life.augmented

Liquid Level Monitoring using ST Time-of-Flight technology

STMicroelectronics

Agenda

1. Liquid level monitoring principle & core Key Performance Indicators
2. ST Solutions and benefits
3. Markets & Applications
4. Support package

Liquid level monitoring principles

life.augmented

Liquid level: The half-full half-empty question

Liquid level monitoring

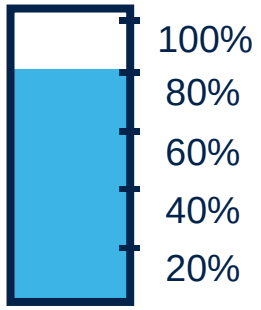
- A widespread use-case, present in multiple applications & markets
- To monitor welcome liquid, or unwanted liquid to be disposed of
- A liquid cannot be considered in isolation from its container. Liquid volume is a real time adequation between the container and liquid within the overall system

An age-old challenge

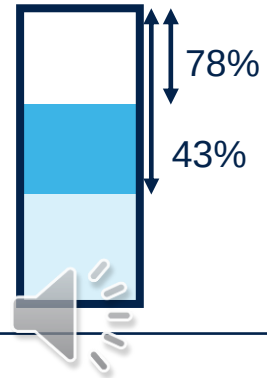
- From 3000-year-old technologies to daring deployment of the most modern technologies and applied technics

Two main liquid level monitoring categories

Point-level measurement

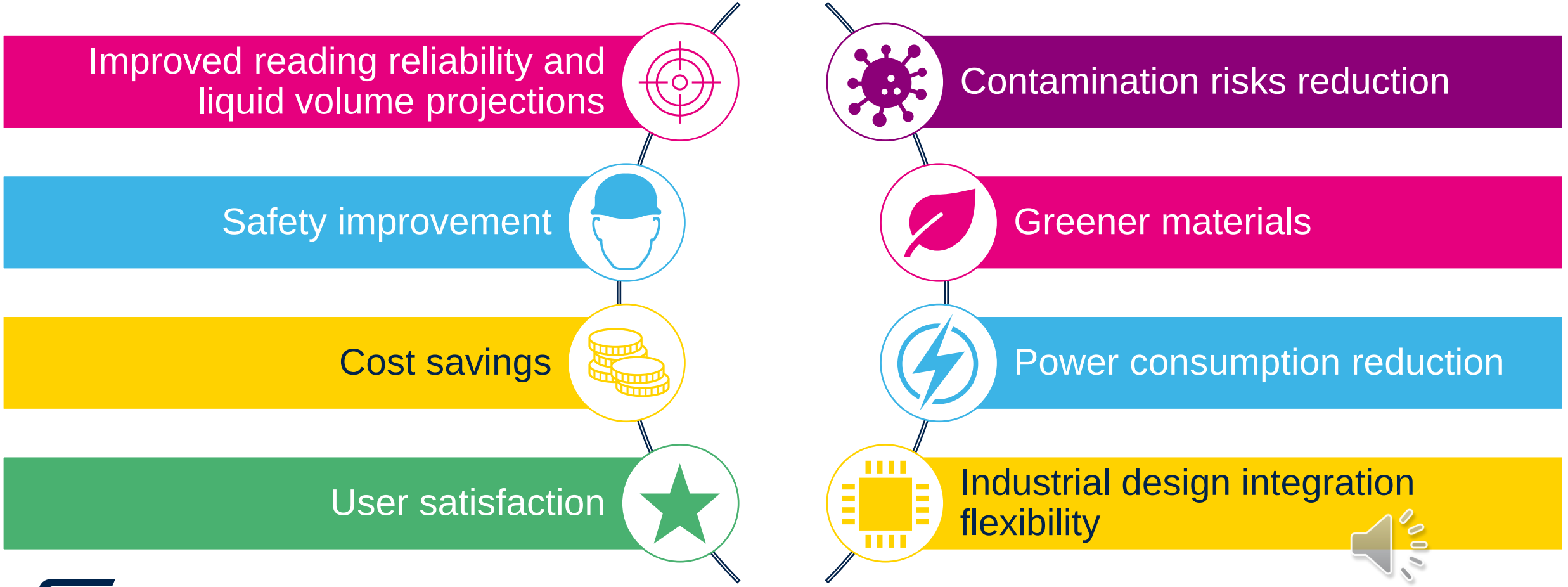


Continuous level measurement



Liquid level Monitoring Core KPIs

KPIs may differ, from those in high safety industrial applications to less stringent consumer systems needs



ST Solutions and benefits

life.augmented

FlightSense™ introduction … Making Light work

Time-of-Flight Principle

- ST proprietary FlightSense™ technology
- True distance measurement
  - Independent of target size, color & reflectance
- Fast and low power
- Truly invisible 940nm illumination

life.augmented

All-in-one optical modules

All-in-One (illumination & sensor) Time of Flight System → Optimized Size, performance, cost mix

ToF Pixel Expertise
SPAD/FPD

Advanced Photonics CMOS Process
(40nm/3D)

Micro-Optics
& Supply Chain

Illumination Expertise
& Supply-chain

Embedded ToF Processing & Depth ISP

Advanced Packaging know-how
& manufacturing

Advanced optics with integrated IR filters

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

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

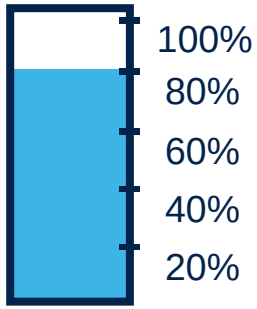
Full Class 1 safety high efficiency VCSEL

life.augmented

Improving liquid level monitoring

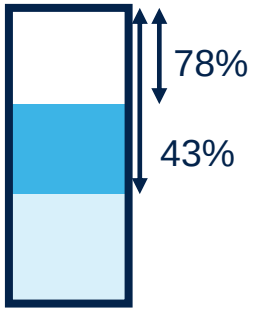
What exists

- **Point level Measurements**



  - Conductivity
  - Float switch
  - Rotating paddle
  - Vibrating (tuning fork)

- **Continuous level Measurements**



  - Capacitance
  - **Optical (Laser, LED)**
  - Cable base (yo-yo)
  - Ultrasound
  - Radar (microwave)

Two ST Solutions

Single-zone ToF sensors

Multi-zone ToF sensors

Core Benefits

- **Not “intrusive”**
  - No moving part offering high reliability
    - Contactless
    - No physical part in contact with liquid
    - No risk of contamination
    - Non-ecology friendly materials free
  - Cost saving
    - BOM, operational time, maintenance
- **Works with all liquids**
  - Water, fuel, oil…
- **Small size**
  - Compatible with challenging industrial designs
  - Easy to retrofit in existing systems

VL53L4CD vs VL53L5CX

A dual throng solution portfolio for best end-system integration adequation

VL53L4CD – High accuracy proximity sensor

Package size : 4.4 x 2.4 x 1 mm
FoV : 18°
Single zone

Short distance linearity

Ultra Low Power mode available

- **Single-zone** sensor
- Narrow **18°** FoV
- Max distance ranging: **130cm**
- Very high-performance **proximity** sensor
- Ambient light immunity: 60cm (under 5Klux)
- Fast ranging frequency (up to **100Hz**)
- Easy to use UltraLite Driver

VL53L5CX – First multi-zone ToF sensor

Package size : 6.4 x 3.0 x 1.5 mm
Square **FoV** : 45° x 45° (**63° diagonal**)
Multi-zone (8x8)

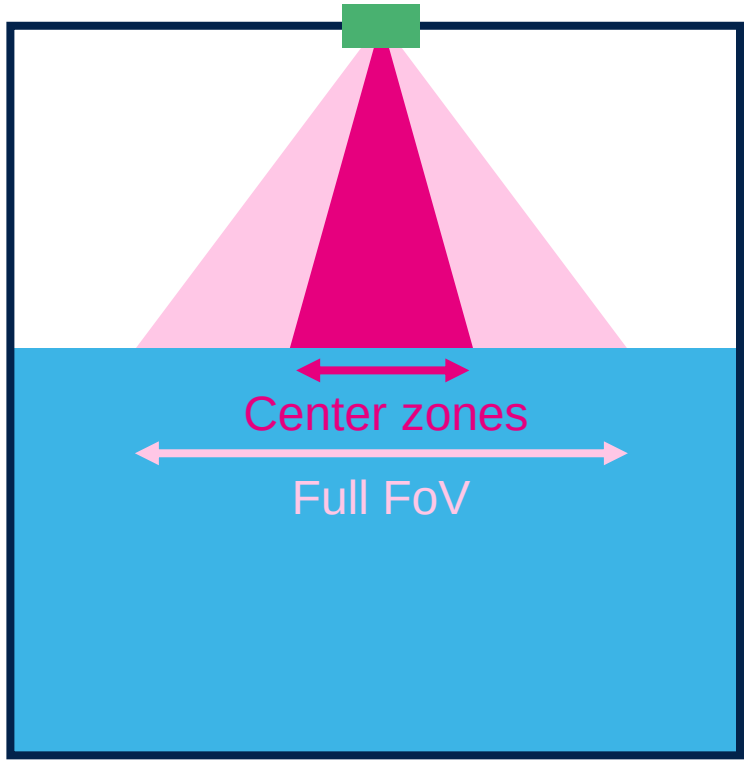
- Parallel **multi-zone** ranging output (4x4 or 8x8)
- **Wide FoV**: 45° x 45° (63° diagonal)
- Up to **400 cm** ranging
- Immunity to cover glass cross-talk beyond 60cm
- **Autonomous mode** available (down to 1.3mA)
- **High ambient immunity**: 170cm (under 5Klux)
- **60Hz** (4x4 zones) frame rate capability

life.augmented

VL53L5CX multi-zones solution

VL53L5CX liquid level monitoring solution uses 12 perpendicular center zones

Step 1 – Extract signal strength and distance from center zones



Step 2 – Take the highest signal strength zone

52	50	71	77	54	72	89	97
86	61	83	73	60	80	91	96
85	52	88	**3683**	**5006**	100	64	100
63	59	**62**	**90**	**4064**	**67**	52	56
73	70	**56**	**97**	**57**	**76**	58	89
64	87	76	**53**	**78**	62	53	87
67	98	51	64	83	54	100	86
50	90	50	67	51	70	83	66

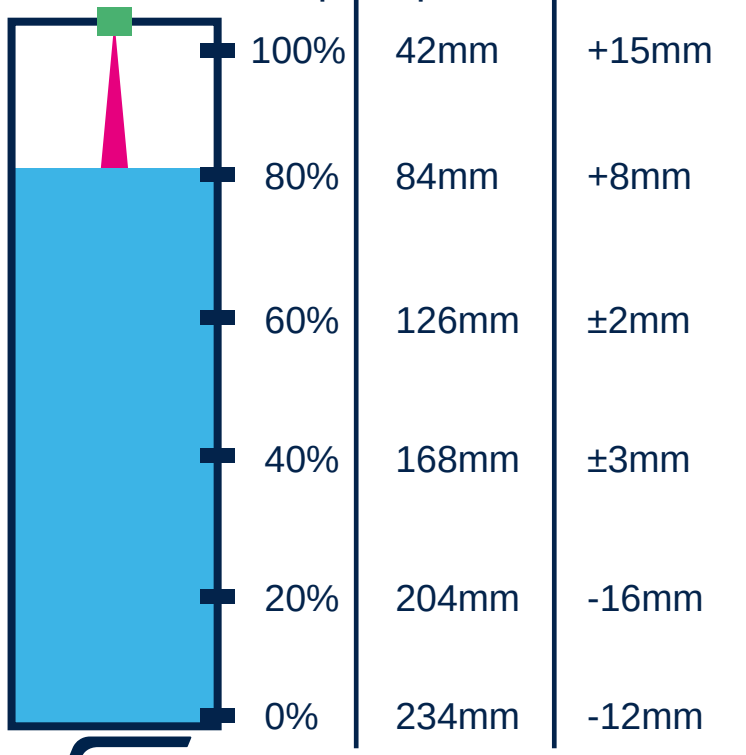
Step 3 – Extract the distance of this zone

60	70	71	63	60	66	66	73
78	61	62	71	80	60	67	63
61	65	74	**76**	**77**	78	65	73
62	68	**70**	**62**	**78**	**63**	63	62
60	78	**78**	**64**	**72**	**61**	63	61
64	62	75	**62**	**62**	69	77	67
70	62	65	77	70	64	69	64
71	60	64	73	63	66	79	80

VL53L4CD single-zone solution

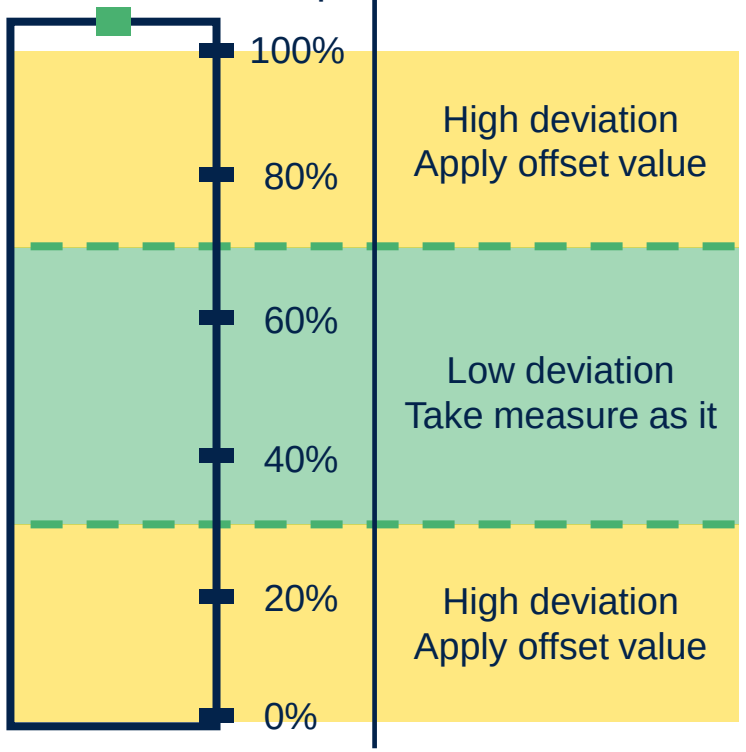
VL53L4CD Liquid Level Monitoring solution characterization & preset process

Step 1 – Characterize your setup conditions

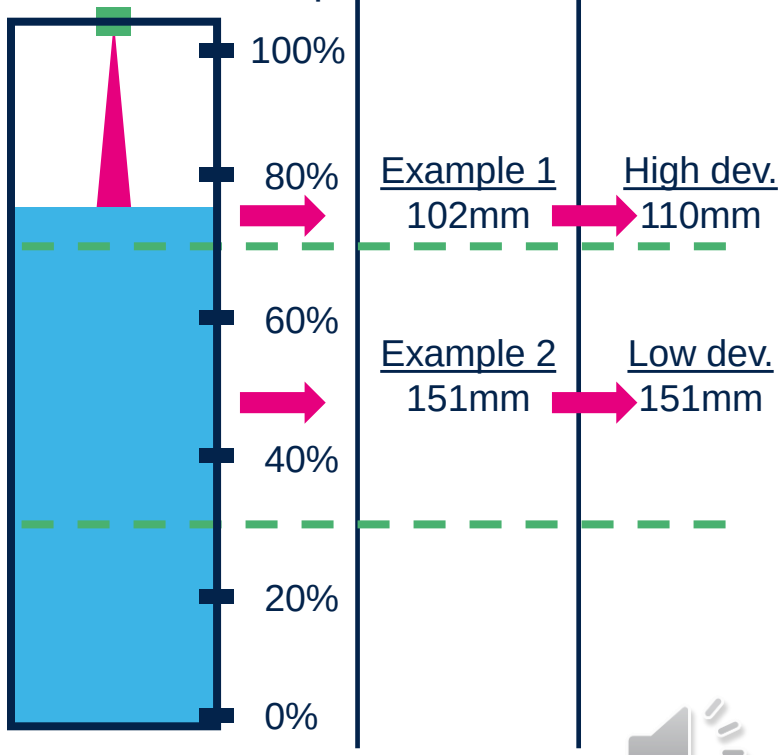


Step	Expected	Offset
100%	42mm	+15mm
80%	84mm	+8mm
60%	126mm	±2mm
40%	168mm	±3mm
20%	204mm	-16mm
0%	234mm	-12mm

Step 2 – Apply the ST algorithms

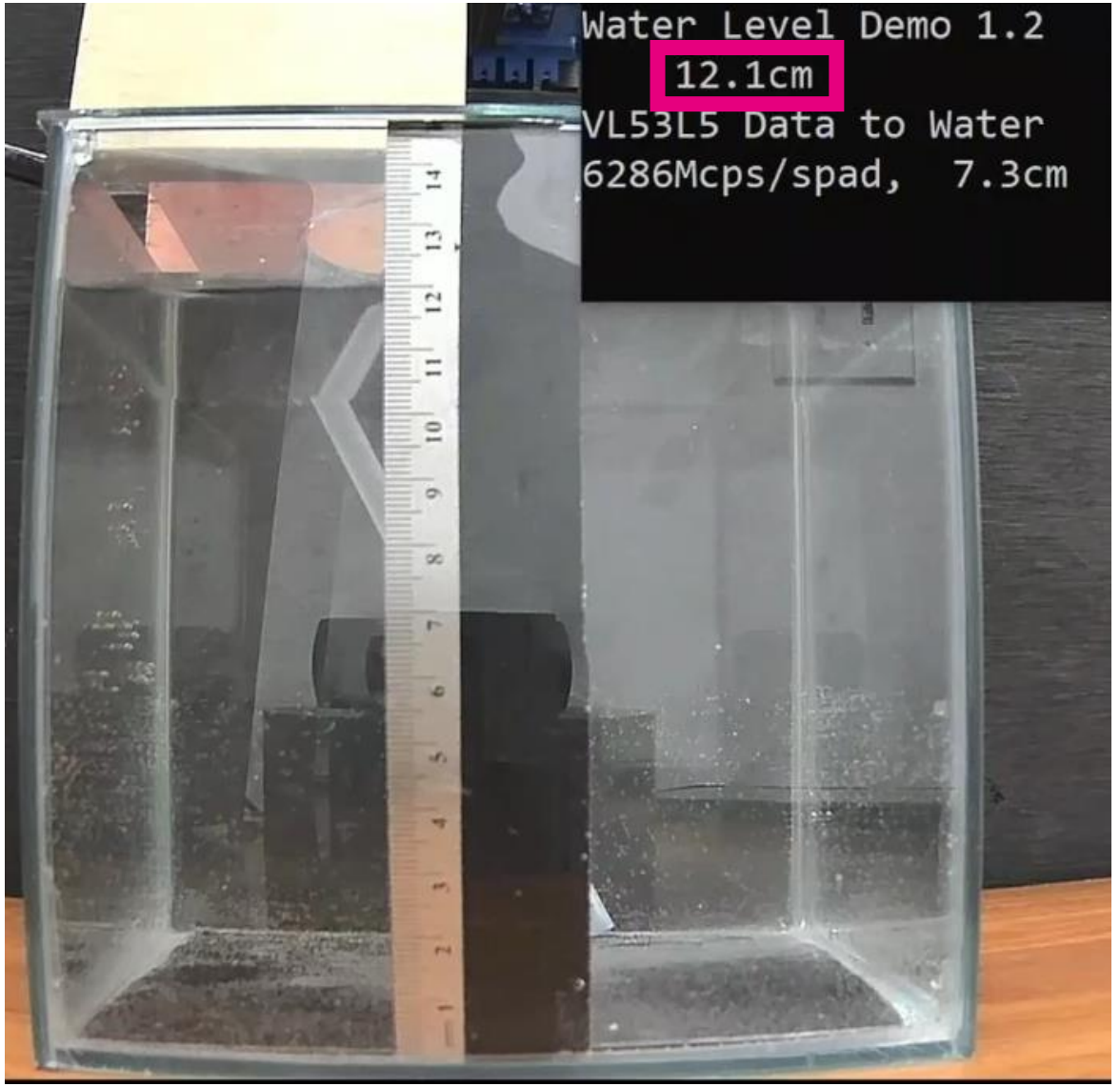


Step 3 – Measure the liquid level



life.augmented

Live demo using VL53L5CX



FlightSense Benefits

Not “intrusive”

- No moving parts, offering high reliability
- Contactless
- No physical part in contact with liquid
- No risk of contamination (drinking water, milk)
- Non-ecology friendly materials free (Neodyme for example)


Small size

- Compatible with challenging industrial designs
- Easy to retrofit in existing systems & invisible illumination

Cost Saving

- No moving parts saving BOM
- Increase of the operational time
- Reduced maintenance costs



Works with all type of liquids

- Water
- Fuel
- Oil
- Milk
- Coffee
- Juice
- …




Connected

- Monitoring in real-time


life.augmented

Markets & Applications

life.augmented

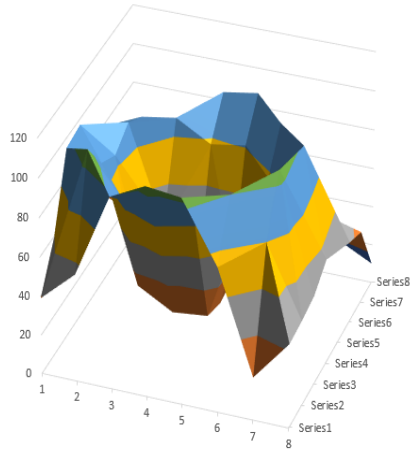
Home Appliance

Real time liquid level measurement allowing end user to anticipate replenishment

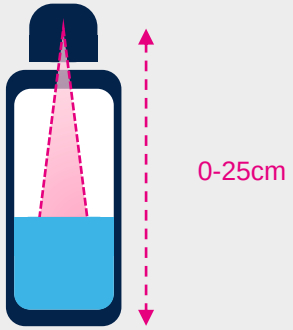
Coffee machine

Multiple use-cases using ST Time-of-Flight sensors:

- Water level monitoring
- Empty capsule container control
- Coffee cup shape identification

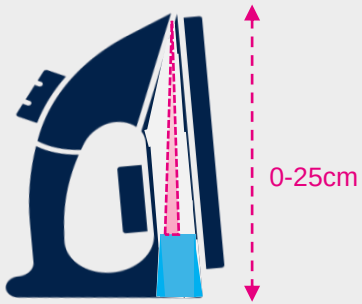


Smart bottle



Smart water bottle liquid level

Steam iron



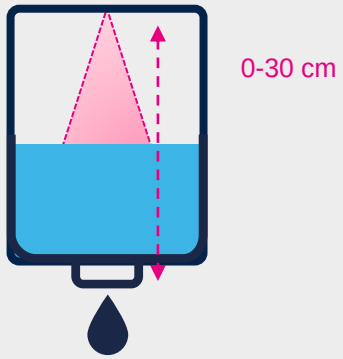
Steam iron remaining water level

Other applications

Sanitary

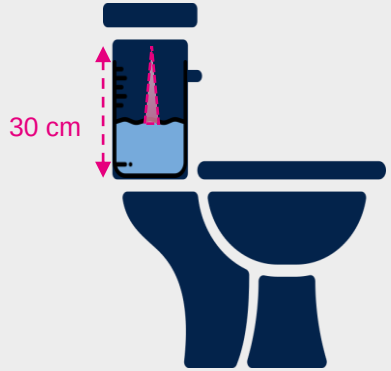
Real time liquid level monitoring enabling efficient replenishment cycle & enhanced user satisfaction

Soap dispensers



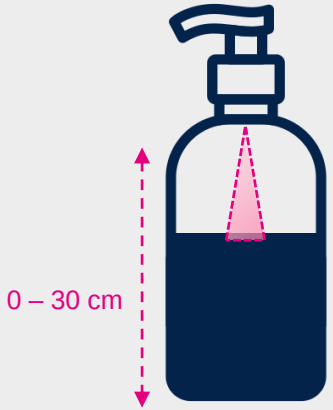
Real time stock management enabling efficient replenishment cycle and user satisfaction

Smart toilets (flush)



Reduce system corrosion risk

Cosmetic containers



Cosmetic containers liquid level

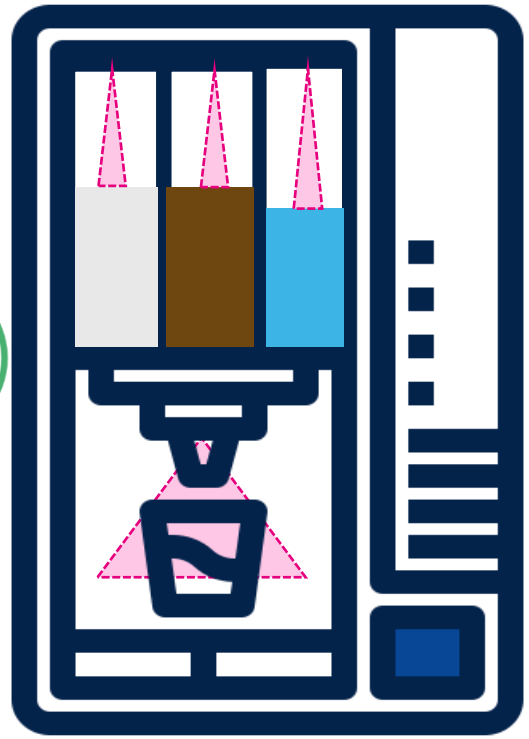
Home automation and Smart building

Combine liquid level monitoring with other ST ToF enabled use-cases

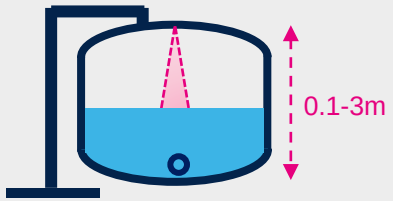
Beverage dispenser

ST released a video presenting all applications for a beverage dispenser:

- Liquid level monitoring
- Gesture recognition
- Cup detection

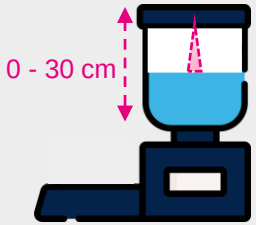


Rainwater tank



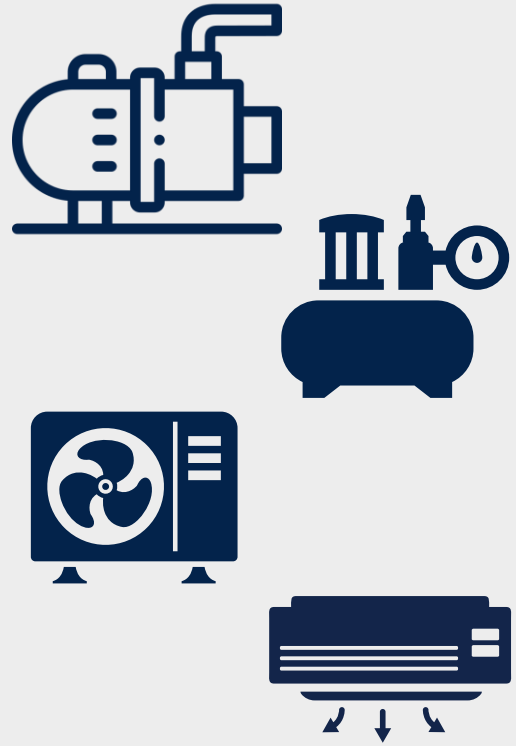
Home rainwater tank liquid level

Smart pet feeder



Pet feeder water level

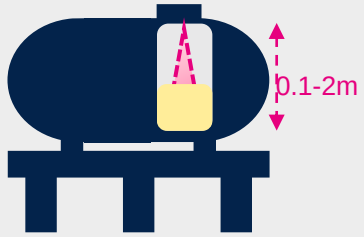
Other applications



Industrial

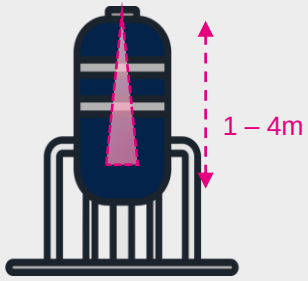
ST ToF solutions addressing multiple applications in the diversified Industrial market

Oil tank



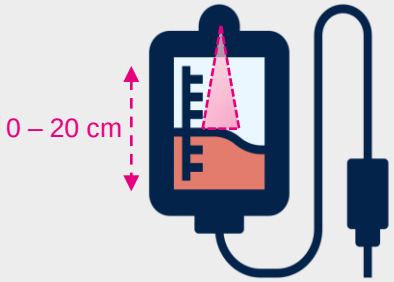
Home oil tank level

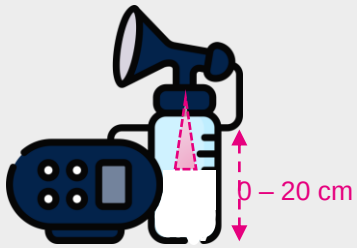
Storage tank



Industrial storage tank liquid level

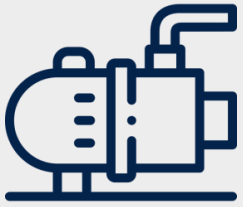
Medical





Transfusion bag or smart breast pump liquid level monitoring

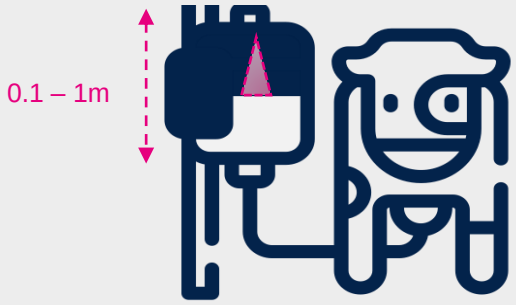
Other applications



Smart Farming

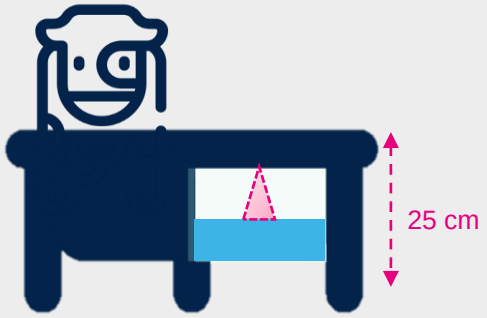
Unlimited markets, ST ToF solutions supporting smart-farming for cattle satisfaction & beyond

Milking machine



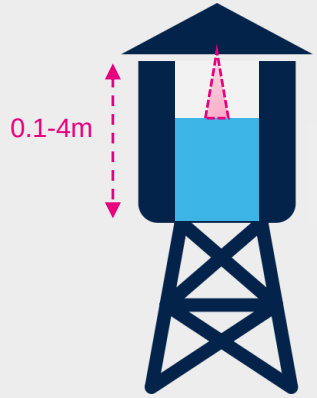
Milk machine liquid level

Drinking trough



Drinking trough liquid level

Water tower



Water tower liquid level

Support package

Technical documentation

Complete toolset for swift and smooth evaluation and integration

- Evaluation boards available
- Software package:
  - CubeIDE projects
  - Characterization tool (for VL53L4CD only)
  - Source code
- Technical documentation:
  - Application Notes
  - User Manual

	VL53L4CD 	VL53L5CX 
Software code	STSW-IMG039_L4CD	STSW-IMG039_L5CX
Application Note	AN5851	AN5843
Evaluation boards 	X-NUCLEO-53L4A1 P-NUCLEO-53L4A1 SATEL-VL53L4CD	X-NUCLEO-53L5A1 P-NUCLEO-53L5A1 VL53L5CX-SATEL

* Standard, widely available product related boards and tools

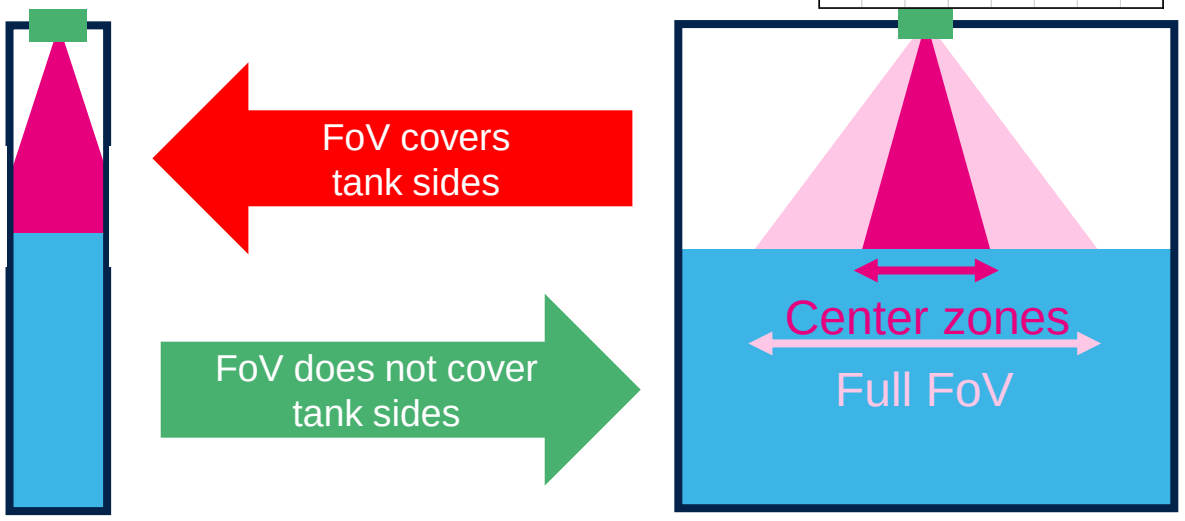
VL53L5CX multizone solution

VL53L5CX Liquid Level Monitoring solution provides highly accurate measurement

Step 1 – Prepare your monitoring

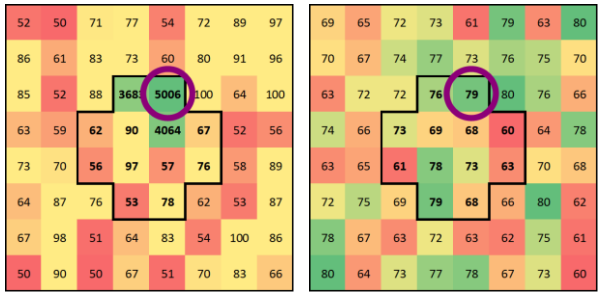
- Take VL53L5CX 12 center zones as displayed
- Center zones must cover the water and not the tank sides

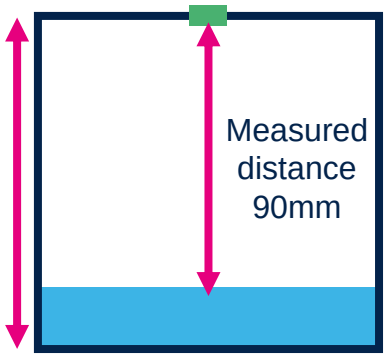
56	57	58	59	60	61	62	63
48	49	50	51	52	53	54	55
40	41	42	**43**	**44**	45	46	47
32	33	**34**	**35**	**36**	**37**	38	39
24	25	**26**	**27**	**28**	**29**	30	31
16	17	18	**19**	**20**	21	22	23
8	9	10	11	12	13	14	15
0	1	2	3	4	5	6	7



Step 2 – Liquid level measurement

- Take highest signal rate center zone
- Extract this zone distance
- To obtain liquid level, subtract measured distance from container height





Software reference: STSW-IMG039_L5CX

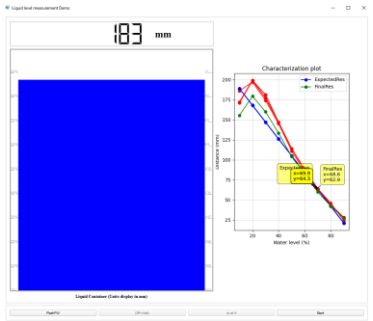
Application Note AN5843

VL53L4CD single-zone solution

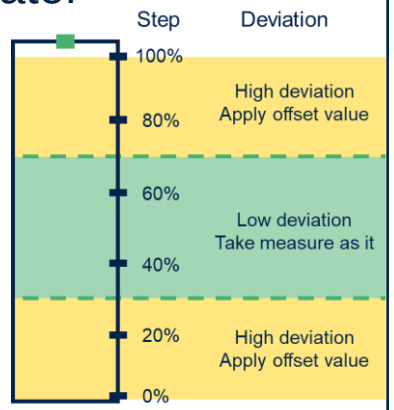
Step by step VL53L4CD Liquid Level Monitoring solution implementation

Step 1 – Use the characterization tool

- Define liquid level indicator count
- For each characterization (min = 4), measure liquid level for each indicator
- Characterization tool creates a lookup table of which offset to apply per level indicator

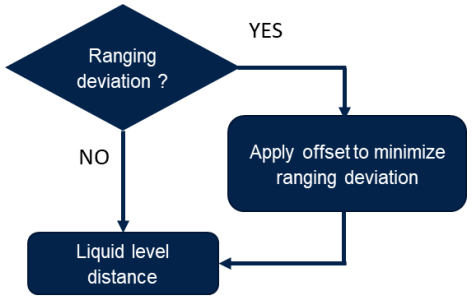


Indicator level	ExpectedRes (mm)	OC_val
C9	21	4
C8	42	4
C7	63	2
C6	84	1.6
C5	105	4.8
C4	126	13.5
C3	147	24.8
C2	168	30
C1	189	20.3



- Define which zones to apply offset to be integrated in system algorithm

Step 2 – Use the ST algorithm



- Measure liquid level
- If measurement is non-linear
- Then, apply offset from lookup table to measured distance
- Else, use ranging as is
- To obtain liquid level, subtract measured distance from container height

Software reference: STSW-IMG039_L4CD

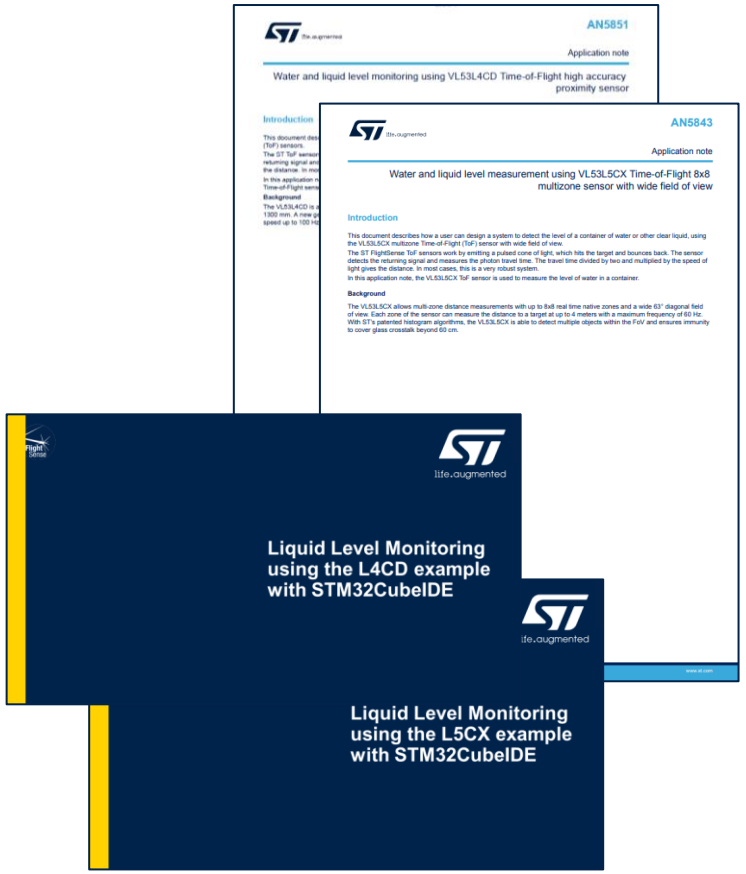
Application Note AN5851

life.augmented

Support on st.com

www.st.com/en/embedded-software/stsw-img039

Documentation



Videos

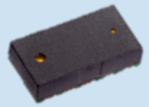
https://bit.ly/3iZSsx1

https://bit.ly/3z7aapN

life.augmented

FlightSense™ VL53L4CD Ordering codes

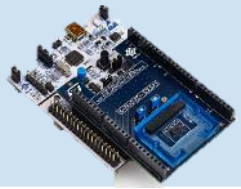
Go to https://st.com/VL53L4CD or contact your usual distributor

Item	Picture	Commercial Product (= Order Code)	Comments
VL53L4CD sensor		**VL53L4CDV0DH/1**	Delivery in T&R MOQ: 4.5ku With protective liner
VL53L4CD Nucleo™ Expansion board		**X-NUCLEO-53L4A1-**	To go along with STM32F401 Nucleo board. Comes with cover-glass holder, 2x cover-window samples
Pack: VL53L4CD Nucleo™ Expansion board + STM32F401 NUCLEO		**P-NUCLEO-53L4A1-**	X-NUCLEO-53L4A2 expansion board delivered together with STM32F401 NUCLEO board
VL53L4CD Breakout boards		**SATEL-VL53L4CD**	2x Breakout boards delivered

life.augmented

FlightSense™ VL53L5CX Ordering codes

Go to https://st.com/VL53L5CX or contact your usual distributor

Item	Picture	Commercial Product (= Order Code)	Comments
VL53L5CX sensor		**VL53L5CXV0GC/1**	Delivery in T&R MOQ: 3.6ku With protective liner
VL53L5CX Expansion board		**X-NUCLEO-53L5A1/**	To go along with STM32F401 Nucleo board. Comes with cover-glass holder, cover-window sample, 3x spacers
Pack: VL53L5CX Nucleo™ Expansion board + STM32F401 NUCLEO		**P-NUCLEO-53L5A1/**	X-NUCLEO-53L5A1 expansion board delivered together with STM32F401 NUCLEO board
VL53L5CX Breakout boards		**VL53L5CX-SATEL/1**	2x Breakout boards delivered

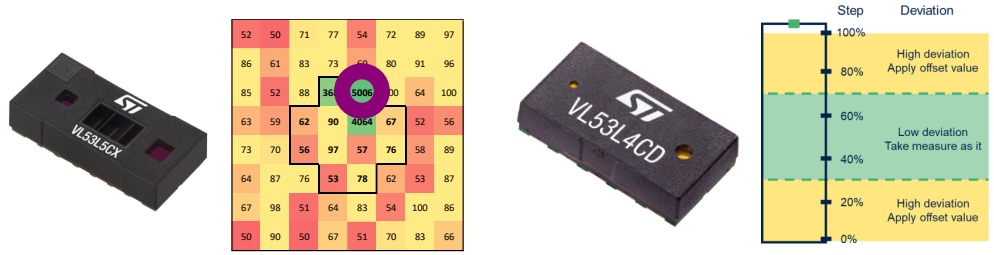
life.augmented

FlightSense™ Summary

Leader on Direct ToF

= 1st

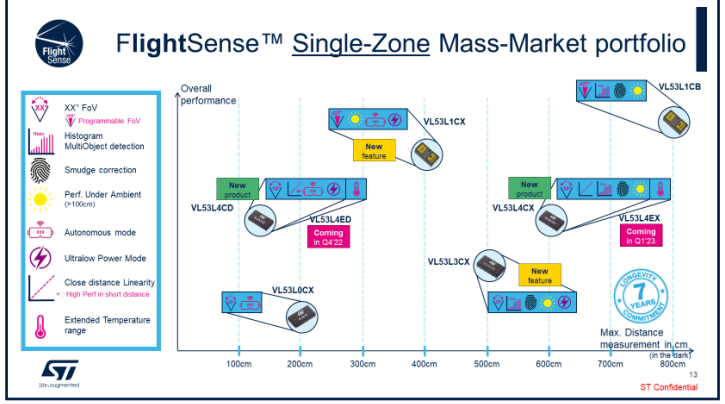
Two liquid level monitoring solutions



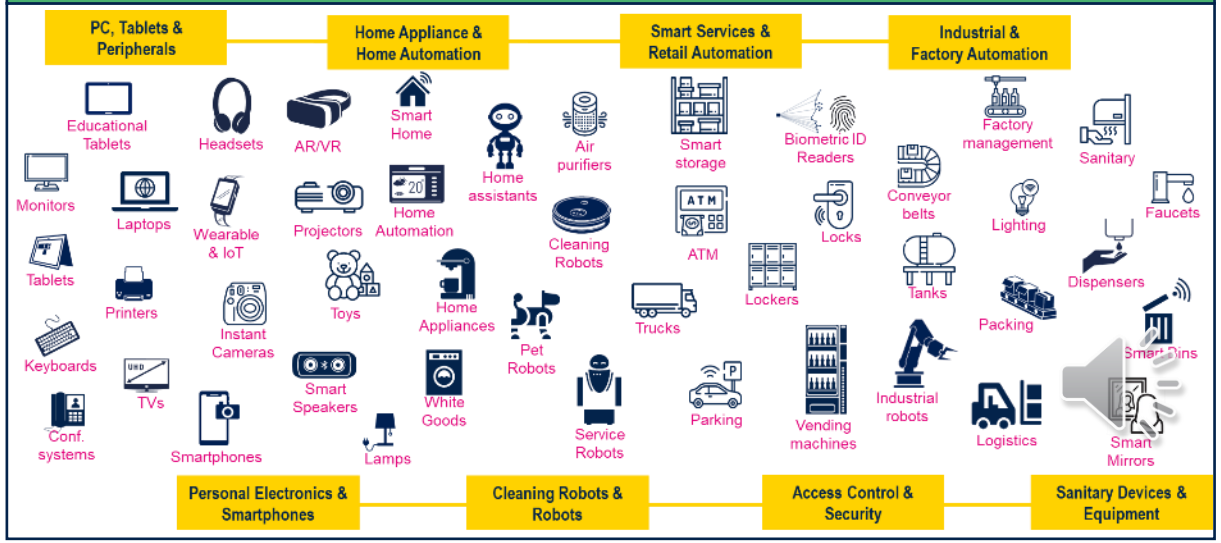
FlightSense benefits

- Not “intrusive”
- Works with all type of liquids
- Small size

Continuous improvement



Unlimited markets & applications



life.augmented

Our technology starts with You

life.augmented