

Ultra-Wide Rectilinear Imaging for High-Performance Vision Systems

Mark Peterson

VP Advanced Technology



About Theia Technologies

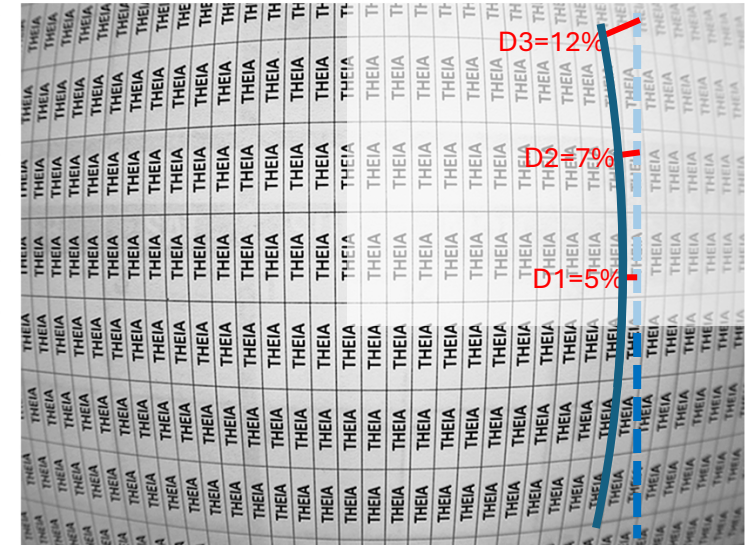


- Founded in 2006
- Patented, award winning Linear Optical Technology®
- Design and distribute from Wilsonville, OR, USA
 - Lenses distributed worldwide
 - OEM thin labeling
- Japanese manufacturing partner
- ISO 9001:2015 certified January 2014
- Megapixel lenses for Machine Vision, ITS, Security, Military and Consumer Electronics markets
- Custom Lens Design and Supply

Rectilinear lens background

Barrel distortion

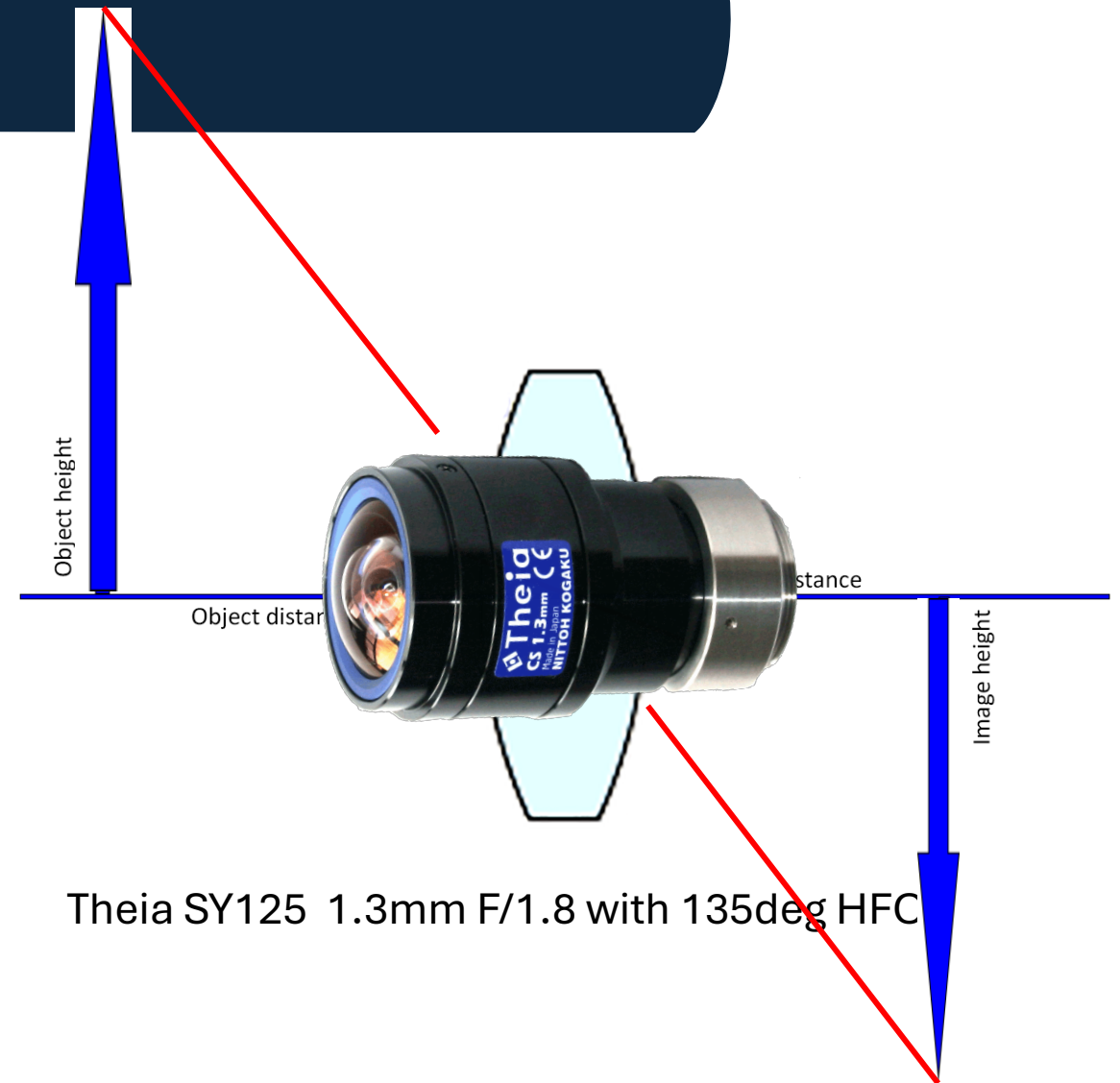
- Object with straight lines
- Straight lines appear curved in the image
- Distortion is a function of radius



$$\text{Distortion} = \frac{\text{Actual} - \text{Predicted}}{\text{Predicted}}$$

Rectilinear lens

- Straight lines are straight in the image
- Simple lens equation
- Wider angle lenses, $> 90^\circ$ are more difficult to correct for distortion
- Rectilinear lenses require more lens elements and aspheric elements



Rectilinear Lens Technology

- Ultra wide fields of view from 90deg to ~140deg
- All-optical distortion correction
 - No software correction
 - No processing latency
 - No processing power usage
- Multi-megapixel optical designs



Typical wide angle lens

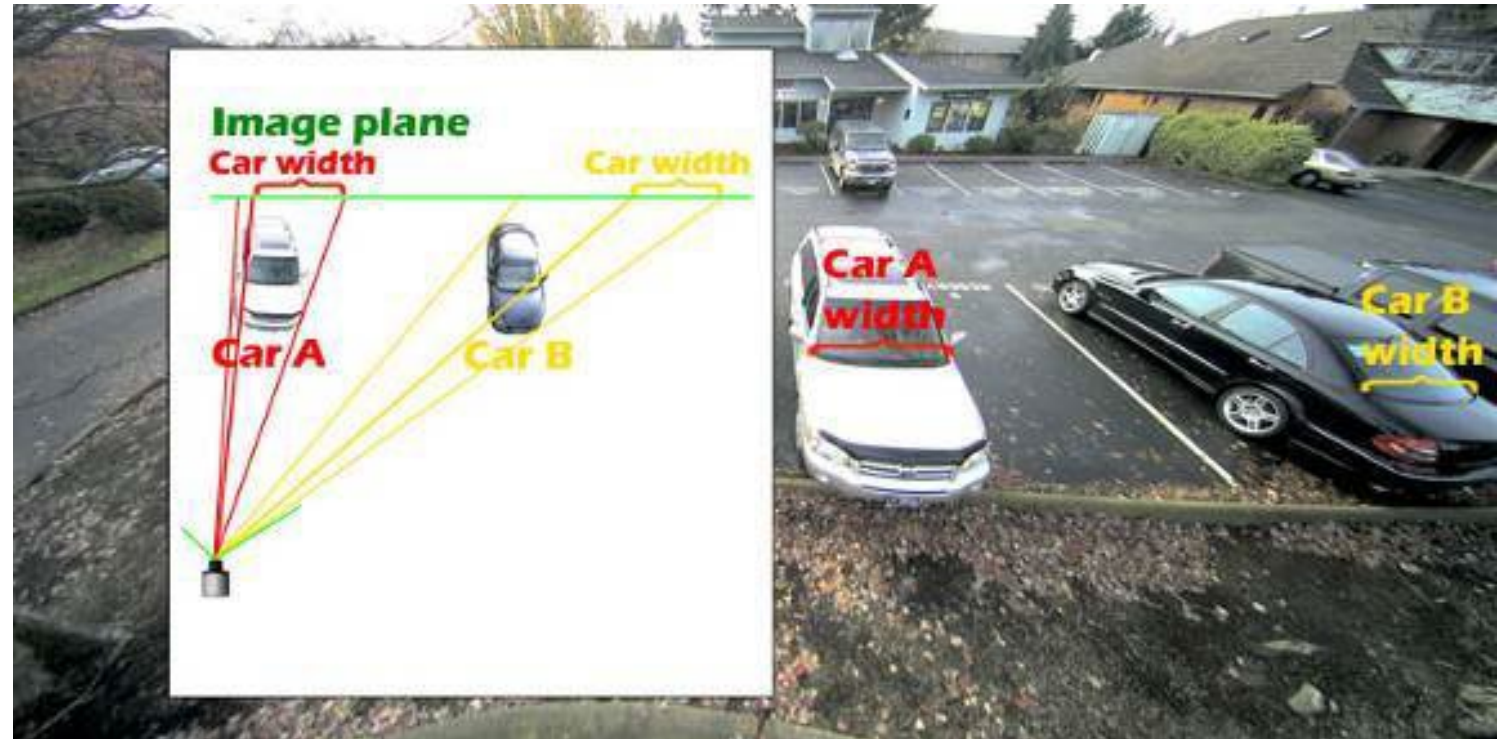


Rectilinear lens

Rectilinear lens characteristics

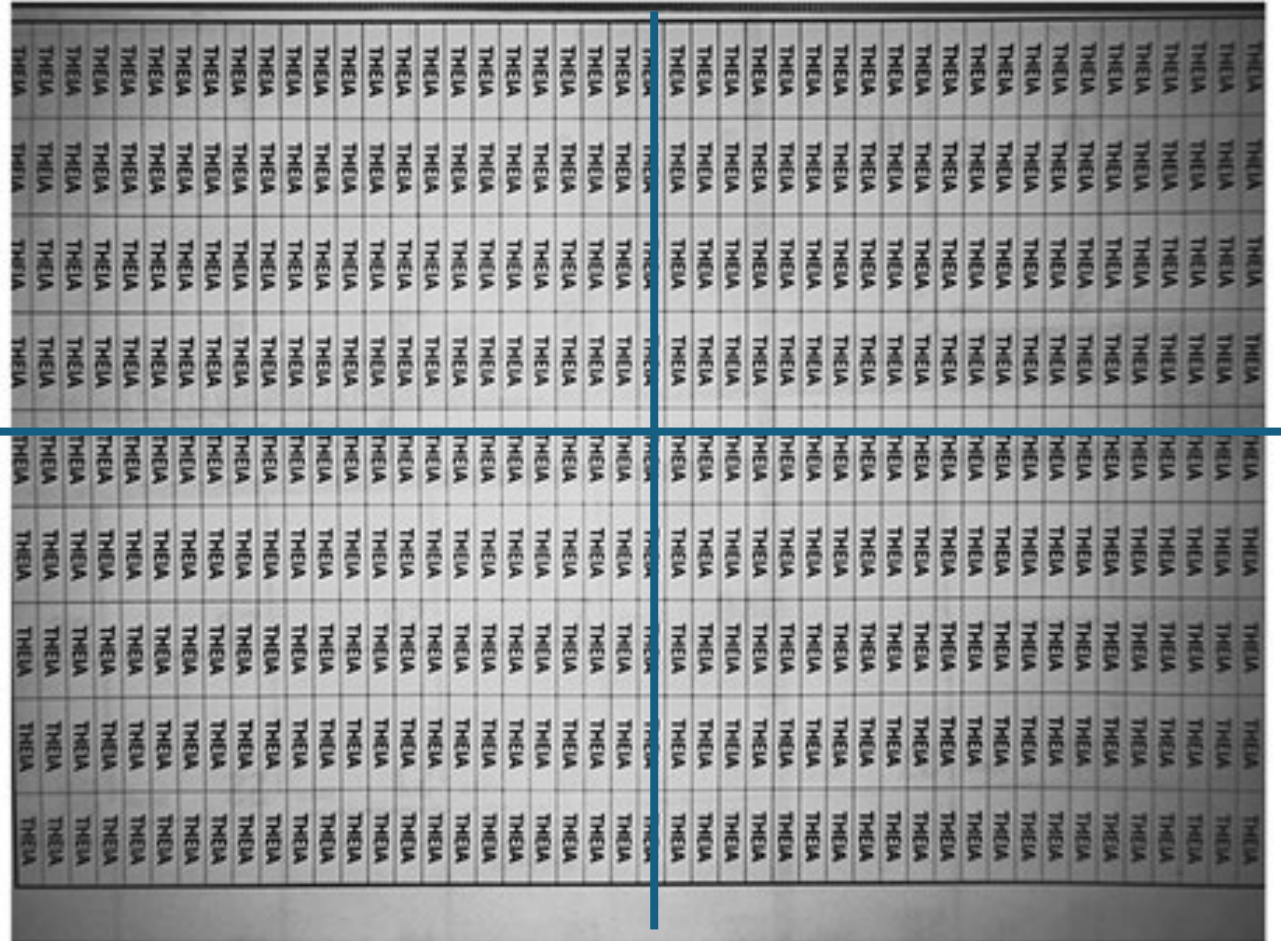
3D stretching

- Imaging the 3D world onto a 2D camera sensor causes wide angles to be stretched
- Sometimes called “volume anamorphosis” or “perspective distortion”
- Like Greenland on a map (Mercator projection)

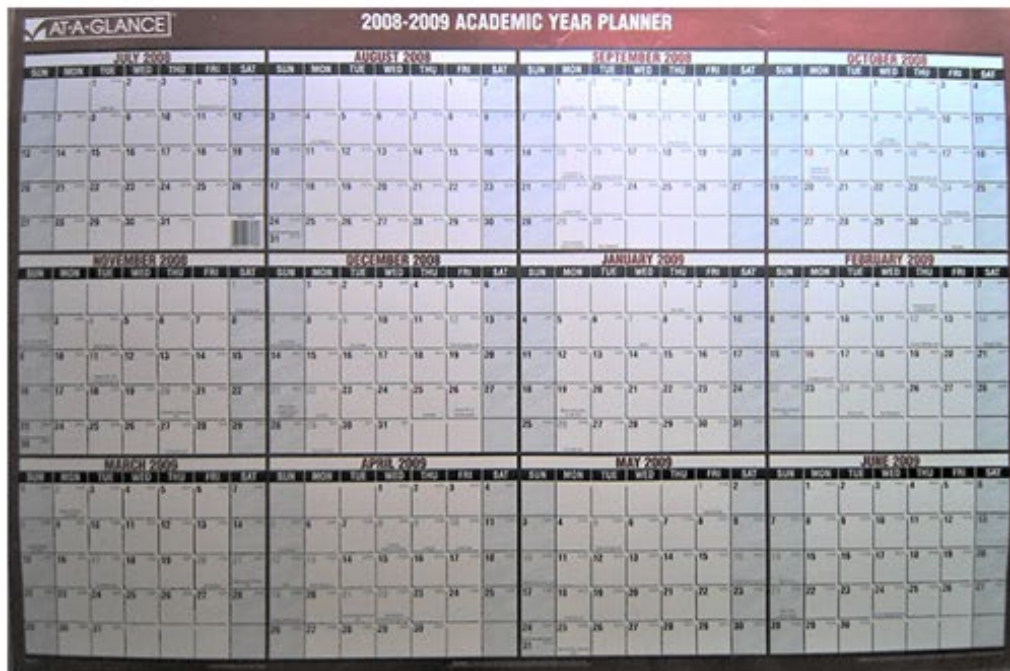


3D stretching

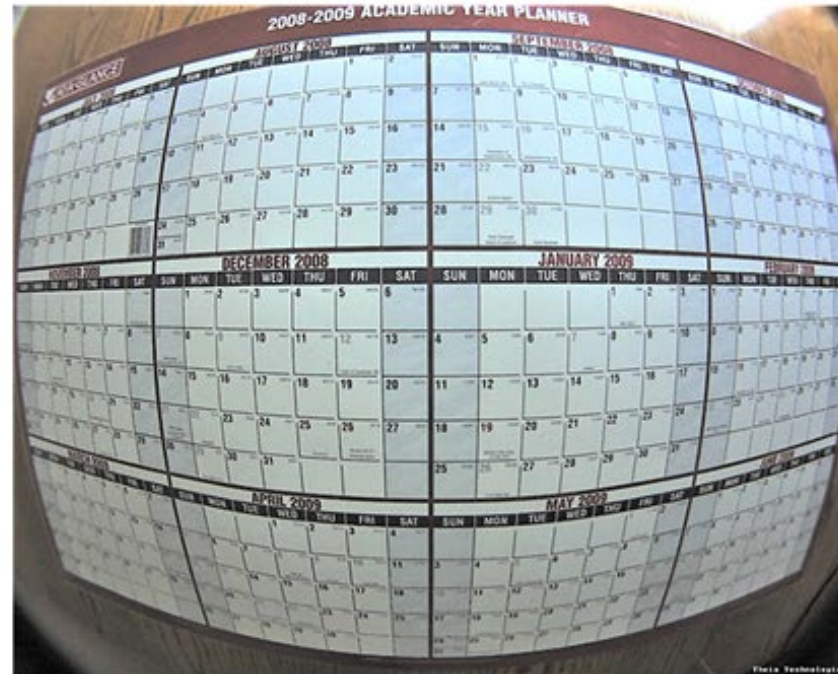
- Flat objects have no 3D stretching
- XY position is easily determined
- Equal resolution in all areas



Rectilinear vs. Fisheye



Lens with Linear Optical Technology®



Typical wide lens

- Fisheye image is compressed as the field of view increases

Keystoning

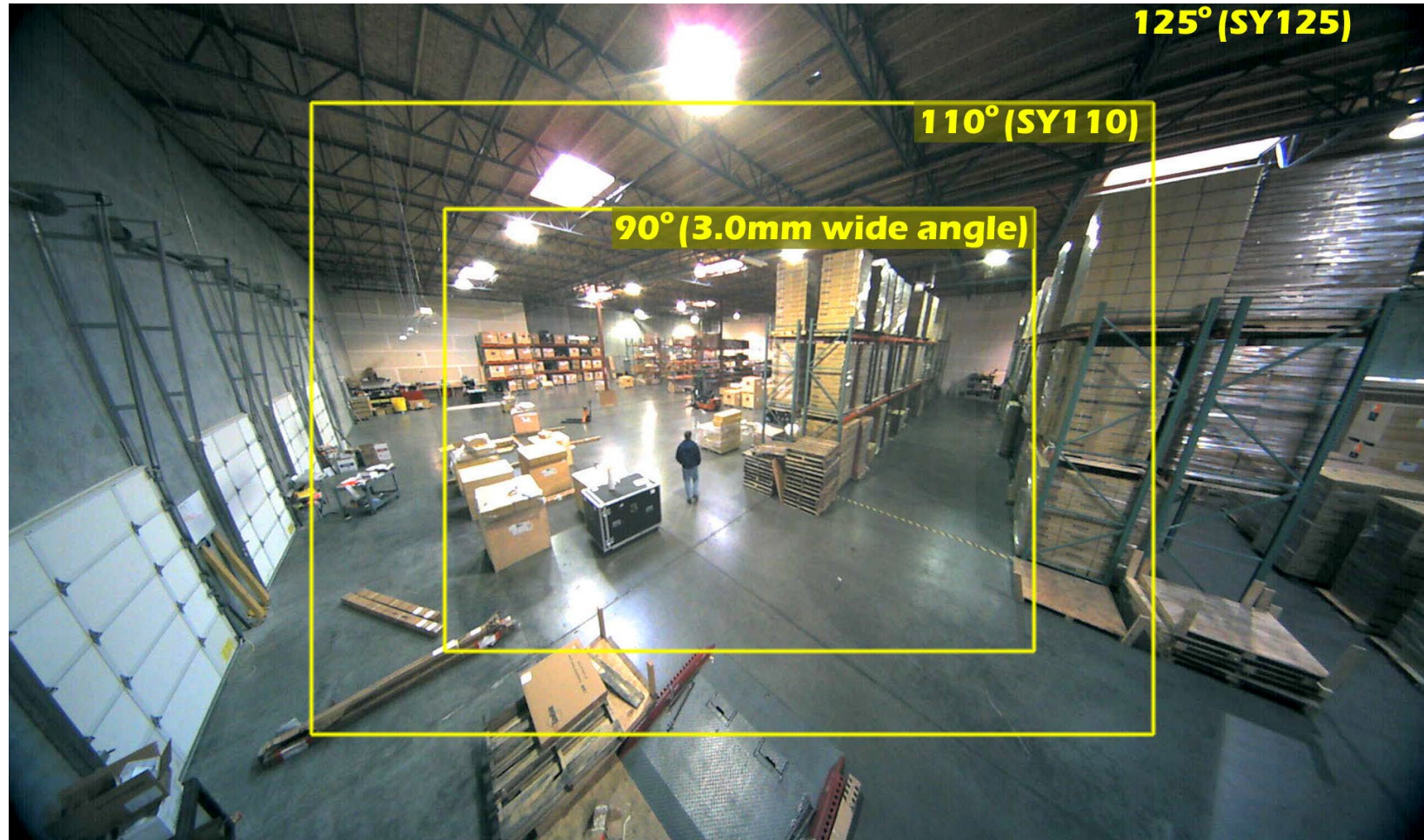
- Parallel lines can appear to converge
 - Optic axis is not perpendicular to the plane of straight lines
 - Similar to lenses with barrel distortion except lines remain straight



Benefits of Rectilinear lenses

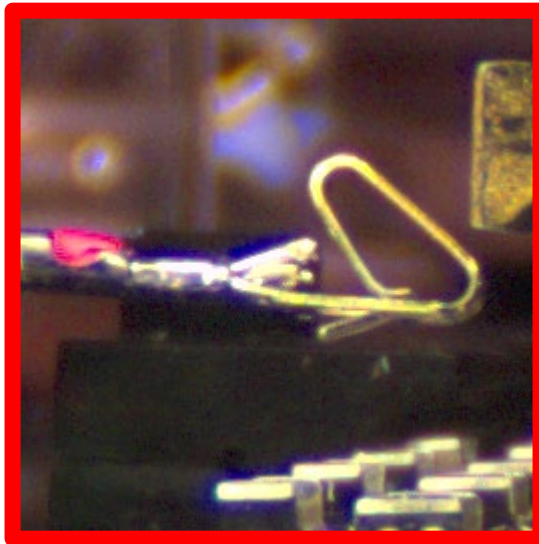
Ultra Wide Angle

- Great for situational awareness
- Up to ~135deg HFOV depending on sensor format

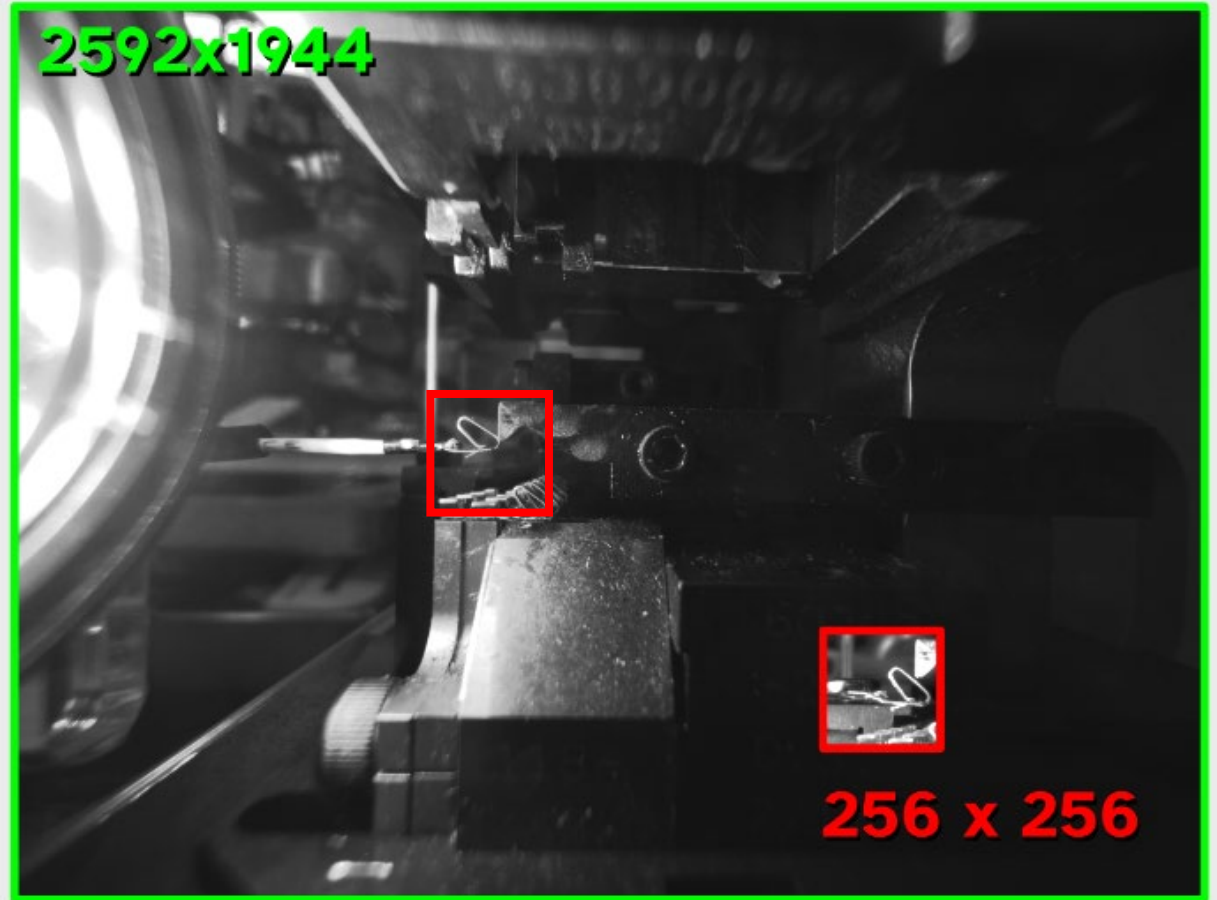


No Dewarping required

- No Latency
- No Image Processing Power Consumption



Images from Hexicurity



Rectilinear lenses in action

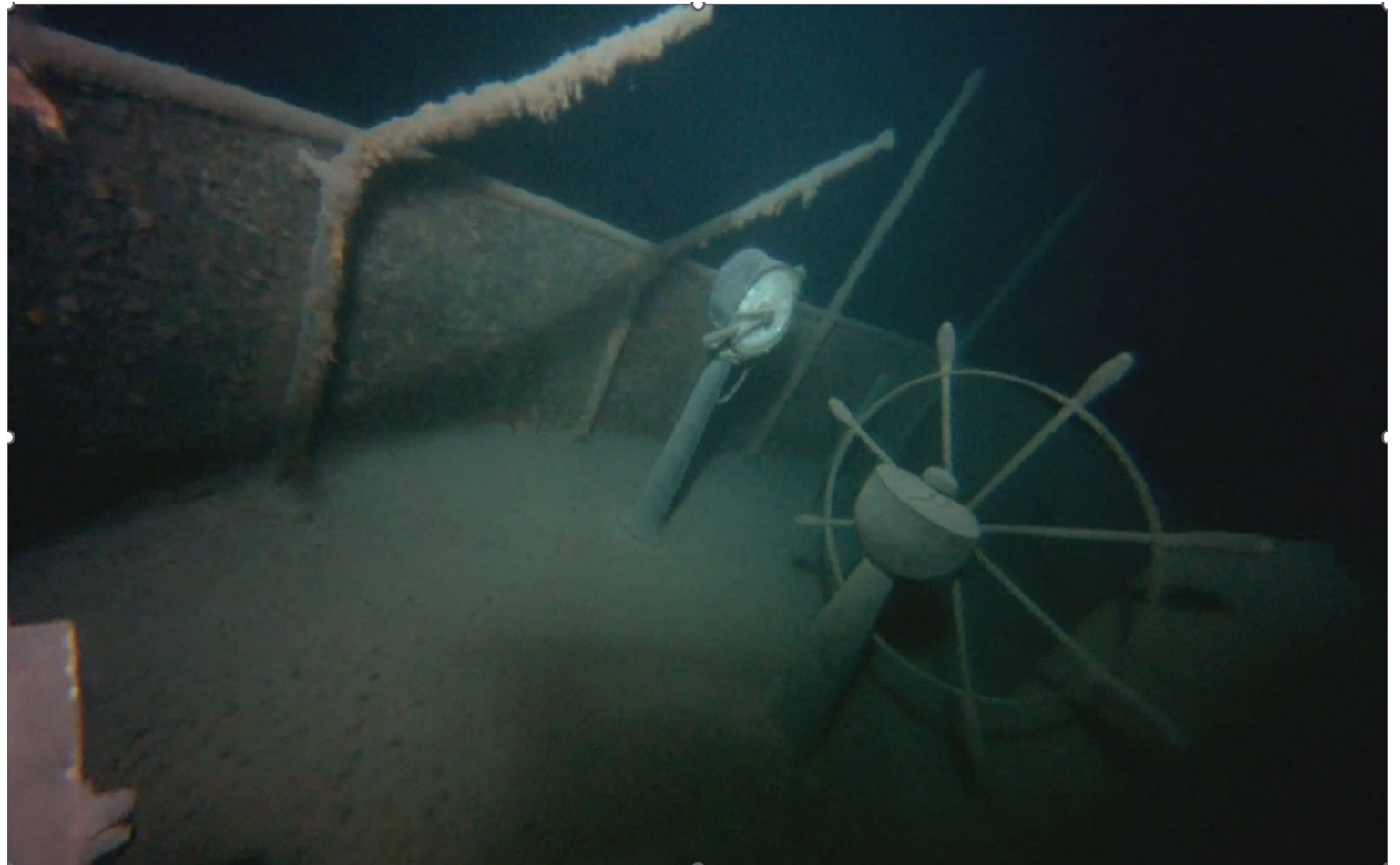
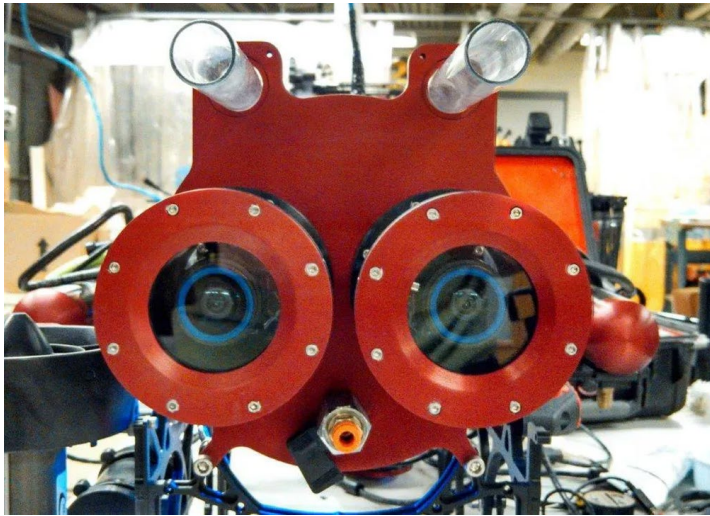
Situational Awareness

- 200 lp/mm lens
- ~120deg HFOV



Underwater autonomous vehicle

- 3D imaging
- 116, 120 or 135deg
- 200 lp/mm
- Through custom window



Autonomous excavator

- 200 lp/mm lens
- 125-135deg HFOV
- Allows 22deg electronic image slewing
- Ximea PCI Express camera to stream uncompressed data with low latency
- Mitholz Ammo Depot



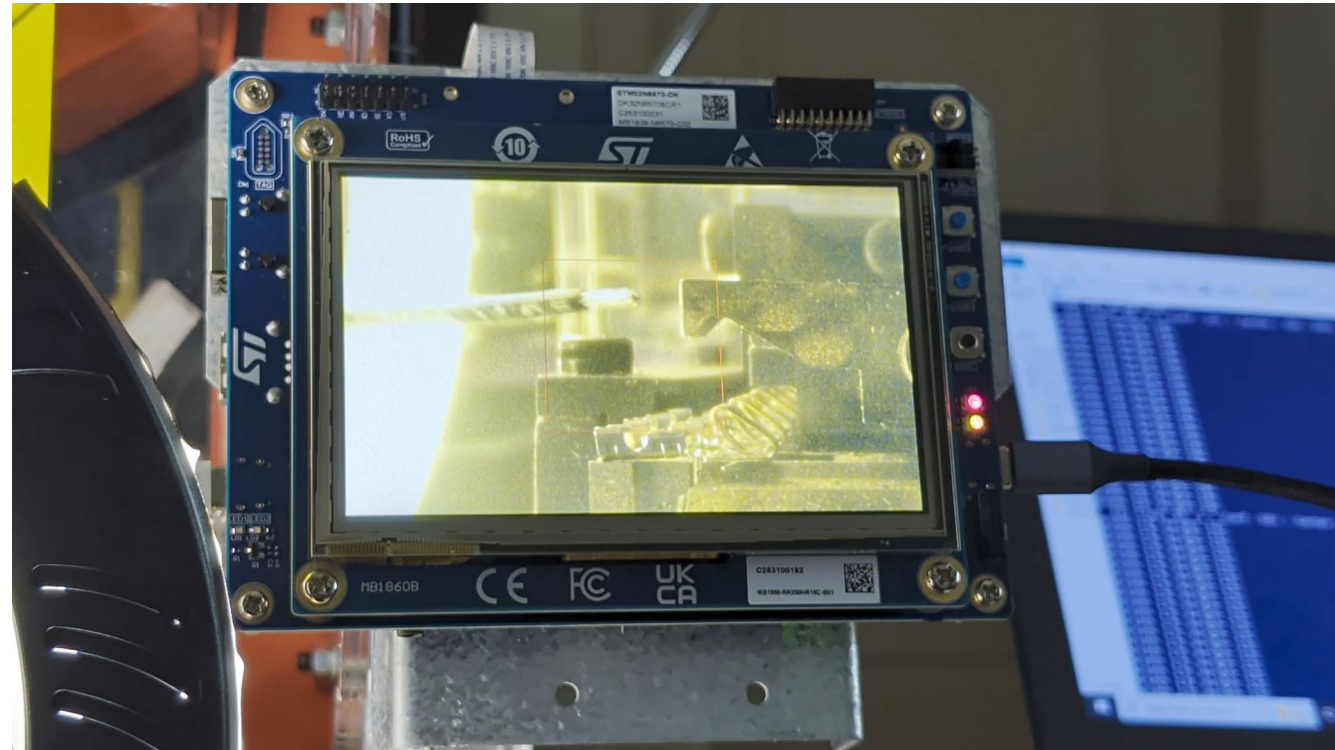
Motion Tracking & Analysis

- 116 – 120deg HFOV
- 200 lp/mm
- DARIMotion markerless tracking system



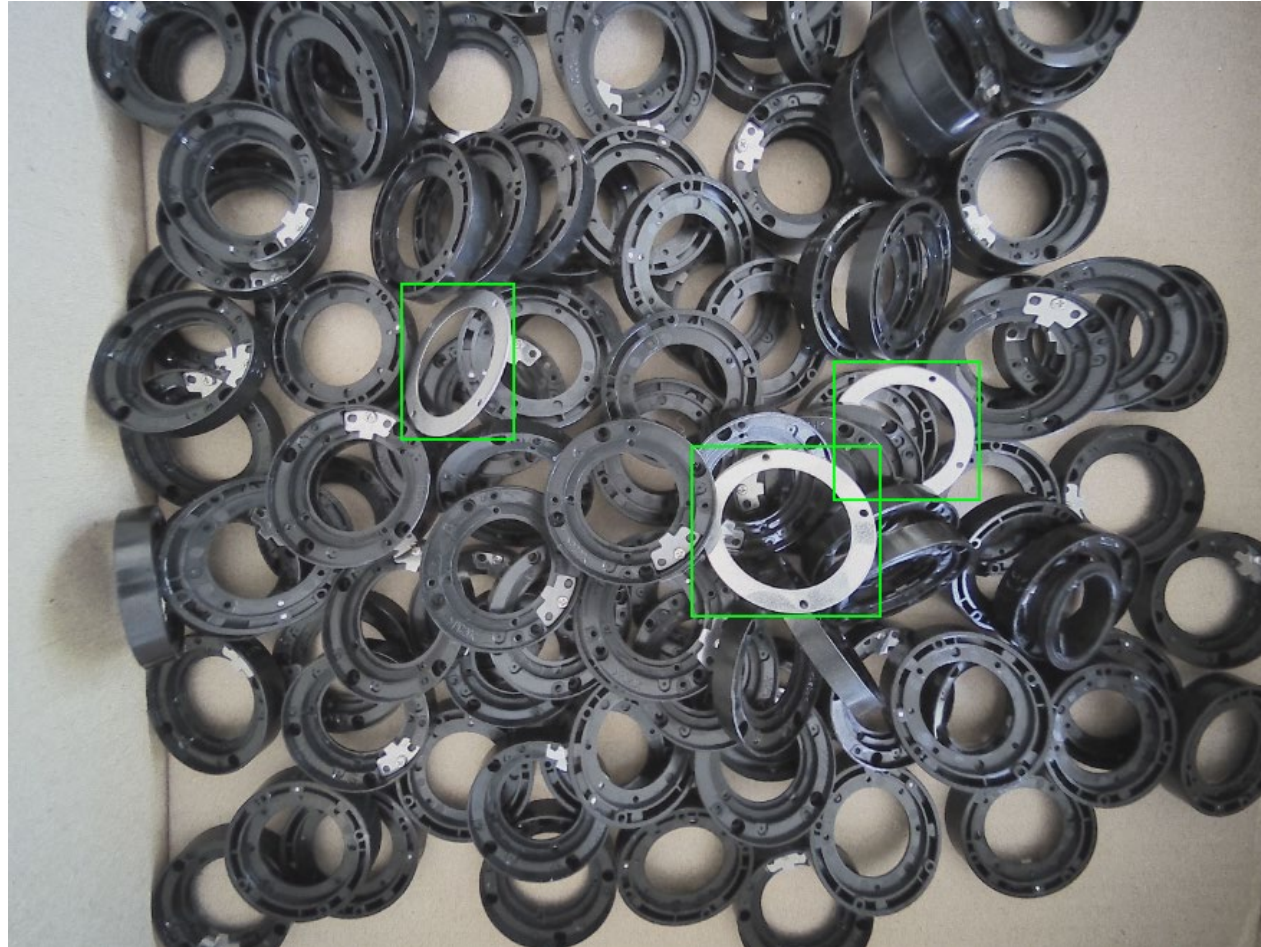
Inspection with Machine Learning

- 2.3mm fixed lens
- 200 lp/mm
- 5mpx camera
- Wire crimp anvil 1.75 in. from front lens element;
- Filter stack within 1.75 in.



Bin picking

- 116deg HFOV
- MOD .1m
- 200 lp/mm
- No latency



Spatial mapping

- 140deg HFOV
- 200 lp/mm



Automotive crash testing

- 116deg HFOV
- 1/1.8" format
- 200 lp/mm
- Ruggedized OTS Lens
- Custom protective hood on front of lens



Theia Rectilinear Lenses



SY125 & MY125	SY110 & MY110	SL183 & ML183	MY23F
1.3mm fixed FL	1.7mm fixed FL	1.8 – 3.0mm varifocal	2.3mm fixed FL
135° HFOV	120° HFOV	120° to 92° HFOV	116° HFOV
7% corner distortion	2% corner distortion	0% corner distortion	<1% corner distortion
Visible or IR only	IR corrected from 640 to 940nm	IR corrected from 640 to 850nm	IR corrected from 640 to 850nm
200 lp/mm	160 lp/mm	200 lp/mm	200 lp/mm
1/2.5" sensor	1/3" sensor	1/2.3" sensor	1/1.8" sensor
0.1m MOD	0.2m MOD	0.3m MOD	0.5m MOD

Contact info

Mark Peterson

Co-founder and
VP Advanced Technology

Theia Technologies

Wilsonville, OR

503-570-3296

info@theiatech.com

www.theiatech.com

