

Sensing at the Speed of Light: Introduction to ST's Time of Flight Technology

Imaging Division



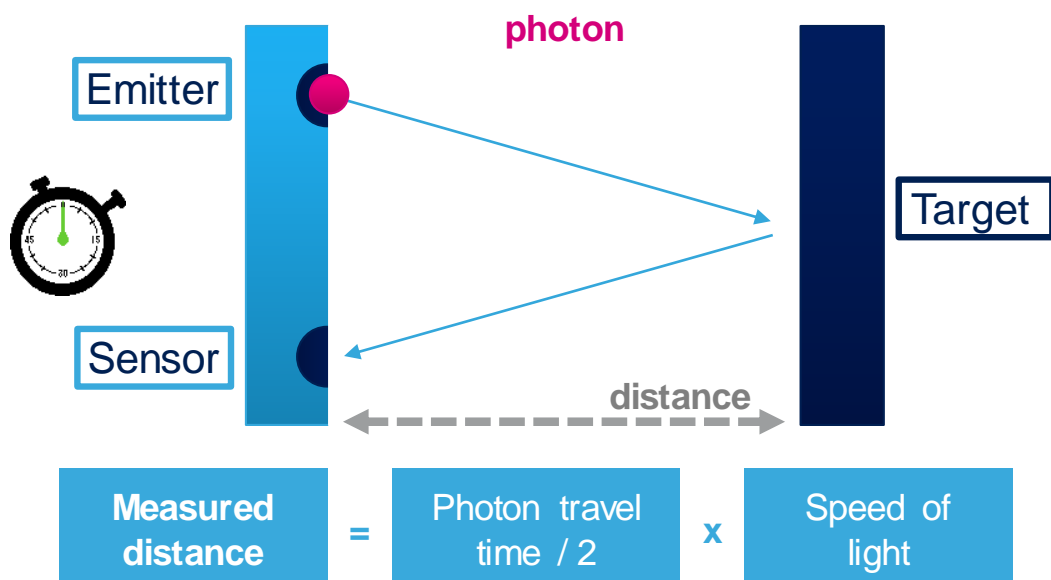


FlightSense™ Breakthrough Technology

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Measurement at the speed of light!

FlightSense™ Principle



Key benefits:

Direct distance measurement

Independent of target size, color & reflectance

Fully Integrated Time of Flight Module

ST #1 World Wide Supplier

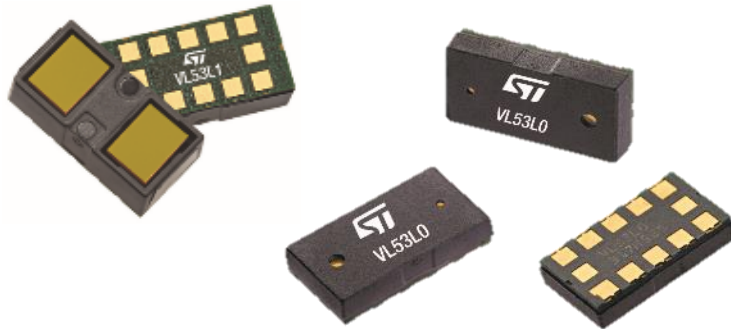
Very fast (few ms)

Low power

Flightsense™

Optical Time-of-Flight Product Family

ST is Worldwide
#1 ToF supplier



Proven track record in
manufacturing

>700Mu products shipped

300% AAGR

Single Photon Avalanche Diode

Ultra fast time resolution enabling Direct ToF
processed in ST CMOS SPAD process



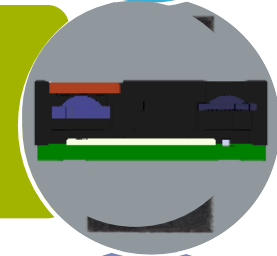
ST Proprietary Time-of-Flight IP

Best compromise of cost, complexity
& power vs performance



Compact integrated system

Sensor, filters, optics, VCSEL and driver integrated
Fully calibrated system



Optimized and reliable supply chain

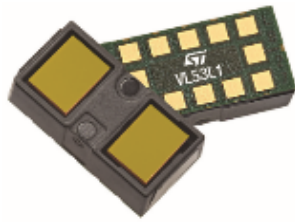
High volume & low cost



Introducing Flightsense™ Technology

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- Ranging Sensor
- Laser IR Light Source
- Ambient Light Sensor (VL6180X)



Accurate

Patented Technology
based on Time-of-Flight



**all in one
solution**

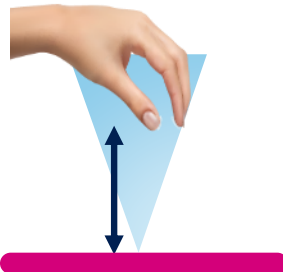
**Flexible
integration**

Invisible Industrial Design

- Easy to integrate
- Can be hidden behind cover glass

**Added
value**

**Ranging & Gesture
Control**



FlightSense™ vs. Other Proximity Sensing Technologies

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	Capacitive	Ultra-Sonic	Conventional IR	ST FlightSense™
Size/Weight	Small/light	2xToF/Heavy	Small/Light	Small/Light
Mechanical integration	Complex (antenna)	Complex (large module)	Easy (if all-in-one)	Easy (all in one, reflowable)
Signal Amplitude	No	Yes	Yes	Yes
Real distance output	No Very un-precise	No (computed)	No (computed)	Real distance in mm (readable thru i2C)
Minimum distance	0cm	10cm	0cm	0cm
Maximum distance	Few cms	Up to 1.5m	20cm	up to 4 meters ⁽¹⁾
Reliable (Vs objects color and reflectance)	No. May detect target in all directions around antenna	No, impacted	No, impacted	Yes even black (3%), gloves, ...
Reliable (Vs material finish/roughness)	No. Sensitive to body or object charge	No. Isotropic, impacted by wide Sound	No. Angular dependency	Yes, with angular dependency
Gesture control Tap vs Swipe		Yes	No	Yes

(1) depending on conditions

FlightSense™ Gesture Recognition

Basic Movement Detection

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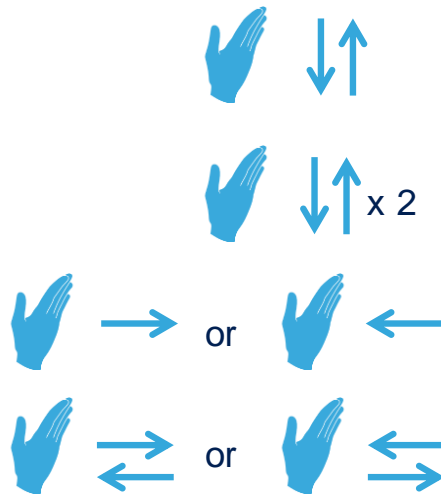
- 4 Gestures from a **single** ToF sensor
- Directional swipe detection when using 2x ToF sensors

Single Tap

Double Tap

Single Swipe

Double Swipe



Name	Description
Single Tap	Press a virtual 'button' on top of the sensor, once
Double Tap	Press a virtual 'button' on top of the sensor, twice
Single Swipe	Slide hand left to right or from right to left over the sensor
Double Swipe	Slide hand from left to right and back to left or from right to left and back to right over the sensor

- Discriminate right to left, from left to right gesture when using 2x sensors

FlightSense™ Product Longevity

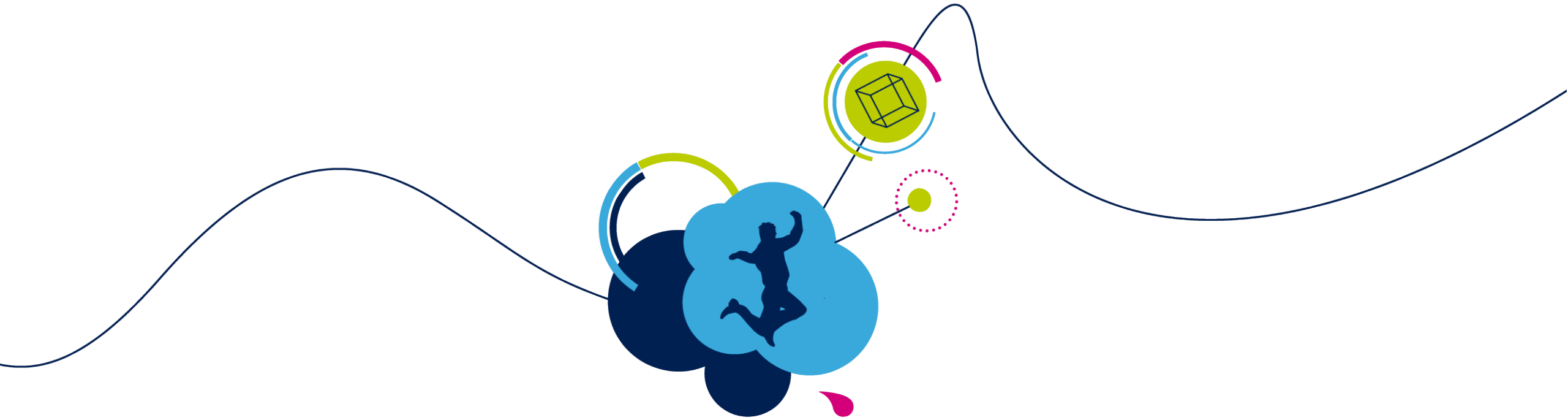
7-years Commitment

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FlightSense™ benefits from ST Longevity Program

- 7-years longevity from Product Introduction Date
- VL6180X since January 2015
- VL53L0X since Sept.2016
- VL53L1X since January 2018



FlightSense™ Product Descriptions

FlightSense™ Mass-Market Products

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VL6180X



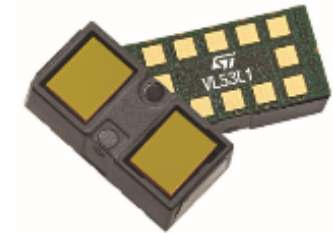
- 1st Generation ST ToF Sensor
- Proximity/ALS sensor up to **60cm**

VL53L0X



- 2nd Generation ST ToF Sensor
- Ranging sensor up to **2m**

VL53L1X



- 3rd Generation ST ToF Sensor, **with lens**
- Ranging sensor up to **4m**, with programmable **FoV**

Main use-cases: proximity, distance measurement, user / object detection, robotics, lighting control, basic gesture...

Endless New Applications

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Drones



PC & Tablet



Vacuum cleaners



Sanitary



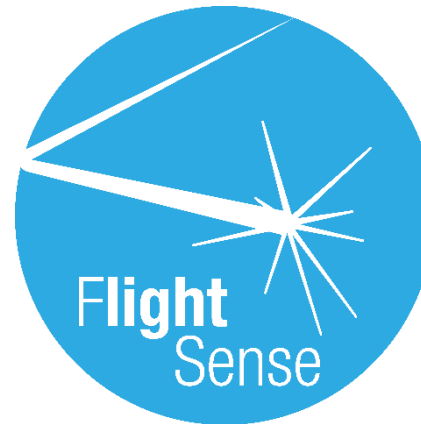
Smart home



Printers



Medical



Service Robots



White Goods



AR/VR



Industrial



Wearable & IoT



VL53L1X Focus

VL53L1X: Product Highlights

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New Generation ToF Sensor with Lens, for Long-distance Ranging and ROI Selection

Enhanced performance:

- **Full FoV ranging: 400cm+** (white target, no IR)
- SPAD array zone selection (2x2; 4x4; full screen) for FoV reduction

Cutting-edge module and silicon:

- **Longest ranging distance miniature ToF product in the market**
- **Integrated lens** for longer range and better immunity to ambient light
- **Programmable settings** to best fit customer's application:
 - Low power with interrupts for user / object detection
 - Long distance ranging
 - High accuracy for small movement detection



VL53L1X: Examples of Applications

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Presence user detection

- Autonomous mode with interrupts
- Low-power
- Long distance 400cm+
- PC, tablets, IoT, portable handsets, security...



Obstacle detection

- Robots: Obstacle avoidance
- Vacuum cleaners: Wall following, cliff detection
- Drones: Take-off and landing, Ceiling detection

Accurate objects distance scanning

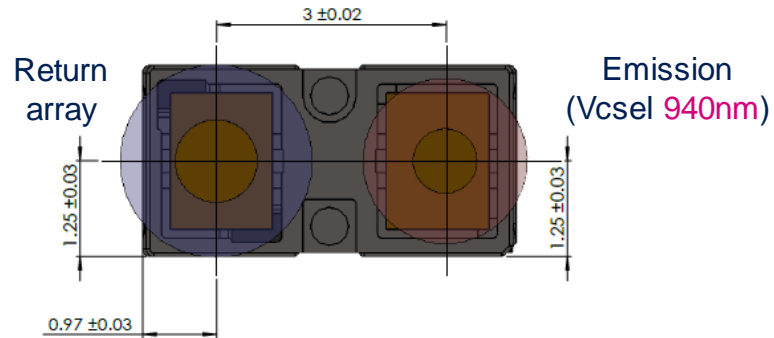
- Vending machines: control of objects in racks
- Coins dispensers: coins counting
- Smart shelves: Consumer scanning



VL53L1X System FoV (Field of View)

Compatible Footprint with VL53L0X: Easy Migration

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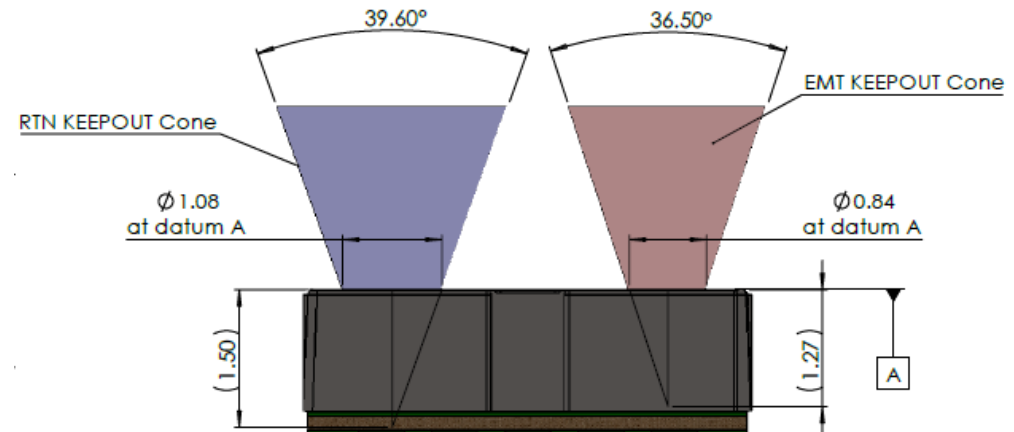


Typical System
Field of View: **27°**

Emission
(Vcsel 940nm)

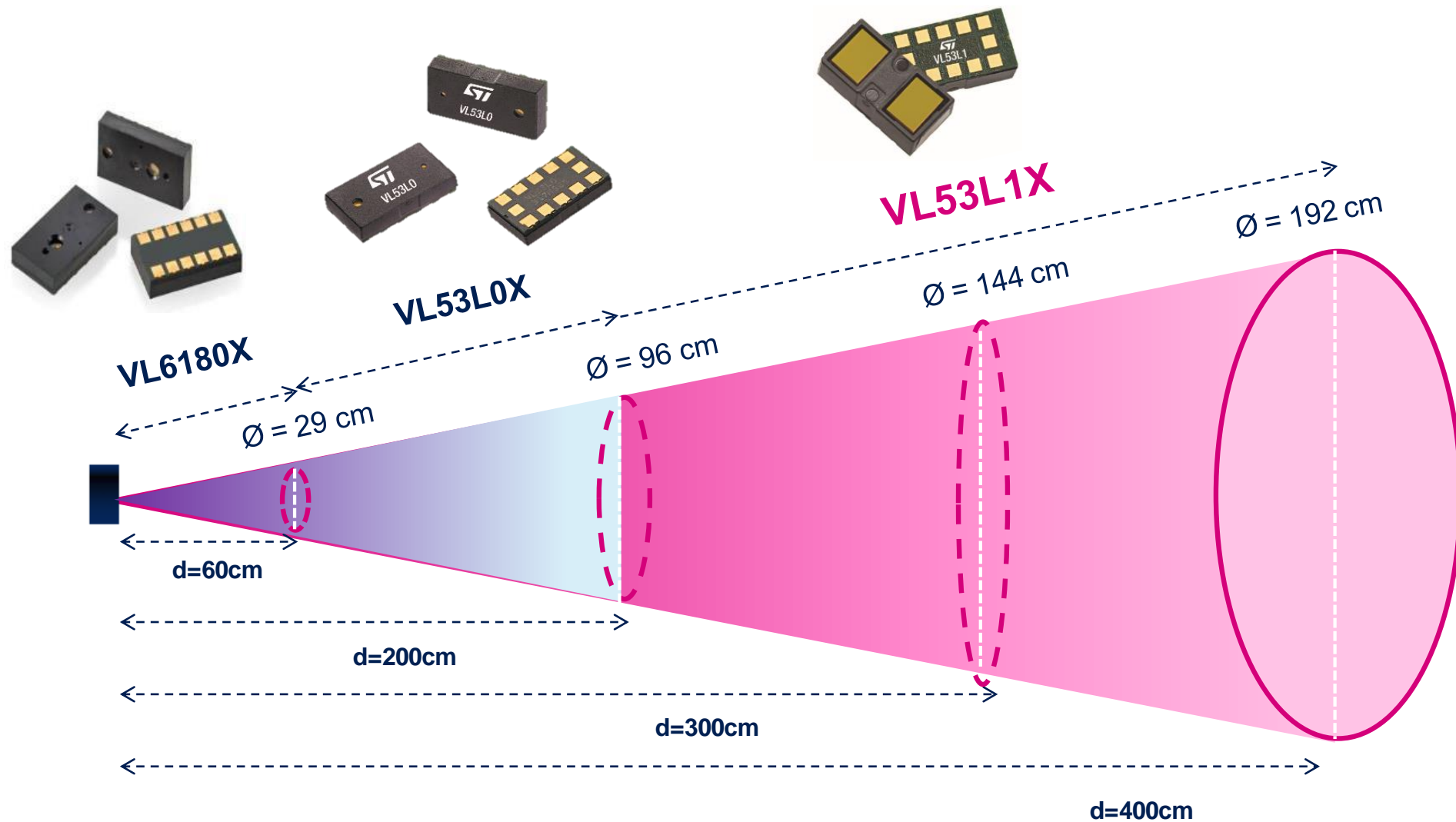
- OLGA12 Package
- **LxW = 4.9 x 2.5 mm**
- **Height: 1.56mm**
- Reflowable (IPC/JEDEC JSTD-020-C)
- **A 30° lens is added on return aperture**
(SPAD array) to increase the signal strength back from the target (8x more signal than VL53L0X)
It **increases ranging performance** and accuracy
- The VCSEL is not equipped with an emitter lens
Emitted optical power is identical to VL53L0X
Retain full laser class1 registration

Exclusion cones for
mechanical integration



Detection Cone

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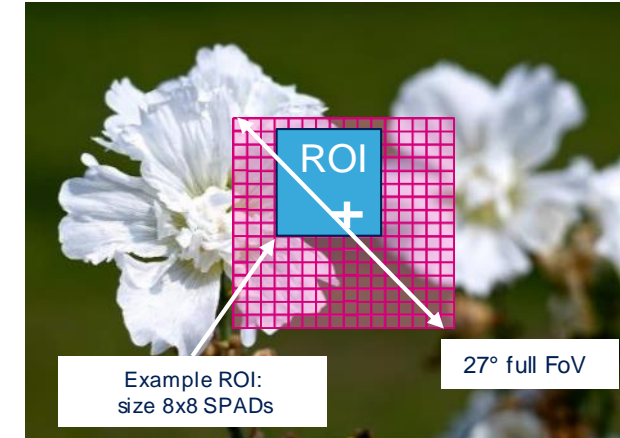


VL53L1X Allows Custom FoV Selection

Region of Interest (ROI) Selection by the User

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- No fixed pre-defined size for the sensing array (Region of Interest)
Unlike other sensors on the market or VL53L0X
- Sensing array is composed by 16x16 SPADs (Single Photon Avalanche Diodes) that **can be selected by customer**
- VL53L1X returns the distance to object covered by the ROI FoV
- **User defines the 2 corners of the array**, through SW driver (API) or the Eval Kit GUI.
It could even be rectangular. Only condition is to have a minimum of 4x4 SPADs array.
- The change of ROI can be done “on the fly” by the host




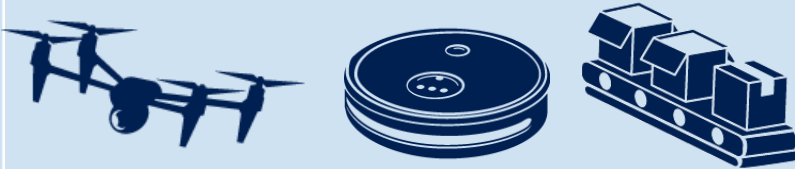


Changing the ROI by software allows to virtually reduce the FoV

ROI zone size	Diagonal FOV covered by the zone *
4x4 spads	6.9° (smallest)
5x5 spads	8.6°
6x6 spads	10.3°
7x7 spads	12.0°
8x8 spads	13.7°
16x16 spads	27.0 (largest, full FoV)

* (Exact FOV per ROI size being characterized)

Adapt VL53L1X Performance to Your Application

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Target performance to best fit application	Autonomous Low Power (ALP)	Fast Ranging
	 <p>PRESENCE</p>	
Description	<ul style="list-style-type: none"> • Low power mode • VL53L1X works as master (autonomous state machine) • Sends Interrupt to host if target detected • ROI size selection 	<ul style="list-style-type: none"> • Fast ranging (up to 10ms) • ROI size selection
Max Ranging (Typical, in the Dark, full FoV, white target 88%)	<p>Ultra low power: 1.3m (20ms) Long range: 3.6m (100ms), up to 4.1m</p>	<p>Up to 4.1m</p>
Accuracy	<p>White: 1.5% Grey: 2.5% (offset +/-25mm)</p>	
Power consumption	<p>Ultra Low power: 0.9 mW (no target, 20ms ranging@1Hz)</p>	<p>Typical: 20mW (33ms ranging @ 10Hz)</p>
Ranging under ambient light		

Autonomous Low-Power User Detection

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Save Power When No User Detected, and Easily Wake-up Your Device for <1mW

- The ToF sensor must consume as little as possible, just to detect if someone is approaching the device in sleep mode
- VL53L1X includes an Autonomous low-power mode, specially defined for this application



Embedded low-power MCU

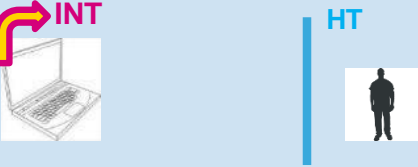
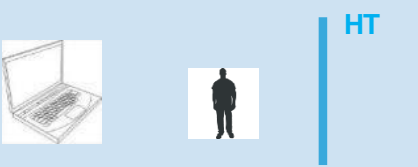

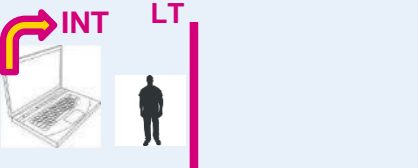
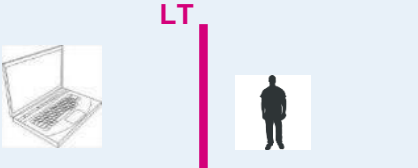

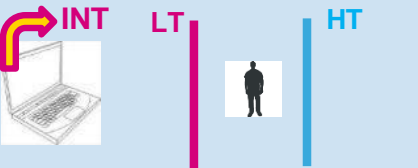
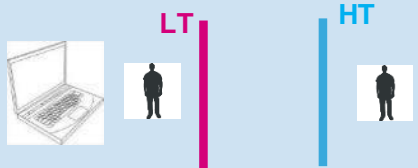
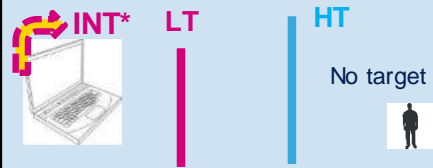
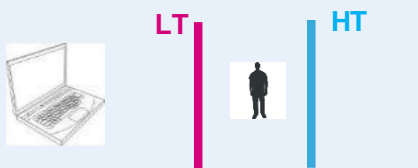
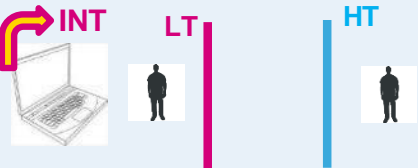

- **Programmable** thresholds and repetition rate
- **Autonomous** state machine in VL53L1X
- Once target detected, an interrupt is sent on GPIO1 pin to wake-up the host (no need of i2C)

Example of Energy Saving:

- **VL53L1X in low-power autonomous mode: 0.9mW** (1Hz, 20ms ranging operation)
- Tablet (iPAD3): Active: 40W, Sleep Mode: 0.4W
- Laptop (iMAC 27"inch): Active: 80W, Display off: 20W, Sleep mode: 1W

Customizable Thresholding

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Threshold condition set in VL53L1X	Human & device situation and Interrupt raised by VL53L1X		
“Above HIGH” (> High)			
“Below LOW” (< Low)			
“In Window” (>= Low AND <= High)			
“Out of Window” (> High OR < Low)			

INT* (optional interrupt), customer choice

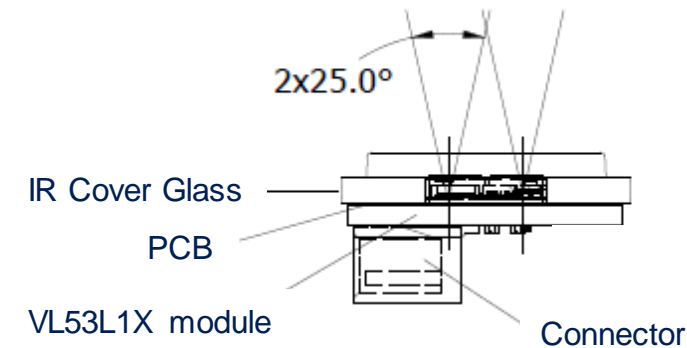
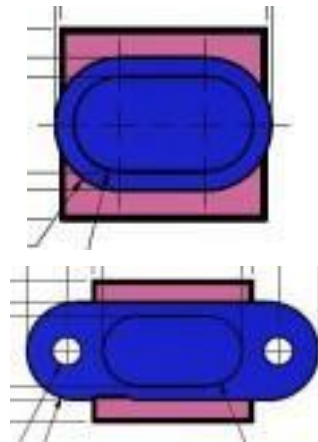
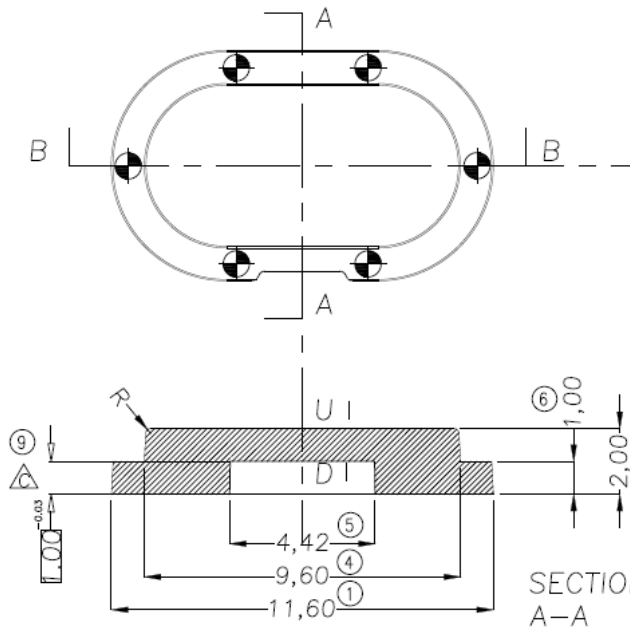


Cover-Glasses and Special Module

for FlightSense™ Sensors

Low Xtalk CG Ready to be Clipped above ToF Sensors, and Fixed on a PCB

- Detail of Cover Glass, with a cavity underneath clipped on the ToF sensor, and a shape around the glass for insertion into a frame
 - One version to be glued on PCB
 - One version with holes to screw the CG on PCB
- Detail of complete module, with ToF sensor soldered on PCB, CG clipped on sensor and glued on PCB, and connector below the PCB



HORNIX OPTICAL TECHNOLOGY INC.

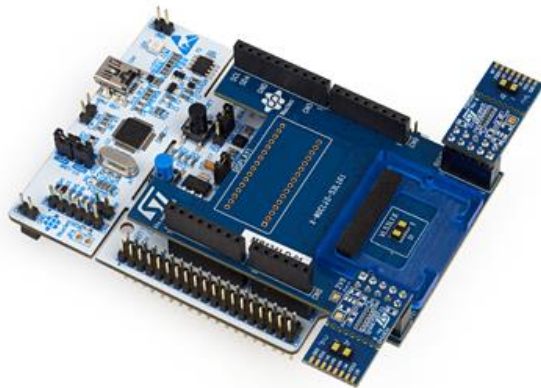


FlightSense™ Development Tools and Technical Support

FlightSense™ Development Tools

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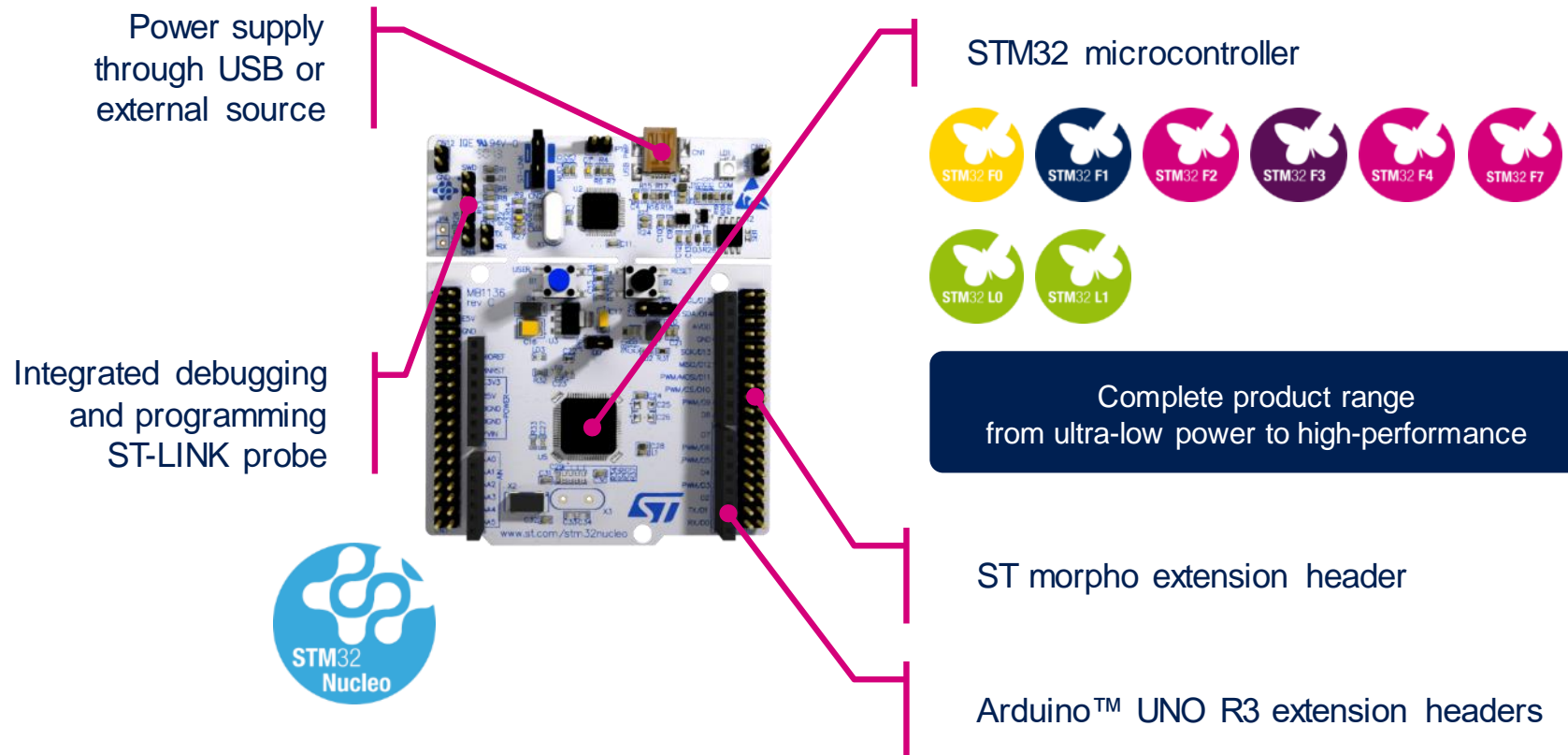
- **Quick and easy evaluation and application development** thanks to X-NUCLEO expansion boards and STM32 NUCLEO boards
- Small form factor satellites for **easy integration** into customers' devices
- Basic evaluation in stand-alone USB, or advanced through GUI on PC



- Complete suite of SW tools and documentation (API, X-CUBE...)
- Code examples for plug and play application (Ranging, ALS, gesture...)

Development Boards (NUCLEO)

- A comprehensive range of affordable development boards for all the STM32 microcontroller series, with unlimited unified expansion capabilities and integrated debugger/programmer functionality.



STM32 Open Development Environment

Expansion Boards Can be Plugged Together

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The building blocks

Your need

Our answer

Proximity, Ranging, microphone
Accelerometer, gyroscope
Inertial modules, magnetometer
Pressure, temperature, humidity



Sense

COLLECT

Bluetooth LE, Sub-GHz radio
NFC, Wi-Fi, GNSS



Connect

TRANSMIT

Audio amplifier
Touch controller
Operation Amplifier



Translate

ACCESS

Stepper motor driver
DC & BLDC motor driver
Industrial input / output



Move / Actuate

CREATE

Energy management & battery



Power

POWER

General-purpose microcontrollers
Secure microcontrollers



Process

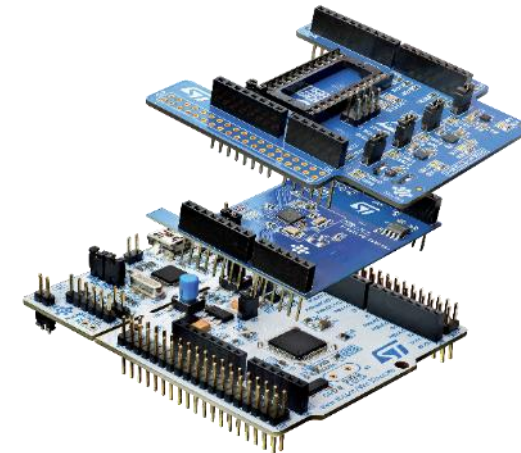
PROCESS



Software



STM32 Open
Development
Environment



VL53L1X Nucleo Expansion Board

X-NUCLEO-53L1XA1 Works with STM32F401RE

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[https://www.st.com/content/st_com/en/extended-query.html?querycriteria=productId=SC1971\\$\\$associatedTo=SC1934](https://www.st.com/content/st_com/en/extended-query.html?querycriteria=productId=SC1971$$associatedTo=SC1934)

**Arduino
Connectors**

VL53L1X

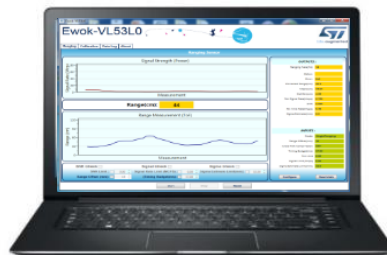
Ranging sensor

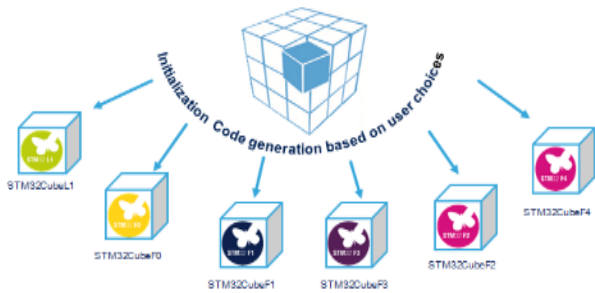
**2x VL53L1X breakout boards
(plugged or hardwired)**

Cover Glass holder
(Can hold Cover Glass and spacers)

Spacers and Cover Glass
3 spacers 0.25/0.5/1mm to create
various air gaps below CG

**PC GUI
interface**





X-CUBE SW Package

for FlightSense™ Sensors

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Nucleo-centric SW package following STM32Cube SW architecture

Code is structured in a way ToF sensors-based applications can be built very quickly on Nucleo platforms

Based on FlightSense™ sensor API

Sensor API appears as a BSP component

Validated on Nucleo pack

Example codes available for various NUCLEO STM32 boards (F401RE, L476RG, L053R8) plugged with ToF sensors X-NUCLEO expansion boards and satellites

Ranging, Ranging with satellites, ALS examples + Gesture detection demos

Examples: RangingAndALS (VL6180X) or RangingWithSatellites (VL6180X or VL53L0X)

1 application: GestureDetect (TAP & SWIPE)

Source code with pre-compiled binaries and Keil, IAR and STM32Workbench projects



FlightSense™ Sensors Adopted by Multiple System Development Tools

“Getting Started” Video for VL53L1X Nucleo Expansion Board

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Videos available on:

- [st.com](https://www.st.com)
- [Imaging YouTube](https://www.youtube.com/watch?v=...)



<https://www.st.com/en/imaging-and-photonics-solutions/vl53l1x.html>



How to Order

Go to St.com or Contact Your Usual Distributor

- **VL53L1X:** https://www.st.com/content/st_com/en/products/imaging-and-photonics-solutions/proximity-sensors/vl53l1x.html#samplebuy-scroll
- **VL53L0X:** https://www.st.com/content/st_com/en/products/imaging-and-photonics-solutions/proximity-sensors/vl53l0x.html#samplebuy-scroll
- **VL6180X:** https://www.st.com/content/st_com/en/products/imaging-and-photonics-solutions/proximity-sensors/vl6180x.html#samplebuy-scroll