

ToF & Radar Sensors Solutions

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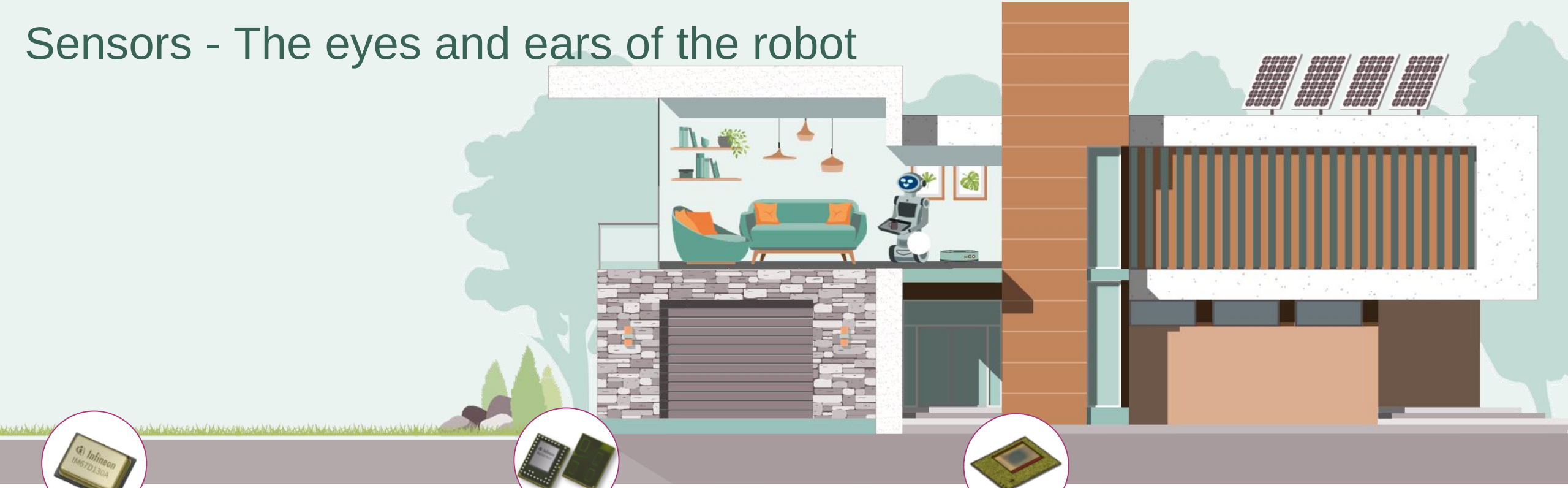
2022 Edition

Sensors - The eyes and ears of the robot



Silicon microphones

- Highest signal to noise ratio (SNR)
- Infineon sealed dual membrane (SDM) for water and dust proof (IP57) on microphone level
- Easy to integrate and small packaging size

RADAR

- 24 and 60 GHz RADAR sensors portfolio
- Compact and cost-efficient radar chips
- High sensitivity for reliable motion and distance detection
- Able to operate without visible lens and through plastic cover

Time of flight

- Up to VGA (640 x 480 points) 3D depth resolution
- Highest level of integration at smallest footprint
- Industry leading performance and sunlight robustness
- Lowest cost 3D cameras with low cost architecture and smallest footprint companion VCSEL driver

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Use-cases for robot vacuum cleaners of ToF & Radar



Object Detection & Avoidance
Move around objects smartly



SLAM
Simulataneous Localization And Mapping



Presence Detection
For intruder alert



Cliff detection
Reduce & simplify BOM and get rid of multiple ultrosonic sensors



Material Detection
Floor type, carpet, pet fluids, etc.

Feature	60GHz Radar	ToF
Technology	Radio wave	IR light
Range	~15m	~10m
Resolution	👍	👍👍
Affected by lighting conditions	No	Limited SBI in every pixel
Affected by dust	No	Yes
Size	👍	👍

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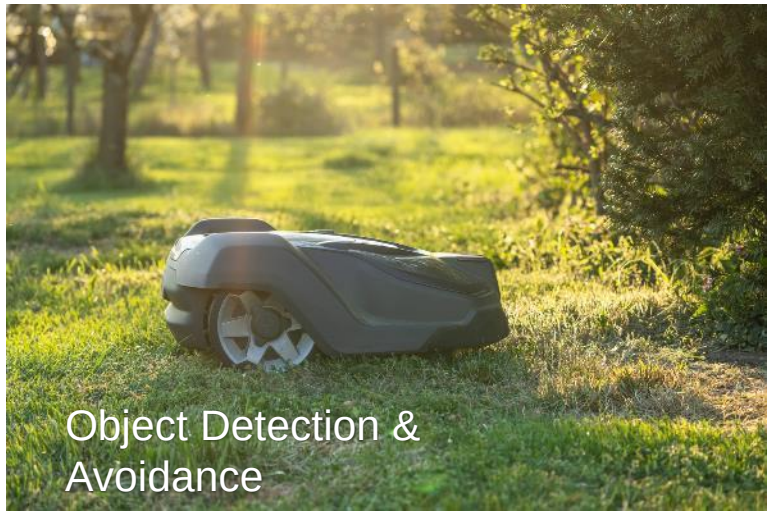
Radar showing several benefits over ultrasonic sensors in lawn mowers

1 Radar sensor can replace multiple ultrasonic sensors to fulfill use cases:
- material detection
- object avoidance.

Added Radar benefit:
- Ultrasonic sensors may not differentiate between dry vs. wet soil which may contribute to increased robotic wear & tear.

Feature	60GHz Radar	Ultrasonic
Technology	Radio wave	Sound wave
Range	~15m	~5m
Resolution	👍	👎
Affected by lighting conditions	No	No
Affected by dust	No	Yes
Size	👍	👍





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Infineon sensors are enabling smarter robots at lower system cost



ToF = 1 sensor for short an long range applications

- **Advanced obstacle avoidance**
  - Obstacles easy to identify in point cloud
- **SLAM optimized camera solution for mapping and navigation**
- **100% replacement for LDS!**
  - lower **build height**
  - **No** mechanical **moving parts**
  - Reduced **BOM**
- Time of Flight camera provides both **3D point cloud** and actively illuminated **infrared image**
  - Allows **operation in the dark**
  - **No** additional **flash light** required
- **Successfully** launched in **multiple robot products**

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Time-of-Flight enabled robotic applications

SLAM and navigation



Time of Flight benefits for mapping

- Accurate long range depth
- High resolution 3D map
- No mechanical parts
- Reduced robot build height possible < 5,5 cm
- ToF imagers provide 3D point cloud and IR night vision data this allows to operate in the dark

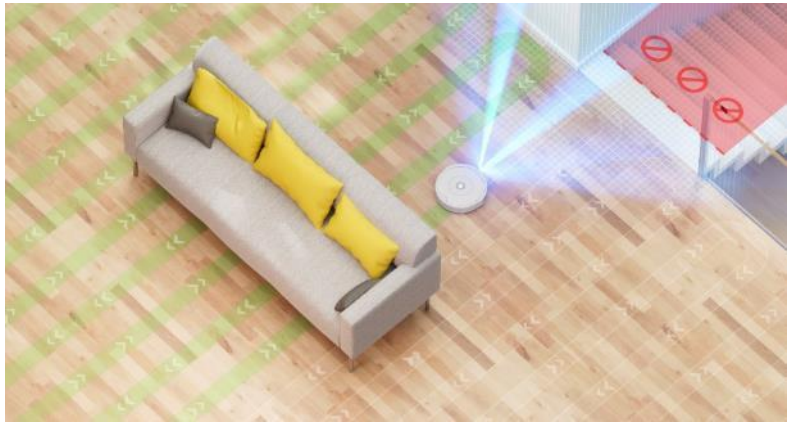
Advanced obstacle avoidance



Time of Flight benefits for obstacle avoidance

- Obstacle segmentation is inherent for 3D ToF imagers
- No previous training required to detect obstacles
- High resolution 640 x 480 pixel ToF data allows to detect even very small objects

Cliff detection



Time of Flight benefits for cliff detection

- No additional sensor required
- Reduced wiring effort and assembly cost compared to traditional cliff-detection sensors
- Obstacle avoidance abd cliff detection my require functional safety. ASIL B imager available

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Infineon XENSIV™ time of flight and RADAR

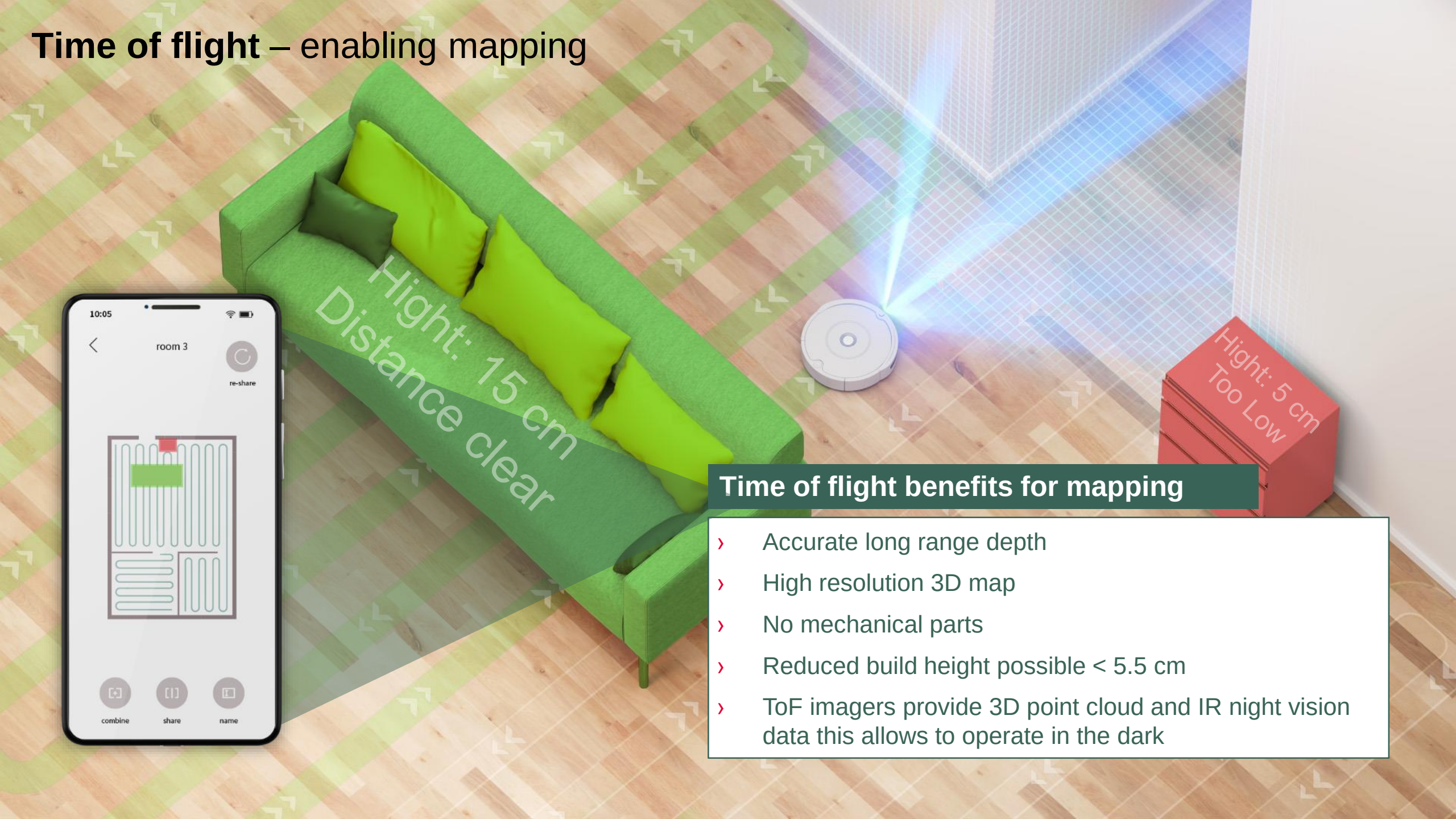
Enabling robotic applications



Time of flight and RADAR applications

- 3D Mapping/SLAM
- Advanced obstacle avoidance
- Cliff detection
- Fusion improved presence detection
- Glass and mirror detection
- Surface detection

Time of flight – enabling mapping



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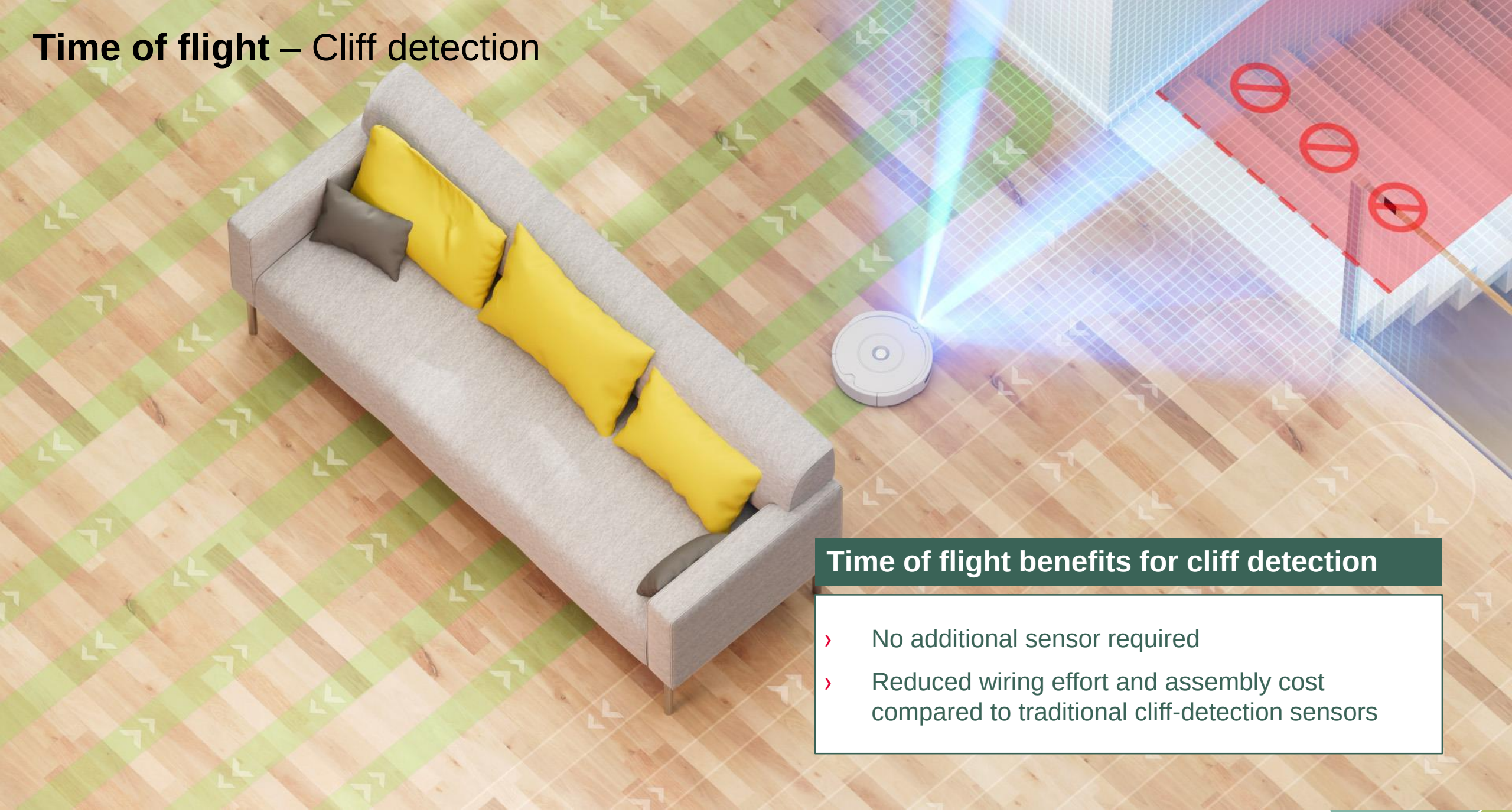
Time of flight – Cliff detection



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Time of flight and RADAR fusion – presence detection



Time of flight and RADAR fusion

- For time of flight the presence of humans or animals are identified as large obstacles
- ToF and RADAR fusion can increase recognition rate
- Segmentation and tracking allows to clean rooms without humans first
- RADAR is most sensitive for vital sensing (breathing and heart beat) - Intruder alert
- Silicon Microphones allow for voice commands and 2-way human interaction

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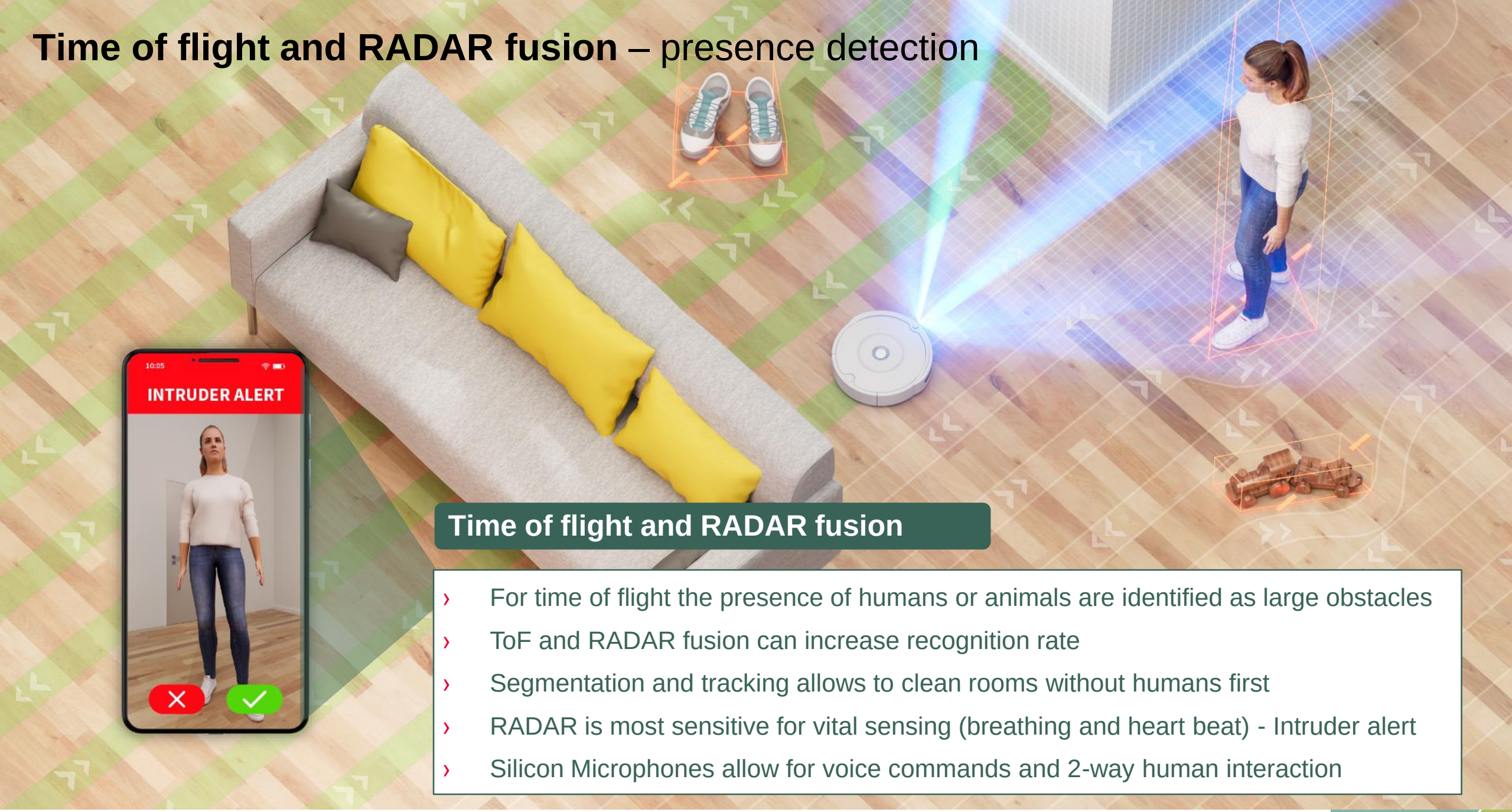
Time of flight and RADAR fusion – presence detection



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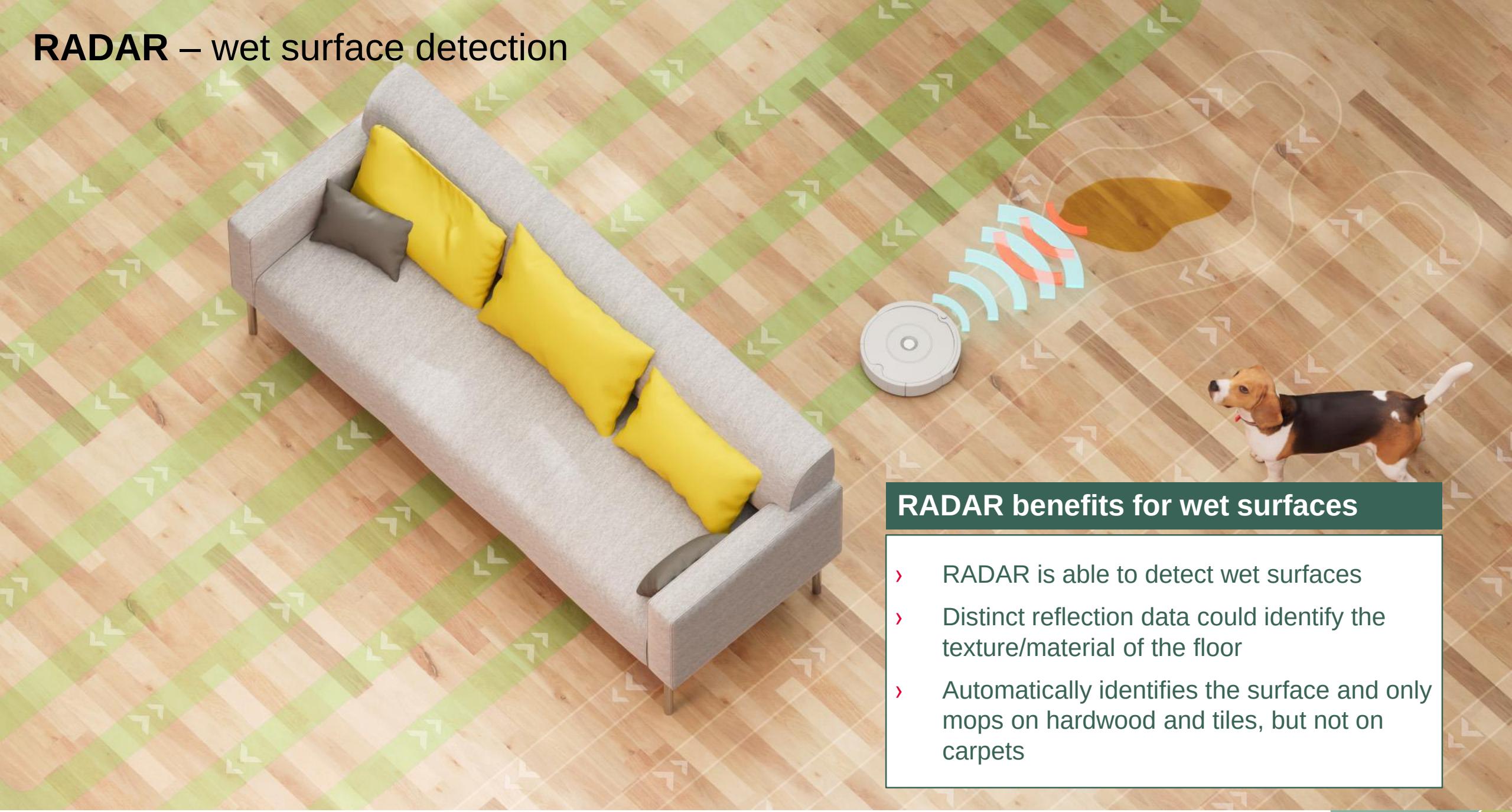
RADAR – wet surface detection



RADAR benefits for wet surfaces

- RADAR is able to detect wet surfaces
- Distinct reflection data could identify the texture/material of the floor
- Automatically identifies the surface and only mops on hardwood and tiles, but not on carpets

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Infineon XENSIV™ time of flight and RADAR

Enabling robotic applications



Benefits & use cases enabled by Time of flight and RADAR applications

- 3D Mapping/SLAM
- Advanced obstacle avoidance
- Cliff detection
- Fusion improved presence detection
- Glass and mirror detection
- Surface detection

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Getting started - **flexx2** by pmd technologies

Time of Flight Evaluation Kit (Explore the FLEXX2 family)

pmd 3D Sensing Family

flexx2 | Getting Started Guide



2. flexx2 Specifications

Parameter	Flexx2
Dimensions	72.1 mm x 19.2 mm x 10.2 mm
Time of Flight (ToF) Sensor	IRS2381 Infineon® REAL3™ 3D Image Sensor IC based on pmd technology
Resolution	224 x 172 Depth Pixels 38,000 Depth Points
Weight, without USB Cable	13g
Measurement range	0.1 – 4 m
Framerate	Up to 60fps (3D frames); 9 pre-defined operation modes
Power consumption	USB3.0 compliant, average 300mW for full system
Illumination	940 nm, VCSEL, Laser Class 1
Software	Royale SDK (C/C++ based, supports Matlab, OpenCV, ROS 1/2)
Viewing angle (H x V)	56° x 44°
Interface	USB3.0 (data & power)
Depth resolution	<= 1% of distance, all modes
Sunlight Tolerance	At 100K Lumens (Full Sunlight), Loses ~10% max range vs. Indoors
Operating System	Windows 10, Linux/ARM

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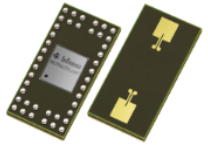
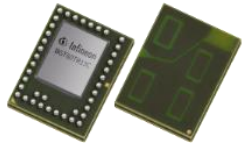
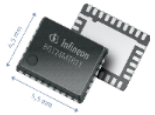
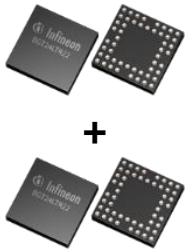
Broad Product Portfolio for 60GHz and 24GHz

	1Tx / 1Rx	1Tx / 2Rx	1Tx / 3Rx	2Tx / 2Rx	2Tx / 4Rx
60GHz	PIR replacement  **3.3x6.5 mm²** **BGT60LTR11AIP** Doppler Radar **Antenna-in-Package**		Consumer  **5 x6.5 mm²** **BGT60TR13C** FMCW Radar **Antenna-in-Package**		(Automotive)  **6 x 6 mm²** **BGT60ATR24C** FMCW Radar **Without Antenna**
24GHz	 ***2.4 x 2.4 mm*** **BGT 24LTR11**  ***4.5 x 5.5 mm*** **BGT 24MTR11**	 ***4.5 x 5.5 mm*** **BGT24MTR12**	 **BGT24MTR11** **+ BGT24MR2**	 ***3.6 x 3.6 mm*** **BGT24LTR22**	 **Cascading** **BGT24LTR22**

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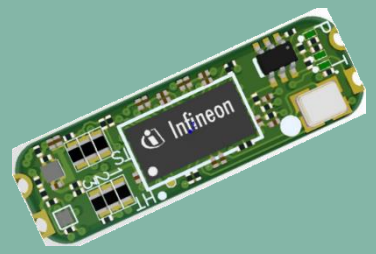
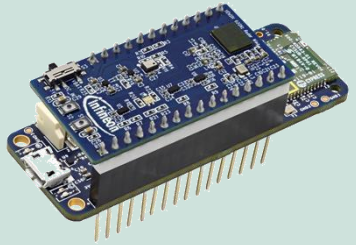
Choose the best evaluation and implementation tool

- Ready to go radar
- Radar development
- Systems development with radar
- XENSIV™ BGT60TR13C SoM

	 **BGT60LTR11AIP Autonomous mode**	 **DEMO 60 GHZ TR13CAIP** w/ RADAR SDK for presence	 **Connected Sensor Kit** FW in ModusToolbox®	 **XENSIV™ BGT60TR13C System on Module (SoM) (Via Partners)**
Presence sensing	Simple motion detection	Micro/macro motion detect, ranging	Micro/macro motion detect, ranging	Micro/macro motion detect, ranging
Additional functions	None	Segmentation, tracking, vital sensing, gesturing	Smart entrance counter	Programmable to also do Smart entrance counter / Advanced presence*
Networking capable	Through Arduino MKR	Through Arduino MKR	Feather board with CYSBSYS-RP01 SoM	Through separate connectivity board
Solution size	20 mm x 6.25 mm	17 mm x 12.7 mm (RF shield)	75 mm x 25 mm	20 mm x 15 mm
Range and field of view	5 m (at 0°) +/- 40 degrees	10 m (at 0°), +/-45	10 m (at 0°), +/-45	10 m (macro motion at 0°) (**qualified up to 5 m**), +/-45
Intended usage	PIR replacement	Eval & testing use cases, development, ref. design	Self-contained IoT system, PoC starter, ref design	Entrance counter presence/motion detector

*Dependent on application and system

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Further Material – Sensors



Portfolio and further information can be found here:

- Link ➔ Radar
- Link ➔ Time-of-Flight (ToF)
- Link ➔ pmd ToF FLEXX cam family

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