APC Webinar

Automatic Passenger Counting with expandable features

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Automatic Passenger Counting

History of APC technologies
Current status of systems
Future/trends of APC technologies
How it benefits transit agencies
Challenges
Accuracy issues
Reliability
Hardware maintenance issues
Etc.

Automatic Passenger Counting

- Detailed counts at stop level for every route
- Calculating on-time performance
- Ridership by trip, route, stop, time-periods, peak time etc
- NTD reporting

Automatic Passenger Counting

Agency expectation of an APC system?

- Most important: Accurate data
- Specify the margin of error it must meet
- Testing methods process of installed product

Automatic Passenger Counting

History of APC technologies

- Counting mats
- Side Beam Barrier
- Weight measurement (train)

- Reflection light scanner (active only)
- Thermo scanner (passive only)

- Combination of active and passive sensor
- Time of flight technology IRMA 3D

- Video based system
- **Time of Flight** (**TOF**) technology produces **3D images**

Automatic Passenger Counting

Current status of APC systems

Counting Mats	Obsolete			
Side Beam barrier	Obsolete, but still in use	UTA, Trapeze (Red pine), Clever Devices		
Active sensor technology	Current	Dilax, Infodev, UTA, IRIS IRMA Basic /INIT		
Active Passive Technology	Will be phased out in 2016	IRIS IRMA advanced /INIT		
Time of Flight 4 pixel	Current	IRIS IRMA 3D/INIT		
Stereoscopic camera	Current	Hella		
Time of flight 3D Images 500 pixel	Current	Iris IRMA Matrix/INIT		

Legacy Sensors

- Horizontal Beams
- Poor accuracy when there is a wide door on the bus and two people walk in at the same time
- What happens if somebody stands in the door way while another person walks out?
- Low accuracy when bulk entries occur

Example installation

- Video camera needs sufficient distance to object, Camera can not mounted in the door area. Needs height clearance
- Dependant on sufficient light
- Vulnerable to changing conditions (temperature, moisture, reflections)
- Active sensor: Low accuracy when bulk entries occur
- Sensors have to correctly adjusted to avoid false counts (maintenance costs)

APC Key Components

- Counting and analyzing

- IRMA System

- Storing and Transmitting

- OnBoard Computer

- Processing & Evaluating

- MOBILEdvm
- MOBILEstatistics

APC system integration

- **Vehicle survey: Width and height of the door**
- **Mounting Location of Equipment**
- **Installation testing and verification**
- **APC Test Ride**
- **APC verification based on IRIS specification related to VDV Standard 457**

Sensor Product Family

IRMA4-Basic
Active Infrared
Signal Detection

IRMA4-Advanced
Active-Passive Infrared
Signal Detection

IRMA4-3D
Infrared Distance Detection

IRMA5-Matrix
Infrared Image Detection

init

Accuracy Overview

	IRMA Basic (Active)	IRMA Advanced (active/passive)	IRMA 3D TOFL	IRMA Matrix TOFL
Passenger error	5%	5%	4%	2%
Balanced error for boarding passengers	13%	10%	8%	4%
Balanced error for alighting passengers	13%	10%	8%	4%
Typical Unbalanced error	NA	NA	10%	< 8 %
Required Passengers	1000	700	500	500

Accuracy IRIS Accuracy Definition

Manual counting is assumed to be error-free.

Stops	Manual counting		IRMA counting		Error (absolute value)	
	In	Out	In	Out	In	Out
1	30	1	28	2	2	1
2	4	0	4	0	0	0
3	4	2	4	4	0	2
4	1	2	1	1	0	1
5	0	15	0	15	0	0
6	5	3	6	4	1	1
7	0	2	0	2	0	0
8	4	6	3	6	1	0
9	2	8	2	8	0	0
10	0	11	0	12	0	1
Total	**50**	**50**	**48**	**54**	**4**	**6**

In this example

$$\text{the passenger error is } = \frac{(48 + 54) - (50 + 50)}{50 + 50} \times 100\% = 2\%,$$

$$\text{the balanced entering passenger error is } = \frac{48 - 50}{50} \times 100\% = -4\%,$$

$$\text{the balanced exiting passenger error is } = \frac{54 - 50}{50} \times 100\% = 8\%,$$

$$\text{the unbalanced error is } = \frac{4 + 6}{50 + 50} \times 100\% = 10\%.$$

Accuracy IRMA Testride MTS San Diego

Statistical evaluation

Total result | Door 1 | Door 2 | **Door 3** | Door 4

No.	File Name	IRMA In	IRMA Out	Manual In	Manual Out	Diff. In	Diff. Out	Abs. In	Abs. Out
1	0300001.uff	6	0	5	0	+1	0	1	0
2	0300002.uff	1	1	1	1	0	0	0	0
3	0300003.uff	1	0	1	0	0	0	0	0
4	0300004.uff	3	7	3	7	0	0	0	0
5	0300005.uff	1	0	1	0	0	0	0	0
6	0300006.uff	2	1	2	1	0	0	0	0
7	0300007.uff	3	2	3	2	0	0	0	0
8	0300008.uff	0	0	0	0	0	0	0	0
9	0300009.uff	0	3	0	3	0	0	0	0
10	0300010.uff	1	1	1	1	0	0	0	0
Sums		36	27	35	27	+1	0	1	0

Error	Boarding	Alighting	Total
Balanced	2.9 %	0.0 %	1.6 %
Unbalanced			

Passenger error: 1.6 %

Statistical base: 62 passengers

25 door operations

24 error-free

OK

init

Accuracy Overview MTS San Diego

Sums	36	27	35	27	+1	0	1	0

Error	Boarding	Alighting	Total
Balanced	2.9 %	0.0 %	1.6 %
Unbalanced			

Passenger error: 1.6 %
Statistical base: 62 passengers
25 door operations
24 error-free

RAW Data

$$\text{Passenger error} = \frac{(36+27)-(35+27)}{35+27} * 100\% = 1.6\%$$

$$\text{Balanced entering passenger error} = \frac{36-35}{35} * 100\% = 2.85\%$$

$$\text{Balanced exiting passenger error} = \frac{26-26}{26} * 100\% = 0\%,$$

Trends of technology

- Manual Sensor Calibration towards easy maintenance free installation

- Fulfillment of higher Accuracy Requirements needs smarter technology Counting for Wheelchair, bikes, stroller.

Automatic Passenger Counting

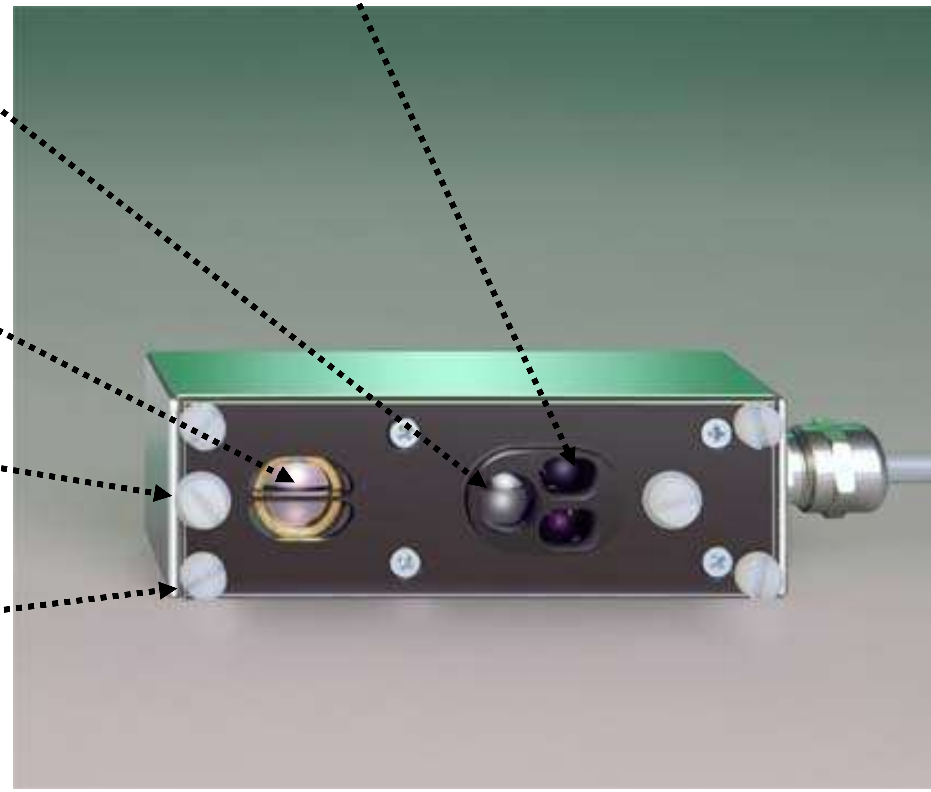
Active Infrared Transmitter

Active Infrared Receiver

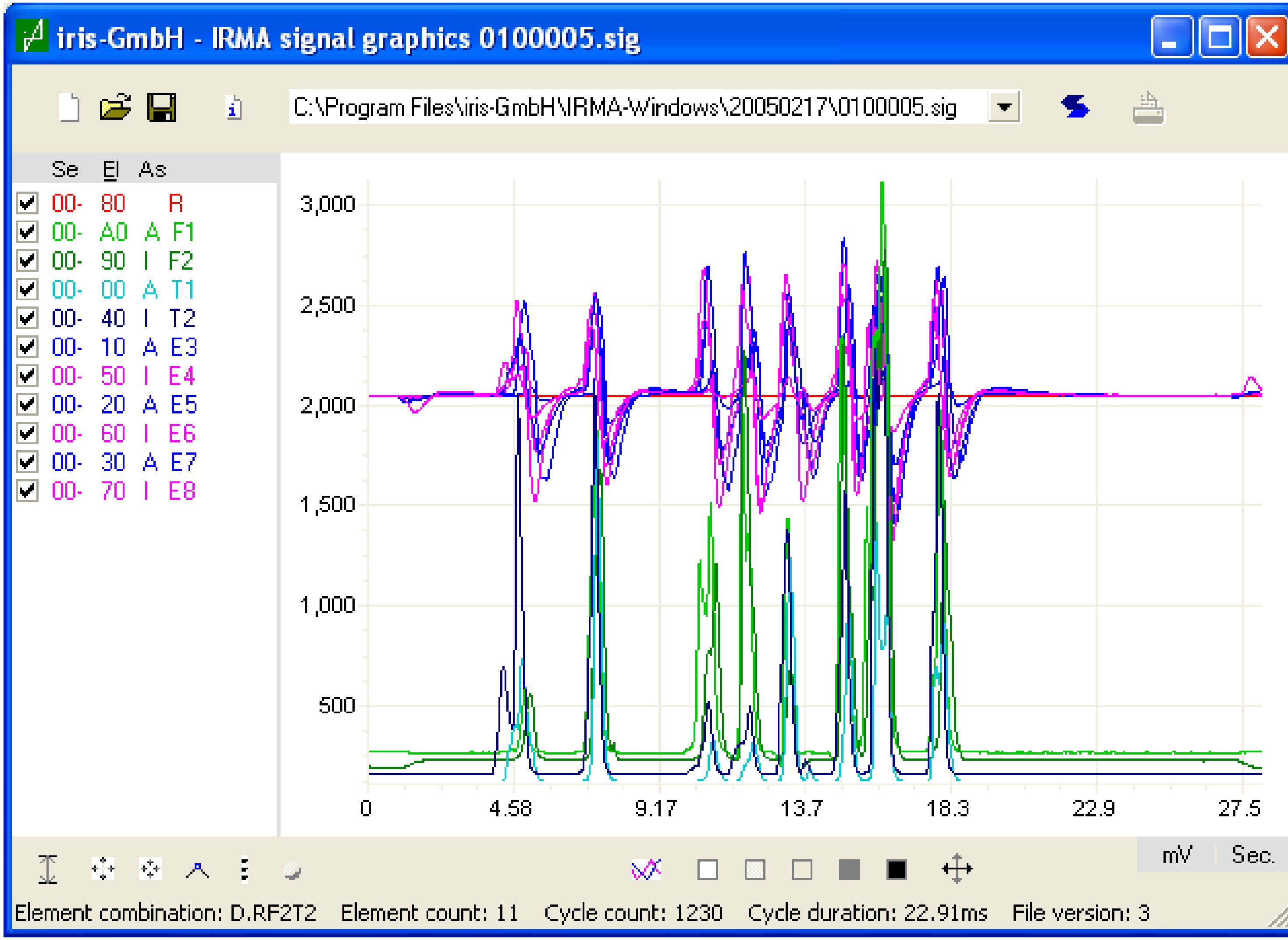
Passive Infrared Sensor

Mounting Screws

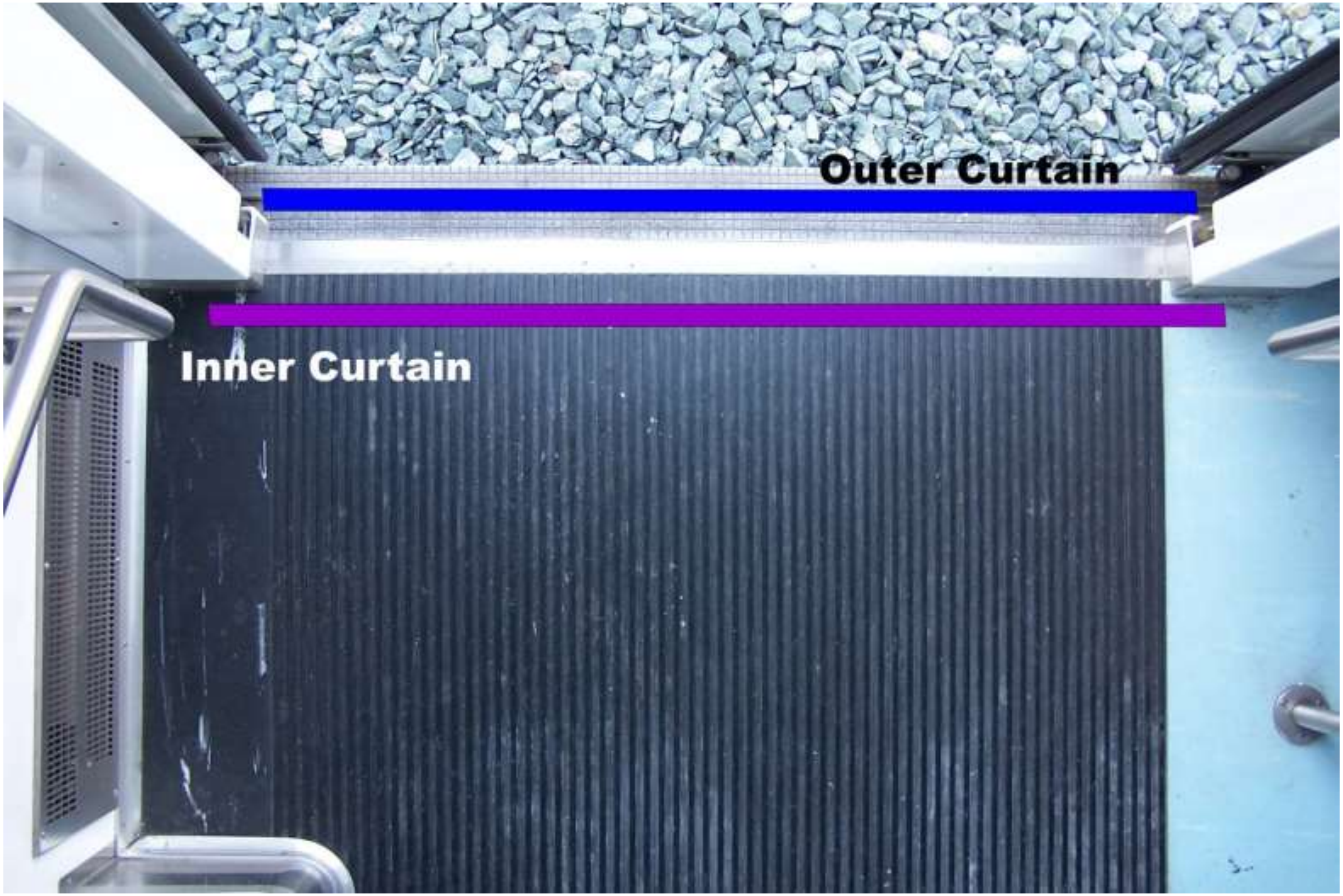
Adjusting Screws



Automatic Passenger Counting



Automatic Passenger Counting

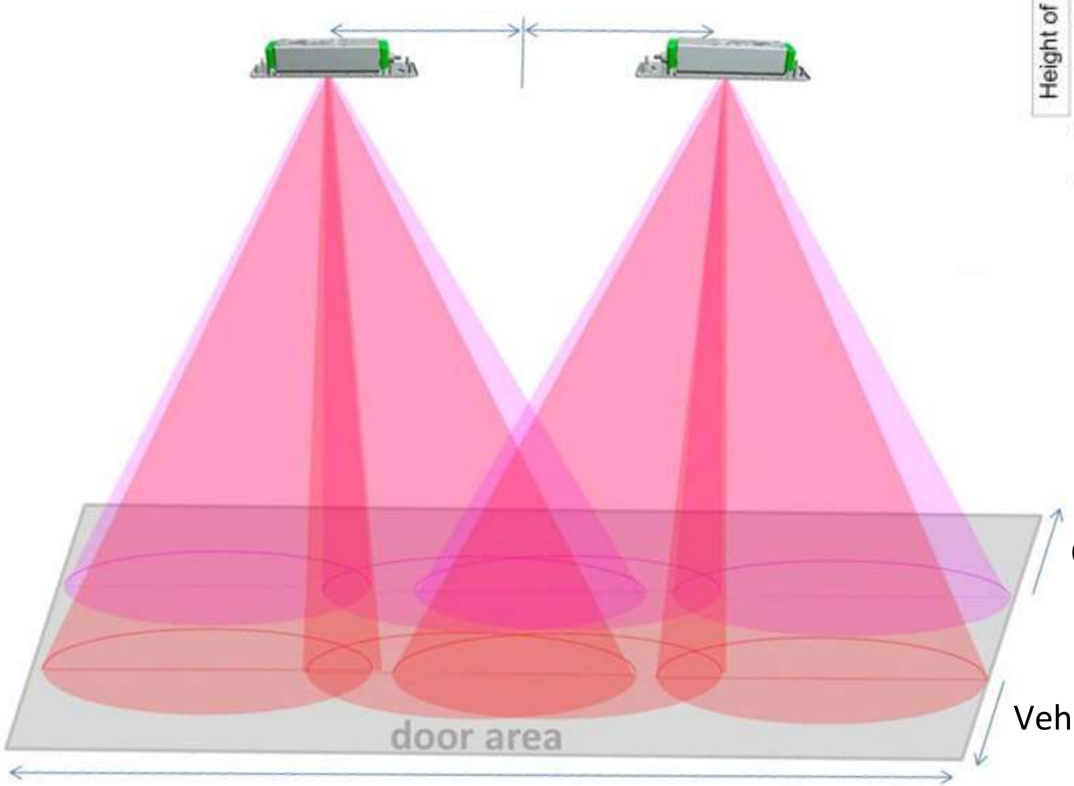


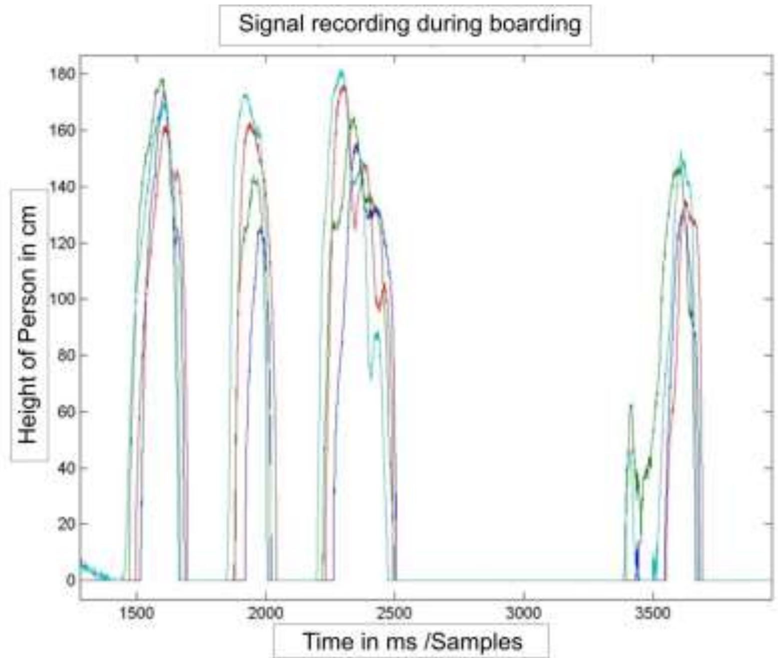
Sensor Overview

- Laser light pulse is emitted and reflected by an object und picked up again by the sensor. The distance results from the runtime between time of emission and time of reception (**T**ime **o**f **F**light).
- Sensor signals are independent of environmental influences and changes:
  - Temperature
  - Luminance
  - Humidity
  - Reflective and non-reflective surfaces

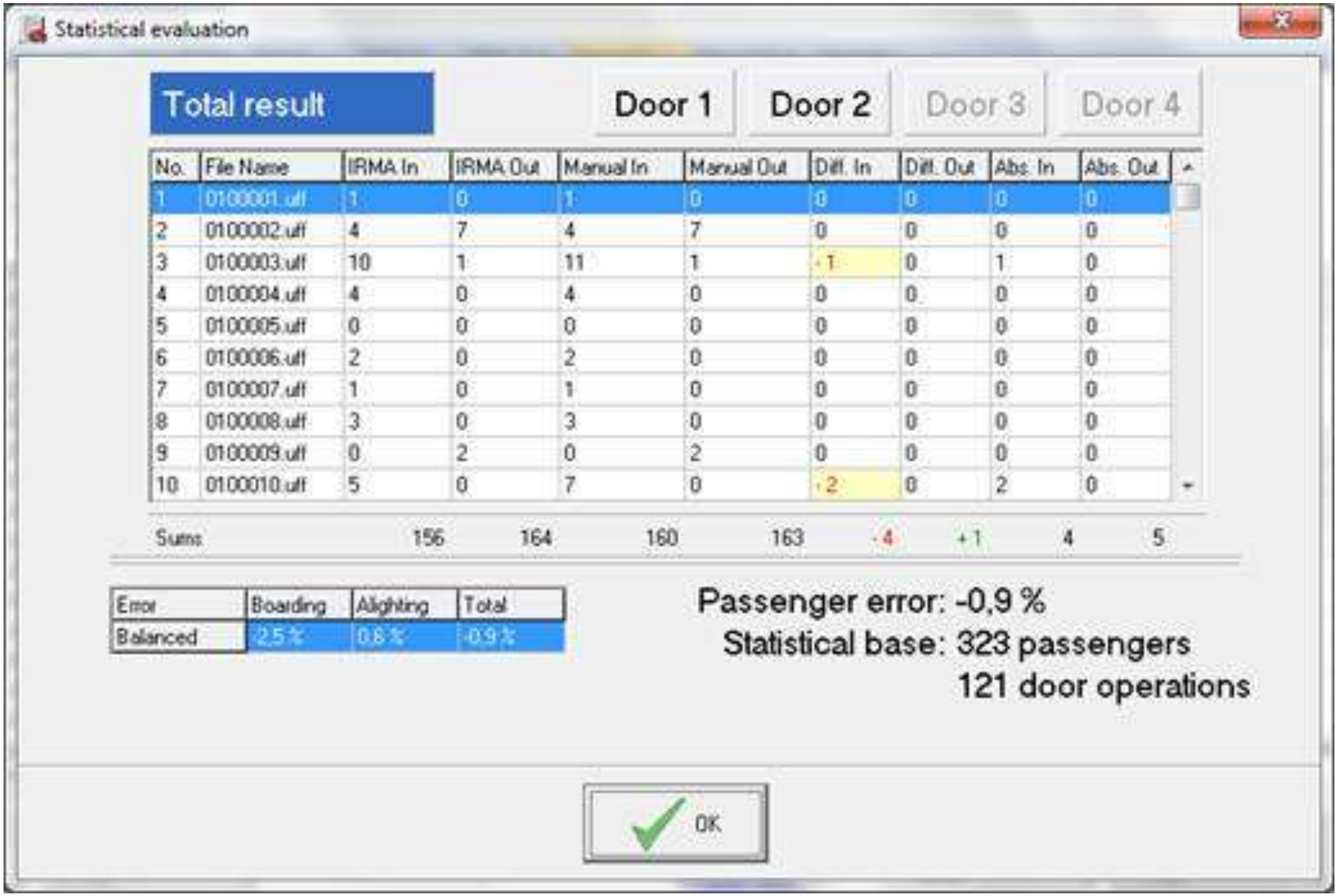
- Analyser processes the sensor signals and calculates the passenger count
- No adjustment of the sensor needed.
- Maintenance free and vandal resistant

Detection Signals Using IRMA 3D Sensor





IRMA 3D testride in DRT Durham



Statistical evaluation

Total result | Door 1 | Door 2 | Door 3 | Door 4

No.	File Name	IRMA In	IRMA Out	Manual In	Manual Out	Diff. In	Diff. Out	Abs. In	Abs. Out
1	0100001.uff	1	0	1	0	0	0	0	0
2	0100002.uff	4	7	4	7	0	0	0	0
3	0100003.uff	10	1	11	1	-1	0	1	0
4	0100004.uff	4	0	4	0	0	0	0	0
5	0100005.uff	0	0	0	0	0	0	0	0
6	0100006.uff	2	0	2	0	0	0	0	0
7	0100007.uff	1	0	1	0	0	0	0	0
8	0100008.uff	3	0	3	0	0	0	0	0
9	0100009.uff	0	2	0	2	0	0	0	0
10	0100010.uff	5	0	7	0	-2	0	2	0
Sums		156	164	160	163	-4	+1	4	5

Error	Boarding	Alighting	Total
Balanced	2,5 %	0,6 %	-0,9 %

Passenger error: -0,9 %
Statistical base: 323 passengers
121 door operations

OK

Iris performed the accuracy test ride two weeks ago

Higher Accuracy Requirements

An APC system with the following additional features shall be proposed:

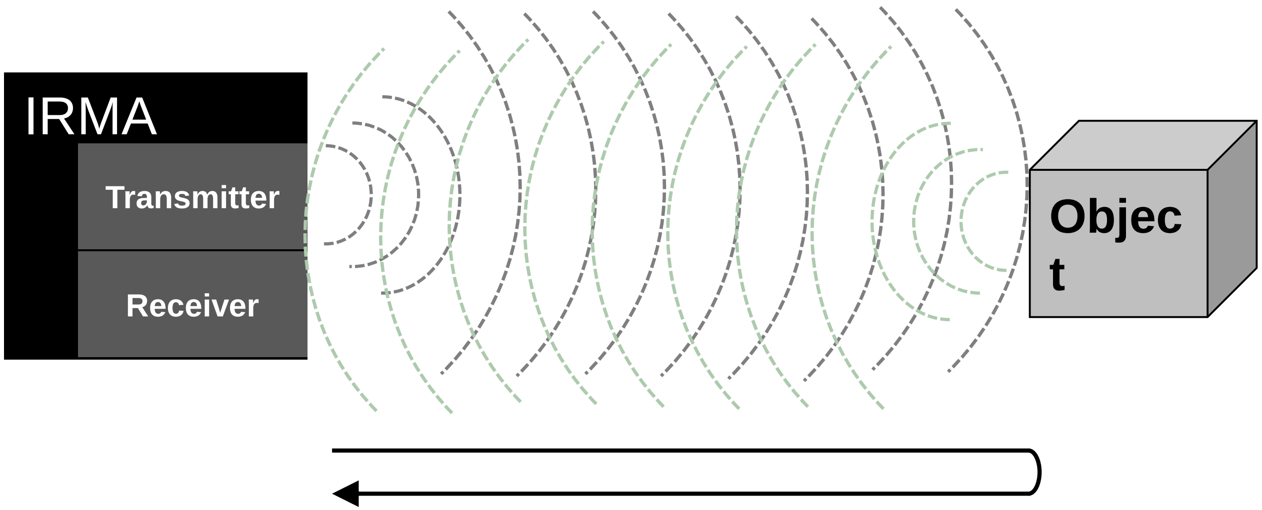
The APC shall have the ability to recognize and classify regular passenger objects such as wheelchairs, stroller, bicycles, etc. with a 95% accuracy.

IRMA Matrix Sensor Features

- Sensor features:
  - 500 detection pixels / image data per sensor (“matrix sensor”)
  - The sensor “sees“ the door area, i.e., works like camera
- Results
  - Easy adjustment to door condition, **no calibration**
  - Door contact cables no longer required
  - Precise counting due to higher quality of signal information
  - Count accuracy 98+% without on-board data manipulation
  - Integration of the analyzer features into sensor (possible due to small subcomponents), i.e., sensor connection directly to on-board system
  - Simple software integration via Advanced Programming Interface (API). The API provides all sensor functions and messages.

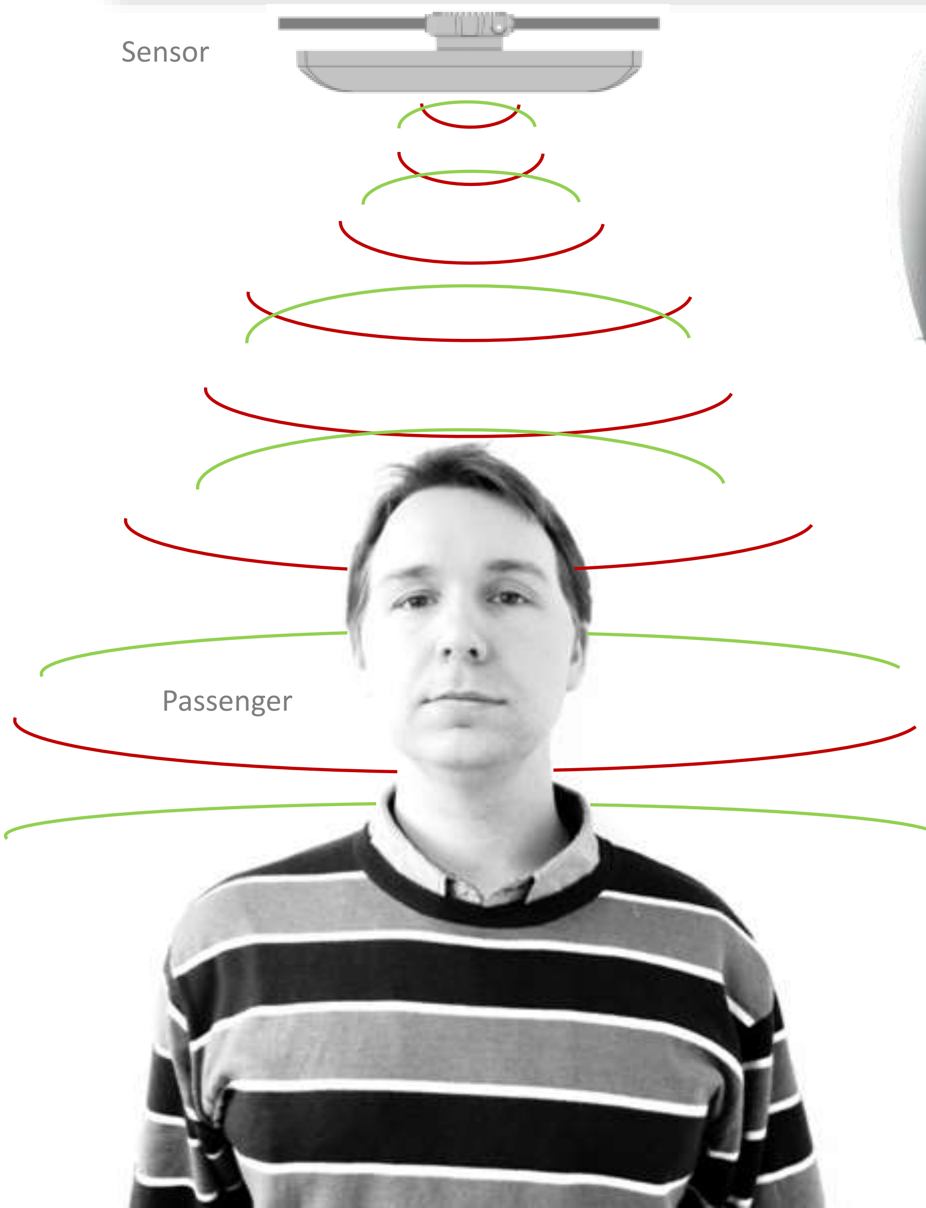
IRMA Matrix 3D vision based on TOFL

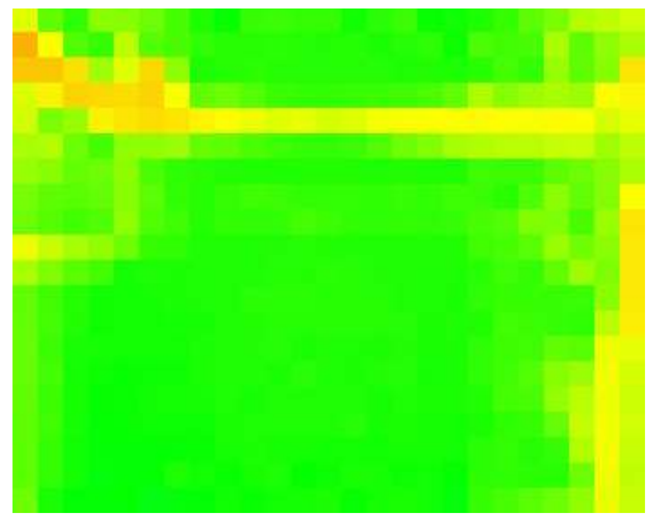
The speed of light converts the **time** of flight into **distance**:



$$distance = \frac{ct}{2}$$

How does the technology work





IRMA Matrix Sensor Features

Surface mount version

IRMA – InfraRed Most Accurate

Flush mount version

500-pixel infrared sensor matrix

Time of Flight technology (ToF)

Real time capture of passenger loads

Low installation effort -*No adjustment work needed*

1 sensor per standard door

Distinction between Passengers and objects, also in bulk entries

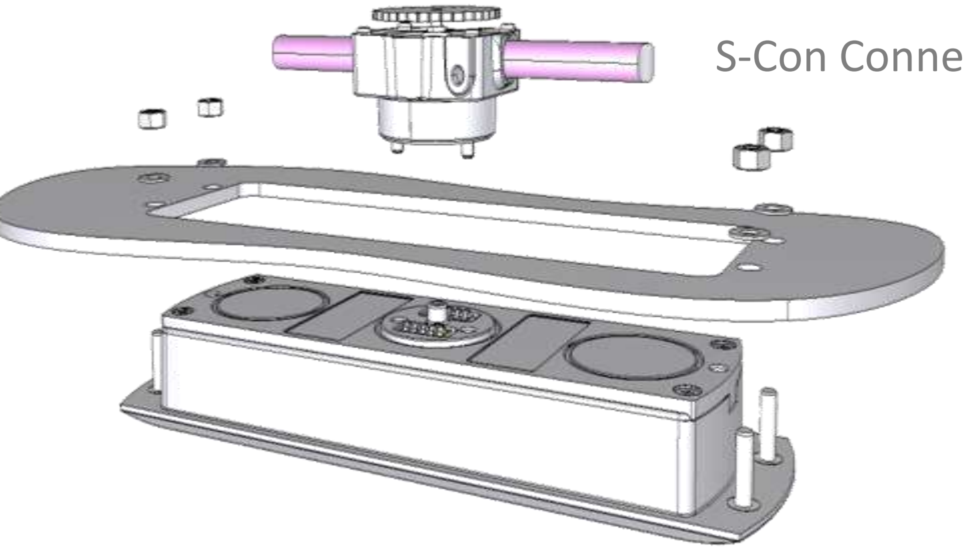
No door contact required - *Sensor recieves door release signal from On-Board-Unit for activation*

Ethernet interface 100 Mbit/s

Can easily be integrated in existing systems

Detection of height profiles -*distiction between adults and children for accrurate revenue distribution*

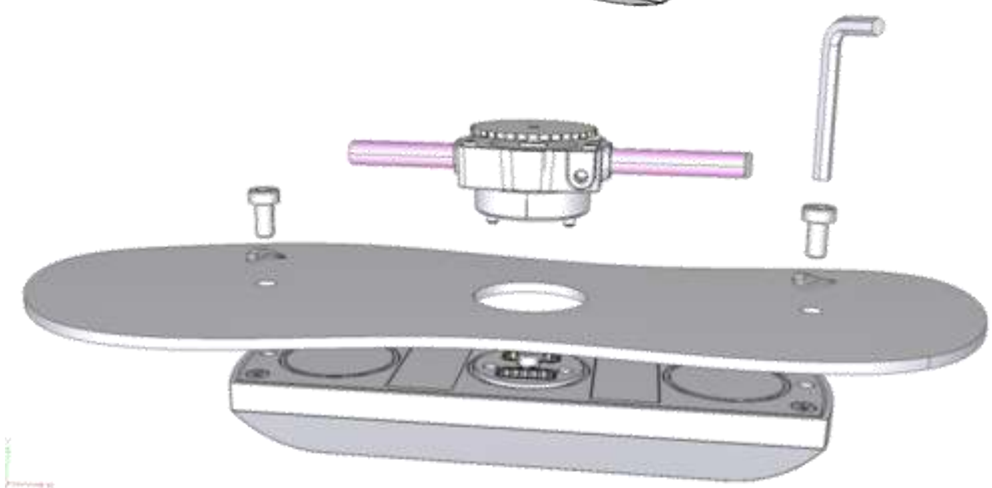
Installation Overview



S-Con Connector

Flush-Mounted-Version

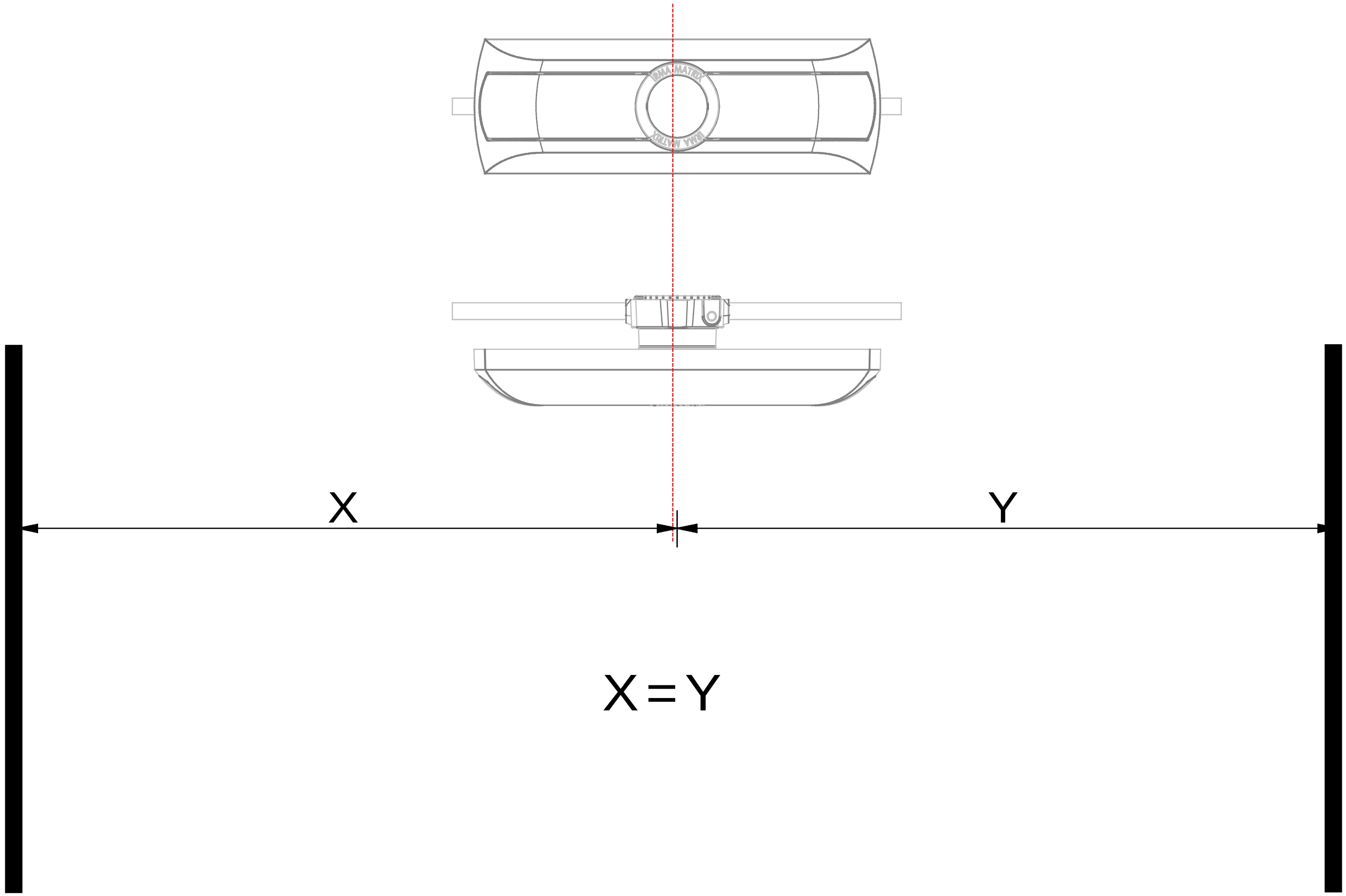
(Vandalism-proof)



External mount-Version

(Vandalism-proof)

Installation Overview



IRMA Test Ride

Statistical evaluation

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8	0100008.uff	0	0	0	0	0	0	0	0
9	0100009.uff	0	0	0	0	0	0	0	0
10	0100010.uff	1	1	1	1	0	0	0	0
Sums		36	42	36	42	0	0	0	0

Error	Boarding	Alighting	Total
Balanced	0.0 %	0.0 %	0.0 %

Passenger error: 0.0 %

Statistical base: 78 passengers

21 door operations

OK

IRMA Test Ride

YRT NOVA bus: 1 sensor per wide door

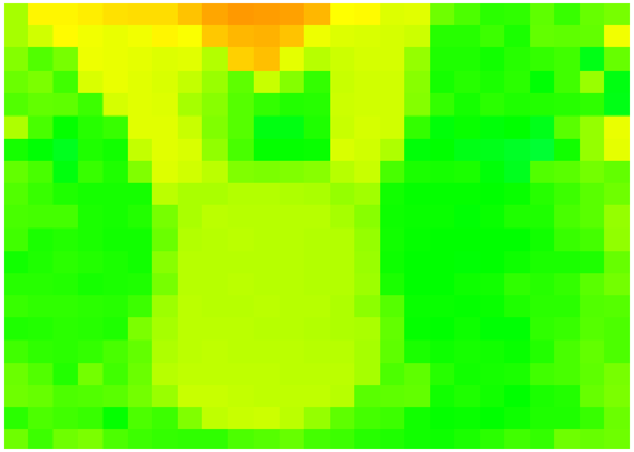
IRMA Test Ride

RTD Gillig bus: 1 sensor per wide door

IRMA Test Ride

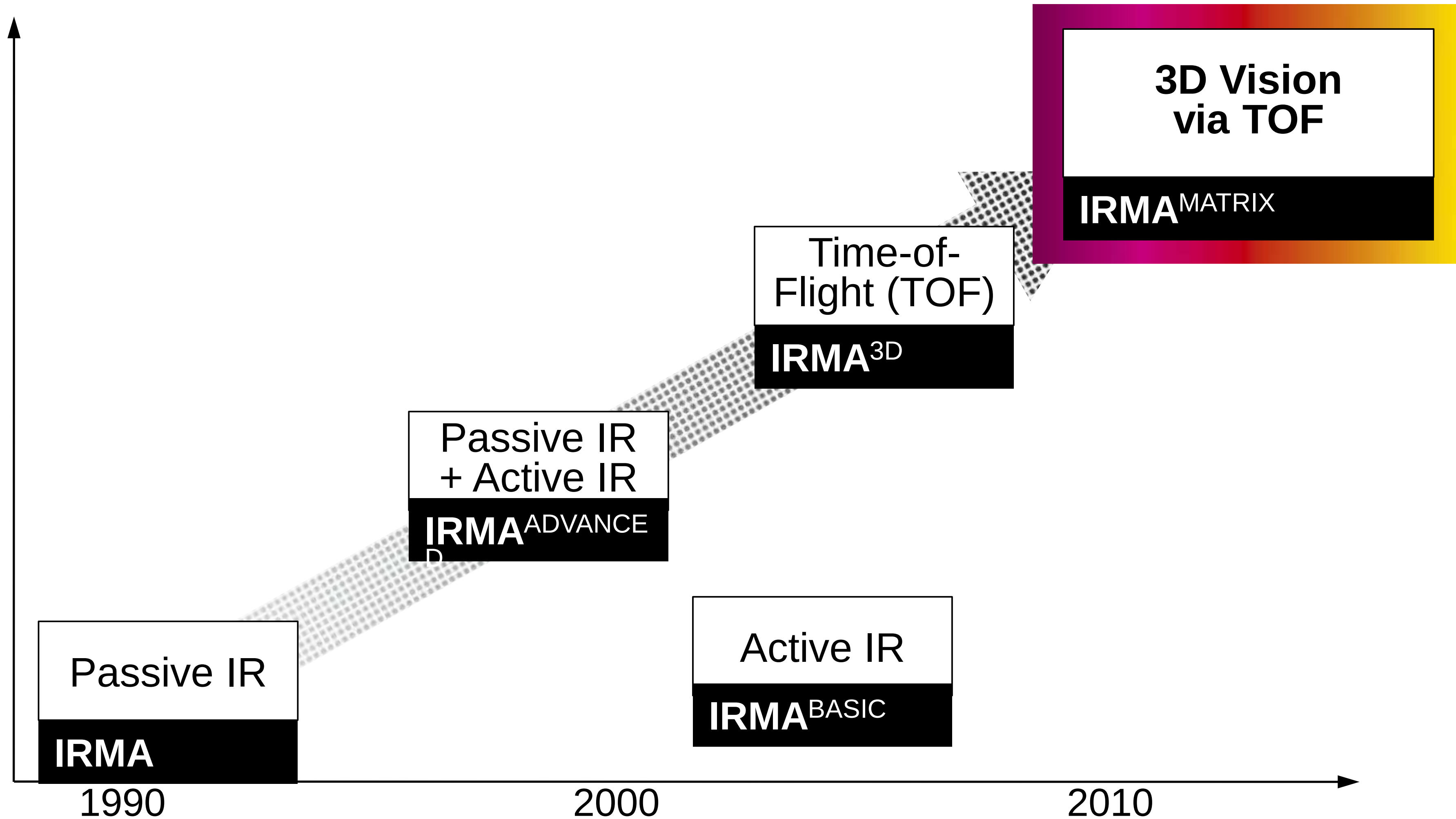
Outlook: Coming Soon

- Height classification
- Detection of
  wheel chairs, strollers, bicycles, …

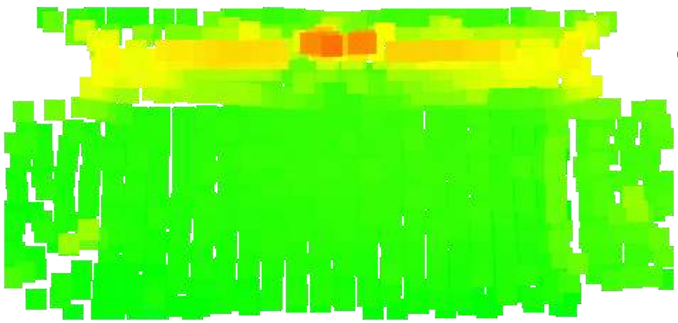


- Detection of vandalism
  (covering, damages)

Sensor Evolution Based on IRIS/INIT

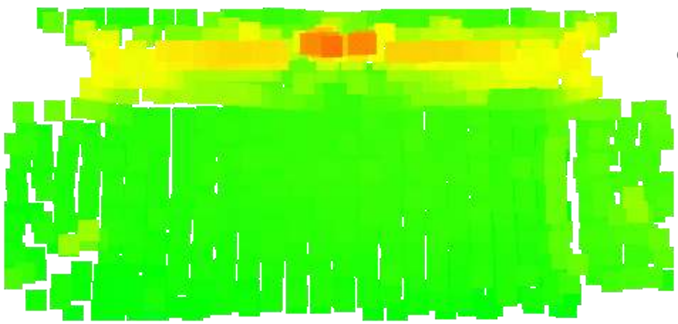


IRMA Matrix 3D vision based on TOFL



- 5th APC generation of iris:
  Latest **Time of Flight** (**TOF**) technology produces **3D images** instead of 2D contrasts of detection area, people and objects.
- Innovative TOF technology:
  evaluates **real distance and contour data** for most accurate people counting
  detects individual people according contour and movement,
  distinguishes between people and objects.
- **High counting accuracy**
  independent of color, temperature, changing background, ambient light, reflections, …

IRMA Matrix 3D vision based on TOFL



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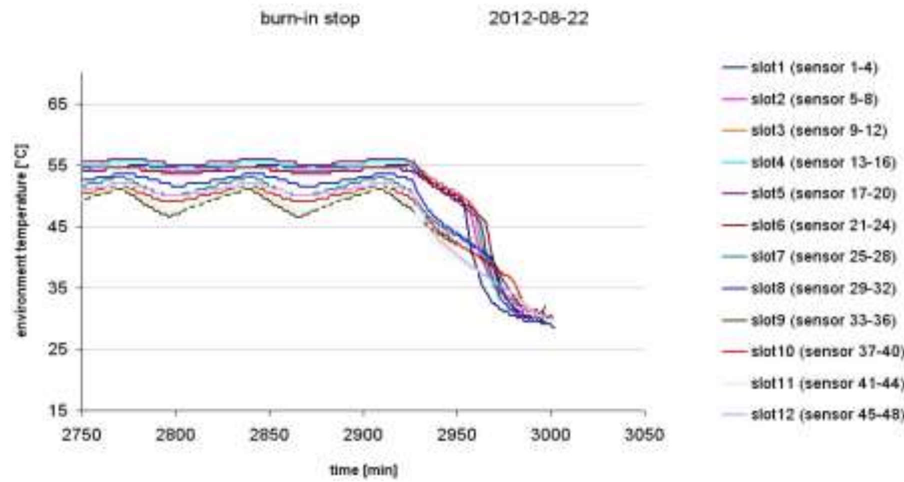
Complete Reporting with MOBILEstatistics

Reliability



- Before the Burn-In must be a pre-test to check if all functions are existent.
- The applicable test is to be performed over a length of time of 46h.
- The quantitative end-test takes place after Burn-In.

Thank you
for your attention

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