LiDAR in a Chip

FlightSense™

Introduction to Time of Flight

Imaging Division
Photonic Sensors Business Line

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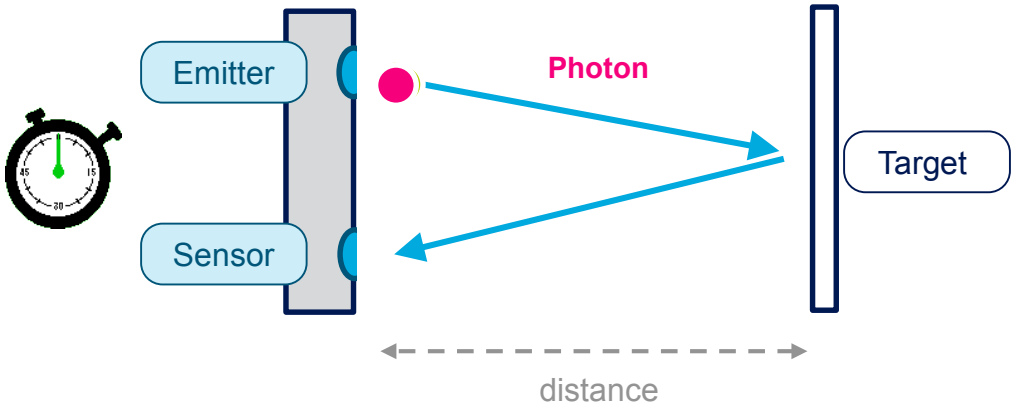
Flightsense™ Breakthrough Technology

Measurement at the speed of light !

FlightSense™ Principle



Measured distance = Photon travel time /2 x Speed of light

1cm round-trip at 67ps!

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

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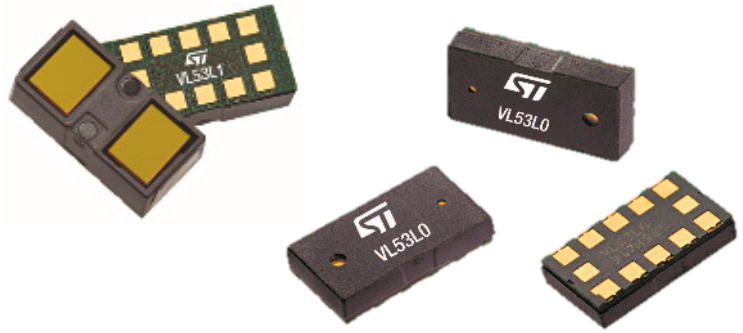
Flightsense™

Optical Time-of-Flight Product Family

ST is Worldwide
#1 ToF supplier

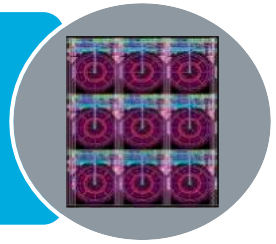


Proven track record in manufacturing

>350Mu products shipped

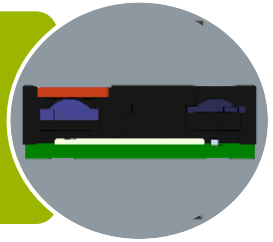
300% AAGR

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

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Introducing Flightsense™ Technology

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

Accurate

Patented Technology
based on Time-of-Flight

all in one solution

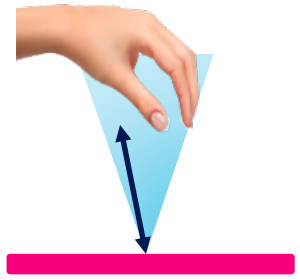
Flexible integration

Invisible Industrial Design

- Easy to integrate
- Can be hidden behind cover glass

Added value

Ranging & Gesture Control



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FlightSense™ vs. Other Proximity Sensing Technologies

	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**

FlightSense™ Supports Gesture Recognition

Basic Movement Detection

- 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

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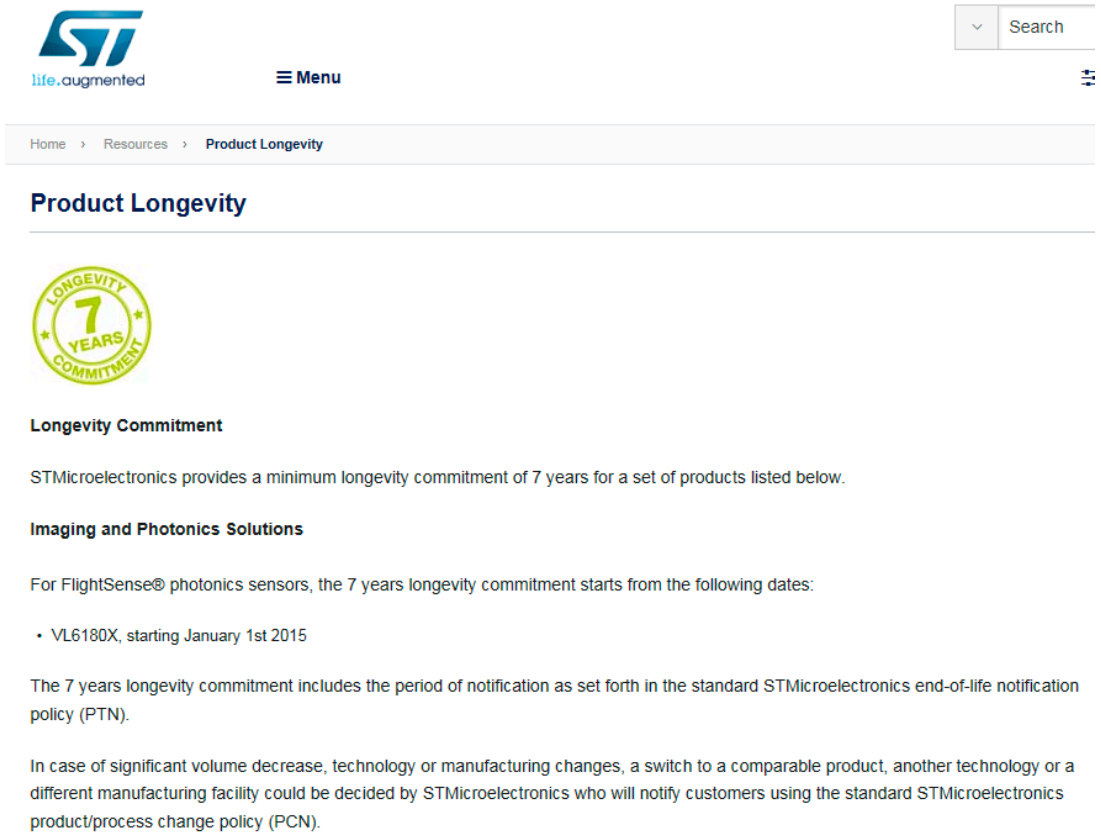
FlightSense™ Product Longevity

7-year commitment

FlightSense™ benefits from ST Longevity Program:

- 7-year longevity from Product Introduction Date
- In place for VL6180X since January 2015, and for VL53L0X since Sept.2016



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Product Longevity

LONGEVITY 7 YEARS COMMITMENT

Longevity Commitment

STMicroelectronics provides a minimum longevity commitment of 7 years for a set of products listed below.

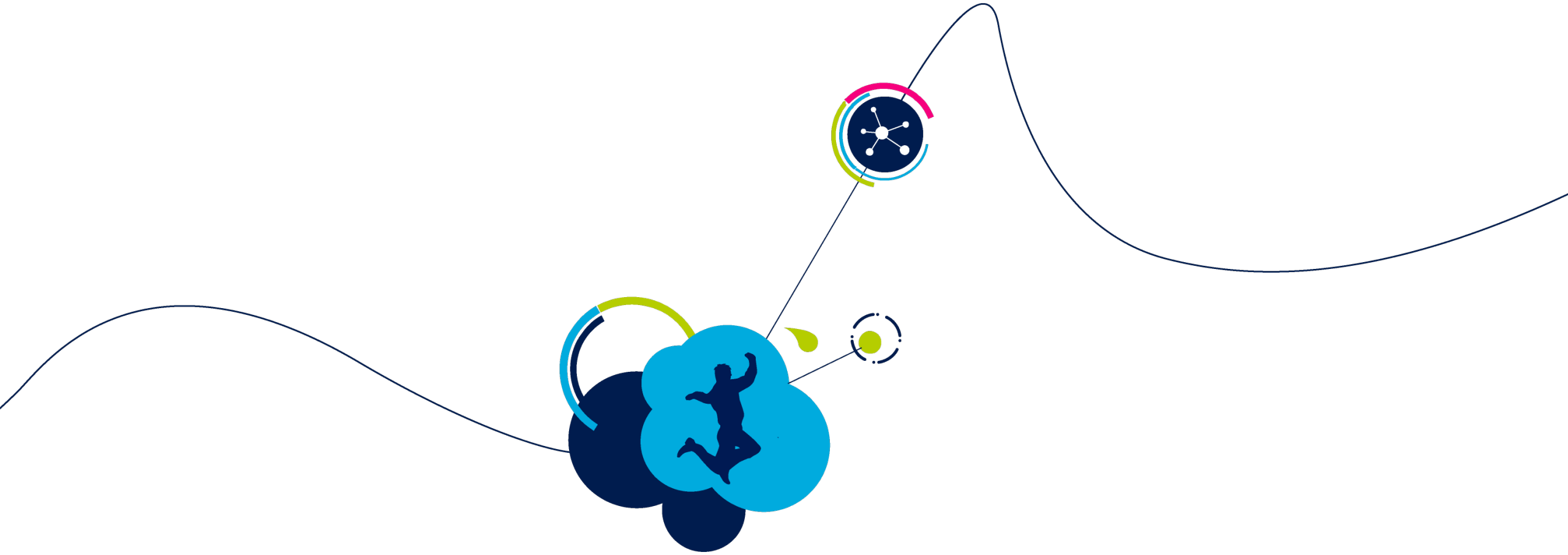
Imaging and Photonics Solutions

For FlightSense® photonics sensors, the 7 years longevity commitment starts from the following dates:

- VL6180X, starting January 1st 2015

The 7 years longevity commitment includes the period of notification as set forth in the standard STMicroelectronics end-of-life notification policy (PTN).

In case of significant volume decrease, technology or manufacturing changes, a switch to a comparable product, another technology or a different manufacturing facility could be decided by STMicroelectronics who will notify customers using the standard STMicroelectronics product/process change policy (PCN).



FlightSense™ Product Descriptions

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ST's FlightSense™ Mass-Market Products

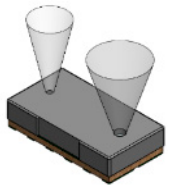
VL6180X
Proximity, gesture & ALS sensor

In Mass-production

- 1st generation ST ToF sensor
- Main features: Proximity sensor & ALS
- Major use cases:
  - Proximity distance measurement
  - Proximity detection
  - Lighting control
  - Basic gesture

VL53L0X
Ranging and gesture sensor

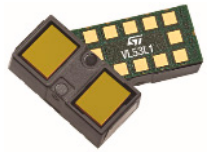
In Mass-production



- 2nd generation ST ToF sensor
- Main feature: Ranging sensor
- Major use cases:
  - Up to 2 meters distance measurement
  - User / object detection
  - Robotics
  - Basic gesture

new VL53L1X
Long distance ranging sensor

In Mass-production



- 3nd generation ST ToF sensor with lens
- Main feature: Long distance ranging sensor, high speed
- Major use cases:
  - Up to 4 meters distance measurement
  - Programmable FoV
  - User / object detection
  - Robotics

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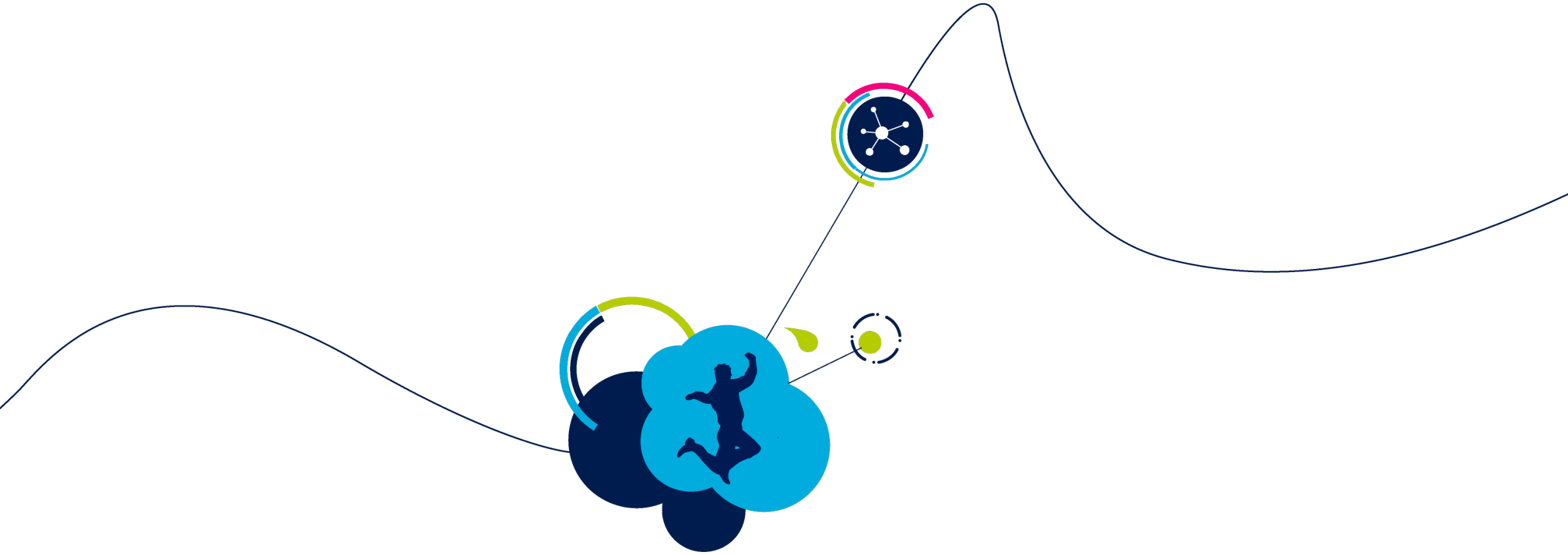

VL53L1X Focus

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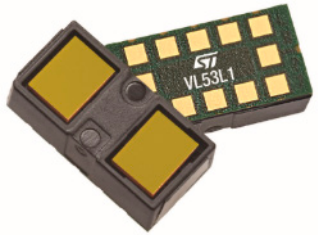
VL53L1X

New generation ToF sensor with lens, for long-distance ranging and ROI selection



Product highlights

OLGA: **4.9 x 2.5 x 1.56 mm**
FoV : 27°
Compatible footprint with VL53L0X

Enhanced performance:

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

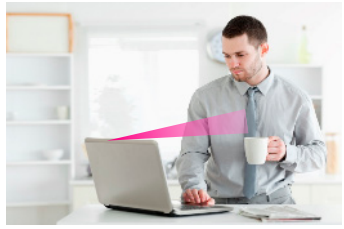
Cutting-edge module and silicon :

- **Fastest miniature ToF product in the market** (up to 16ms ranging with full ranging spec)
- **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

Applications

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

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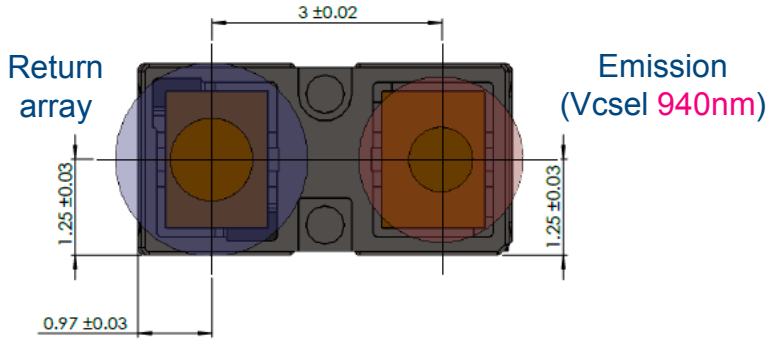
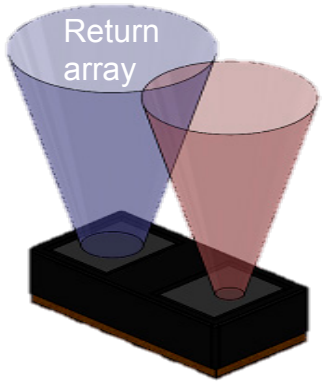
VL53L1X System FoV (Field of View)

Compatible footprint with VL53L0X : Easy migration





Typical System Field of View : **27°**

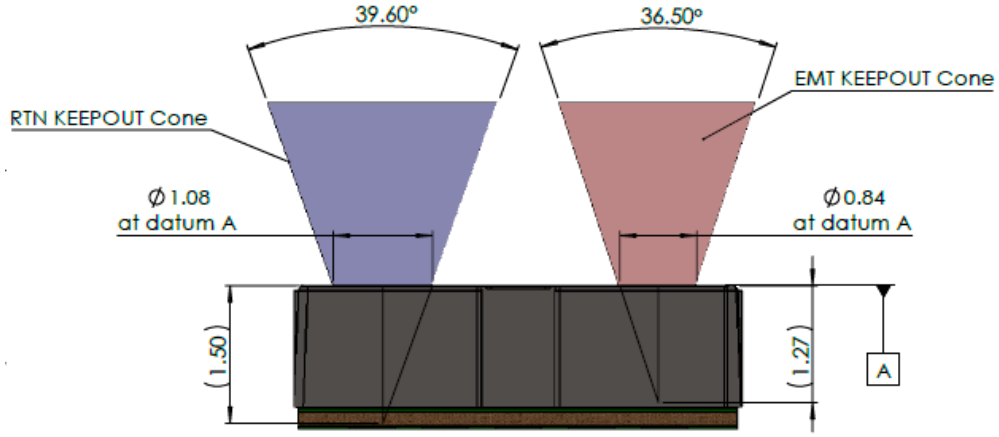
Emission (Vcsel 940nm)

- OLGA12 Package
- **LxW = 4.9 x 2.5 mm**
- **Height : 1.56mm +/- 40um (max 1.6mm)**
- 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



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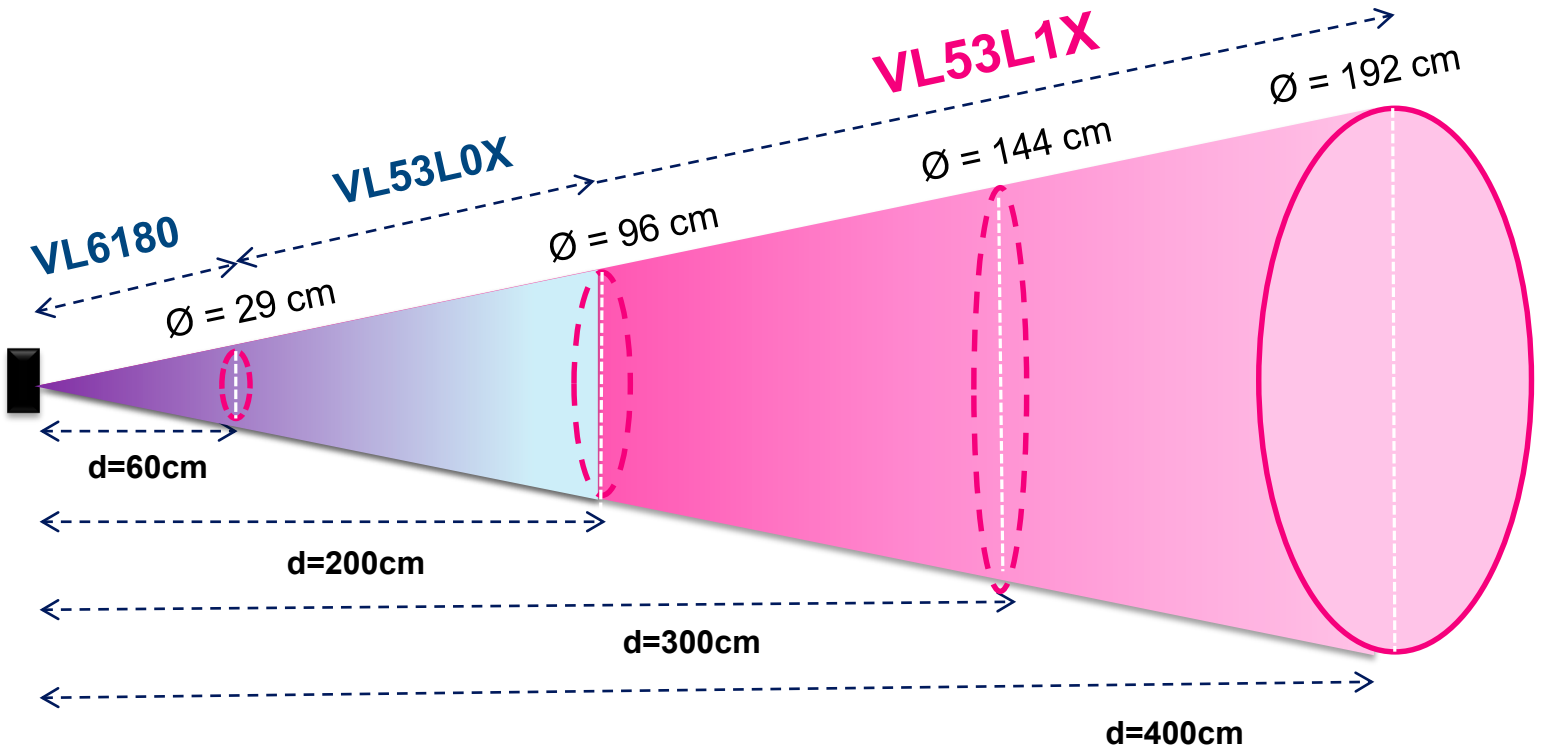
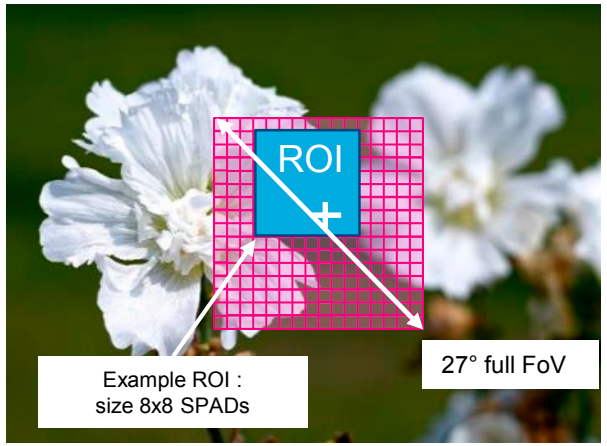
VL53L1X Detection Cone



VL53L1X Allows Custom FoV Selection

Region of Interest (ROI) selection by the user

- VL53L1X as no fixed pre-defined size for the sensing array, unlike other sensors on the market, or VL53L0X
- VL53L1X sensing array is composed by 16x16 SPADs (Single Photon Avalanche Diodes) that can be **selected by customer**
- The sensing array is called “**ROI**” **(Region or Interest)**
- VL53L1X returns the distance to object covered by the ROI FoV
- User defines the 2 corners of the array, through SW driver (API) or through 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)

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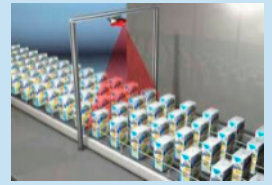
Adapt VL53L1X Performance to Your Application

Target performance to best fit application	Autonomous low power (ALP)	Fast Ranging
	 	 
Description	• Low power mode • VL53L1X works as master (autonomous state machine) • Sends Interrupt to host if target detected	• Fast ranging (Twice faster than ALP) • ROI size selection
Application type	• User / object detection • Laptop and tablets, Smartphones • Sanitary (smart faucets…) • IoT devices • Security	• Obstacle detection • Low-cost or low-power MCU-based devices • Security • Industrial
Max Ranging (Typical, in the Dark, full FoV)	White 88% or Grey54% : 2.8m (76ms; 13Hz) Grey 54%: 2.65m (30ms)	White 88%: 4.1m (67ms; 15Hz)
Accuracy	White: 1.5% Grey: 2.5% (offset +/-25mm)	White: 2.5% Grey: 2.5% (offset +/-25mm)
Ranging under ambient light	■■■□	■■□□

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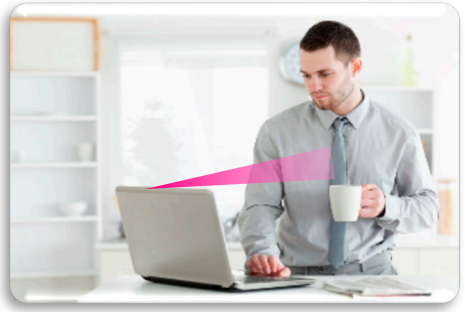
Autonomous Low-Power User Detection

Save battery when no user detected, and easily wake-up your device for <1mW



- For user detection application, most of the time there is nobody in front of the device
- The device must be in sleep mode, waiting to be awakened by the ToF sensor
- The ToF sensor must consume as little as possible, just to detect if someone is approaching the device. When user is in front, it must wake-up the host
- 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

Example of Low-Power User Detection

"Waking-up the PC" state machine

There is no target in front of PC
The System is in Std-by mode

ToF sensor in "Autonomous Low Power"
RangingFreq ~ 1 Hz
TimingBudget ~ 20 ms

Target Detected ?
(RangeStatus)

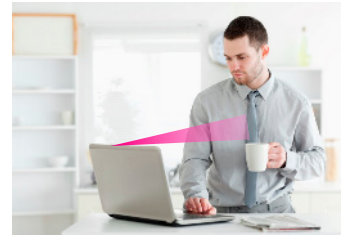
NO

YES

The ToF sensor generates an interrupt when target is detected

ToF sensor in "Autonomous"
RangingFreq ~ 1 Hz to 50Hz
TimingBudget ~ 20ms to 1sec.

The host wakes-up and programs ToF sensor in "Autonomous" mode, with OEM programmable RangingFreq and TimingBudget, until the target leaves the sensor FoV



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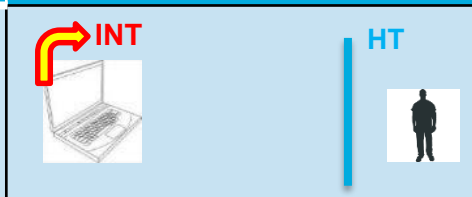
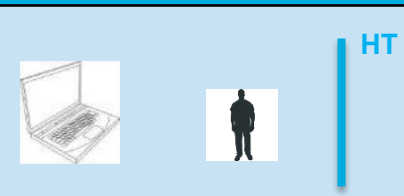
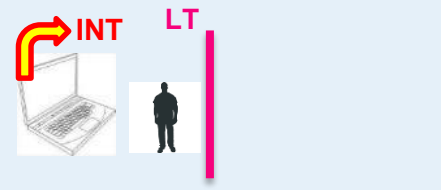
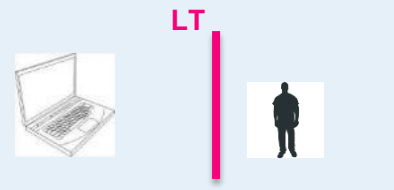
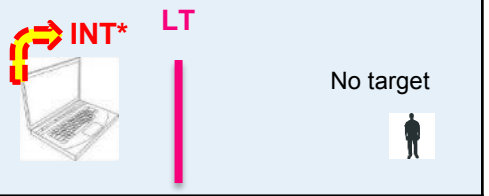
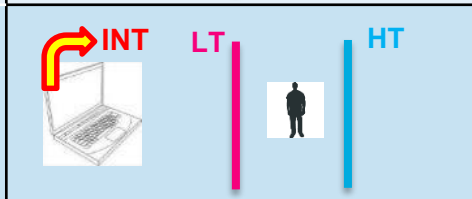
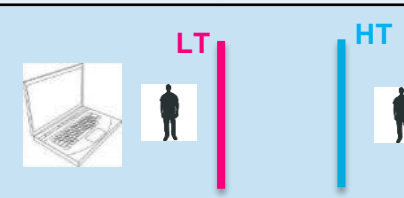
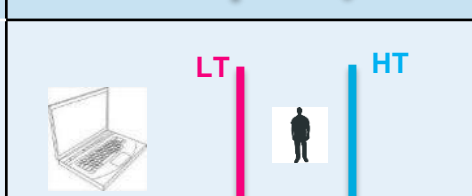
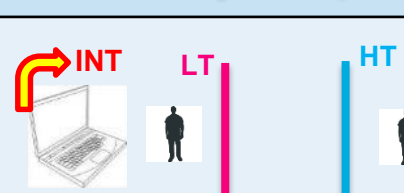
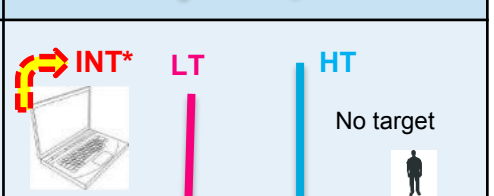
Customizable Thresholding

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*

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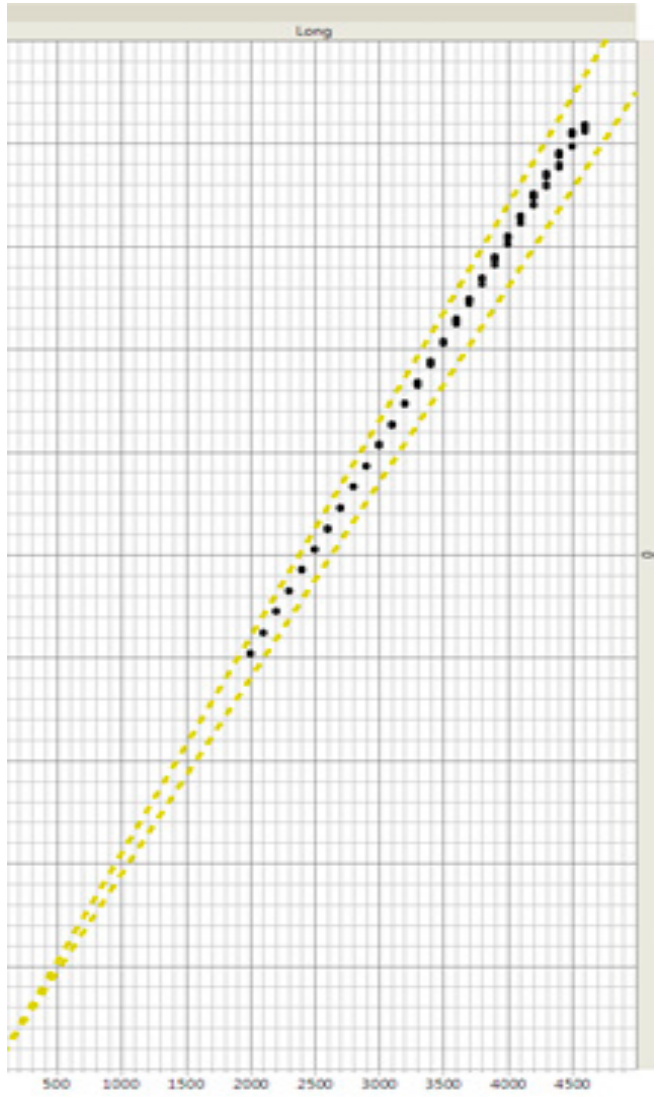
Long-Distance Ranging Settings

- Ranging distance ~4.5m

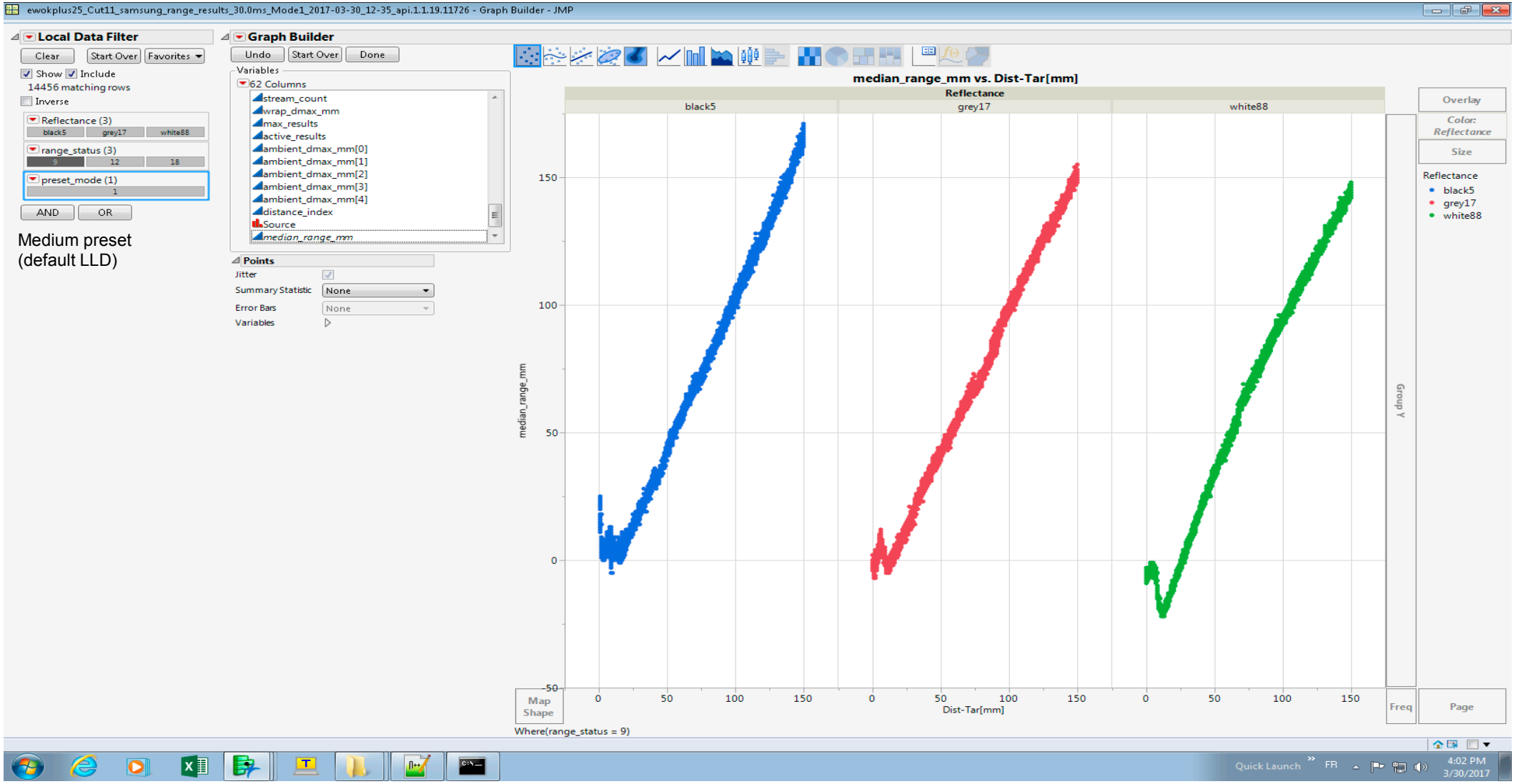
  (White target, no CG, 60ms timing budget, no ambient IR)

- Recommended for applications requiring long distance ranging, in low IR ambient



Example of Short-Distance Ranging (5mm to 150mm)

with high Xtalk cover-glass, FoV, in dark, 30ms, lite SD



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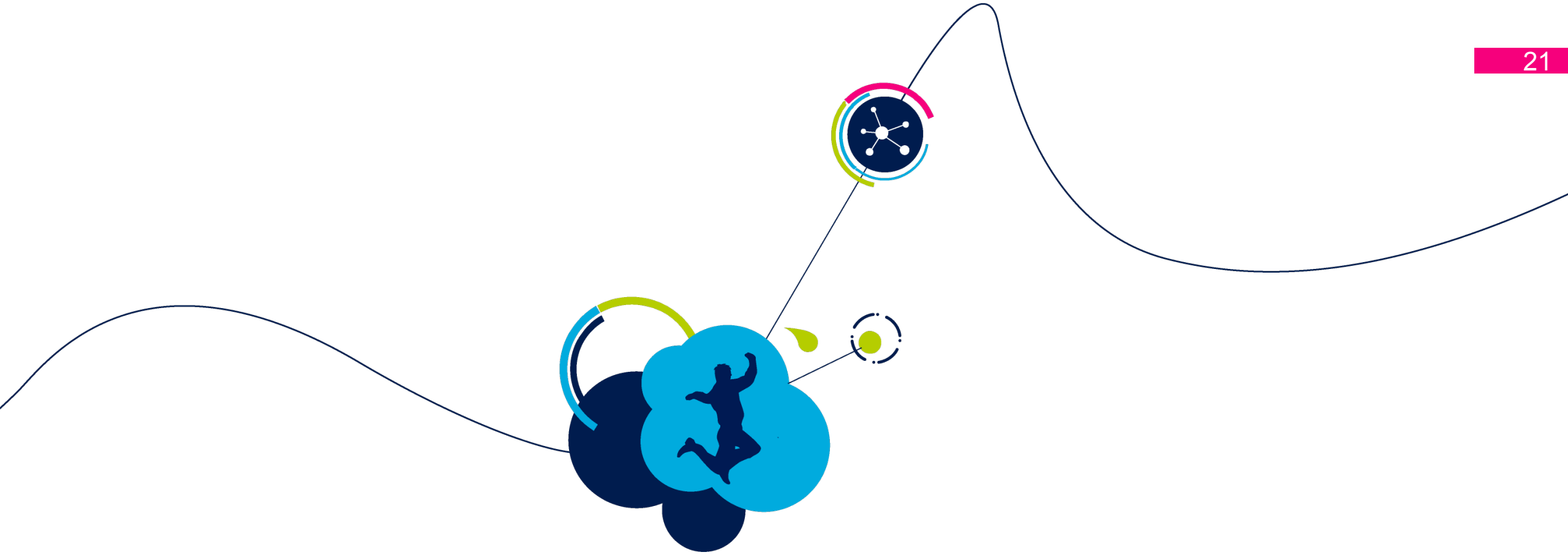

Cover-Glasses and Special Module for **Flight**Sense™ Sensors

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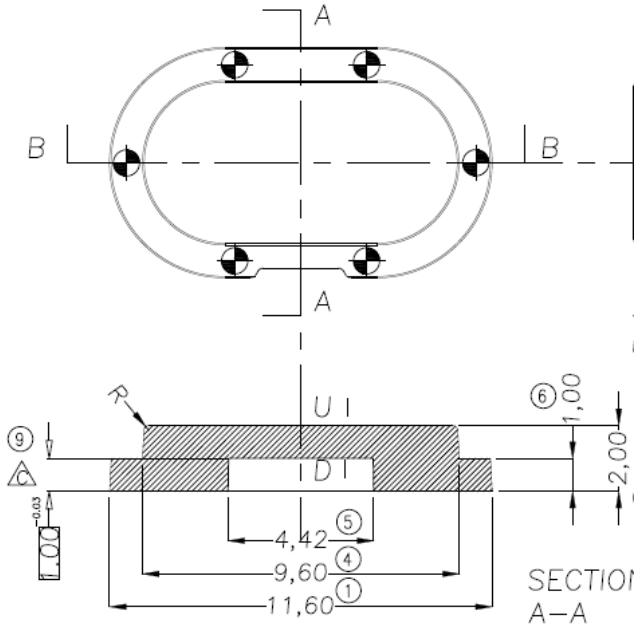
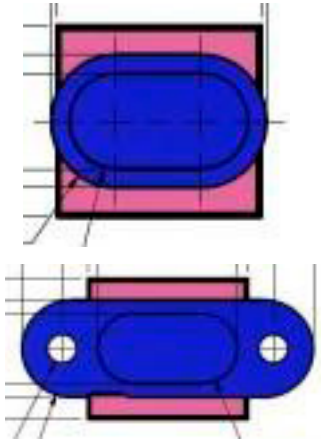
Clipable Cover Glass by Hornix (China)

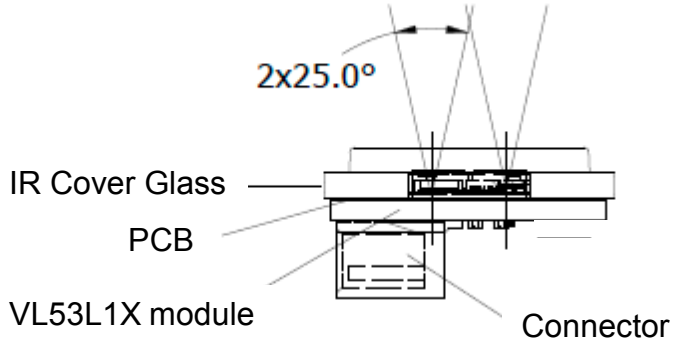
Low Xtalk CG ready to be clipped above ToF sensors, and fixed on a PCB

- 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



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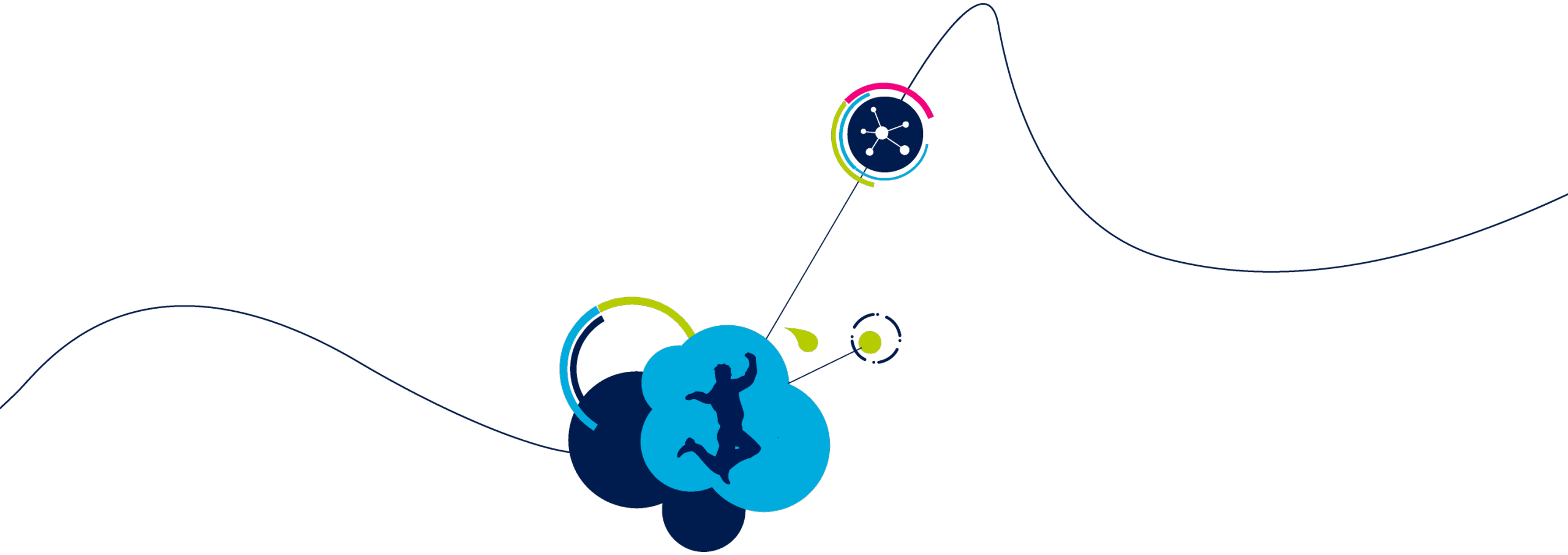
HORNIX OPTICAL TECHNOLOGY INC.



FlightSense™ Development Tools and Technical Support

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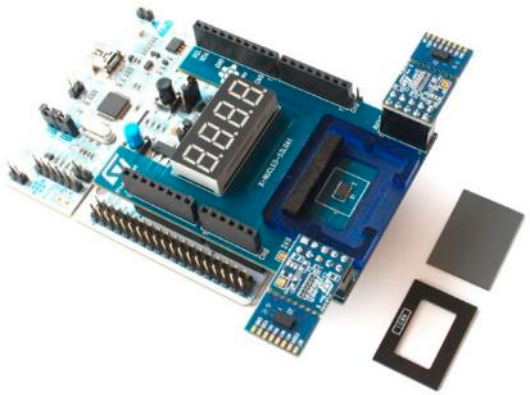
FlightSense™ Development Tools

- 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

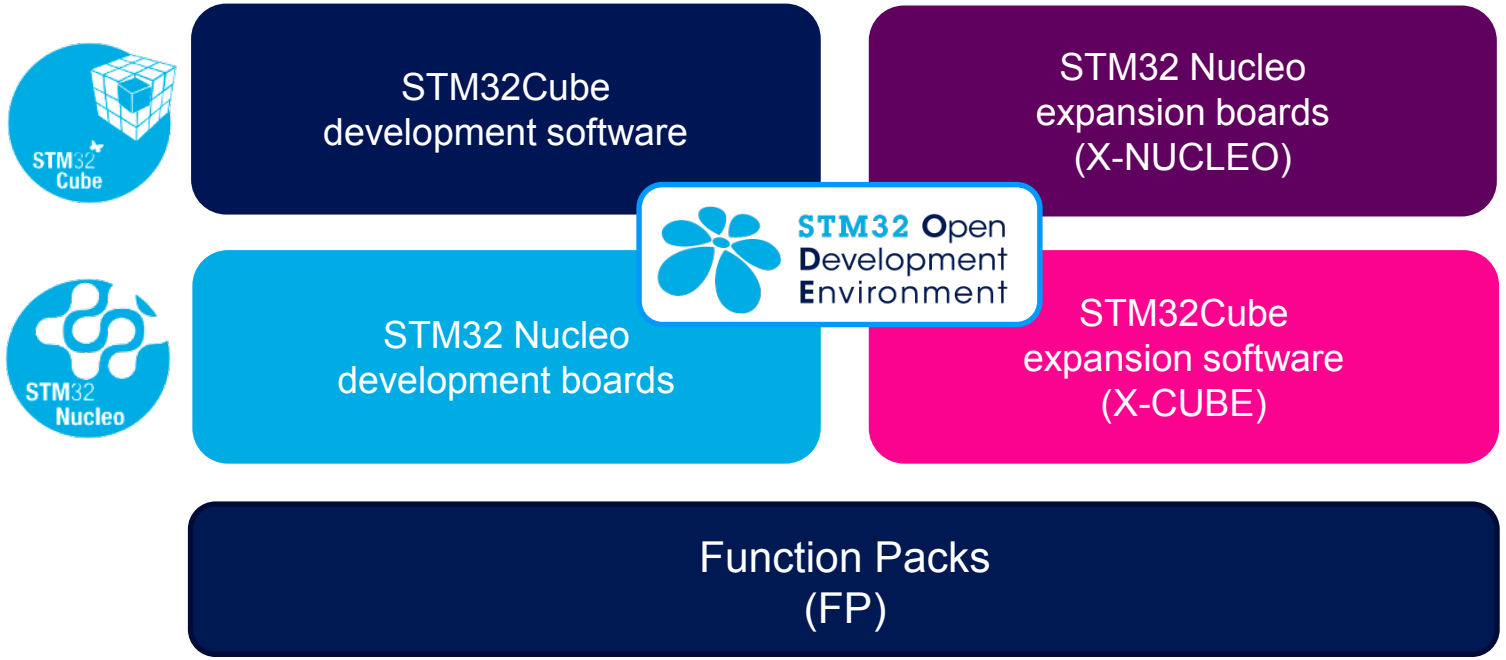


- Complete suite of SW tools and documentation (API, X-CUBE…)
- Code examples for plug and play application (Ranging, ALS, gesture…)

STM32 Open Development Environment

Fast, affordable prototyping and development

- The STM32 Open Development Environment (ODE) consists of a set of stackable boards and a modular open SW environment designed around the STM32 microcontroller family.

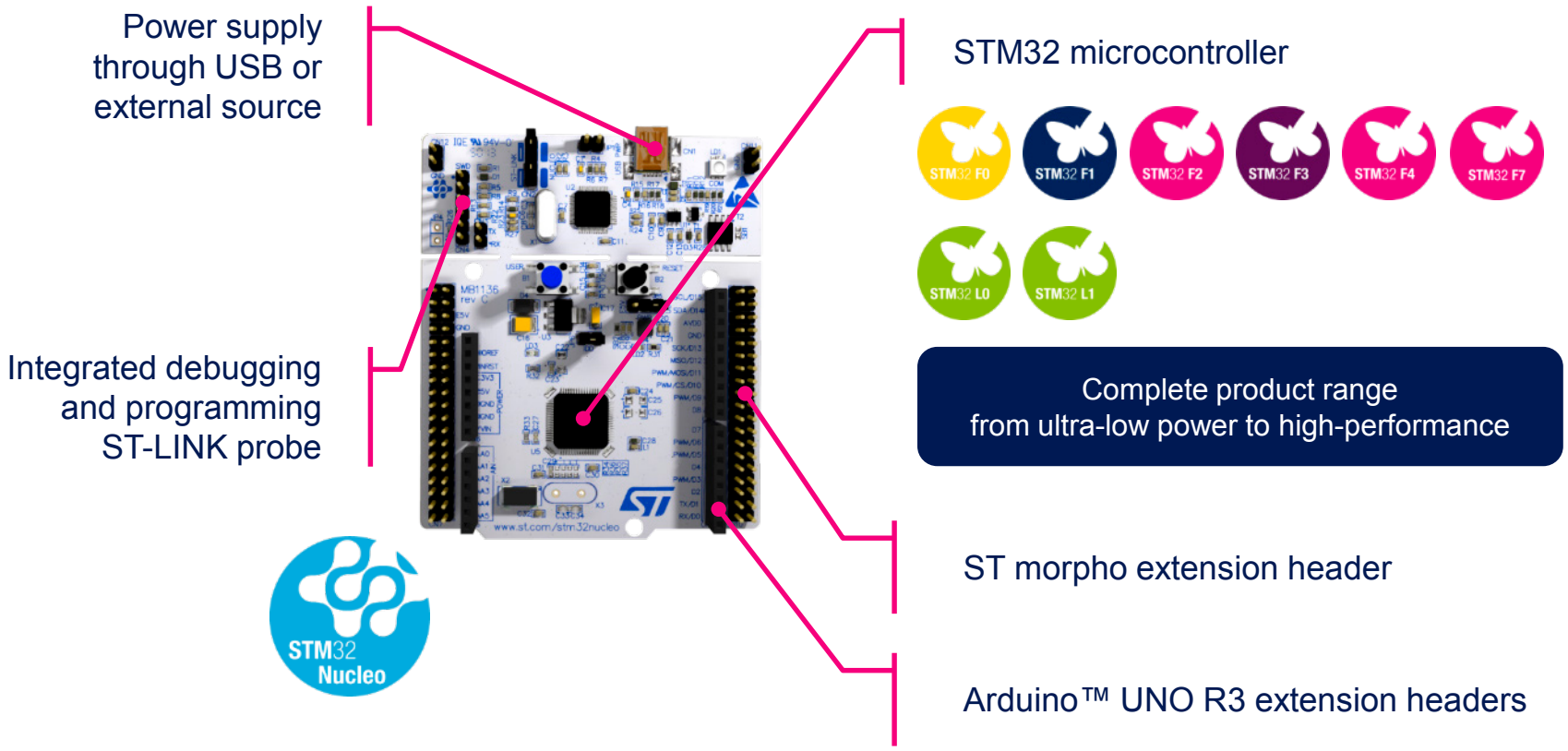


www.st.com/stm32ode

STM32 Nucleo

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.



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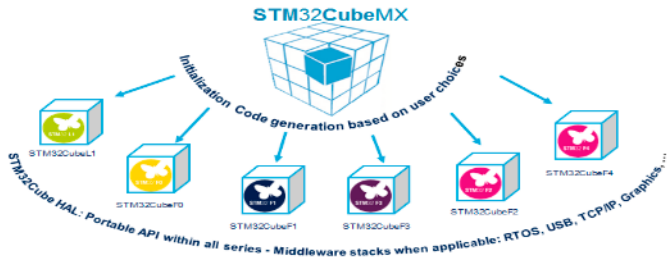


X-CUBE SW Package for FlightSense™ sensors

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

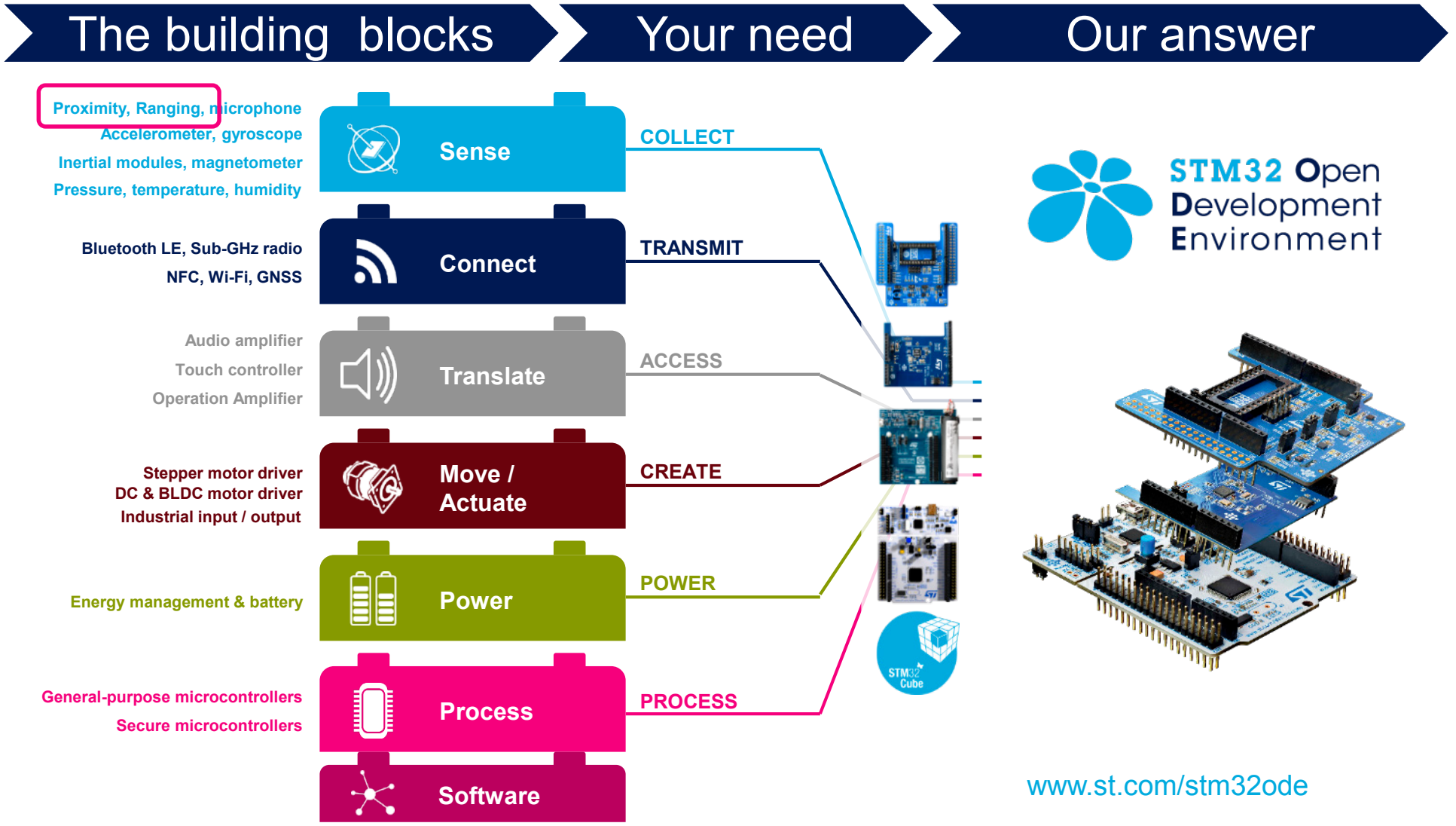
Based on FlightSense™ sensor API
Sensor API appears as a BSP component

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

STM32 Open Development Environment

Expansion boards can be plugged together



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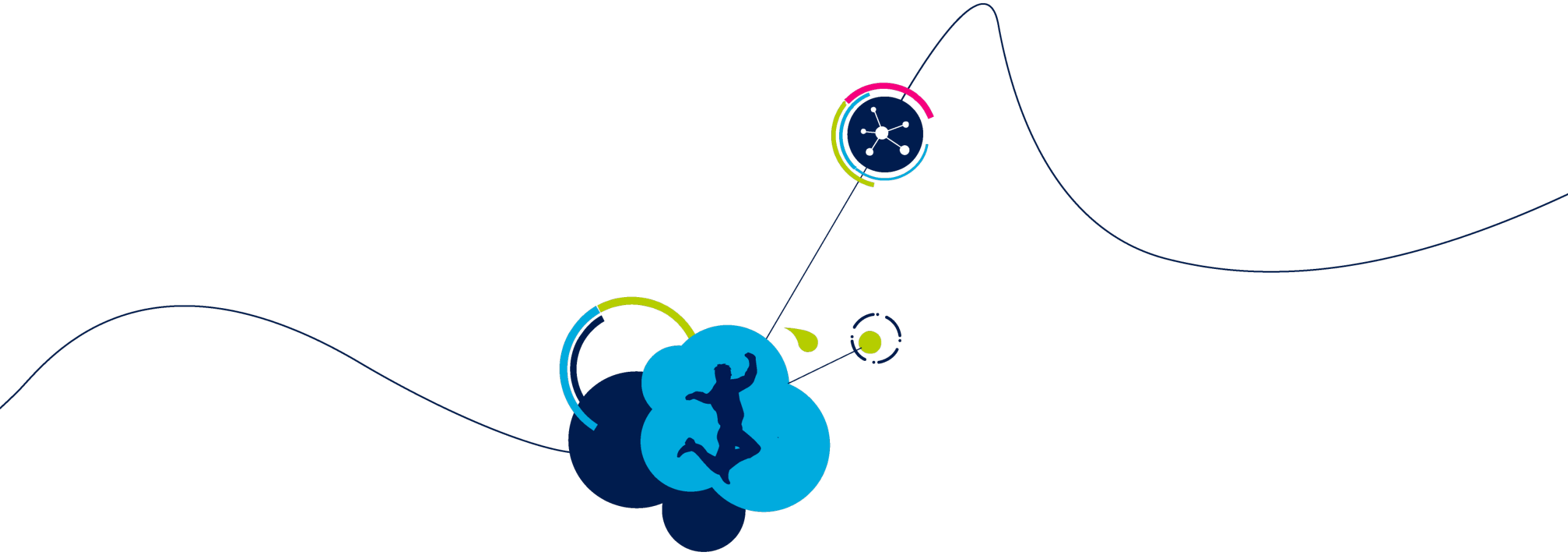

FlightSense™ Sensors Adopted by Multiple System Development Tools

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“Getting Started” Video for VL53L0A1 Nucleo Expansion Board

- https://www.youtube.com/watch?v=RvUaD1A7jBs

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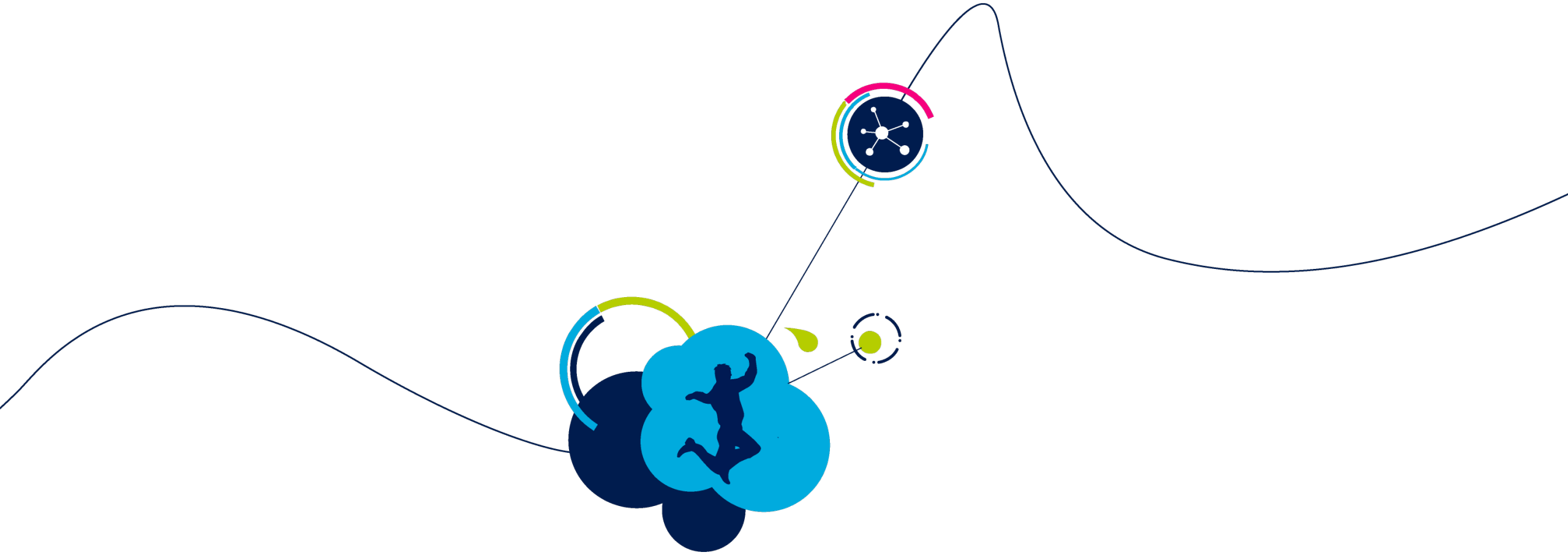

VL53L1X Development Tools and Technical Support

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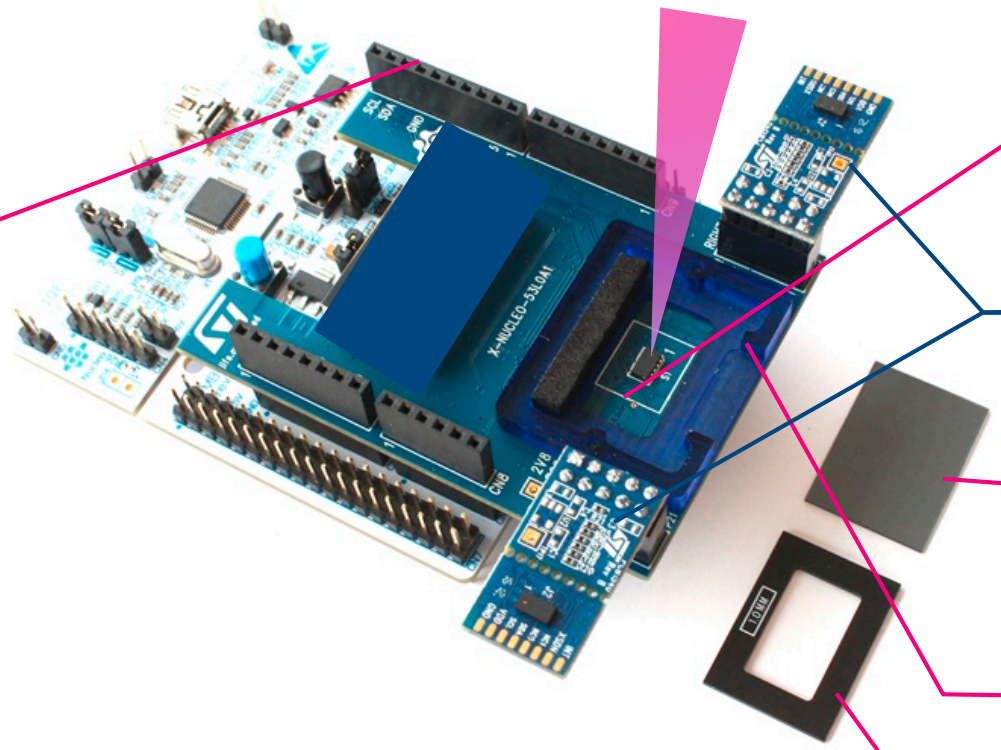
VL53L1X Nucleo Expansion Board

X-NUCLEO-53L1XA1 works with STM32F401RE

Available in Q1.18



Arduino
Connectors

VL53L1X
Ranging sensor

2x VL53L1X satellites
(plugged or hardwired)

Cover Glass sample
(PMMA material. Low XTalk)

Cover Glass holder
(Can hold Cover Glass and spacers)

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

PC GUI interface

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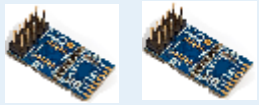
VL53L1X Ordering Codes

Go to **www.st.com/VL53L1X** or contact your usual distributor

Item	Picture	Commercial Product (= Order Code)	Comments
VL53L1X sensor		**VL53L1CXV0FY/1**	Delivery in T&R MOQ: 3.6Ku With protective liner LT = 12 weeks
VL53L1X Nucleo™ Expansion board		**X-NUCLEO-53L1A1/**	To go along with STM32F401 Nucleo board. Comes with cover-glass holder, 2x cover-window samples, 3x spacers, 2x 2v8 Breakout boards
Pack: VL53L1X Nucleo™ Expansion board + STM32F401 NUCLEO		**P-NUCLEO-53L1A1/**	X-NUCLEO-53L1A1 expansion board delivered together with STM32F401 NUCLEO board
VL53L1X Breakout board		**VL53L1X-SATEL**	Available in March18

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