</b> <b>RAM &gt;0.1kB</b>	ROM 23.4kB RAM 1.2kB	<b>ROM 3.3kB</b> <b>RAM 0.03kB</b>	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  
x 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 6kB RAM 89kB	ROM 6kB RAM 89kB
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**)



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

# Differences between VL53L5CX and VL53L7CX



	VL53L5CX	VL53L7CX
Field-of-View	45° x 45° (65° diag.)	60° x 60° (90° diag.)
Resolution	8x8 and 4x4	
Max distance ranging*	400 cm	350 cm
Processing mode	Histogram	
Common features	Motion indicator Autonomous low power mode	
STGesture™ supported	YES	soon
Driver	100% compatible	
Power consumption	Typical: 95mA   Low power**: 1.3mA	
Module size	6.4 x 3.0 x 1.5 mm	6.4 x 3.0 x 1.6 mm

# VL53L7CX GUI demo

The screenshot displays the VL53L7CX GUI interface. At the top left, the title 'VL53L7CX' is shown. Below it are navigation tabs: 'Mini Depth-Map', 'Calibration', 'Data Log', and 'About'. The main area features a grid of 8x8 cells, each representing a range-finding zone. The top-left 3x3 cells are highlighted in red, while the rest are green. A large, semi-transparent 'Flight Sense' watermark is overlaid on the grid. On the right side, there are two control panels: 'Device Control' and 'Display Control'. The 'Device Control' panel includes settings for Zone Mode (8x8), Power Mode (Continuous), Ranging Rate (15 Hz), Integration Time (5), Sharpener (3), CoverGlass On (unchecked), Rotation (None), and Sensor (Centre). The 'Display Control' panel includes Range Gradient Min (10 mm), Range Gradient Max (2000 mm), Median Range (checked), Peak Signal Rate (unchecked), Ambient Signal Rate (unchecked), Target Status (unchecked), and Zone Number (unchecked). A 'Rate from Device (Hz): 15.53' is displayed below the Device Control panel.

Row	Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8
1	R:77	R:80	R:90	R:156	R:1675	R:1670	R:1707	R:1708
2	R:85	R:88	R:174	R:1674	R:1676	R:1651	R:1679	R:1677
3	R:174	R:1652	R:183	R:1666	R:1635	R:1675	R:1667	R:1669
4	R:1651	R:1638	R:1653	R:1658	R:1638	R:1650	R:1666	R:1674
5	R:1641	R:1635	R:1649	R:1642	R:1648	R:1646	R:1658	R:1650
6	R:1628	R:1631	R:1636	R:1643	R:1642	R:1640	R:1636	R:1661
7	R:1622	R:1608	R:1621	R:1631	R:1630	R:1638	R:1646	R:1673
8	R:1625	R:1603	R:1616	R:1608	R:1620	R:1632	R:1649	R:1676

# VL53L7CX GUI demo

Figure 2. Expansion board with VL53L7CX



Figure 4. Evaluation kit board installed on Nucleo STM32-F401RE, with two optional satellites

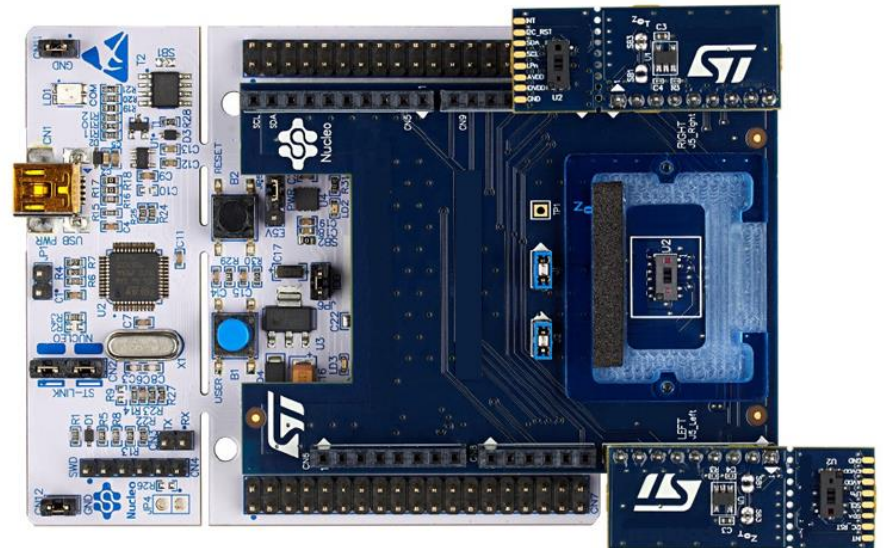
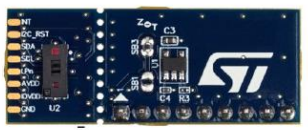


Figure 3. (Optional) VL53L7CX satellite board populated with a single sensor



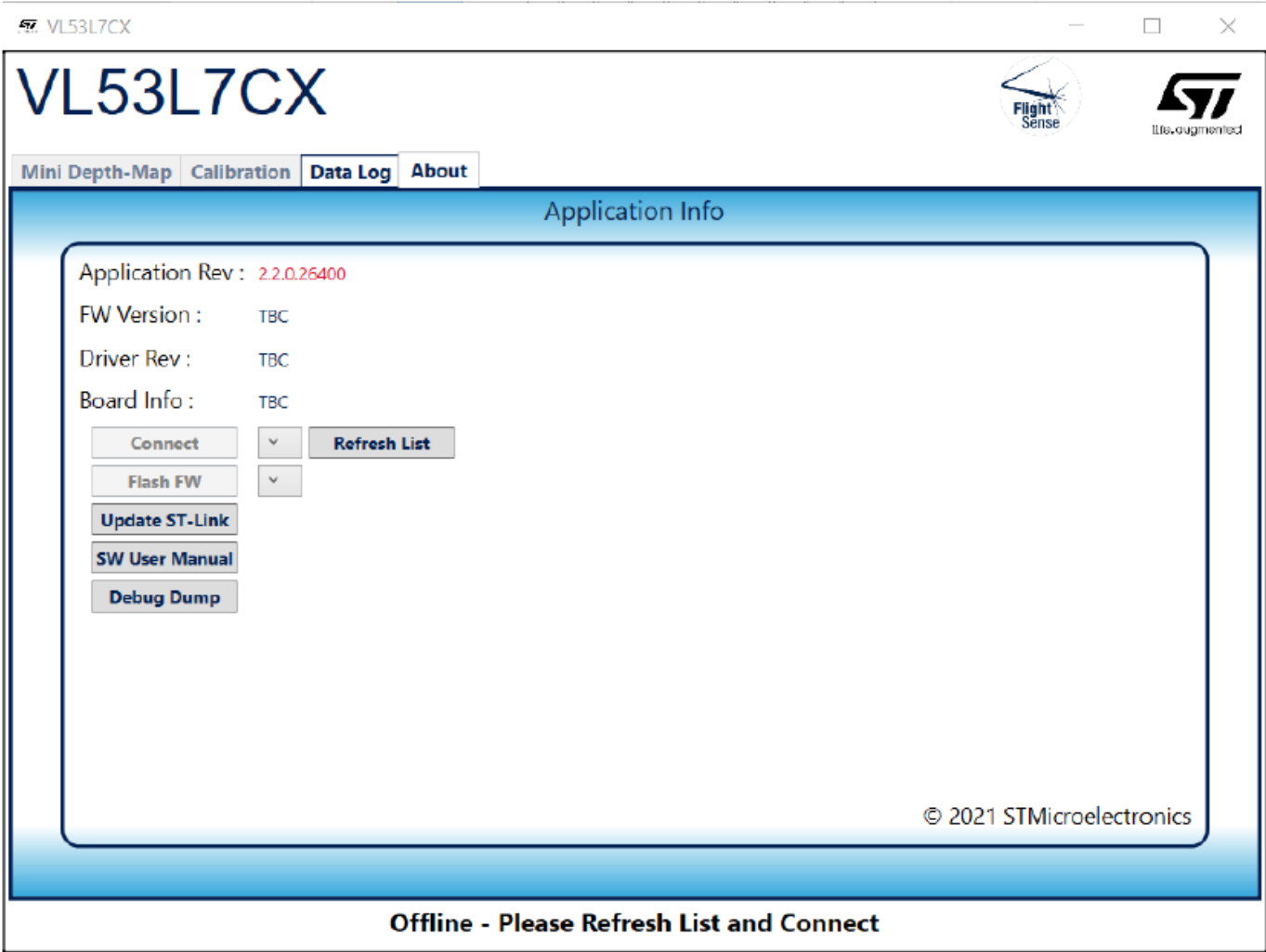
## 1.3 Getting started with evaluation kit

To use the evaluation, follow the general steps recommended below:

- Assemble the kit as described in [Section 1.1: Hardware installation](#)
- Install the GUI as described in [Section 1.2: Software installation](#)
- (Optional) If a cover glass is to be used, put the cover glass sample into the cover glass holder. Make sure that the cover glass is positioned flat above the sensor.
- Connect the Nucleo board to the host PC
- Start the VL53L7CX\_Gui application
- Flash the firmware to the Nucleo board using the button on the About tab
- (Optional) If the cover glass is to be used, perform Xtalk sensor calibration.
- Proceed to obtaining and logging ranging data as reported by the sensor
- Once all the above is finished, close the VL53L7CX\_Gui application
- Disconnect the Nucleo board from the host PC

# VL53L7CX GUI demo

Figure 5. About tab layout



# VL53L7CX GUI demo

**Table 1. Functional description of the fields contained in the “About” tab**

Item	Description
Application REV	This field displays the revision number of the GUI
FW Version	If a sensor device is detected, the Nucleo firmware version will be displayed here
Driver version	If a VL53L7CX driver (ULD) is loaded into the Nucleo, the driver version will be displayed here
Connect	Press this button to connect the application to the selected COM port in the list. The text in the bottom corner of the tab will change from "OFFLINE" to "CONNECTED"
Refresh list	Press this button to update the list of detected COM ports available
Flash FW	After clicking this button, firmware is uploaded to the Nucleo board. The text "flashing will be displayed while the update is performed

Item	Description
Update ST-link	If the Nucleo host board for the evaluation kit has an older version of ST_Link installed, use this button to update it
SW User Manual	After clicking this button, GUI user manual opens as a PDF file
Debug dump	This button may be used to upload and store the revisions of firmware and driver used in the setup

# VL53L7CX GUI demo

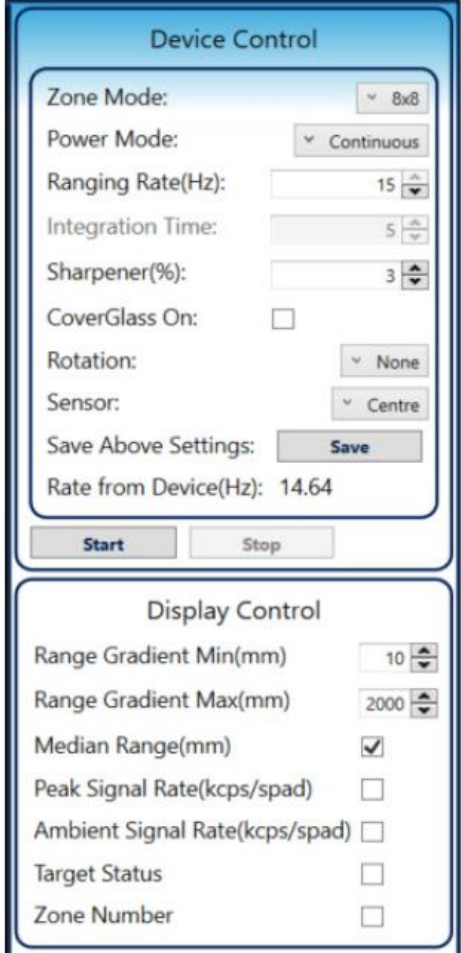
The screenshot displays the VL53L7CX GUI interface. At the top left, the title 'VL53L7CX' is shown. Below it are navigation tabs: 'Mini Depth-Map', 'Calibration', 'Data Log', and 'About'. The main area features an 8x8 grid of range-finding data points, each labeled with 'R:' followed by a number. A diagonal line of red cells runs from the top-left to the bottom-right, indicating a range gradient. The rest of the grid cells are green. A large, semi-transparent 'Flight Sense' watermark is overlaid on the grid.

On the right side, there are two control panels:

- Device Control:** Includes settings for Zone Mode (8x8), Power Mode (Continuous), Ranging Rate (15 Hz), Integration Time (5), Sharpener (3%), CoverGlass On (checkbox), Rotation (None), Sensor (Centre), and a Save button. A 'Rate from Device' of 15.53 Hz is displayed.
- Display Control:** Includes settings for Range Gradient Min (10 mm), Range Gradient Max (2000 mm), Median Range (checked), Peak Signal Rate (checkbox), Ambient Signal Rate (checkbox), Target Status (checkbox), and Zone Number (checkbox).

# VL53L7CX GUI demo

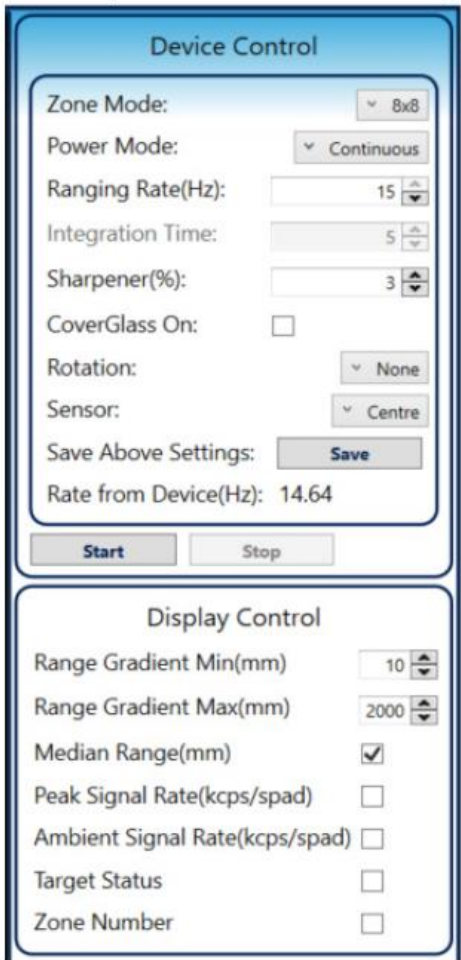
Figure 7. Control panel of the mini-depth map tab



Item	Description
Zone mode	Selection of the number of regions used during ranging: 4x4 or 8x8. Default 8X8.
Power mode	Selection of ranging mode continuous (better maximum ranging distance and ambient immunity), or autonomous (lower power consumption). When the ranging mode autonomous is selected, it enables the possibility to change integration time.
Ranging rate (Hz)	Selection of the communication frame rate with the sensor. For 4x4 mode, valid values are between 1Hz and 60Hz. For 8x8 mode, valid values are between 1Hz and 15Hz.
Integration time (ms)	For autonomous mode only, it allows dimming the VCSEL timeout. A lower value allows a reduction of power consumption, but it also reduces the ranging performances.
Sharpener (%)	Select a new sharpener value. A higher value blurs more zones when objects are close into the FOV. For more information, please read VL53L7CX User Manual (UM2884)
Coverglass on	Use Xtalk calibration data when a coverglass is present at the top of the sensor
Rotation	Select the rotation of the displayed data. May be used to align with a camera orientation. Options are: NONE, 90°, 180°, 270°, MirrorX, MirrorY

# VL53L7CX GUI demo

Figure 7. Control panel of the mini-depth map tab



Item	Description
Sensor	Sensor used for ranging. Default is center.
Save above settings	Save the evaluation kit settings. The configuration is saved even if user closes the software.
Range gradient min.	Determines the min range of the colour gradient, default 100 mm, Range is 0 mm to 5000 mm.
Range gradient max.	Determines the max range of the colour gradient, default is 200 mm, Range is 200 mm to 5000 mm.
Median range (mm)	Option to display distance (mm) when ranging. Default is checked.
Peak signal rate (kcps/spad)	Option to display signal rate when ranging. Default is checked.
Ambient signal rate (kcps/spad)	Option to display ambient rate when ranging. Default unchecked.
Target status	Option to display the target status. Default is unchecked
Zone number	Option to display the zone identifier. Default is unchecked.

# VL53L7CX GUI demo

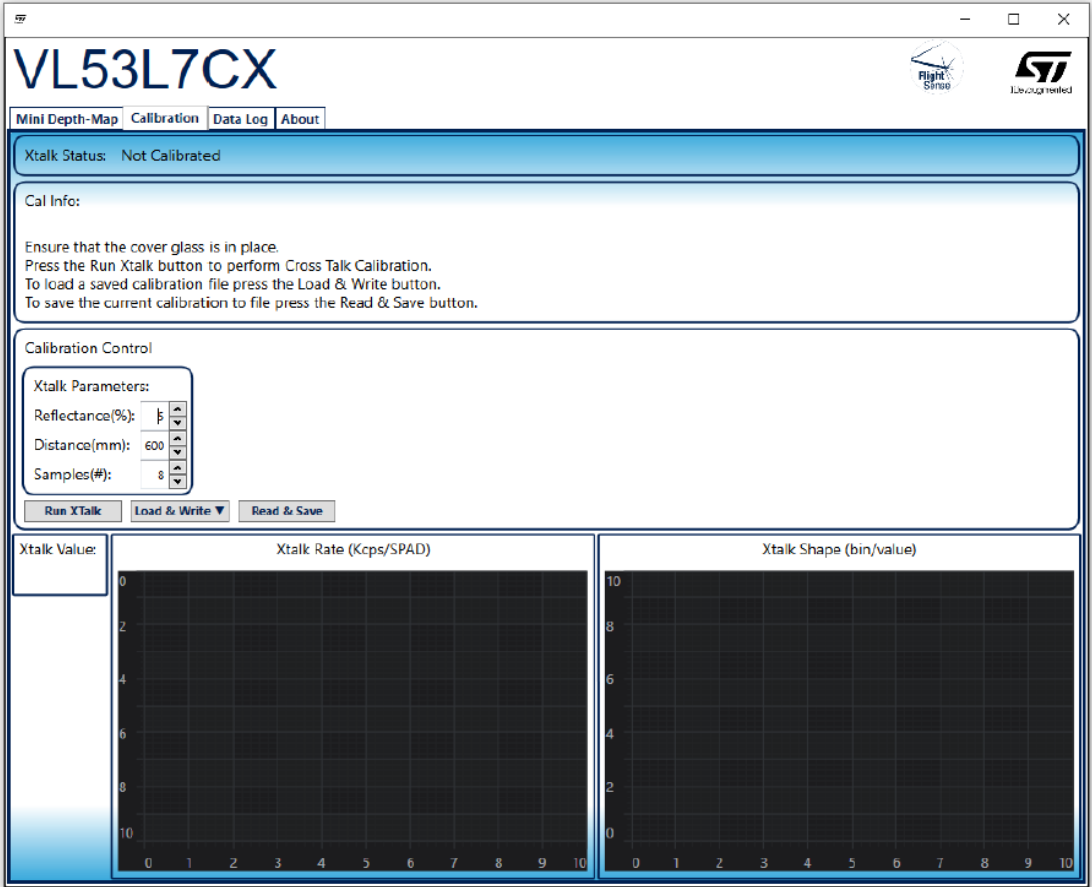


Table 3. Description of the functionality of the controls available to user on the calibration tab

Item	Description
Run Xtalk	When pressed, the GUI will perform xtalk calibration and display the results.
Load and write	Allows the user to select an existing calibration file and load it into the sensor memory
Read and save	Allows the user to read current sensor calibration configuration and save it to file
Reflectance [%]	Option to change the default calibration target reflectance. A low reflectance is recommend for xtalk to ensure no /minimal target is signal is returned during calibration
Distance [mm]	Option to change the default calibration distance. Xtalk calibration requires a target >600mm to ensure the target signal does not interfere with the xtalk calculation
Nb samples	Option to change the default calibration number of samples. Default unchecked. More samples mean more time but also give more signal to calibrate from

# VL53L7CX GUI demo

Figure 9. Data logging tab

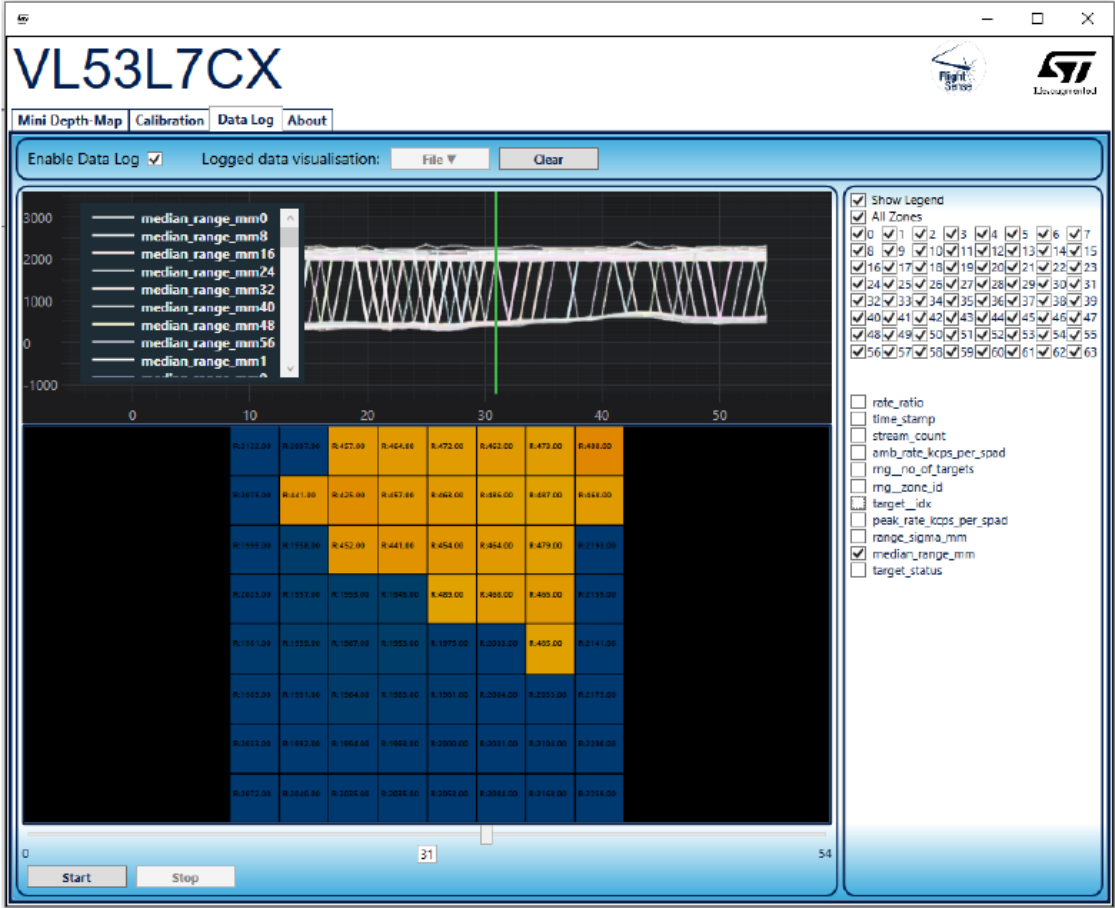


Table 4. Description of the function of the fields and buttons on the data logging tab

Item	Description
Enable data log	Turns on data logging when ranging to create a csv file in default file location: C:\Users\ <username>\AppData\Local\STMicroElectronics\VL53L7CX\DataLog</username>
File	Loads in a previously created data log .csv file. The user can select which values to view on a graph using the checkboxes on the right
Clear	Button to clear any loaded files and so revert back to default data log tab state
Start	Start playback of the log sequencing through frame by frame
Stop	Stop the playback and freeze the display on the current frame

# VL53L7CX GUI demo

**Table 5. Description of datalog elements**

Item	Description
All Zones, 0-15 / 0-63	Zone number based on 4x4 or 8x8 configuration. It is possible to enable or disable displaying data for all zones with the "All Zones" option or select individual zones by their number.
time_stamp	Measurement timestamp in ms.

Item	Description
stream_count	Range measurement identifier. On starting ranging this value increments for every range from 0 to 255 then from 128 to 255, repeating.  Note: For 8x8 mode the increment will be +4 each count.
amb_rate_kcps_per_spad	Ambient rate measurement performed on the return array, with no active photon emission, so as to measure the ambient signal rate due to noise. Expressed in kcps (kilo counts per sec.) per spad.
rng_no_of_targets	Number of targets found in the zone.
ng__zone_id	The zone identifier for the subsequent data in the log
target_idx	The target identifier (0, 1,2, 3) within a particular zone
peak_rate_kcps_per_spad	Signal rate measured during the VCSEL pulse divided by the number of SPAD's expressed in kcps per spad.
range_sigma_mm	Range sigma estimate. A sigma estimate for the noise in the reported target distance.
median_range_mm	Measured distance in millimeter
target_status	Status of the measurement. 5 is consider as 100% valid. See User Manual UM2884 for more information.

## 4 Troubleshooting

### 4.1 Cannot connect to COM port

1. Check the USB cable connected between the STM board and the PC
  - If not present – plug it in before opening the app
2. Check device manager for the COM port
  - If not present, check cables, check for LD1 lit up on STM board
3. If the COM port is present in Device Manager, try accessing it with another utility e.g. TeraTerm. Connecting with baud rate 921600 – N – 1, no flow control
4. Reset the STM board – Look for the string “Photonics device detected” being output. This indicates the COM port and the STM board are functional
  - If TeraTerm does not connect it may indicate another application has opened the port. Close all other apps not being used.
5. Try another USB port
6. If using a hub (ideally, it should be self powered)
  - Try connecting directly to the PC. If this is a desktop the USB ports on the rear are typically better (greater power delivery)
7. Try another USB cable – round cables perform better than flat cables (again possible power issue)

## 4.2 COM port connected but sensor not detected

1. Check the sensor expansion board is plugged in – correct orientation and no pin misalignment.
2. Try accessing it with another utility e.g. TeraTerm - Connecting with baud rate 921600 –N – 1, no flow control.
3. If TeraTerm does not detect the device it may be that it is not plugged in or the Nucleo firmware needs updated. Use the Flash FW button on the about tab to reflash the device.

## 4.3 Flash FW button failed (workaround)

1. Check the device is present in Device Manager
2. Copy the .bin file from C:\ProgramFiles\STMicroelectronics\VL53L7CX\_Gui\Resources to the drive with the Nucleo device (e.g. NODE\_F401RE(drive letter:)) by drag and drop
3. Close the application
4. Unplug / reinsert the device
5. Restart the application

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