

EPIC World Photonics Technology Summit 2019 Experience with Industrialization for Automotive of New Sensing Technologies Example Night Vision

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Content

- Veoneer – who we are and what we do
- Night Vision using Long Wave Infra Red (FIR)
- Lessons learnt with Night Vision that may be relevant for new automotive photonics developments
- Closing remarks

What we do



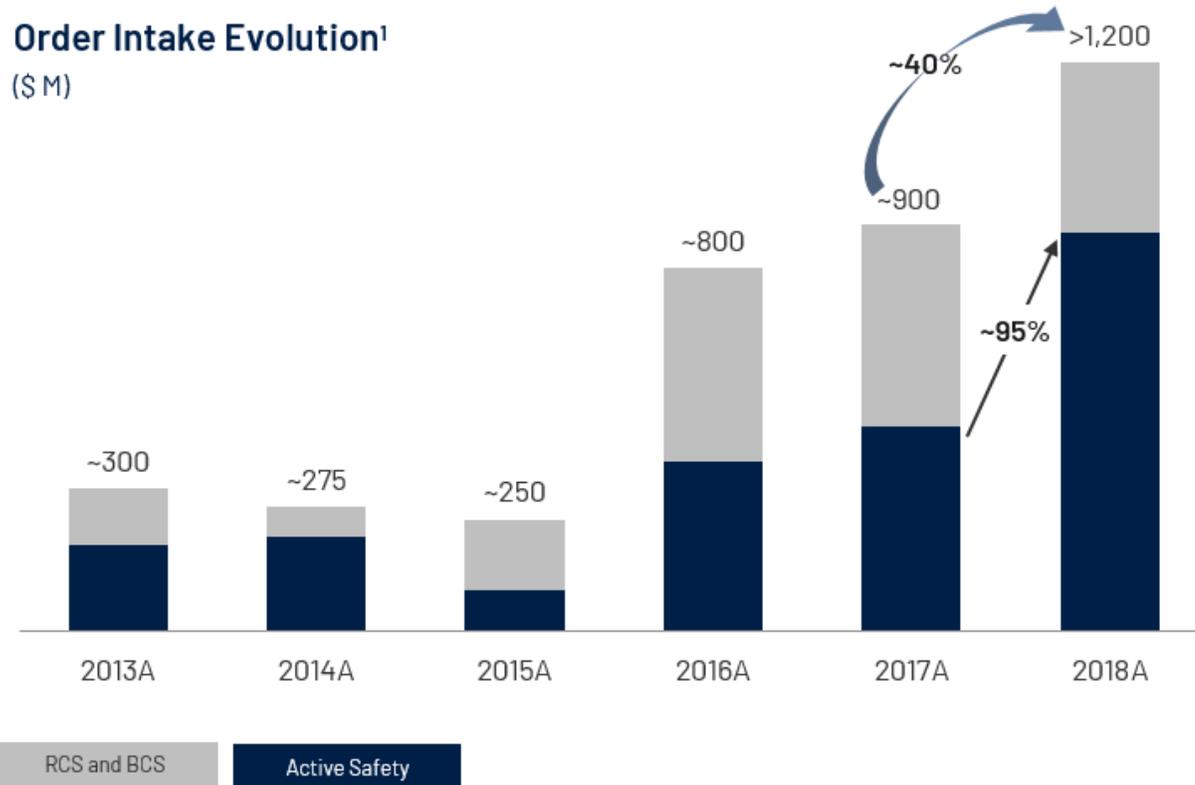
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Rapid expanding business

Estimated lifetime order value ~\$5.9B

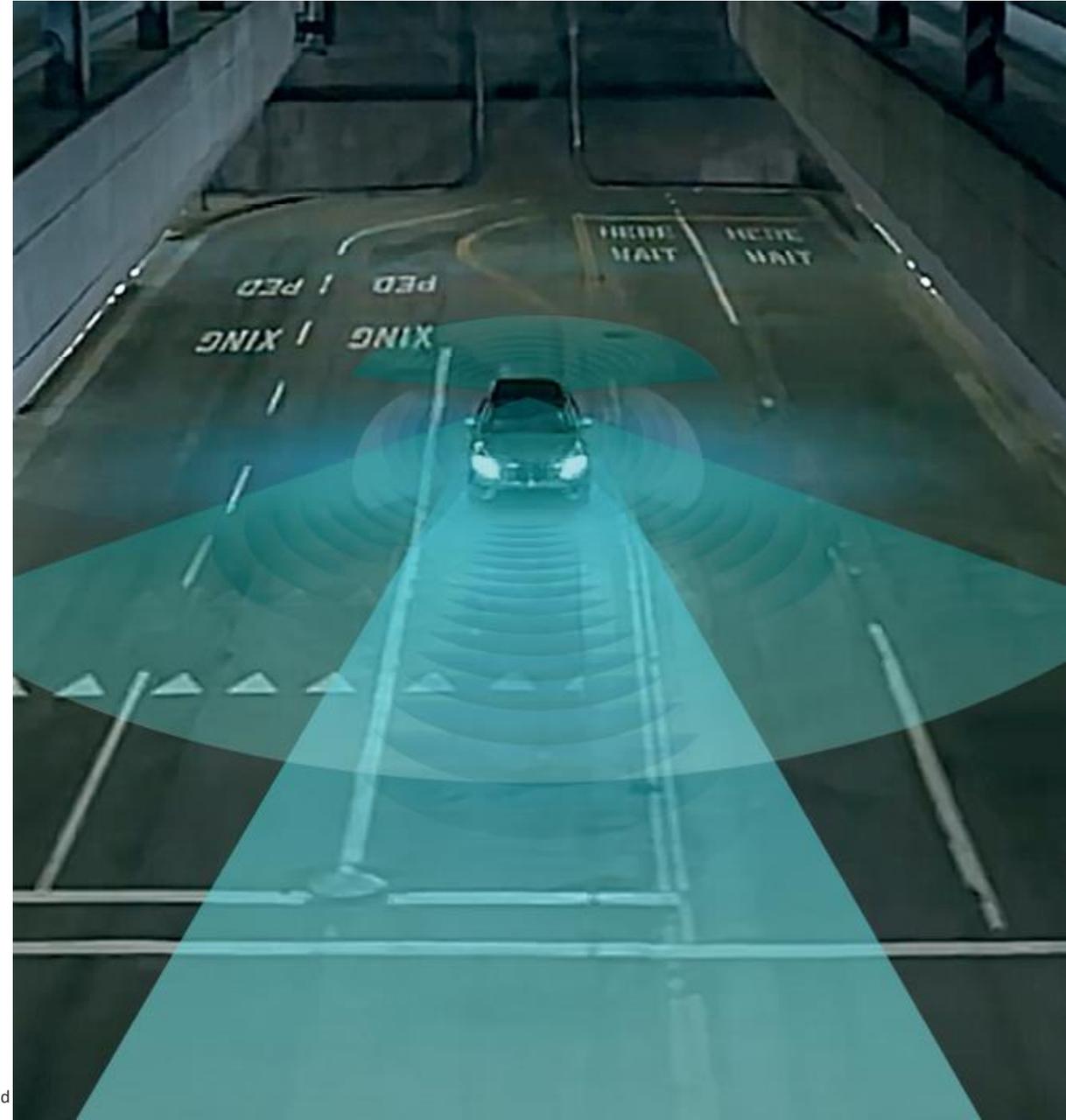
Order Intake Evolution¹

(\$ M)



¹Order Intake \$ value is defined as estimated average annual sales attributable to documented new business awarded based on estimated average annual product volumes, average annual sales price for such products, and exchange rates.

Lifetime order value is defined as estimated total lifetime sales attributable to documented new business awarded based on estimated product volumes and pricing, and exchange rates.



A Tech Company Delivering Automotive Grade electronics



More than 4 million
Camera Sensors Delivered



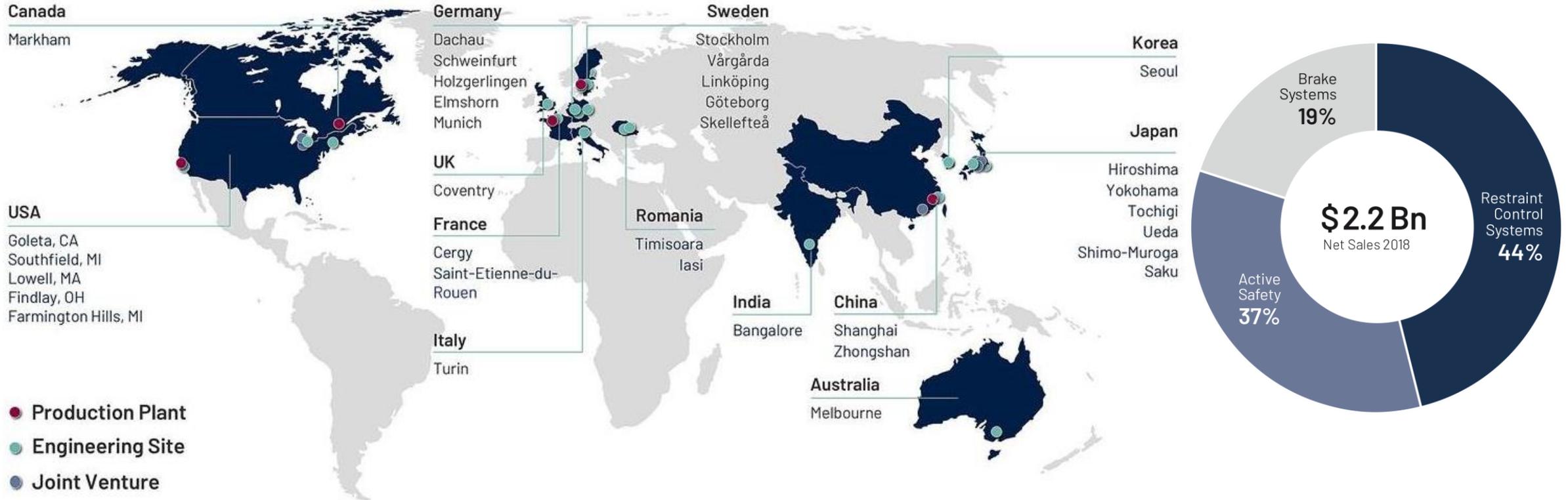
>33 million
Radar Sensors Delivered



~750 million
Airbag ECUs and Crash Sensors Delivered

Delivered during the past decade, as Veoneer and as part of Autoliv

A Global Footprint



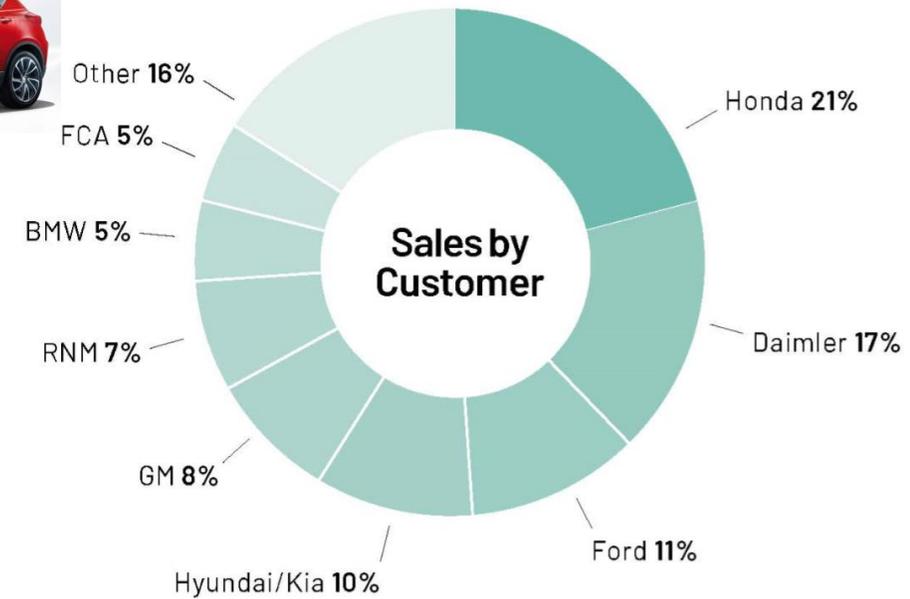
9,200 ASSOCIATES
~5,200 in R,D&E

13 COUNTRIES
10 MANUFACTURING SITES
26 TECHNICAL CENTERS

1,100 ENGINEERS
HIRED DURING 2018

2019 Key Launches and Mid-Cycle Model Facelifts

including all major product areas



Night Vision development



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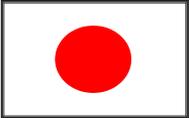
Night Vision development

Share some common traits with many photonics developments for automotive, e.g., LiDAR

- Initially too expensive for automotive
 - The sensor may be more expensive than the car
- New technology the automotive community wasn't accustomed to
 - Requirements unclear
 - Installation questions
- Many new components had to be industrialized for high volume, high quality at low cost
- Unclear timing
- **First year of automotive production may be higher than previous *accumulated* production**

Main driving force for Night Vision 1(2)

Many pedestrian fatalities in darkness

				
Pedestrian fatalities	4,884*	7,000	24,500	1,884
% of total traffic fatalities	12%	14%	25%	32%
% at night time	71%	47%	-	68%

* <http://www.iihs.org/iihs/topics/t/pedestrians-and-bicyclists/fatalityfacts/pedestrians>

Pedestrians

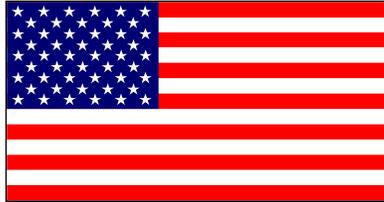


Animal Accidents Can Be Deadly



Main driving force for Night Vision 2(2)

Many animal accidents in darkness & twilight

		
Deer/Vehicle Accidents ¹	1,090,000	500,000
Human Fatalities ²	200	300
Human Injuries ^{2,3}	26,647	30,000
Property Loss ¹	3.5 B\$	1.0 B€

Sources: (1) State Farm, (2) Langley, et al 1995-2004, (3) Center for Disease Control and Prevention 2001-2002

Animal Detection



Night Vision with Marking Light



Animal Detection with Marking Light System

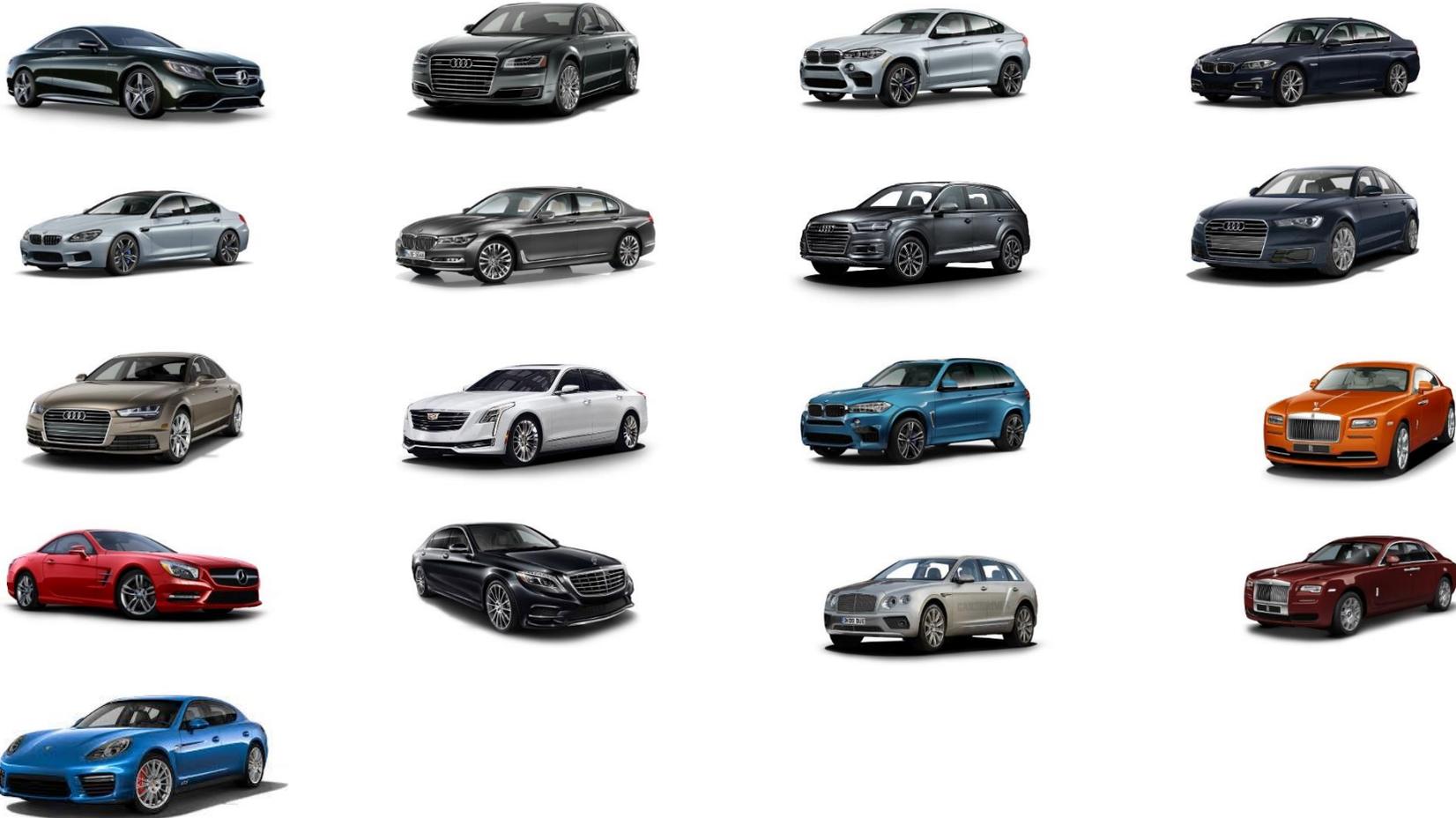


Example installation



Night Vision Image in Center Cluster Display

Night Vision Vehicles



Longwave IR (FIR) camera

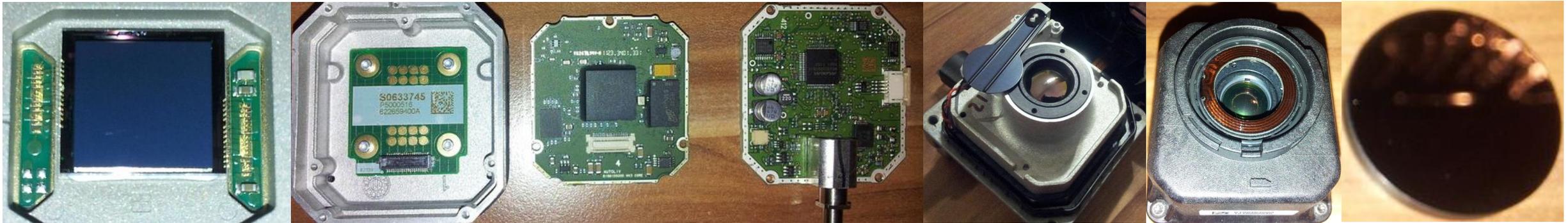
Micro-bolometer

Electronics

Shutter

Housing with heater ring

Protective Window
DLC coated
Germanium



Complete Assembly
With high-pressure cleaner



Heater: To manage icing in the winter and condensation in humid conditions

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Major issues with
Night Vision
that may be relevant
for new automotive
photonics
developments

1. Abrasion

Protective window made by DLC coated Germanium susceptible to abrasion and stone impacts



Specification of protective window

- Specified in accordance with military specifications and some automotive specs, mainly headlights.
- The windows were tested extensively according to specs and passed.
- Some time after launch we started seeing rejects where the DLC coat was completely removed.

What really occurred in the field

- We didn't consider "sandblasting" due to "high speed driving" in desert environments
- These conditions removed the DLC coating
 - Drops transmission > 30%
- Cause of warranty claim.



Sand abrasion should have been foreseen with better **requirements engineering**, at least to some degree

Drivers in sandy conditions protect their vehicles by tape etc.



Remedies

- Additional protection. Wire grids in front of the window. Do not work, because the grid would need to be so fine that transmission would be critically compromised
- Harder window material. Diamond windows were tried. Worked better, but very expensive.
- Tougher coating. Boron Phosphide considered, the toughest know coating. Capacity is limited and reserved for military projects. Expensive. Dangerous manufacturing processes.
- Eventual solution: Move the camera from under the bumper into the grill
- **The grill is a styling issue**

2. Heat management

- The Night Vision camera can't differentiate between the heat of interest and heat out of the field of view
 - The camera can vary in temperature but needs to have a uniform temperature
- Mounting the camera to the heavy front bumper beam should have provided enough thermal inertia
- During system tests strange gradations superimposed on the image. Occurred intermittently
- Extensive search for cause
 - Added temperature sensors on the bracket, but didn't believe the results:
 - Thermal change of 20°C/s recorded, about 6°C/min inside the camera!
 - “Back-flow” of hot air from the engine at traffic lights and stationary traffic
- Forced a complete design of the entire sensor
- **Late discovery (during system testing) meant major efforts to meet launch timing**



3. Rain drops

- Rain drops on protective window caused “heat flash”
 - Due to design of the enclosure
 - Back scatter from heated window

4. Installation tolerances

- Initial sensor form factor 8:3
 - Mainly horizontal field of view
 - To reduce detector cost
- Installation and alignment slowed vehicle assembly
 - Not possible to align accurately enough at vehicle production rate
- Increased vertical field of view
 - Changed to form factor 4:3
 - Doubled vertical pixels to allow for electronic alignment
- Increased detector cost substantial to allow sensor installation **to keep phase with vehicle assembly line**

5. Export control concerns

- The US Government has very strict ideas on the transfer (export) of anything that originated in the US.
 - Include 'friendly nations' like Canada, Europe Japan & South Korea.
- If the product is subject to export control and the product have non-US destinations, it is easier to use a non-US supplier even if the other supplier belong to a country that has signed the Wassenaar Arrangement.
- For development partnerships (thus not just the products) an approval of the US Government is required
 - Technology assistance agreements (TAA) can be obtained but it takes time.
 - For commercial technologies handled by the Department of Commerce
 - Military technologies require Department of State
 - The export license approval for Night Vision to Germany and points beyond took 2 years
 - Plan accordingly

Summary & Conclusions

An aerial night view of a city street intersection, showing buildings, roads, and traffic lights. The Veoneer logo is overlaid in white text on the right side of the image.

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Closing remarks

- Lessons learnt with Night Vision development that may be relevant for other automotive photonics developments:
 - Pay a lot of attention to requirements engineering *early* in the project
 - Pay especial attention to maybe perceived non-core function like:
 - Mounting location
 - Ambient exposure like temperature and abrasion
 - Vibration and EMC
 - Export control
- Thank You for your attention!

Thank You for your
attention

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Automotive Qualification Tests

- Summary of qualification tests completed and passed for the Type A automotive DMD and hermetic automotive DMDs
- Test results assure reliable operation in specified conditions
- Several iterations
- Significant time duration required ***on an existing high volume product***

Test Category	Tests	Conditions	
		Type A Package	Hermetic DMD Package
Accelerated Environmental Stress	<ul style="list-style-type: none"> • Unbiased HAST • Temperature Cycling • Power and Temp Cycling • High Temp Storage • Low Temp Storage • Biased HAST 	<ul style="list-style-type: none"> • 110C/85%RH, 264hrs • -55C/125C, 500cyc • -40C/90C, 1000cyc • 105C, 2000hrs • -40C, 1000hrs • N/A 	<ul style="list-style-type: none"> • 110C/85%RH, 264hrs • -55C/125C, 1000cyc • -40C/105C, 1000cyc • 125C, 1000hrs • -40C, 1000hrs • 110C/85%RH, 264hrs
Life Tests	<ul style="list-style-type: none"> • High Temp Operating 	<ul style="list-style-type: none"> • 90C, 1000hrs 	<ul style="list-style-type: none"> • 105C, 1000hrs
Package Assembly Integrity	<ul style="list-style-type: none"> • Wire Bond Shear • Wire Bond Pull 	<ul style="list-style-type: none"> • Standard • Standard 	<ul style="list-style-type: none"> • Standard • Standard
Cavity Package Integrity	<ul style="list-style-type: none"> • Mechanical Shock • Vibration • Acceleration • Fine/Gross Leak • Package Drop • Die Shear/Pull 	<ul style="list-style-type: none"> • 1500G, 1.5 msec • 20G, 20 – 2000 Hz • 10,000G • Standard • Standard • Standard 	<ul style="list-style-type: none"> • 1500G, 1.5 msec • 20G, 20 – 2000 Hz • 10,000G • Standard • Standard • Standard
Electrical Verification	<ul style="list-style-type: none"> • ESD • Characterization • Electrical Distribution 	<ul style="list-style-type: none"> • HBM, CDM • Per datasheet, tri-temp • Per datasheet, tri-temp 	<ul style="list-style-type: none"> • HBM, CDM • Per datasheet, tri-temp • Per datasheet, tri-temp

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