



# ACCURACY TEST REPORT

All-Out Test for Reliable Accuracy

VS330 Bathroom Occupancy Sensor

The LoRaWAN logo is located on the left side of the diagram. It consists of the text "LoRaWAN" in a blue, sans-serif font, with a blue signal icon to the left of the text. The logo is enclosed in a white speech bubble shape that points towards the sensor.

PIR | ToF

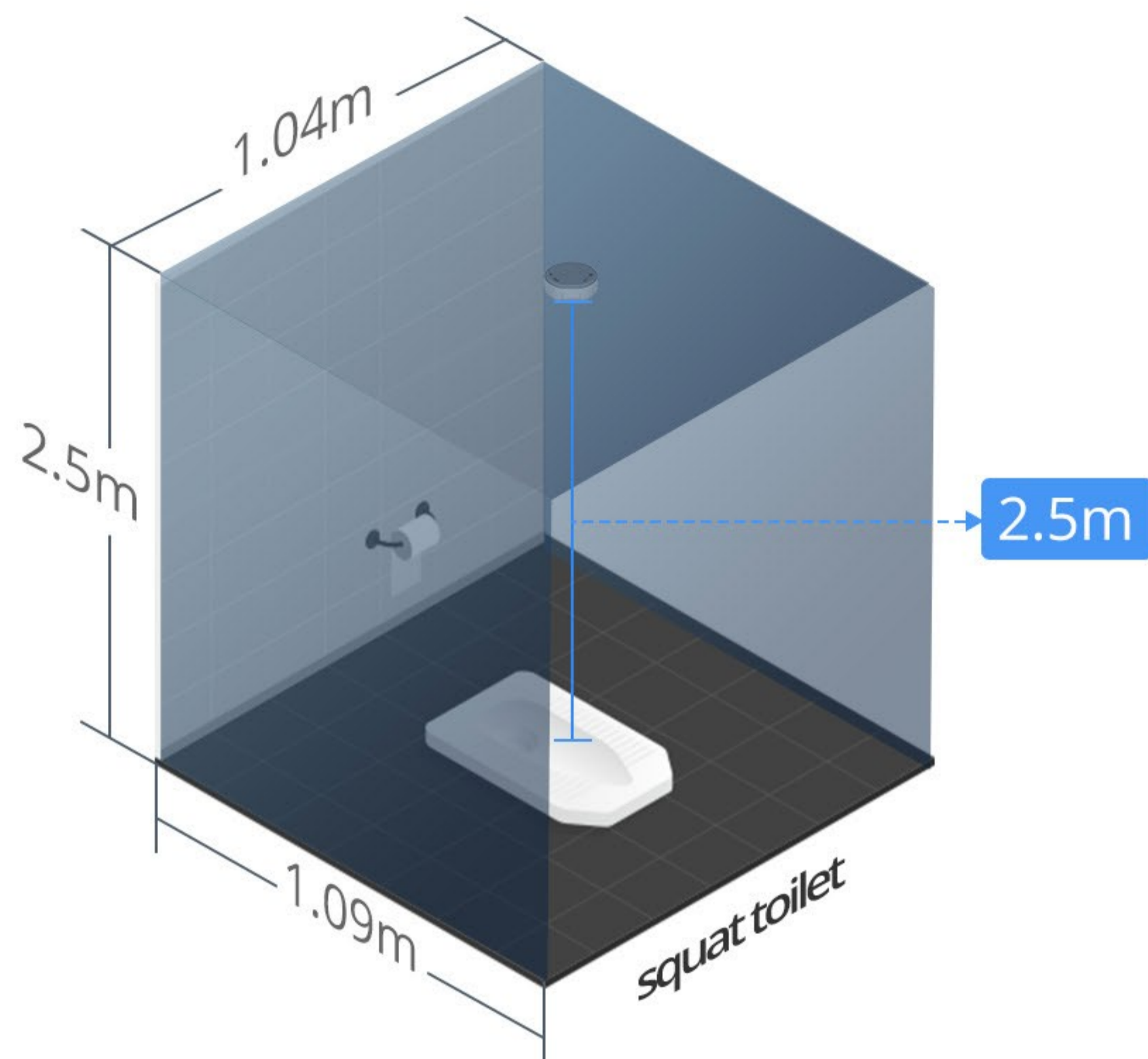


## TEST ENVIRONMENT

### Size of the Restroom

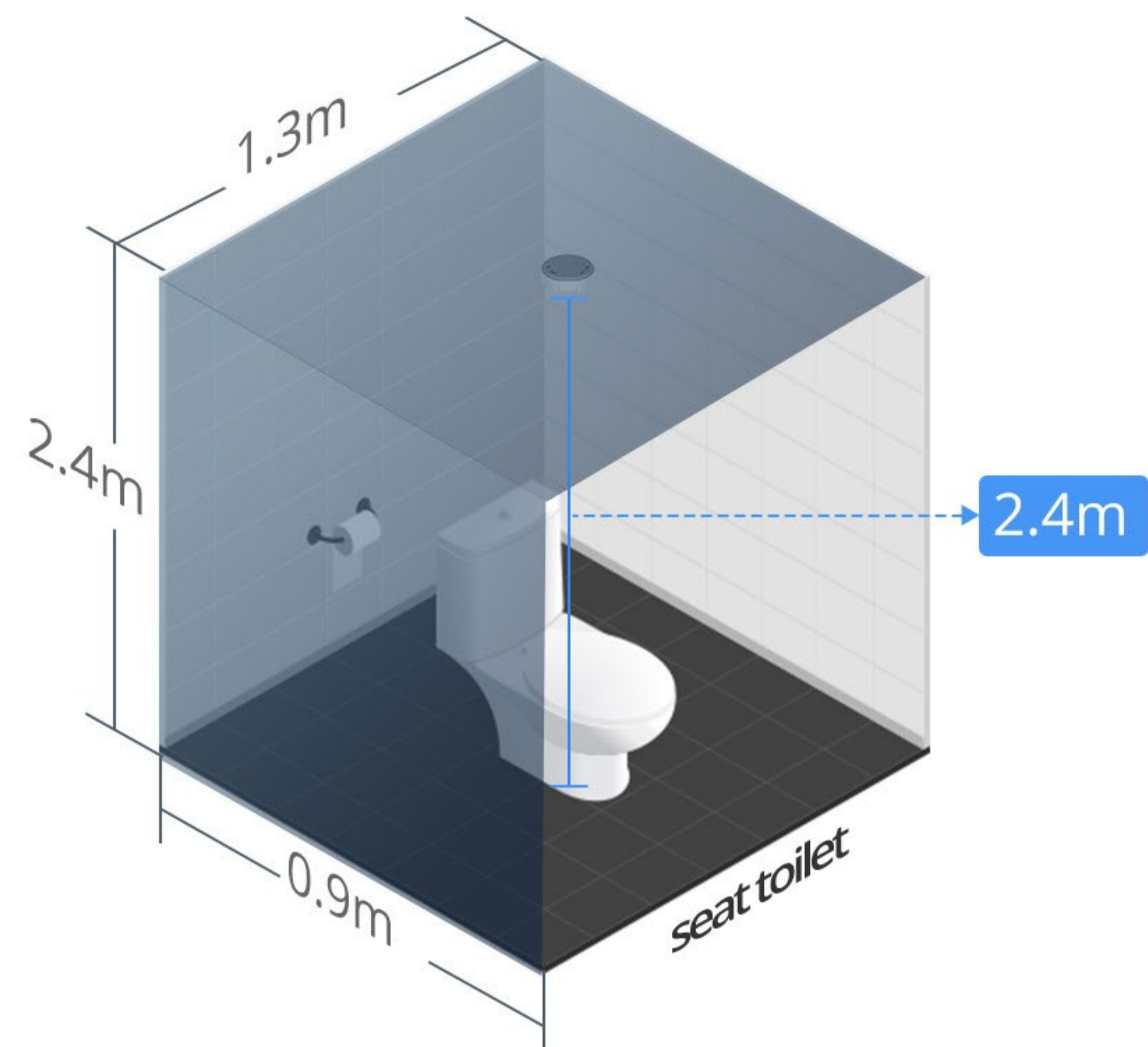
#### Squat Toilet

- 1.09m (L) \* 1.04m (W) \* 2.5m (H)
- Device Installation Height: 2.5 meters



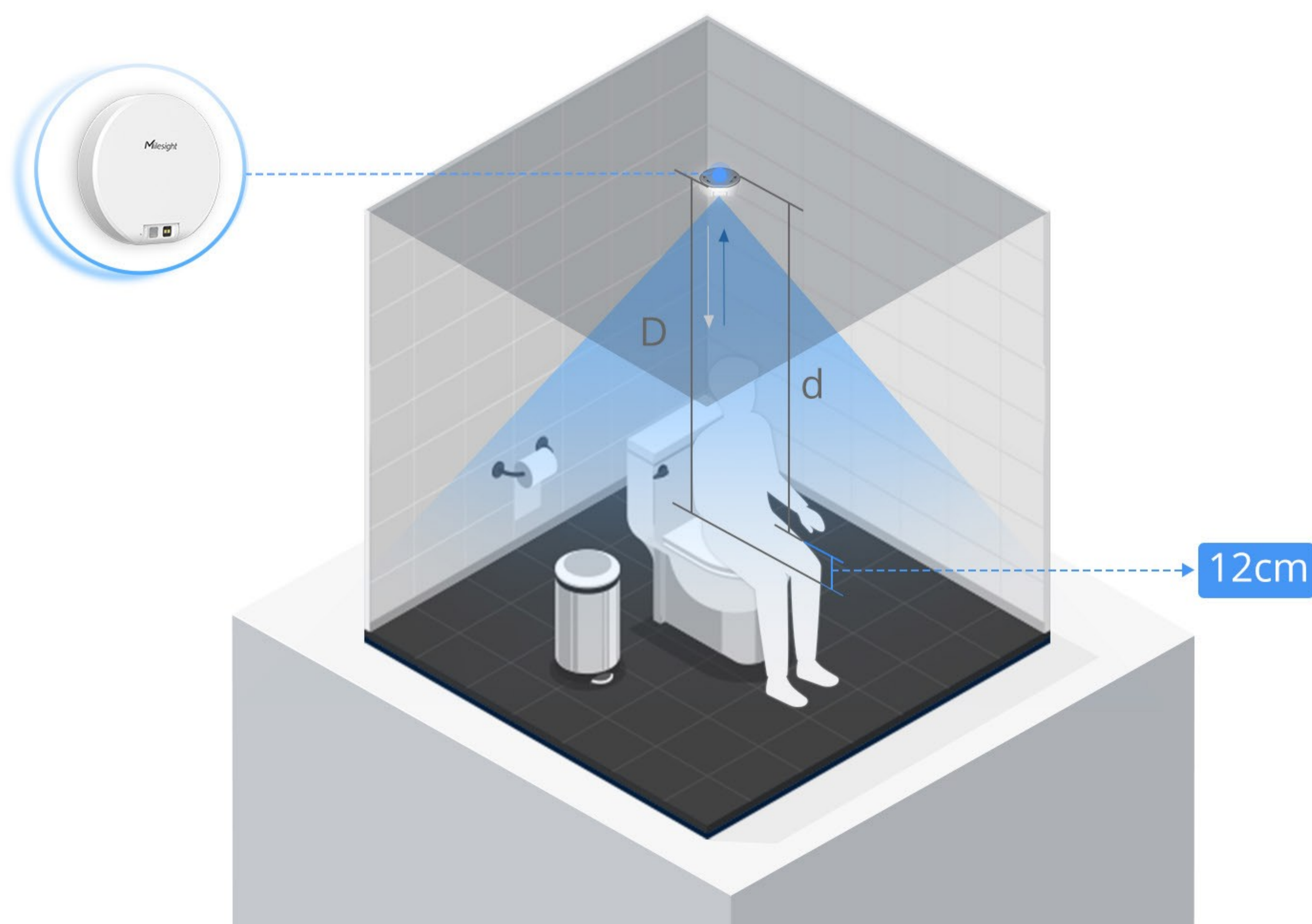
#### Seat Toilet

- 1.3m(L) \* 0.9m(W) \* 2.4m(H)
- Device Installation Height: 2.4 meters



## CONFIGURATION

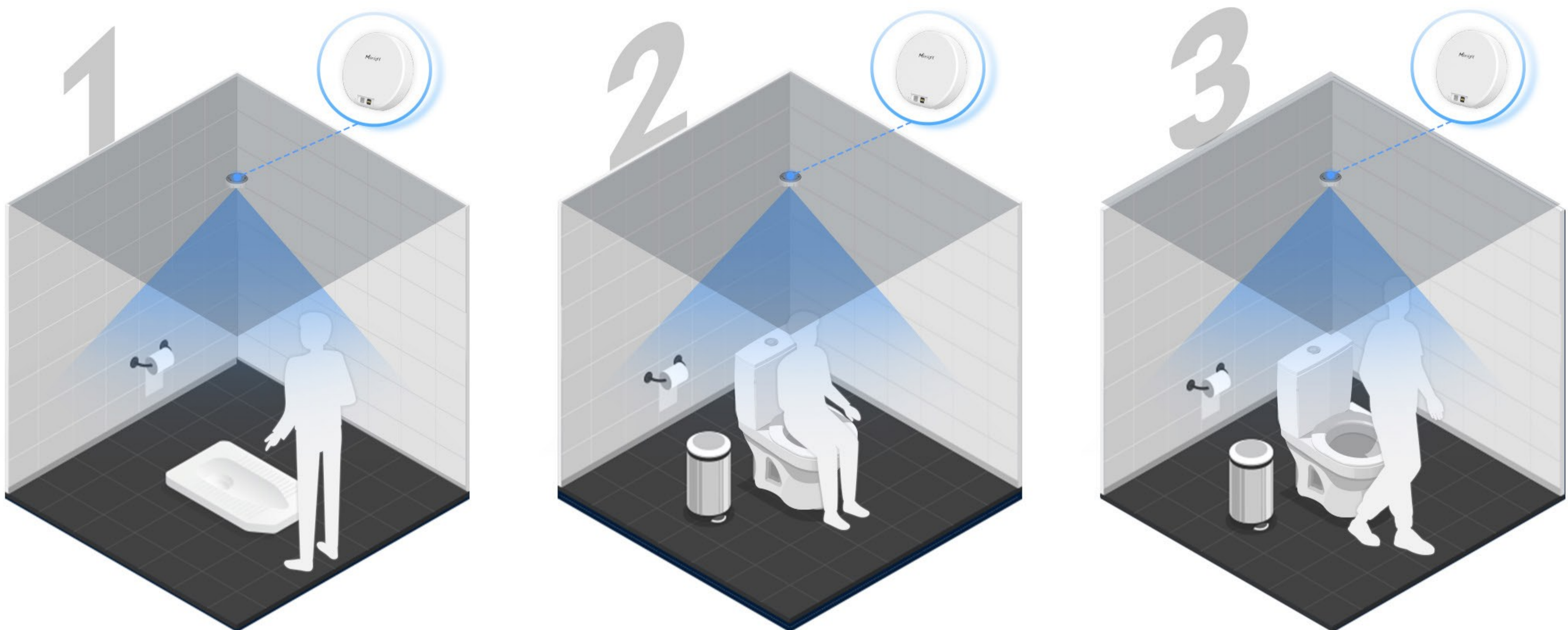
### Height of Human Presence: 12cm



# TEST RESULTS

## 1. Motion Test

Test Items	Total Number of People	Accuracy	
		Seat Toilet	Squat Toilet
Entering the cubicle and standing for 30 seconds	36	100%	100%
Sitting/Squatting for 2 minutes	36	100%	100%
Sitting/Squatting and then standing for 30s	36	100%	100%



### Analysis

Recognizing dynamic users with high accuracy is crucial for cubicle occupancy detection since movements are irregular and uncontrollable. Combining dual technologies of PIR and ToF, the people in different motions and statues like entering, standing, sitting, squatting, and existing can be precisely detected to reveal real-time occupancy conditions accurately.

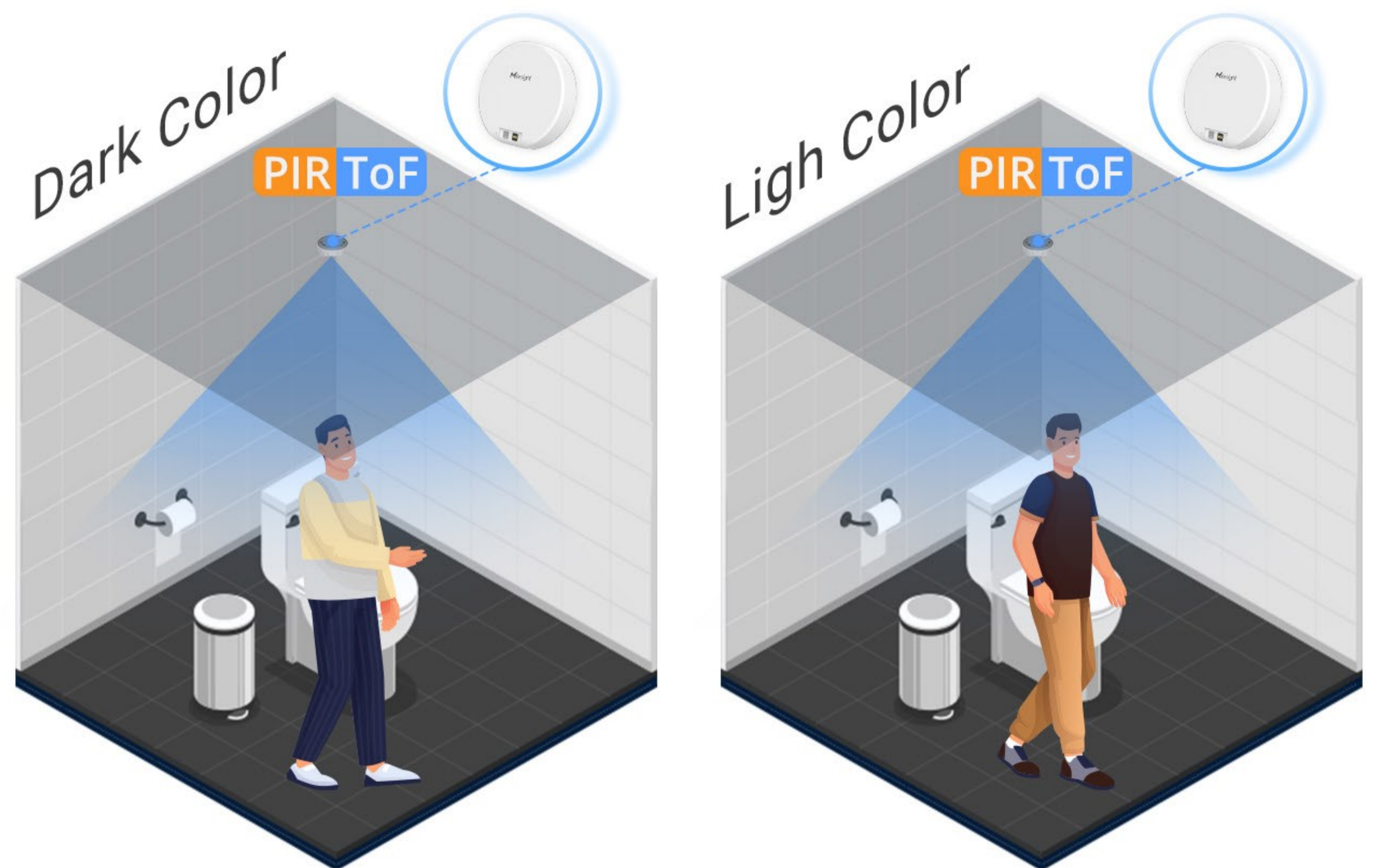
# TEST RESULTS

## 2. Clothing Testing

Test Items	Total Number of People	Accuracy	
		Seat Toilet	Squat Toilet
People dressing in dark color	14	92.30%	100%
People dressing in light color	21	100%	100%

### Analysis

Theoretically, wearing clothing of dark colors can potentially reduce accuracy in ToF detection since dark colors like black have a weak reflective ability while having a strong absorption ability, which may lead to fewer photons reflection and cause accuracy deviation.

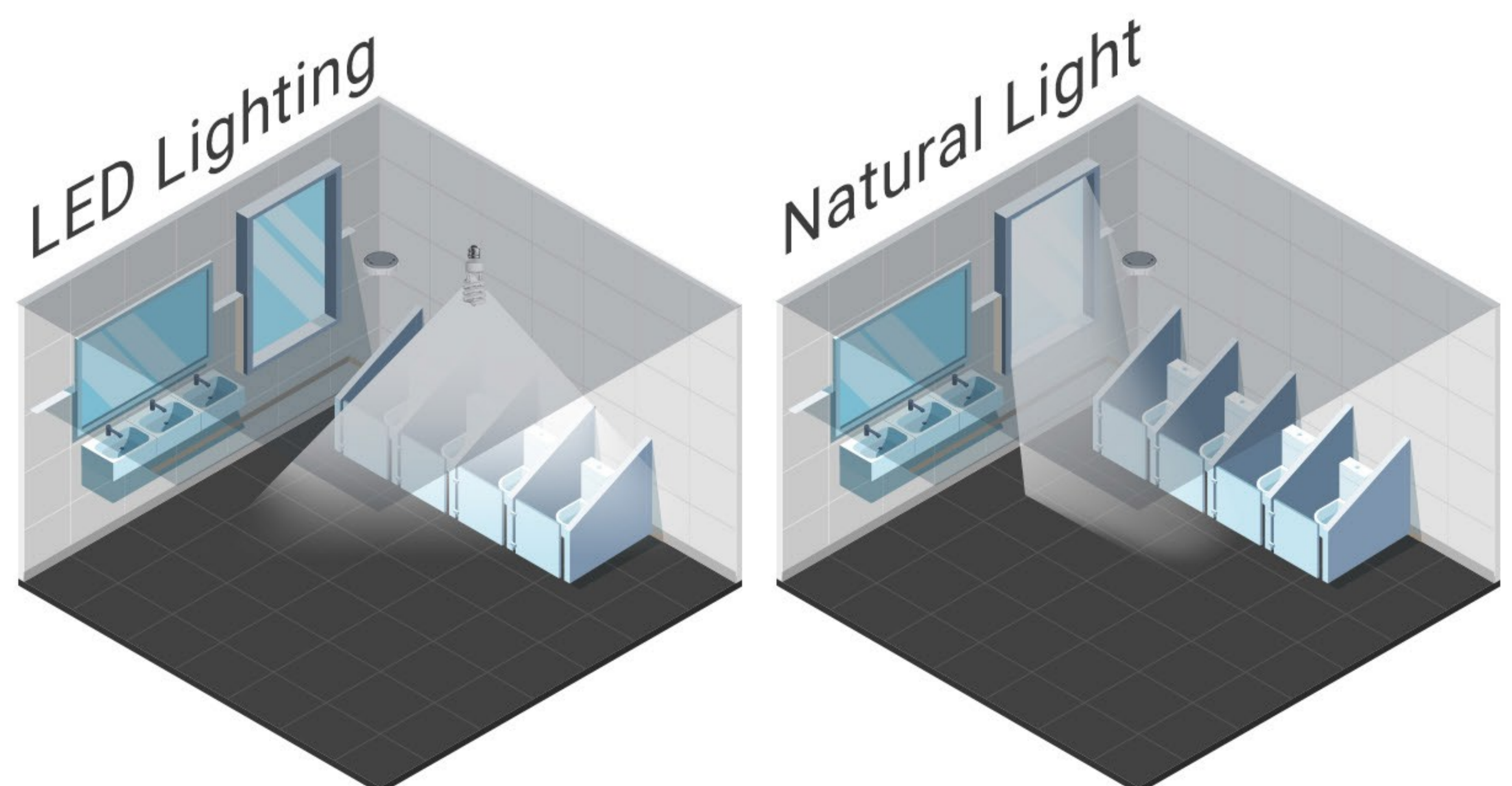


## 3. Lighting Environment Testing

Test Items	Total Number of People	Accuracy	
		Seat Toilet	Squat Toilet
Indoor LED Lighting	36	100%	100%
Indoor Natural Light	36	100%	100%

### Analysis

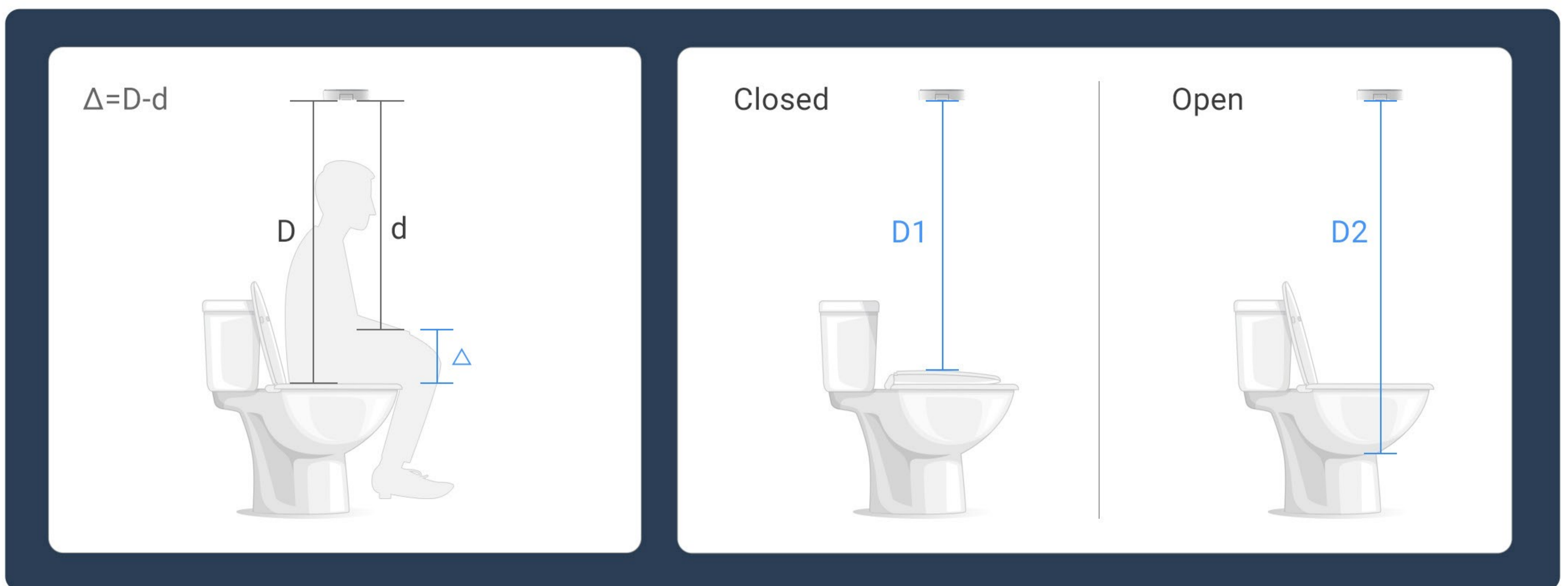
Lighting types have little influence on ToF performance as the ToF technology emits laser light itself and it calculates flight time to detect objects instead of imaging. So it is not demanding in lighting types like LED lighting and natural light as long as there is no direct light in between the area of in and out to affect laser light it emits. To sum up, it can perform perfectly in any lighting type.



# TEST RESULTS

## 4. Self-Learning Algorithm Accuracy Testing

Test Items	Total Number of People	Accuracy
		Seat Toilet
Toilet Seats Left Closed	36	100%
Toilet Seats Left Open	36	100%



### Analysis

The ToF sensor in VS330 is equipped with a lens that can focus the photons on the 16x16 SPADs sensing array. To determine if a cubicle is occupied, it requires an original distance (shown as "D" in the picture) and the detected distance when the cubicle is occupied (shown as "d" in the picture). The algorithm will calculate the difference between "D" and "d" (shown as "Δ" in the picture) to determine if someone is using the toilet. Since "D" the original distance is not always fixed, as in squat toilet, it can be different when the toilet seat is open or closed. With embedded Self-Learning Algorithm, VS330 can avoid misdetection that may caused by the different "D" and further enhance accuracy.

# INFLUENCE FACTORS

Influence Factors		Influenced or Not	Accuracy
Objects	Hats or Helmets	N	Relatively small objects compare to the human body will not affect the results of ToF detection.
	Animals	Y	Animals that emit infrared similar to the human body will affect PIR results
	Objects	N	Objects without infrared will not affect PIR results
	Clothing Color	Y	Wearing clothing of dark colors can potentially reduce accuracy in ToF detection.
Environment	Bright	N	Low light or complete darkness environment will not affect the accuracy of the human presence detection.
	Dark	N	
	Direct Lighting	Y	Directly light will affect the detection result especially when the direct light is in between the area of in and out.
Environment	Wall Mounting/ Ceiling Mounting	N	The accuracy will not be affected by the installation method as long as the sensor probe is aligned with the toilet.
	Strong Reflections within Installation Area	Y	Strong reflections within the installation area can negatively affect the detection accuracy as they significantly impact how light travels in the environment.

## CONCLUSION

The accuracy of Bathroom Occupancy Sensor VS330 is evident through numerous tests, exceeding 99.5%. Using a combination of ToF and PIR technology, the VS330 can effectively determine human presence, despite different conditions such as body movement, clothing, and bathroom size. However, some factors such as objects resembling a human or direct sunlight will still impact its results. Avoiding these detrimental elements, VS330 will yield the best detection accuracy.

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