SCRAMBLUX

A new apporach to LiDAR testing and calibration

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The SCRAMBLUX Instrument for LiDAR Testing

SCRAMBLUX has built a LiDAR agnostic test instrument

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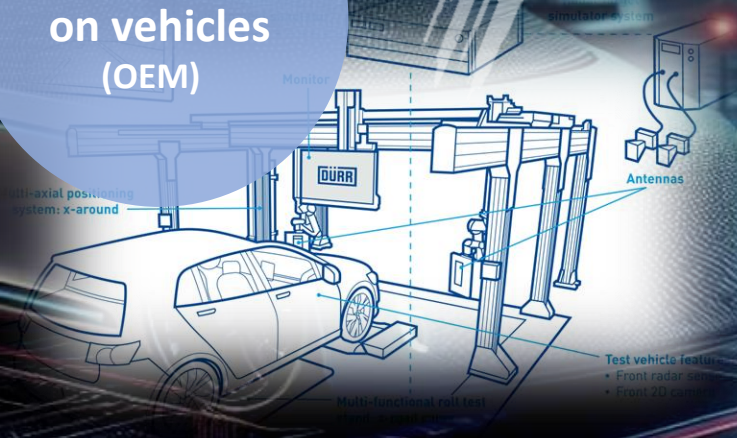
Our Mission is to deliver a Metric and an Instrument that can follow the LiDAR throughout it´s entire lifecycle as the Single Test Standard for LiDAR characterization.

Production
(Tier 1/Tier 2)

Installation on vehicles
(OEM)



Aftermarket and Periodic Technical Inspection (PTI)

The SCRAMBLUX BeamScrambler SXI

SXI significantly outperforms all other existing solutions

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Our **patented** Beam Scrambler technology enables us to push the frontiers of **LiDAR testing** and **calibration** technology further than before

15x shorter Cycle Time /LiDAR

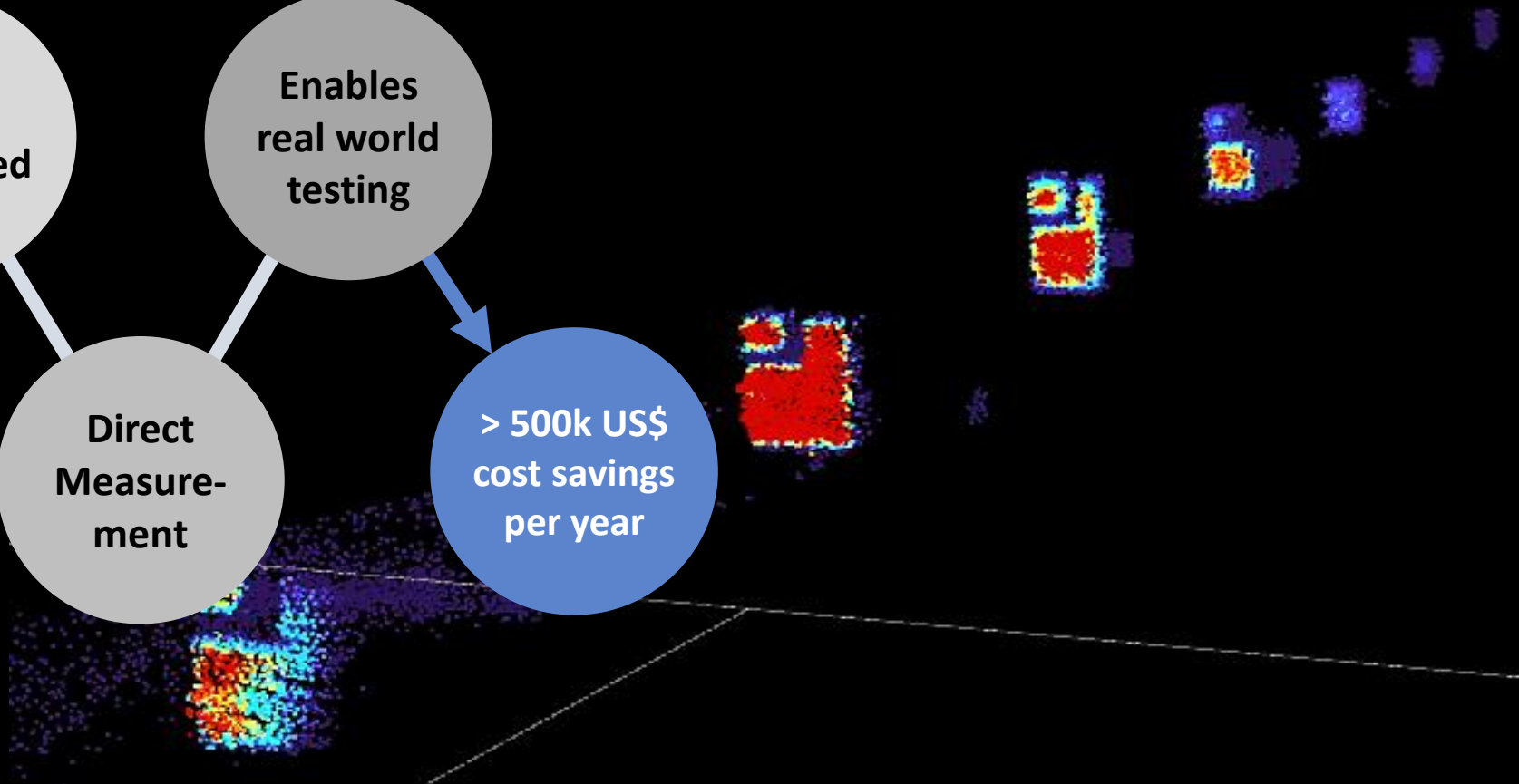
120x smaller Footprint

Fully automated

Direct Measure-ment

Enables real world testing

> 500k US$ cost savings per year



What are the SCRAMBLUX Competitors offering?

The SXI significantly outperforms all competitors on the market

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Compact Systems

KEYSIGHT TECHNOLOGIES Anritsu

- Fiber based or fully electronic systems
  - **Pros**:
    - Compact systems
    - Requires one operator
  - **Cons**:
    - Indirect measurement
    - Continuous NRE costs
    - Requires motion systems
    - Long Cycle Time/LiDAR

Large Systems

HORIBA MAGNA

- LiDAR test ranges at factories
  - **Pros**:
    - Can test in real world environment
    - Direct measurement
  - **Cons**:
    - Huge infrastructure and HR investments
    - Tailored solution
    - Long Cycle Time/LiDAR

The BeamScrambler USPs

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Ultra-Fast
(CT ≤10sec/LiDAR)

Compact footprint
(≤ 1m²)

Direct measurement
of key performance parameter

Real-World
environmental testing

The SXI Roadmap

The LiDAR agnostic SXI evolves as the LiDAR market matures

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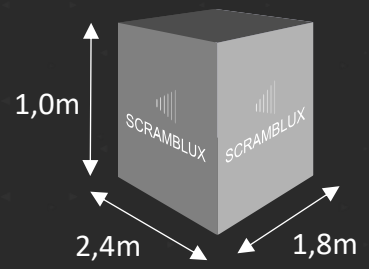
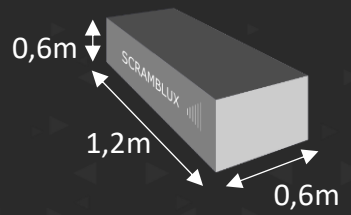


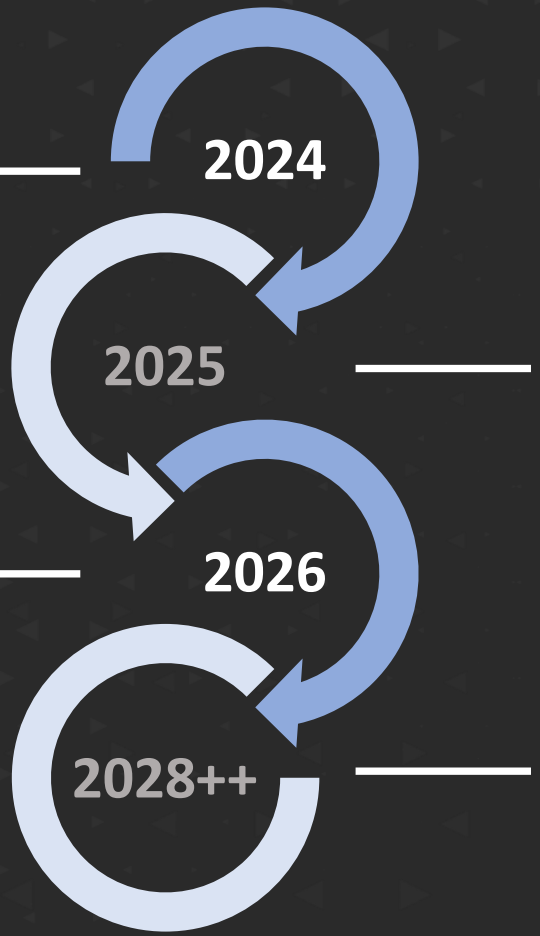
ALPHA

- Prototype System
- Production Line Ready
- Ready to test *your* LiDAR



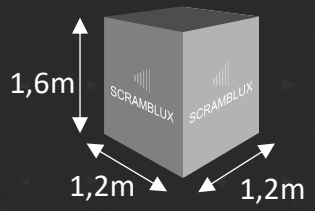
COMPACT

- Dedicated OEM System
- Module in ViL test jigs
- Smaller footprint
- 4D Scene capable



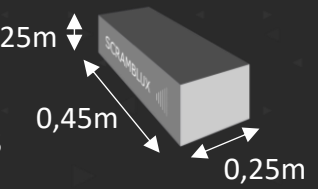
ONE

- Production System
- Optimized for Production Lines
- Extended Features
- Stand-Alone Development System



X

- Ultra-Compact System
- Intended for workshops during PTI
- Man portable
- Size, Cost & Feature Optimized for Aftermarket



The Principle

We explored the limitations of our instrument with some experiments

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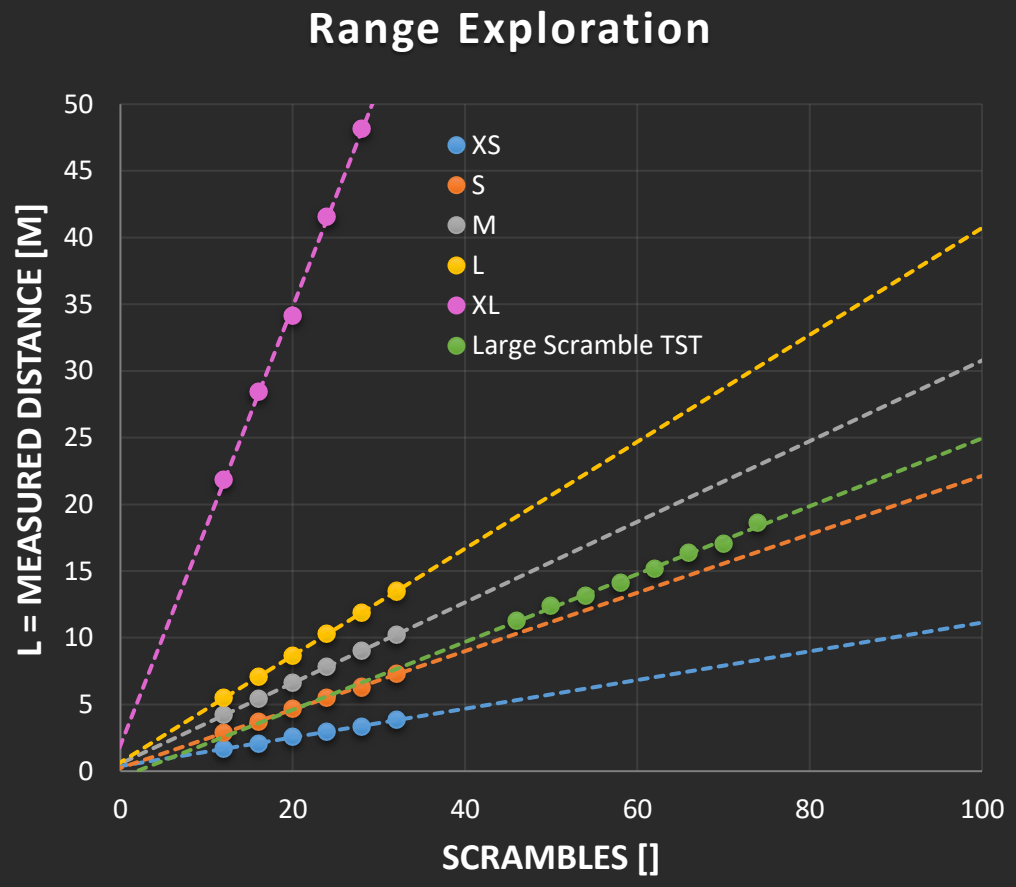
- The range scales with scrambles:
  → **Our Technique is linear**
- The performance scales with geometry:
  → **Our Technique is scalable**
- There are **no upper limit** to maximum range: →
  Performance is set by cost



The 3D LiDAR checkered board

We have derived a proprietary LiDAR equation for our instrument

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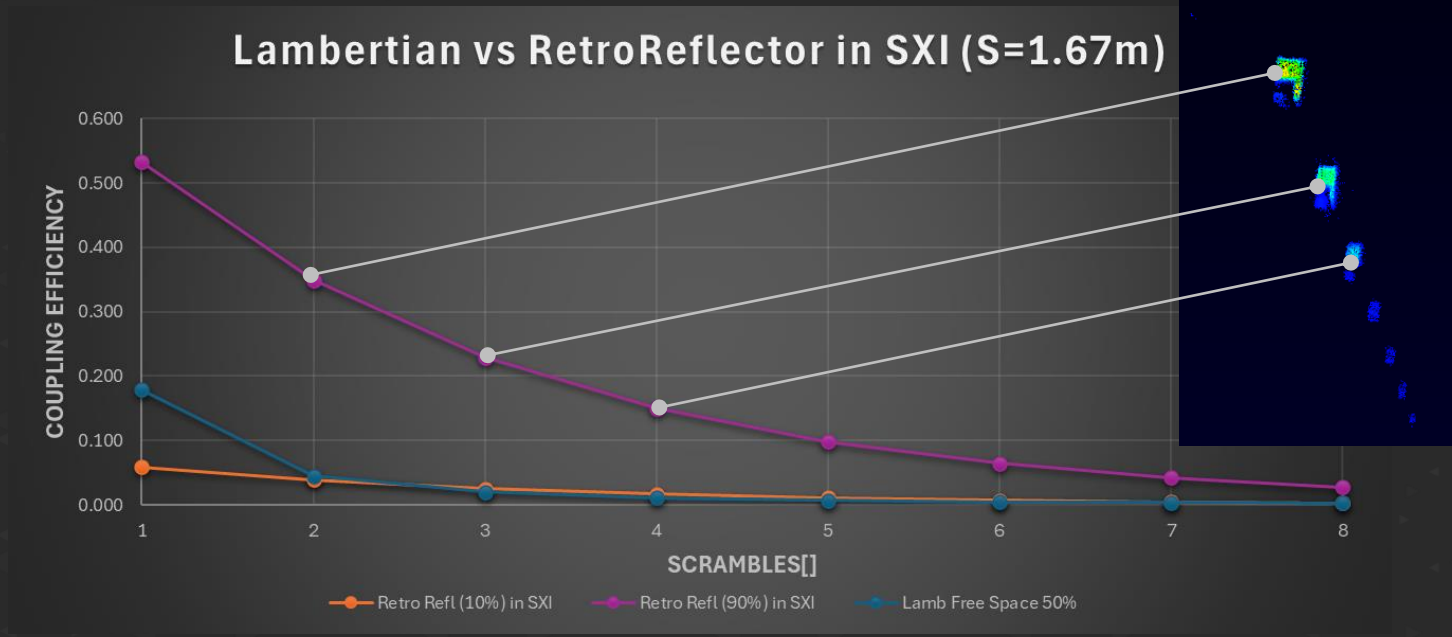
LERR: Lambertian Equivalent Retro Reflectors

- Lambertian reflectance at any distance/Scramble
- Tunable reflectance of Retro Reflector
- Generate 3D “checkered boards for LiDARs”
  - Series of Equidistant Targets
  - Reflectance scales with depth
- LERR target targets are calibrated to Lambertain in Tunnels and outdoor ranges



The BeamScrambler SXI

We have built an SXI-α and we offer LiDAR test services in our lab

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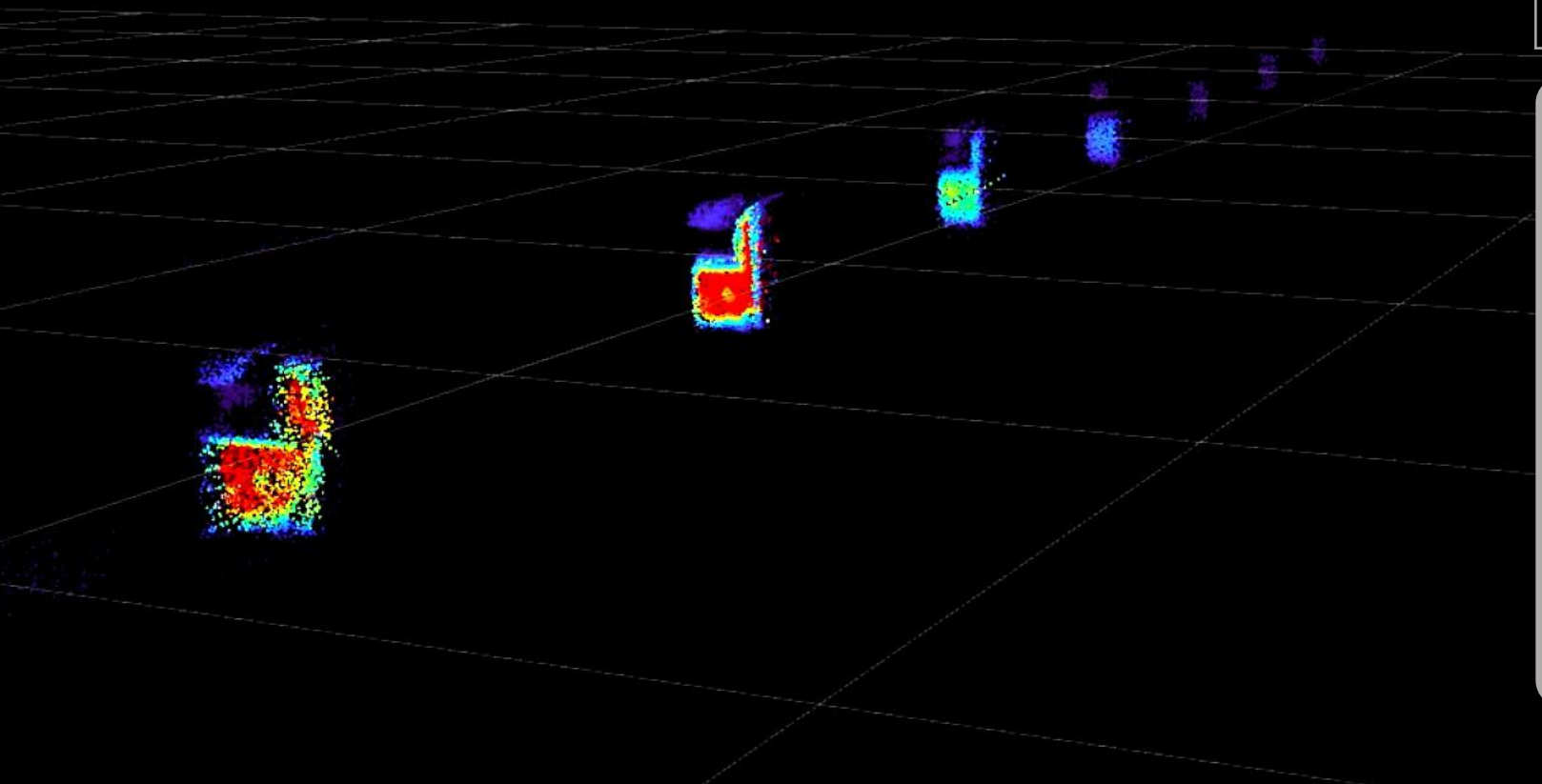
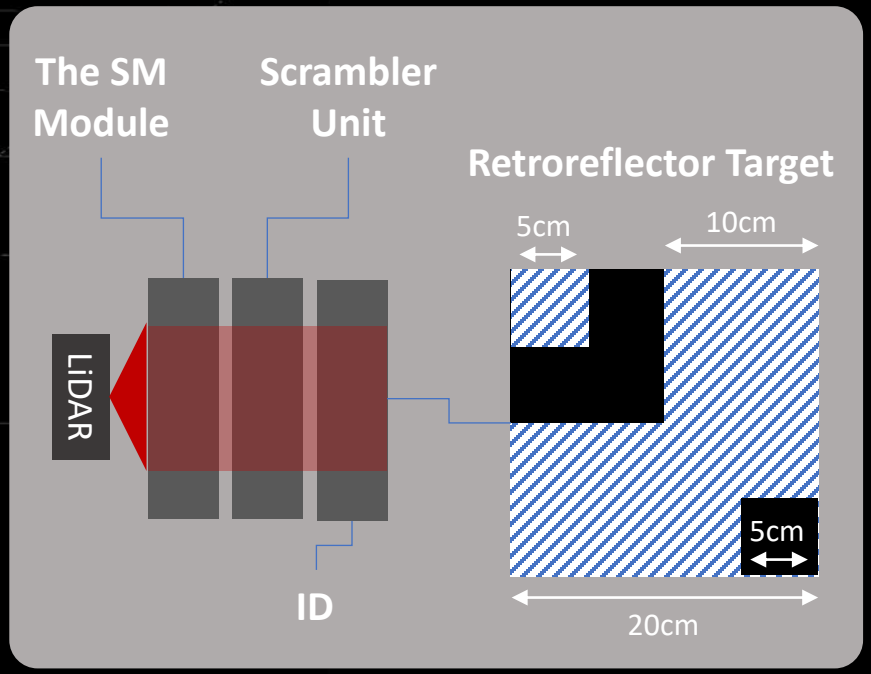
We have created a **3D Checkered Pattern** test target for LiDARs



Parameter	Typical	Unit
Accuracy depth	± 0.01	m
Wavelength	905	nm
Repetition	1.67± 0.01	m



The Dynamic LERR

Lambertain Equivalent Retro Reflectors (LERR) in SXI

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With LERR we can generate pixelized target planes with programmable reflectivity

Our **LERR model** can be used to build **pixelized targets** and “draw” **dynamic** gray scale scenes for the LiDAR

https://www.youtube.com/watch?v=6ykdfc8iwcE

Exploring the 4th dimension

Our system offers beside a 3D scene moving Target/Obstacles

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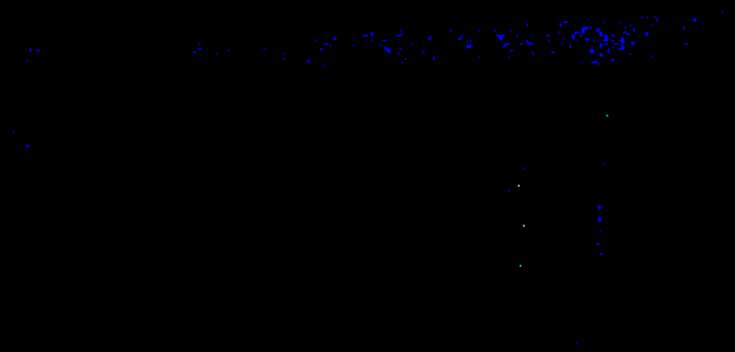
The evolution of our targets is defined by the industry needs

-> FMCW lidar and Sensor Fusion Testing



https://www.youtube.com/watch?v=exec88JZVds

LiDAR TEST SERVICES

Test YOUR LiDAR in our instrument

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Parameter	Min	Max	Typical	Unit
Variable Distance	2 ± 0.003	30 ± 0.003	30 ± 0.003	m
Variable Target Reflectivity	1	90	90	Lambertian Reflectivity %
Angular Resolution	0.001	20	na	°
Radial Resolution	na	na	na	m
FoV Full system	na	40x160	40x160	V°xH°
Tx/Rx Alignment	0.001	na	na	°
0° Alignment	na	na	na	°
Laser Peak Power	0.1	5	5	%
Revisit Rate	0	100	100	%
False Positive Detection Rate	0	100	100	%
Angular Accuracy	0.001	na	na	°
Angular Separability	0.001	na	na	°
False Alarm Rate	0	100	100	%

- **We can test YOUR LiDAR** in our lab using The SCRAMBLUX alpha
- Test parameters are derived from standards (**DIN-SAE 91471**)
- All LiDAR are tested against same metric using the patented SCRAMBLUX technique
- Your team is always welcome to join in the measurements

The LiDAR EoL Test and Calibration Solution

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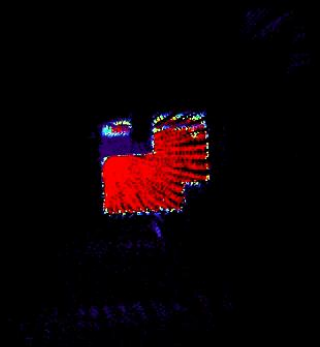

https://www.youtube.com/watch?v=fkjjfdRfXG0

Parameter	Min	Max	Typical	Unit
Range	2 ± 0.01	50 ± 0.01	35 ± 0.01	m
Wavelength	500	950	905	nm
Cycle Time	5	15	10	sec
Targets/frame	1	15	8	--

- The SCRAMBLUX Instrument is comprehensive LiDAR End of Line (EoL) **test and calibration solution**
- It enables the use of **the same metric** for testing throughout the life cycle of the LiDAR (Tiers 1,2; OEM; PTI)
- The SXI is **agnostic** to type of scanning beam LiDARs (ToF, FMCW, RMCW)
- **We can test YOUR LiDAR** in our lab using SXI-alpha

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Thank you for your attention!

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