

The logo for Jabil Optics, featuring the word "JABIL" in a large, bold, white sans-serif font above the word "OPTICS" in a smaller, white sans-serif font. The logo is positioned on a dark blue background that is part of a larger graphic element consisting of overlapping geometric shapes in shades of blue and green.

JABIL
OPTICS

The title text is centered on the right side of the slide. It is written in a bold, dark blue, sans-serif font. The background behind the text is a blurred, close-up view of a camera lens, showing the intricate details of the lens elements and their reflections.

**BLINDED BY THE LIGHT:
RESOLVING THE AMBIENT
LIGHT PERFORMANCE ISSUE
OF A TOF CAMERA**

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January 2022

A FULL-SERVICE SOLUTION ENABLEMENT COMPANY



MARKETS WE SERVE



Healthcare Smart Packaging Mobility Consumer Lifestyles & Wearables Defense & Aerospace Cloud Computing & Storage Networking & Telecom Digital Home Point of Sale Automotive Optics Capital Equipment Industrial & Energy

OUR ABILITY TO EXECUTE



~250K

Employees



130+

Locations in
29 Countries



27,000+

Supply Chain
Partners



1,600+

Capabilities



400+

Brands



\$29.3B

FY21 Revenue

MARKETS REQUIRING AMBIENT LIGHT OPERATION

LAST MILE



AGRICULTURE



AUTONOMOUS FORKLIFTS



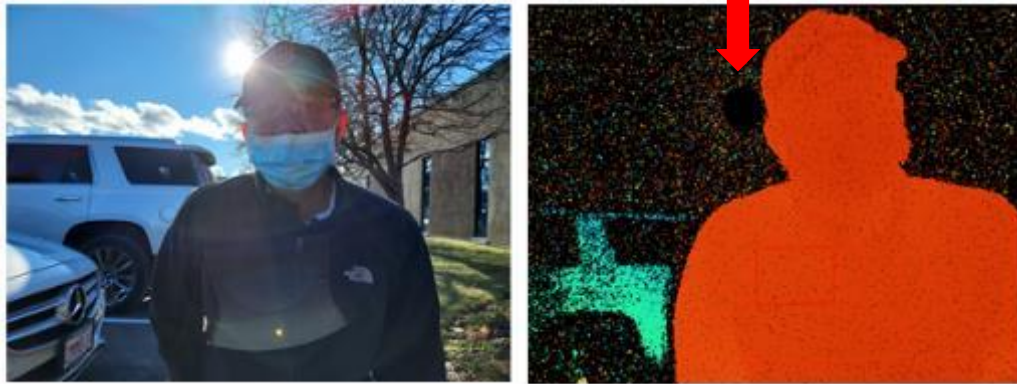
AUTOMOTIVE LIDAR



INDOOR



AMBIENT LIGHT POSES A SIGNIFICANT CHALLENGE FOR DEPTH CAMERAS



940nm iToF Camera



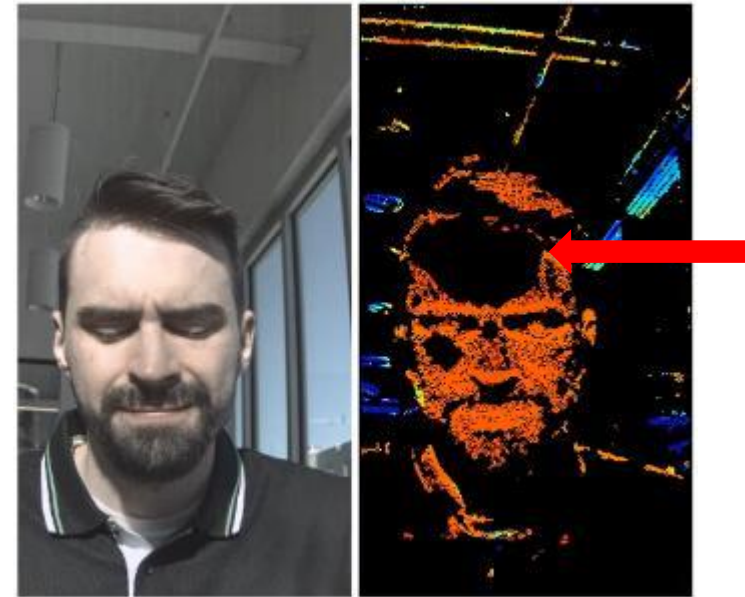
940nm iToF Camera

Notice the dark spots in the depth images. If this were on a moving robot or vehicle, the blind spot could pose a safety risk.

IT ISN'T JUST TOF DEPTH CAMERAS THAT SUFFER

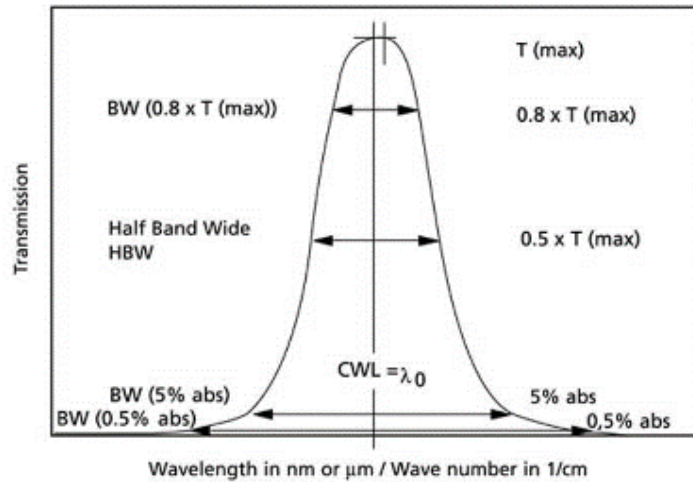


850nm Active Stereo Camera



Visible Spectrum Depth Camera

Narrow Bandpass Filter



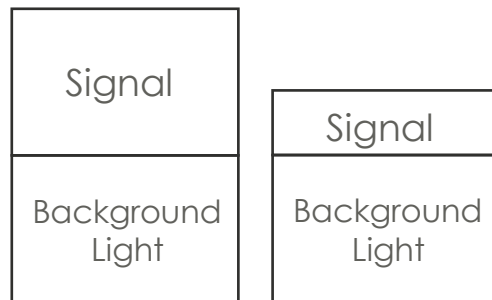
Background Subtraction

$$\Phi (\text{phase}) = \tan^{-1} \left(\frac{Q_{270} - Q_{90}}{Q_{180} - Q_0} \right)$$

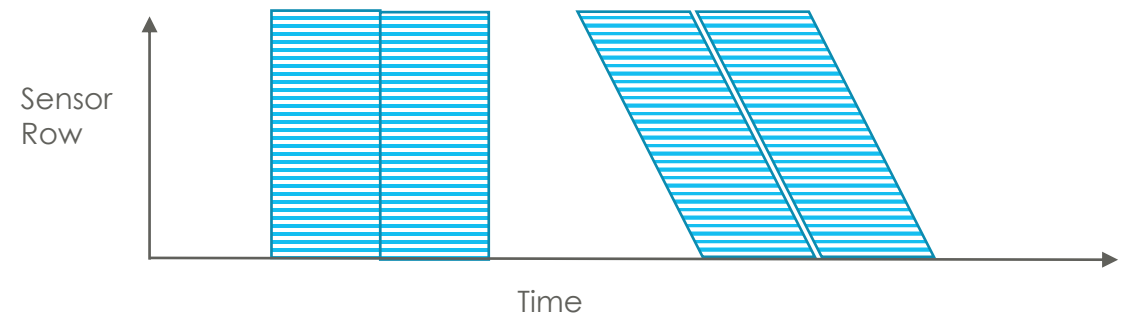
$$\text{Amplitude} = \sqrt{(Q_{180} - Q_0)^2 + (Q_{270} - Q_{90})^2}$$

$$Z (\text{depth}) = \frac{c}{2f_m} \times \frac{\Phi}{2\pi}$$

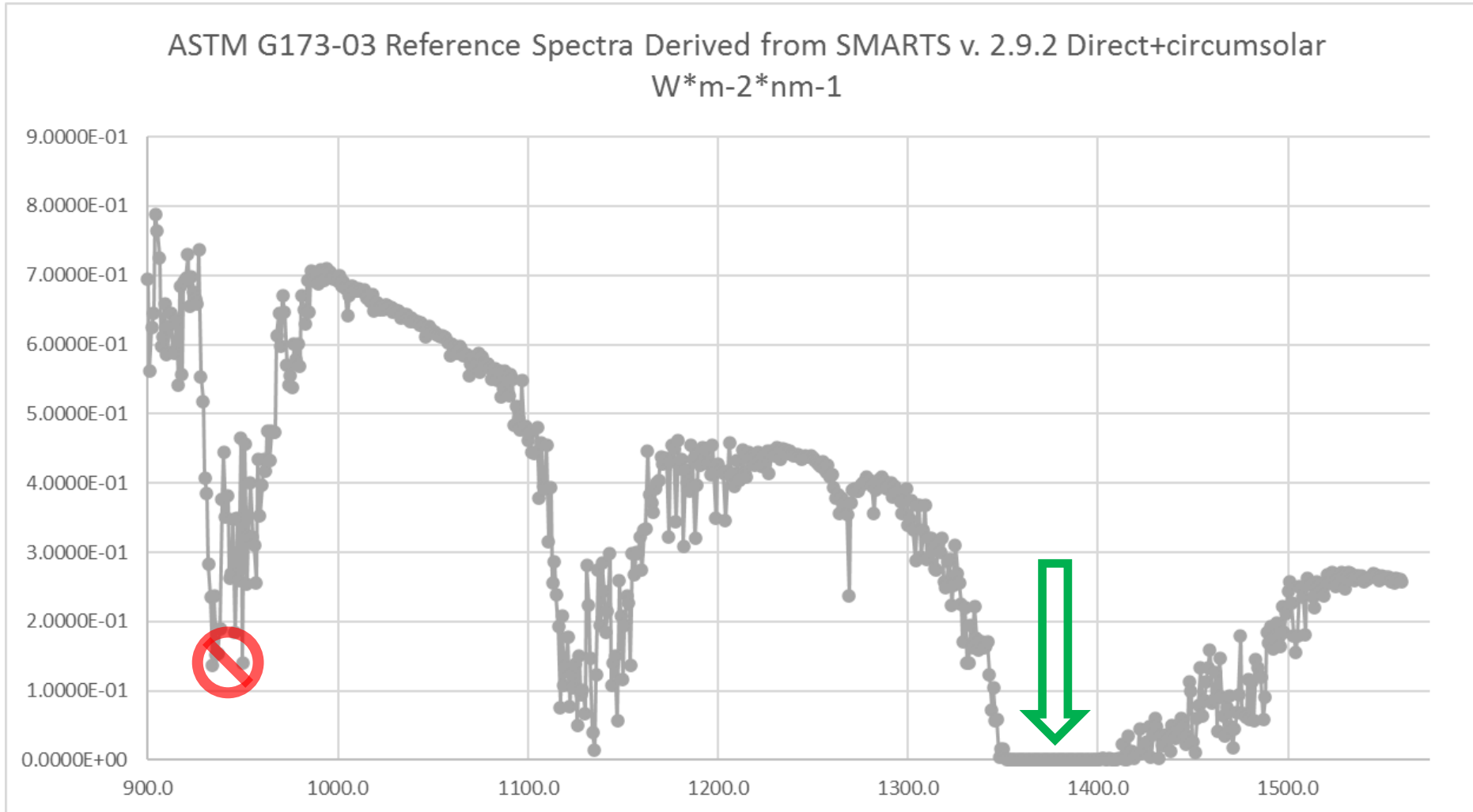
Large Full Well Capacity



Global Shutter vs Rolling Shutter



IF YOU CAN'T BEAT THEM.....



1380NM: INCREASED SIGNAL AND INCREASED SAFETY



ISSUE

Active illumination is reduced by $1/r^2$



CONSTRAINT

Laser eye safety limits the amount of laser power at 940nm



SOLUTION

Use a wavelength that can increase the magnitude of the signal while remaining below laser eye safety / skin safety limits (MPE)



1380nm

Potential for order(s) of magnitude more laser power than 940nm⁽¹⁾

Table A.5 – Maximum permissible exposure (MPE) of the skin to laser radiation ^{a, b}

Wavelength λ nm	Exposure time t s					
	$<10^{-9}$	10^{-9} to 10^{-7}	10^{-7} to 10^{-3}	10^{-3} to 10	10 to 10^3	10^3 to 3×10^4
180 to 302,5		$30 \text{ J} \cdot \text{m}^{-2}$				
302,5 to 315	$3 \times 10^{10} \text{ W} \cdot \text{m}^{-2}$	$C_1 \text{ J} \cdot \text{m}^{-2}$ ($t \leq T_1$)	$C_2 \text{ J} \cdot \text{m}^{-2}$ ($t > T_1$)		$C_2 \text{ J} \cdot \text{m}^{-2}$	
315 to 400			$C_1 \text{ J} \cdot \text{m}^{-2}$		$10^4 \text{ J} \cdot \text{m}^{-2}$	$10 \text{ W} \cdot \text{m}^{-2}$
400 to 700	$2 \times 10^{11} \text{ W} \cdot \text{m}^{-2}$	$200 \text{ J} \cdot \text{m}^{-2}$	$1,1 \times 10^4 t^{0,25} \text{ J} \cdot \text{m}^{-2}$		$2\,000 \text{ W} \cdot \text{m}^{-2}$	
700 to 1 400	$2 \times 10^{11} C_4 \text{ W} \cdot \text{m}^{-2}$	$200 C_4 \text{ J} \cdot \text{m}^{-2}$	$1,1 \times 10^4 C_4 t^{0,25} \text{ J} \cdot \text{m}^{-2}$		$2\,000 C_4 \text{ W} \cdot \text{m}^{-2}$	
1 400 to 1 500	$10^{12} \text{ W} \cdot \text{m}^{-2}$	$10^3 \text{ J} \cdot \text{m}^{-2}$		$5\,600 t^{0,25} \text{ J} \cdot \text{m}^{-2}$		$1\,000 \text{ W} \cdot \text{m}^{-2} \text{ }^c$
1 500 to 1 800	$10^{13} \text{ W} \cdot \text{m}^{-2}$	$10^4 \text{ J} \cdot \text{m}^{-2}$				
1 800 to 2 600	$10^{12} \text{ W} \cdot \text{m}^{-2}$	$10^3 \text{ J} \cdot \text{m}^{-2}$		$5\,600 t^{0,25} \text{ J} \cdot \text{m}^{-2}$		
2 600 to 10^6	$10^{11} \text{ W} \cdot \text{m}^{-2}$	$100 \text{ J} \cdot \text{m}^{-2}$	$5\,600 t^{0,25} \text{ J} \cdot \text{m}^{-2}$			

^a For correction factors and units, see Table 9.
^b There is only limited evidence about effects for exposures of less than 10^{-9} s. The MPEs for these exposure durations have been derived by maintaining the irradiance applying at 10^{-9} s.
^c For exposed skin areas greater than $0,1 \text{ m}^2$, the MPE is reduced to $100 \text{ W} \cdot \text{m}^{-2}$. Between $0,01 \text{ m}^2$ and $0,1 \text{ m}^2$, the MPE varies inversely proportional to the irradiated skin area.

The exposure limit values for the eye and skin are significantly higher at 1380nm than at 980nm. This is because the focusing effect of the lens has hardly any influence at 1380 nm because the light no longer reaches the retina.

(1) Depends on many factors

JABIL RESEARCH AND DEVELOPMENT PROGRAM

Goal: Develop a ToF depth camera based on 1380nm illumination

Outcome: Performance comparison of the 1380nm depth camera to current NIR depth cameras and active stereo cameras on the market

Timeline: 1Q22-2Q22

Risks: Limited selection of sensors, filters, lasers in the 1350nm-1400nm range



1380nm proof-of-concept
3D Depth camera



Outdoor scene with sun
facing camera



Outdoor scene captured
with 940nm 3D Depth
camera



Outdoor scene captured
with 1380nm proof-of-
concept 3D Depth camera -
the sun is gone!

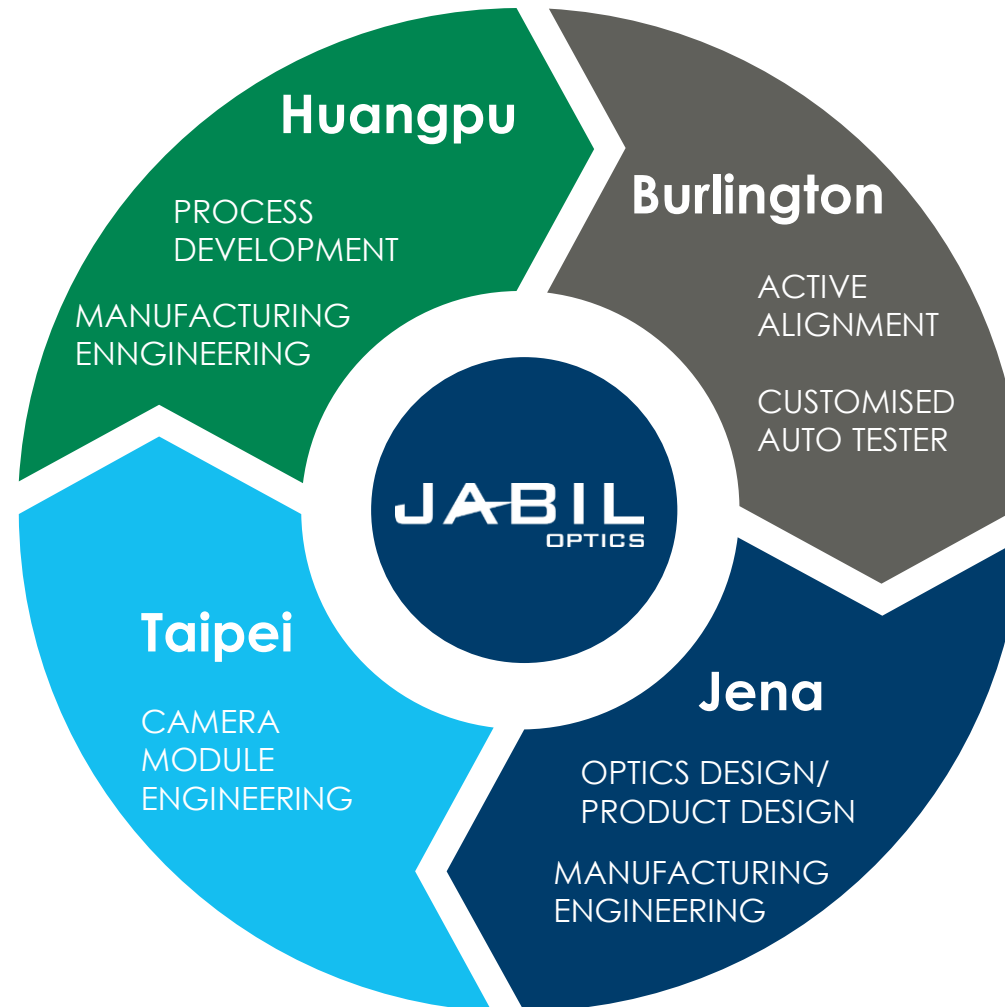
WHAT JABIL OPTICS CAN DO FOR YOU....

PROCESS DEVELOPMENT

- Advanced process solutions
- Optimal material and component selection
- Customized adhesive solutions
- Equipment guidance and selection

MANUFACTURING ENGINEERING

- Design and procurement of optical lens assemblies and sub-assemblies
- New product introduction
- High-volume production of optical solutions
- Final goods assembly
- Test
- Pack-out



ACTIVE ALIGNMENT

- Active alignment
- Precision components placement
- Lens assemblies
- Gluing technologies
- Chip-on-board, Chip-on-flex
- Chip-on-stiffener, FlipChip
- Wire-bonding and ACF bonding
- Assembly automation

PRODUCT DESIGN

- World class optics design
- Electrical engineering
- Design for high-volume manufacturing
- Design to cost

WHAT YOU CAN DO FOR JABIL OPTICS....

Dream
innovative
products



Supply (SWIR)
image sensors
lasers (VCSELs, EELs)
filters



Collaborate
design cutting
edge technologies



Demand
world-class
manufacturing
partner



THANK YOU



JABIL
OPTICS

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