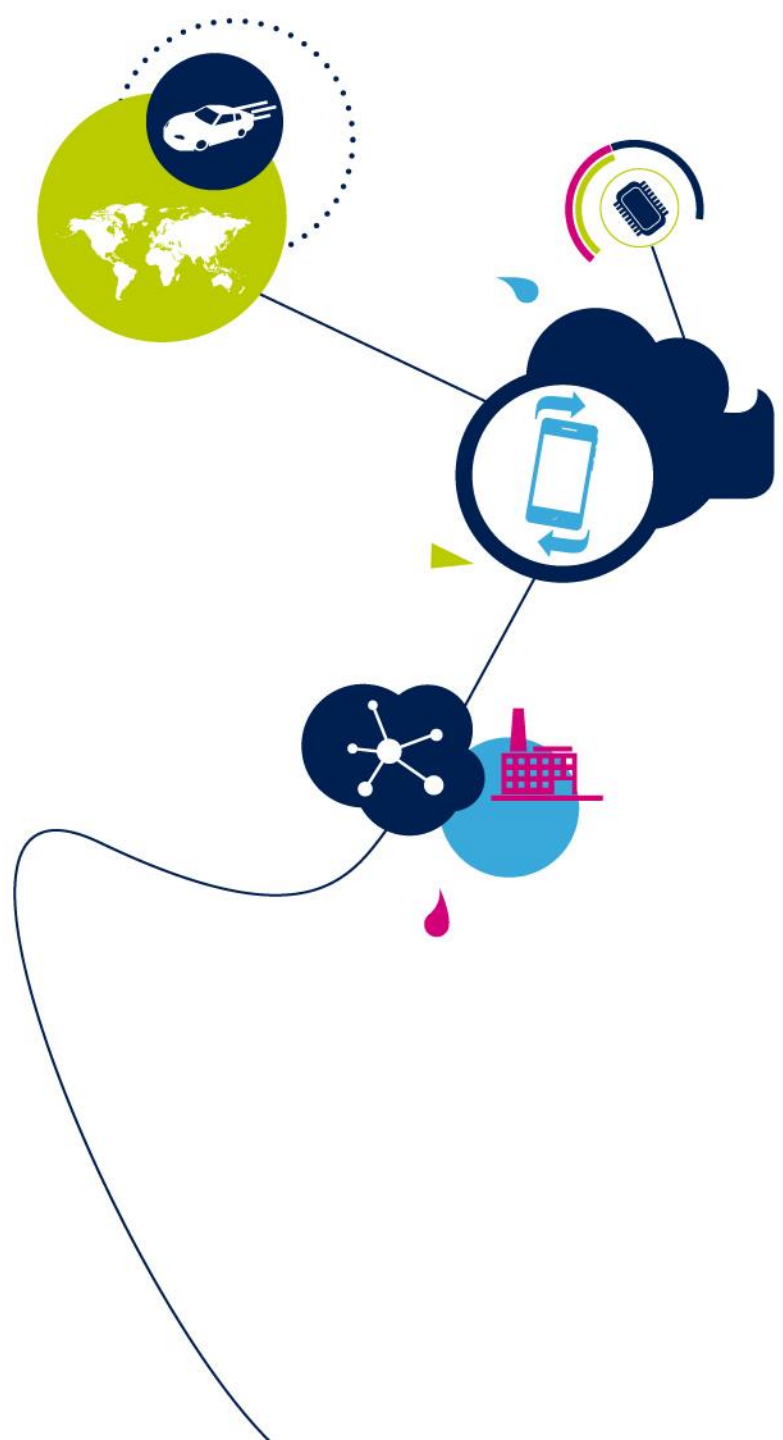


Self-Driving Cars: The Next Revolution

Johnson WANG

Infotainment Marketing Manager
Automotive Product Group
Greater China & South Asia Region
STMicroelectronics





- Among the world's largest semiconductor companies
- Serving over **100,000** customers across the globe
- 2018 revenues of **\$9.66B**, with year-on-year growth of **15.8%**
- Listed: NYSE, Euronext Paris and Borsa Italiana, Milan
- Signatory of the United Nations Global Compact (UNGC), Member of the Responsible Business Alliance (RBA)

- **~46,000** employees worldwide
- **~ 7,400** people working in R&D
- **11** manufacturing sites
- Over **80** sales & marketing offices

Smart Driving Success

Our Key Ingredients: Technologies, Products... Solutions!

Smart Power

BCD

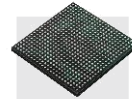


VIPower

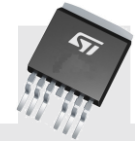


Automotive

Digital



Power & Discrete



Automotive Solutions

System Basis Chip
Engine Management System
Audio Amplifier
Motor Control
Door Modules

Protected FETs:
High-Side Switches
Low-Side Switches
H-Bridge DC Motor Driver
Power Distribution (**VIPZero**)

32-bit MCUs
Radar
Vision System
Positioning (GNSS)
Infotainment Processors
Telematics Processors

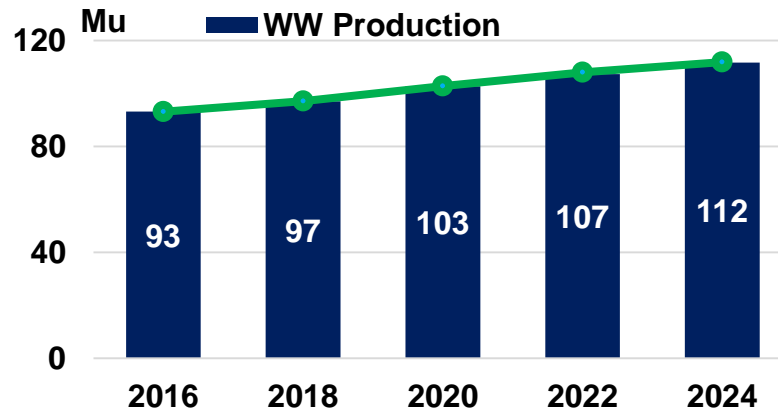


High & Low Voltage
MOSFETs
EOS Protections
High Efficiency **Diodes**
EMI Filters
IGBT

Automotive & Transportation Market Trend

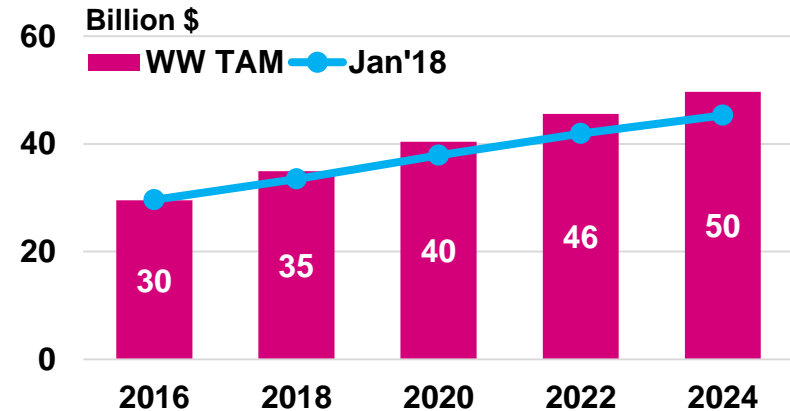
Light Vehicle and Automotive Semiconductor Market

Production Light Vehicles



Region	2017	2022	CAGR %
AMERICA	20.4	22.2	1.5%
APAC	49.9	57.2	2.8%
EMEA	24.9	28.2	2.5%
Total	95.1	107.4	2.4%

Semiconductor TAM (by SA)



Region	2017	2022	CAGR %
AMERICA	7.9	11.0	7.0%
APAC	14.8	21.2	7.5%
EMEA	9.9	13.4	6.3%
Total	32.5	45.6	7.0%

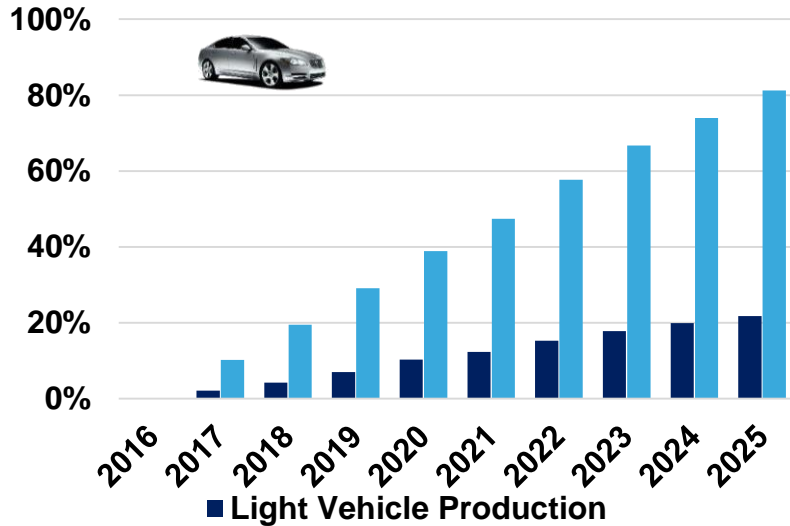
Source: Strategy Analytics – May 2018
LMCA – June 2018

Automotive & Transportation Market Trend

Growing Double Speed

Cumulated Growth Rate vs 2016

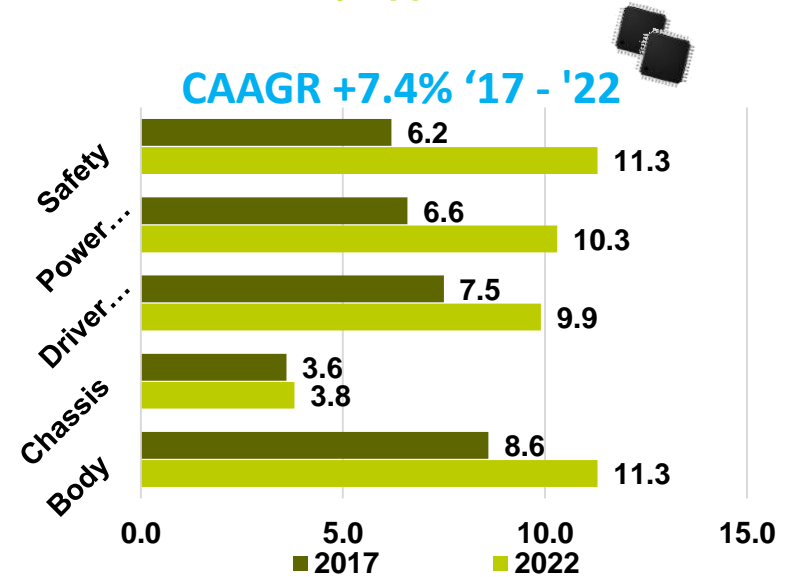
Light Vehicle Production & Semiconductor TAM



More than Double Speed Semiconductor Growth vs. LV Car Market

Automotive Semiconductor Demand

Growth by Application



Safety App. Double digit Growth CAAGR +12.7%
Powertrain App. Growth CAAGR: +9.1%

Source: Strategy Analytics – July 2018
LMCA – June 2018



ST is Making Driving Safer

6

Autonomous Driving



What Autonomous Driving Means

- Use of a range of technologies to enable a vehicle to become completely autonomous or self-driving, requiring no human interaction



Data Points – Autonomous Driving

The Need for Safer Driving

Annual global road crash statistics

- Nearly 1.3 million people die in road crashes each year, on average 3,287 deaths a day
- An additional 20–50 million are injured or disabled
- Road traffic crashes rank as the 9th leading cause of death and account for 2.2% of all deaths globally
- Road crashes are the leading cause of death among young people ages 15–29, and the second leading cause of death worldwide among young people ages 5–14
- Road crashes cost USD \$518 billion globally, costing individual countries from 1–2% of their annual GDP
- About 94% of accidents caused by human error



Source: Association for Safe International Road Travel



Data Points – Autonomous Driving

The Need for Safer Driving

Road accidents

1,300,000

deaths per year due to road accidents



94%

of accidents caused
by human error



Data Points – Autonomous Driving

World Urbanization – Mexico City – An Example

8.6 million intercity population

21.2 million greater city population

+7%

increase in travel time
between 2015 to 2016

+59 minutes

extra travel time per day
due to congestion



Pollution



Parking

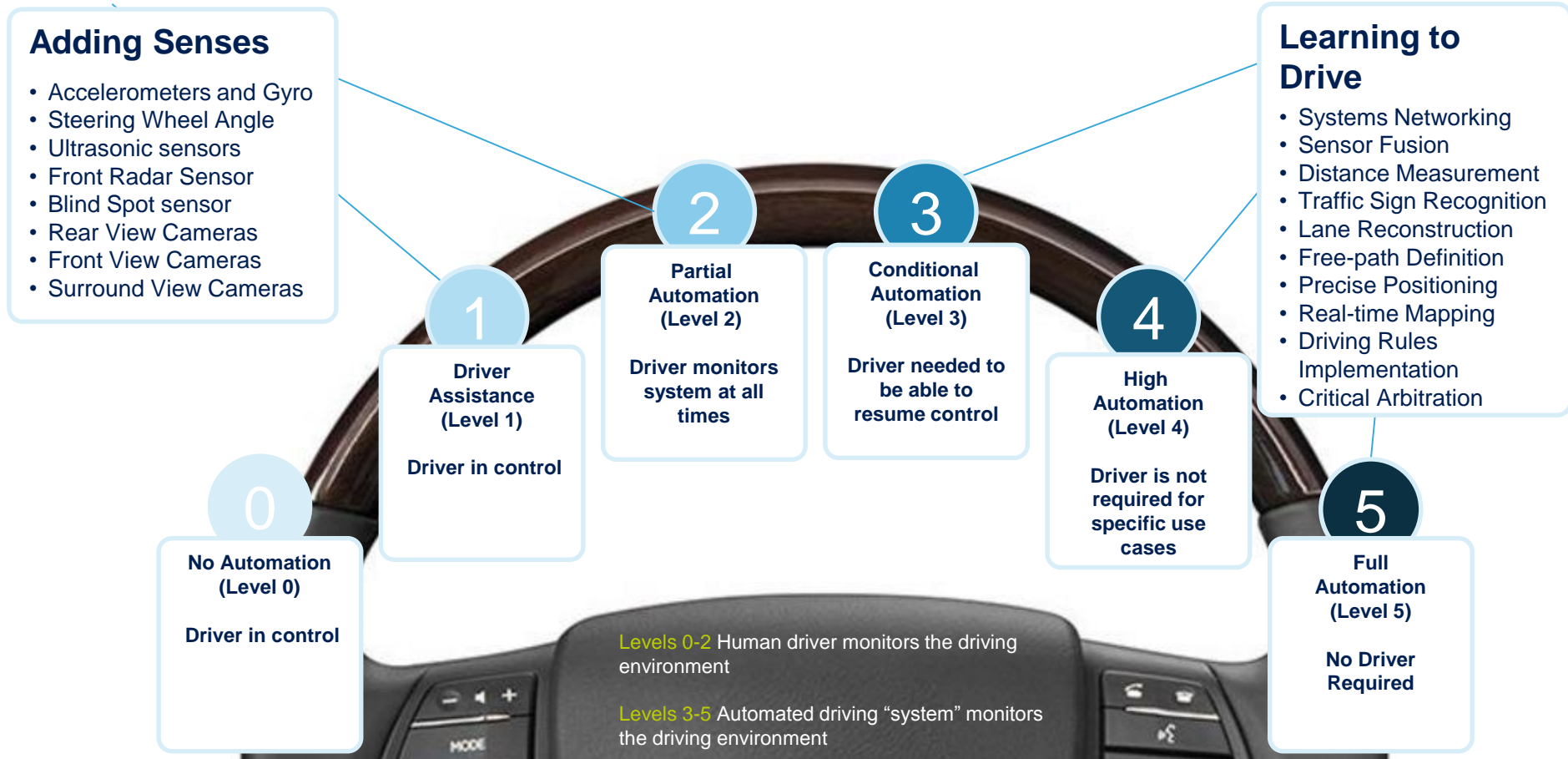


Congestion



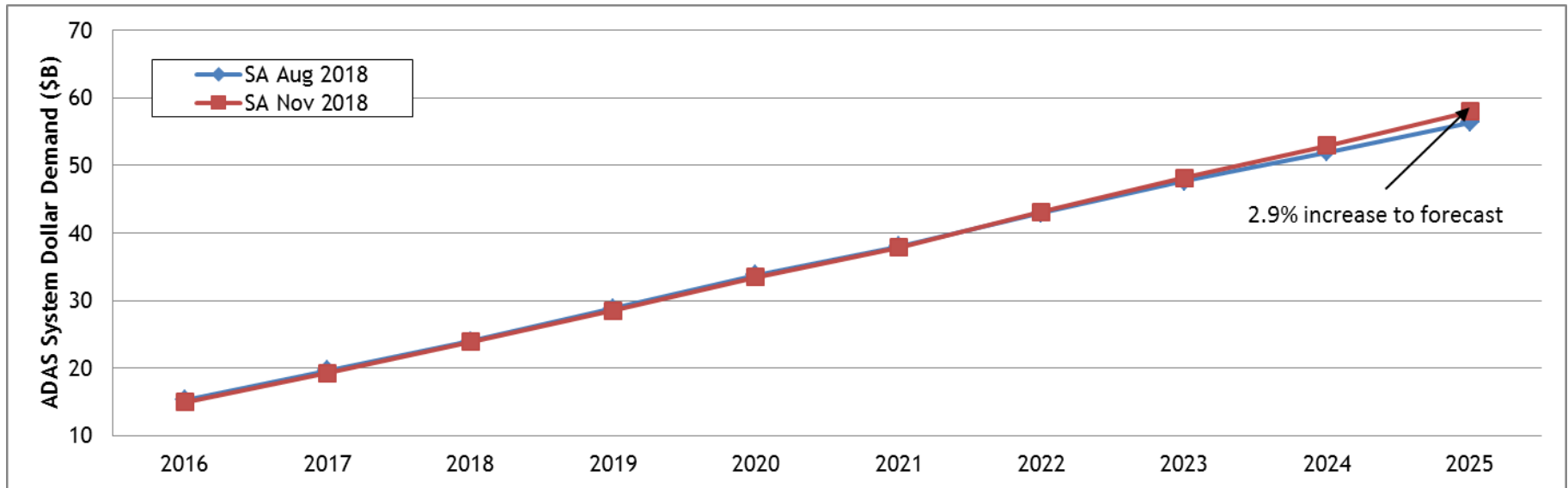
Safety

The 5 Levels of Vehicle Automation



Advanced Driver Assistance Systems

One of the Fastest Automotive Growth Areas

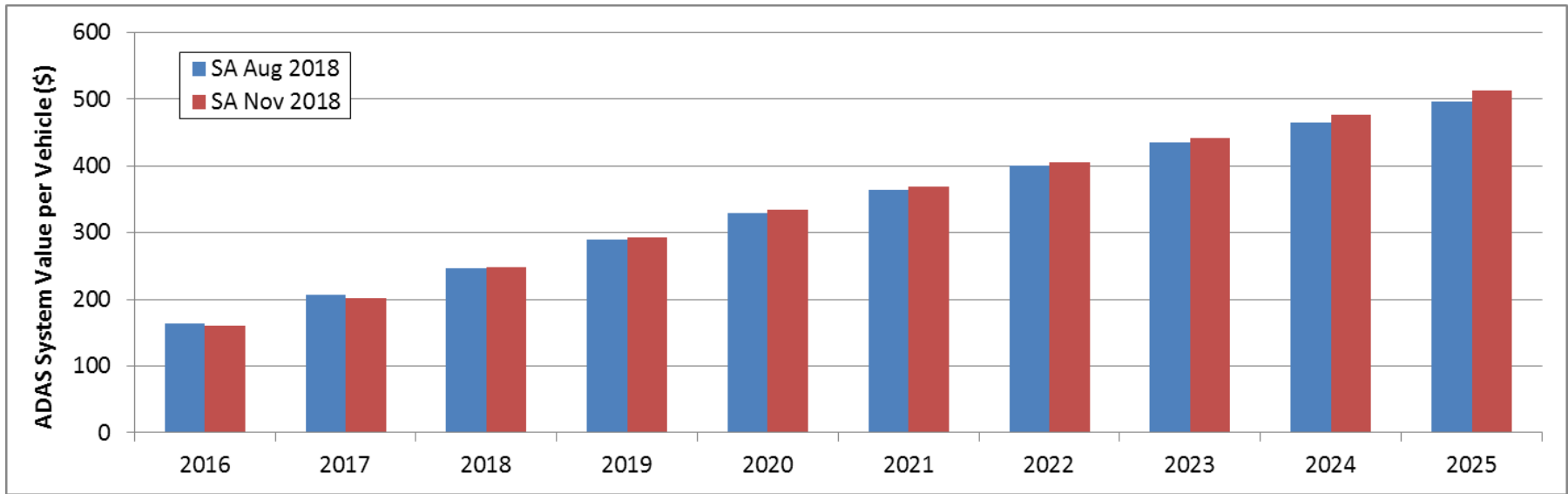


- ADAS demand forecast has increased in the long term, by up to 2.9% in 2025
- The main reason for this increase is that the LDWS and Distance Warning forecasts have been increased after feedback from clients that they were seeing OEMs increasing their orders for these systems

Resource: Strategy Analytics, Inc, Nov 2018.

Advanced Driver Assistance Systems

Total ADAS Value Per Vehicle (\$)

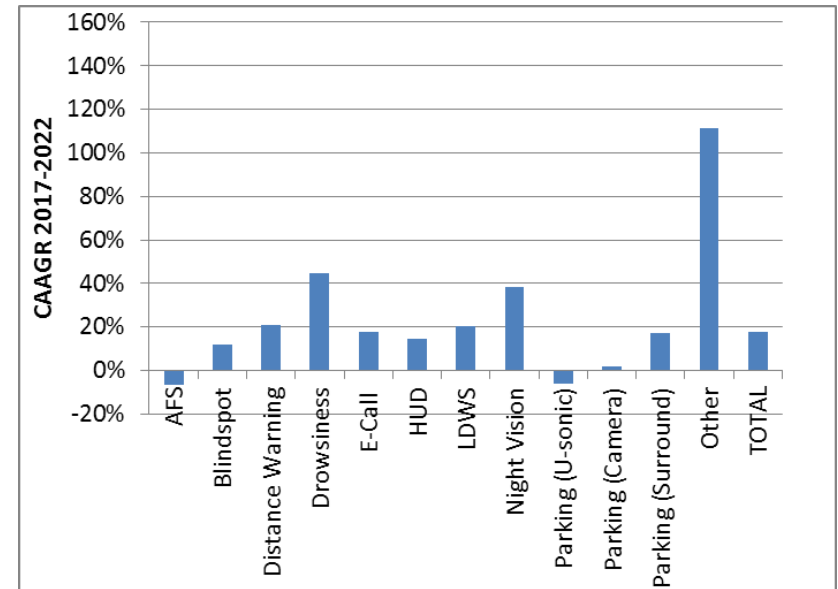
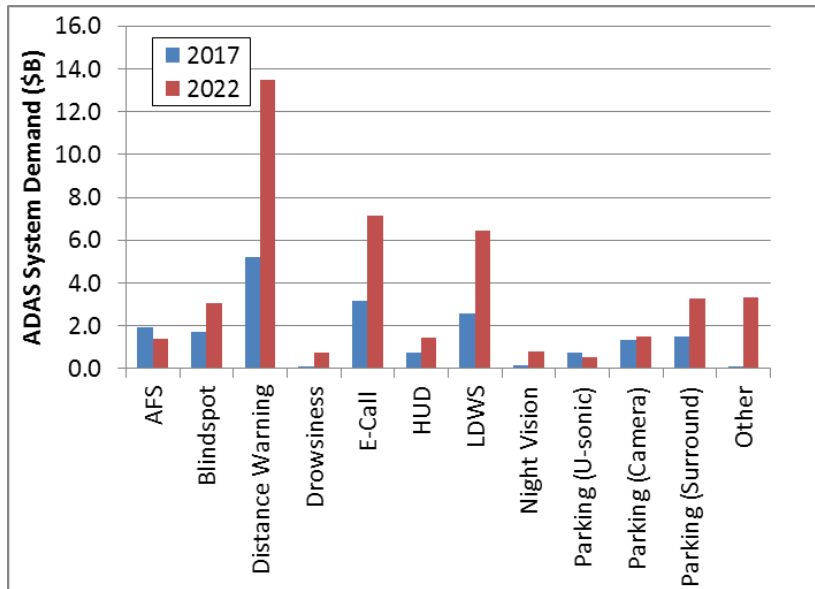


- Averaged across all vehicles, the value of ADAS features per vehicle will grow from \$160 in 2016 to \$514 by 2025

Resource: Strategy Analytics, Inc, Nov 2018.

Advanced Driver Assistance Systems

Growth Areas – System Types

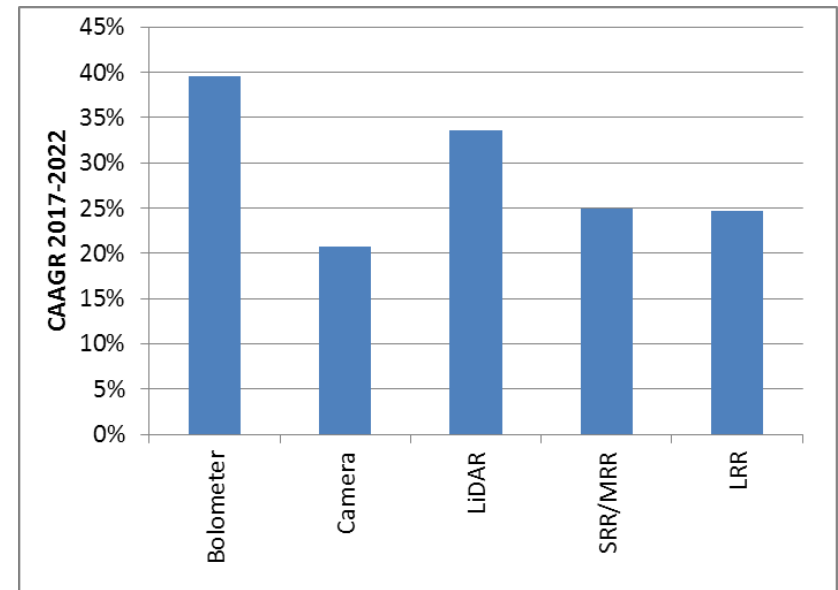
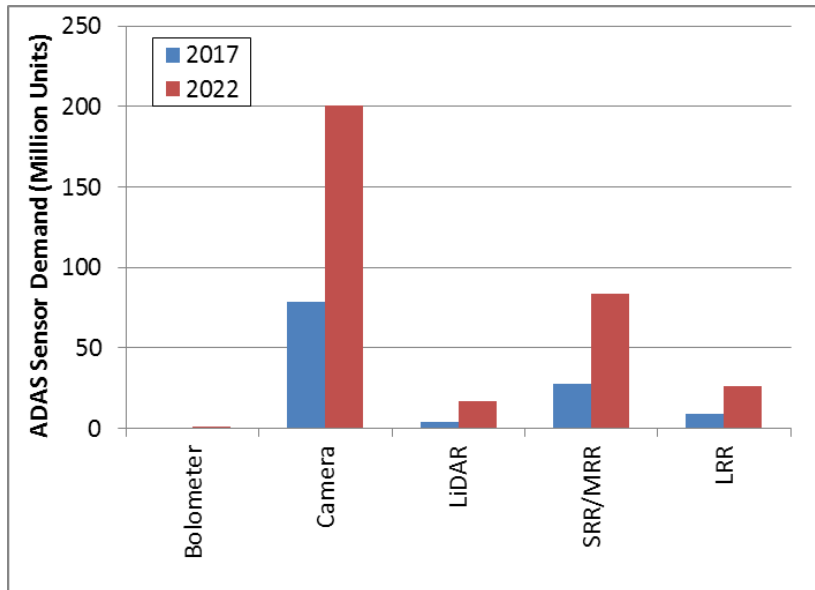


- Distance Warning to see best combination of growth and market size – includes AEB
- Strong growth in Drowsiness Monitoring / DMS solutions
- New “Other” systems still emerging in 2022 – high growth rate due to current tiny market size

Resource: Strategy Analytics, Inc, Nov 2018.

Advanced Driver Assistance Systems

Growth Areas – Sensors (Units)



- Camera unit growth slower due to maturity of rear-camera applications. LiDAR growth strongest of the volume sensors
- Ultrasonic sensors not included in above charts: there is still growth here (albeit slowing), reaching over 336 million sensors by 2025

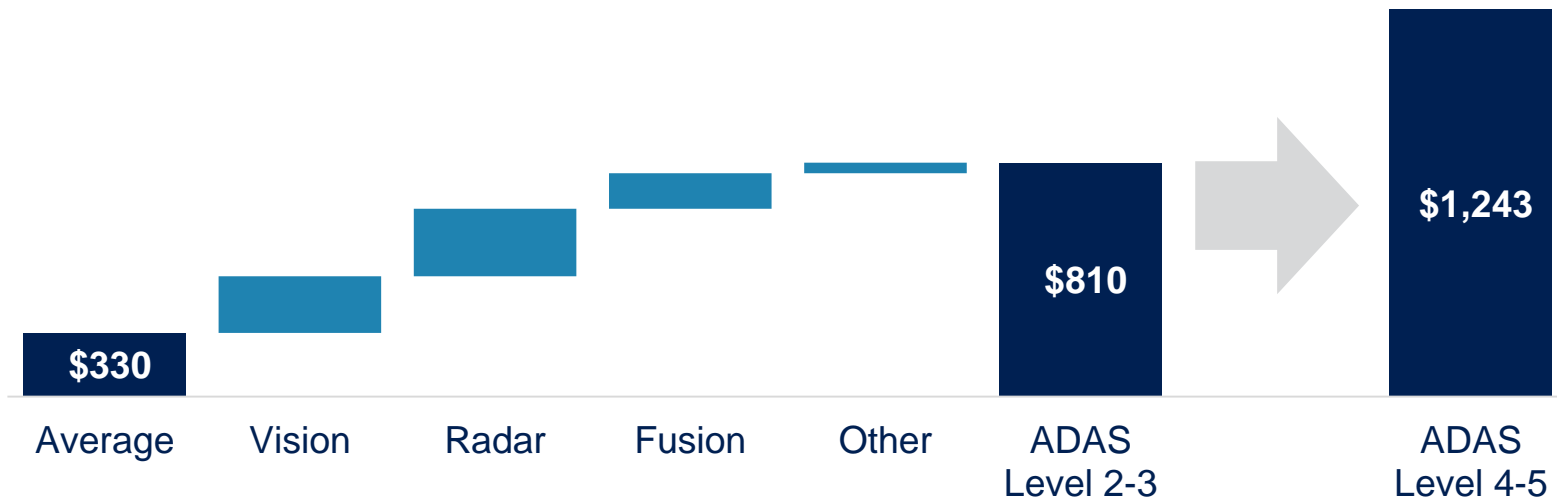
Resource: Strategy Analytics, Inc, Nov 2018.

Autonomous Driving Opportunity

Silicon Content

15

Autonomous Driving Content increase by ADAS levels



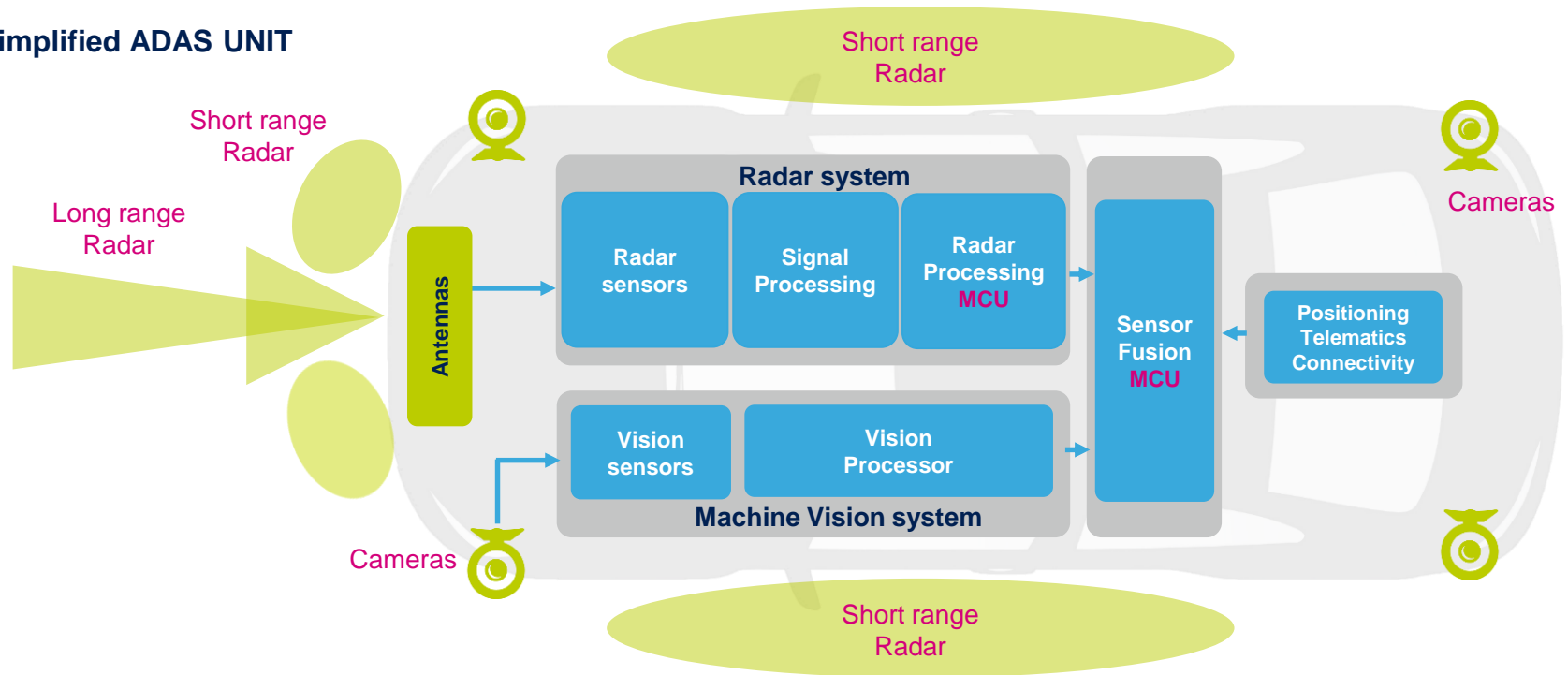
Source: Strategy Analytics and ST

ADAS Overview

Advanced Driver Assistance Systems

Camera and radar coupled with V2X, Telematics and GNSS* – Sensor Fusion

Simplified ADAS UNIT



* GNSS: Global Navigation Satellite System

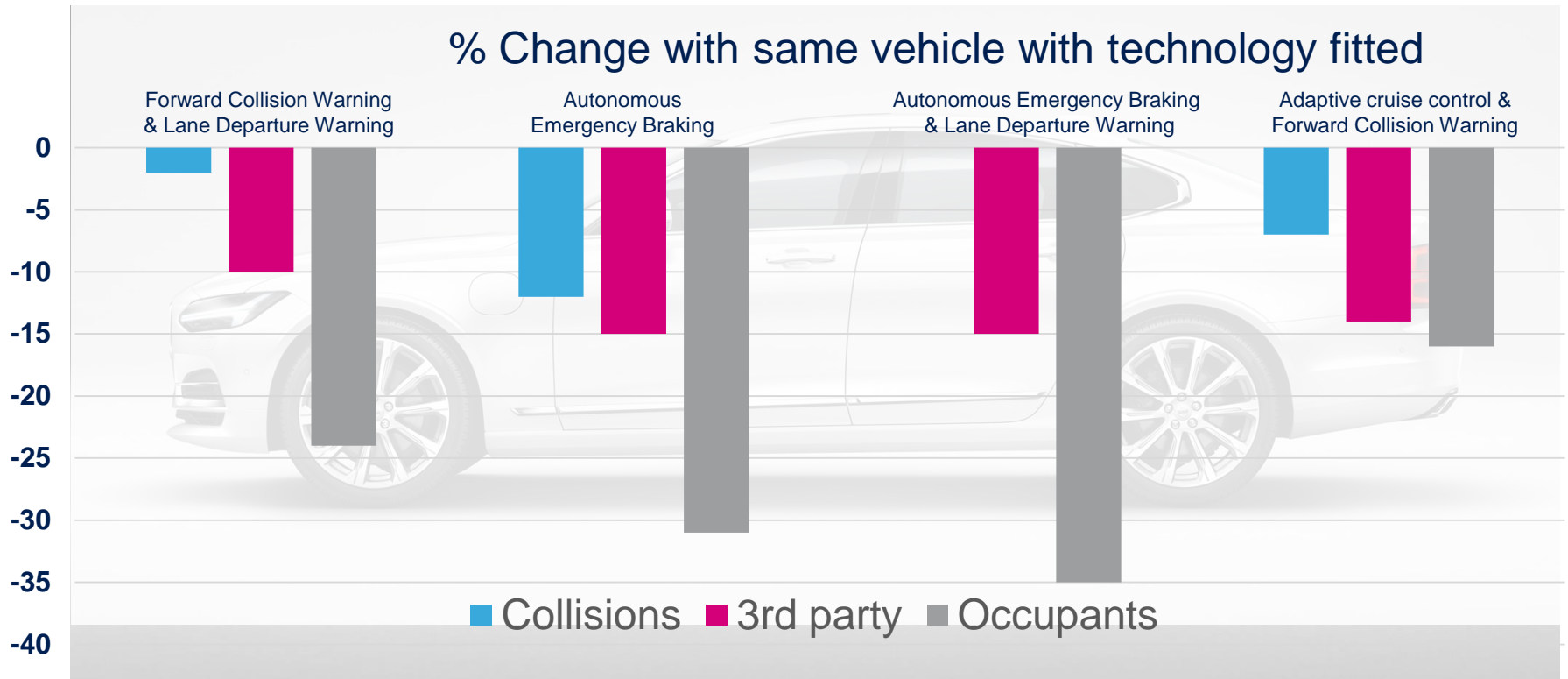
Crash Avoidance Technologies & Effectiveness

Automatic brake	Lane departure	Blind spot	Headlight
			

% Incidence	Automatic brake	Lane departure	Blind spot	Headlight
Rear end (29%)	Effective	Not Effective	Not Effective	Not Effective
Crossing (24%)	Not Effective	Not Effective	Not Effective	Effective
Off road (19%)	Not Effective	Effective	Not Effective	Effective
Lane (12%)	Not Effective	Effective	Effective	Not Effective
Animal 6%)	Effective	Not Effective	Not Effective	Effective
Wrong sense (2%)	Effective	Effective	Not Effective	Effective
Reversing (2%)	Not Effective	Not Effective	Effective	Not Effective
Ped/cyclist (2%)	Effective	Not Effective	Not Effective	Effective

Source: NHTSA

Benefits of Collision Avoidance



Source: IHS



Autonomous Driving : ST Inside

Vision Based Systems

20

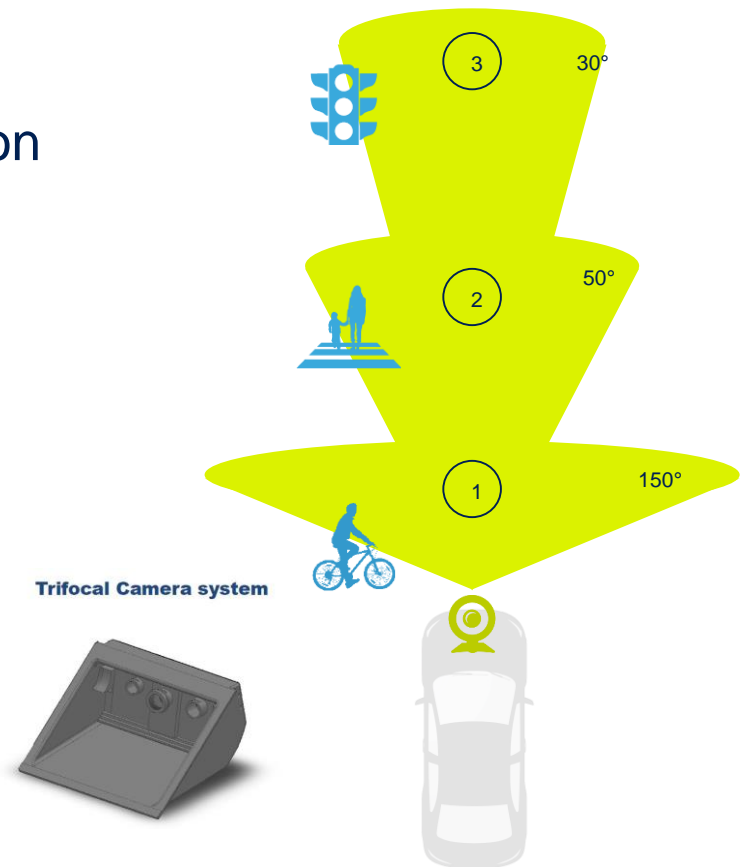
- Richest source of raw data about the scene - only sensor that can reflect the true complexity of the scene.
- The lowest cost sensor - nothing can beat it, not today and not in the future.
- Cameras are getting better - higher dynamic range, higher resolution
- Combination of Radars / Lidar* / Ultrasonic: for redundancy, robustness



*Lidar: Light detection and ranging

The Next Phase for Vision Technology

- From sensing to comprehensive perception
- Machine learning used already for object sensing
- Autonomous driving needs
 - Path planning based on holistic cues
 - Dynamic following of the drivable area
- Deep learning is now being applied



Machine Vision : ST & Mobileye

22

EyeQ3™ 3rd Generation vision processor

- Detection of driving lanes
- Recognition of traffic signs
- Detection of pedestrians and cyclists
- Seeing obstacles how the human eye sees them
- Adapting cruise speed
- Emergency braking when car ahead slows suddenly



EyeQ4™ 4th Generation enables

- Detection of more objects, more precisely
- More features required for automated driving
Free-space Estimation, Road Profile Reconstruction
- Monitoring of environmental elements (fog, ice, rain) and their safety impact
- Detailed understanding of the road conditions allowing automatic suspension and steering adjustment
- Highly automated vehicles

EyeQ5™

The Road to Full Autonomous Driving: Mobileye and ST to Develop EyeQ®5 SoC targeting Sensor Fusion Central Computer for Autonomous Vehicles

Rear and Surround Vision Systems

23

VG6640 HDR Sensor and STV0991 Image Processor



High performances HDR sensor & versatile system-on-chip with advanced and instant **HDR image signal processing**

Compact, low component count & **low energy** automotive camera system

New smart camera system designed to help customers develop secure and **advanced automotive camera applications**

ST Imaging Automotive Offer

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Market Driver

Positioning

ST Product Offer



Sensing & Viewing Camera

- Front-Facing
- Rear & Surround View
- eMirror

Image Sensor + ISP

- Native Flicker Free pixels
- HDR, low noise, high-sensitivity
- Image Signal Processing & Algorithms

Rolling Shutter sensor

VG6640 1.3MP HDR
VG6768 2.5MP HDR
LED Flicker-Free

ISP

STV0991 for Ethernet
STV0971 for LVDS



In-Cabin Optical Sense

- Driver monitoring

Optical System for 2D sensing

- Global Shutter Sensor

Global Shutter sensor

High Dynamic Range
1.6Mp and 2.3Mpixels



Digital LiDAR

- Autonomous Driving

Digital LiDAR SoC Receiver

- Cost optimized
- Scalable vs today's solution(s)
- Embedded ToF digital processing

Foundry

ST Imaging Automotive Offer

Building on our Differentiated Technology Portfolio



Sensing & Viewing Camera

Rolling Shutter

- **FSI, 3.75um**
- **132dB**
- Staggered HDR
- Low Noise
- High Sensitivity
- **BSI, 3.2um**
- **145dB**
- No Memory
- Low Noise
- High Sensitivity
- **Flicker Free**



In-Cabin Optical Sense

Global Shutter

- **FSI, 3.2um**
- **96dB**
- HDR
- Low Noise
- High MTF
- Multi-ROI / expo
- **3D, 3um**
- **96dB**
- HDR
- Low Noise
- High MTF
- **Embedded Machine Vision**



LiDAR

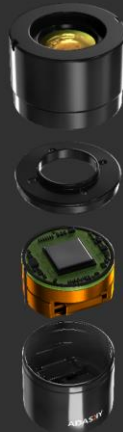
FlightSense™

- **#1 ToF supplier >450Mu shipped**
- 40nm & 3D CMOS SPAD
- **In-Cabin** all-in-one ToF module with optics, VCSEL, driver, sensor
- **LiDAR** integrated SoC receiver solution

Hi-Res Thermal Camera : ST & ADASKY

Based on micro-bolometric thermal imaging technology (FIR)

- Complete solution – Camera to Computer Vision
- Passive technology
- Shutterless technology
- VGA @ 60fps
- Lowest power consumption (<750mW)
- Unique sunburn protection algorithms
- Dedicated ISP for superior image quality (ADA1)
- Built for automotive - ISO 26262 ASIL-B ready
- Scalable solution enables cost reduction
- State of the art Computer Vision algorithms
- Large annotated data sets for machine learning

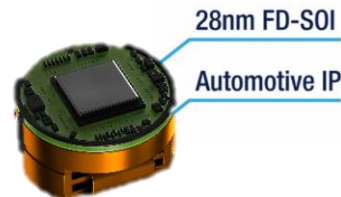


System description

- Thermal imagery based Advanced Driver Assistance System (ADAS) for avoidance of forward collisions with 3d party objects: Pedestrians, bicyclists, animals, general objects, moving and static vehicles.
- The system will detect and warn about obstacles up to 130 meters, 24/7 in all weather conditions. Main advantage in night time and extreme weather.

Silicon implementation

- 28nm FD-SOI
- 12x12 250pin, 0.65pitch FlipChip BGA
- ISO-26262 ASIL-B ready
- AEC-Q100 grade 2 (-40c to 105c)



Long and Short Range Radar ICs

A radar system can use 2 classes of sensors to provide complete coverage

Short-range radar (24GHz)

- Cover almost the entire azimuthal angle and can see all around the car (100° to 360°)
- Distances up to several tens of meters



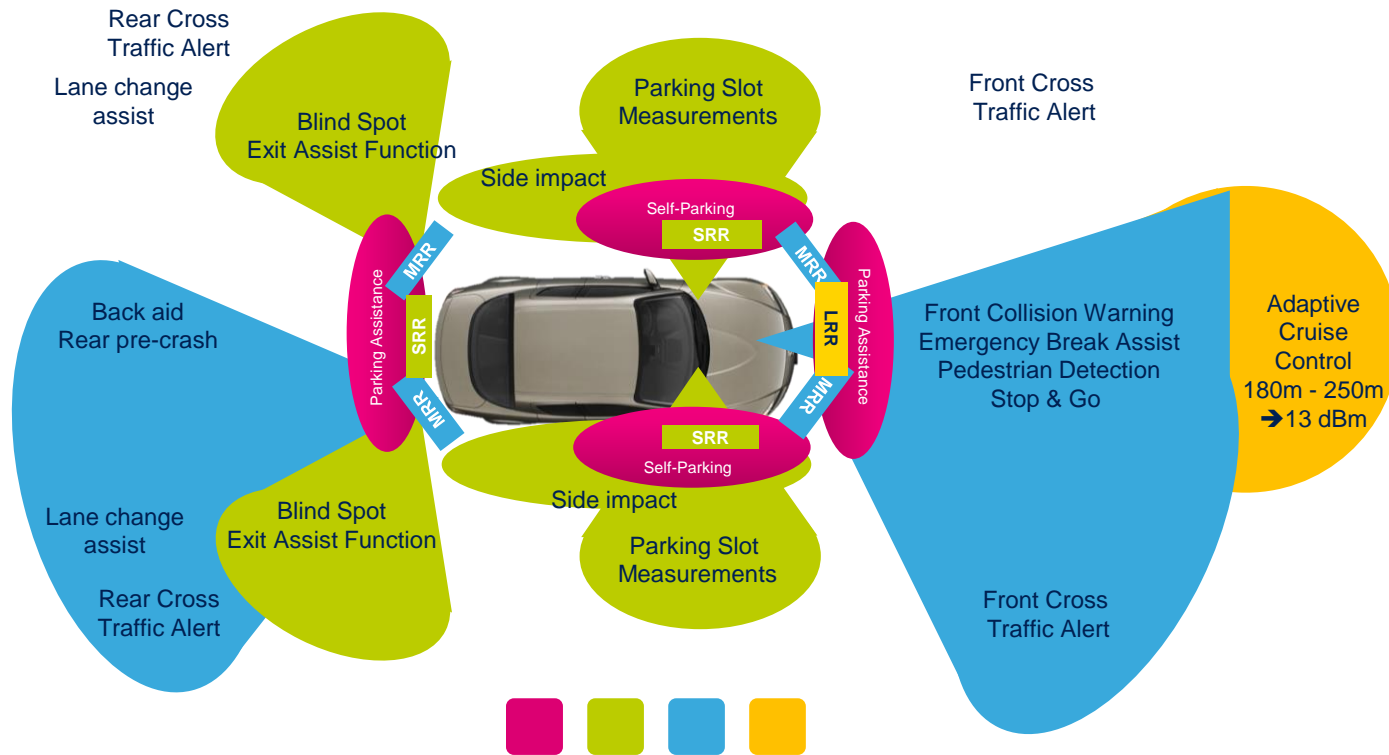
Long-range radar (77GHz)

- Highly integrated
- More transmit power allows greater distance (up to 250m)

Radar technology complements Machine Vision

- Radar can detect objects at longer distances but with less detail and limited recognition capability compared to cameras
- Radar can also be used for redundancy and for added security
- Radar is effective for blind spot detection and emergency braking, efficient also in difficult weather conditions

Automotive Radar Applications



Ultra-short, Short, Medium and Long Range Radar Sensors

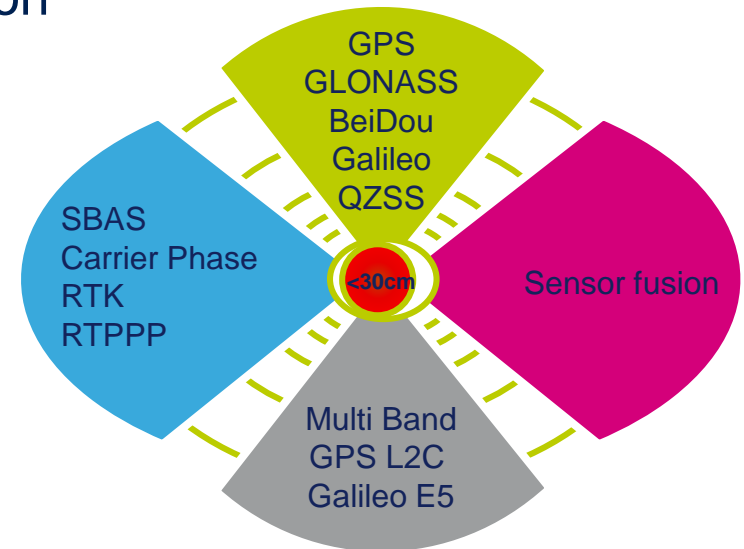
GNSS* Positioning

More Precision Enables More Safety Features

Precise Positioning: Towards Autonomous Driving

Precise Positioning to enable < 30cm precision

- Lane detection
- Positioning data for V2X sharing
- Collision avoidance
- Autonomous parking
- Autonomous driving
- eCall accident location



* GNSS: Global Navigation Satellite System

V2X Communications: ST & Autotalks

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Vehicle-to-Everything (V2X) Autotalks to start mass deployment in 2019

Key Features

- Autotalks' technology addresses all key V2X challenges: communication, reliability, cybersecurity protection, safety-grade, positioning accuracy and vehicle installation
- The chipsets exceed all requirements specified by the USDOT V2V notice of proposed rulemaking (NPRM)

Key Benefits

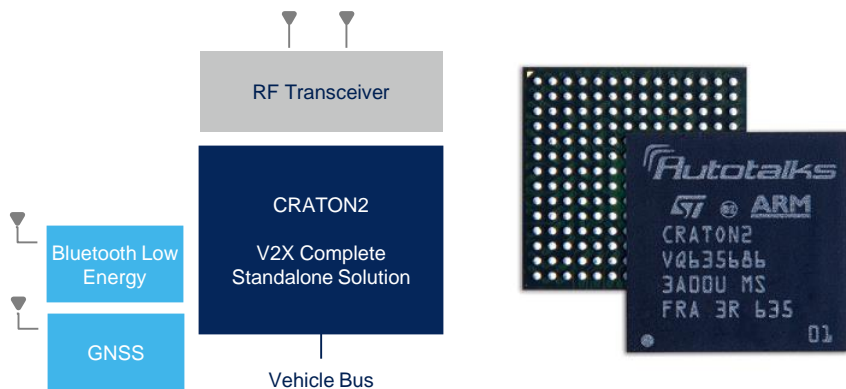
- Significantly improves overall road safety
- Improves road mobility
- Effectively coordinates vehicles and self-driving cars



V2X Communications: ST & Autotalks

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Available now, CRATON2



Future Developments

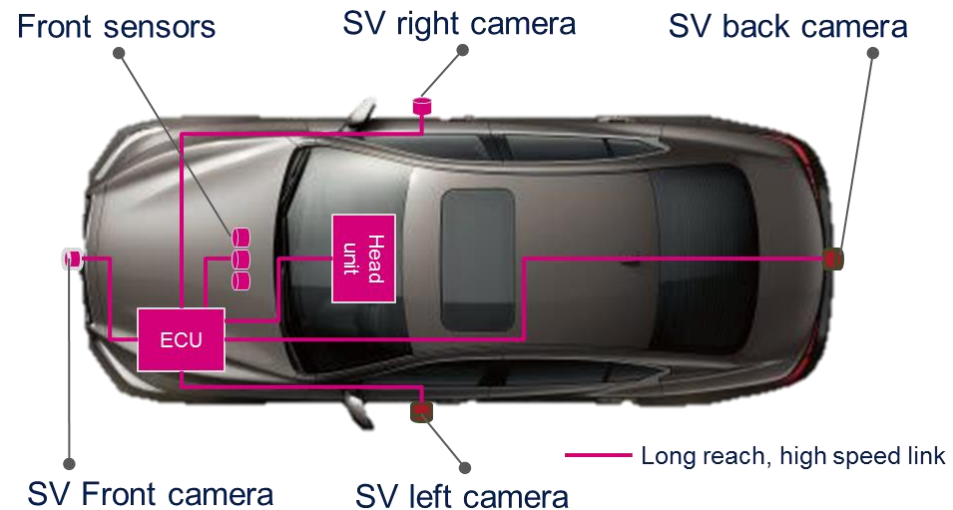


- All needed V2X blocks
- Pre-integrated Software
- Smallest footprint

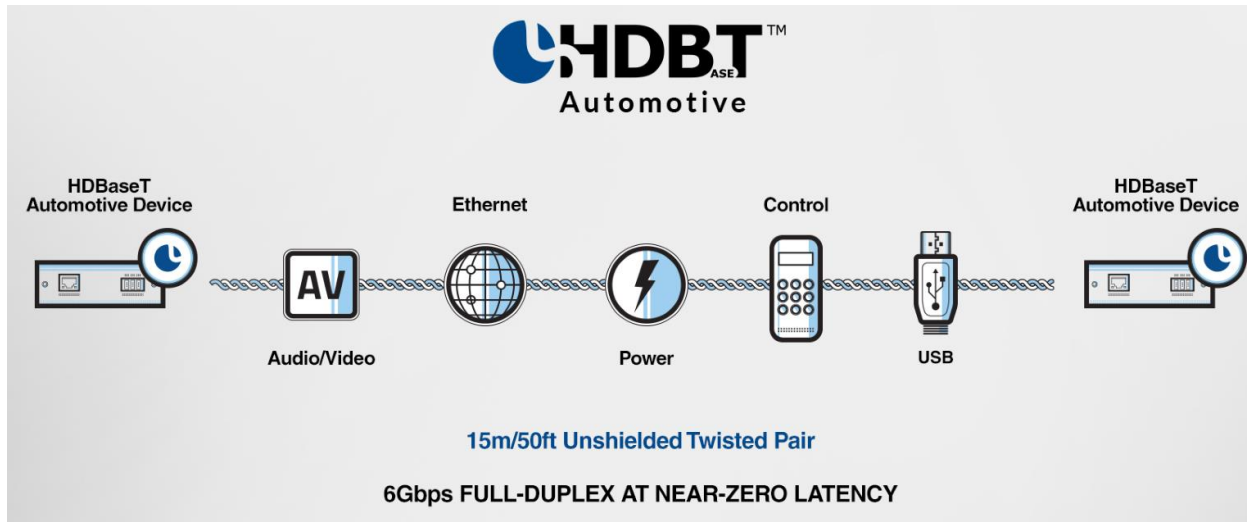
- DSRC (ITS-G5 - WiFi 11.p) V2X
- CMOS 40 nm
- Production 2019
- ADAS level 4

High-Speed, Long Length, Cost-Effective, EMC resistant

- Future in-vehicle applications like autonomous driving, increase the need for the transmission of high levels of data to and from sensors and car systems
- An example requirement will be transmitting uncompressed video data from cameras to processing ECUs
- Up to 15 meters of automotive cabling distances, including up to 4 inline connectors, have to be covered. The transmission of scalable data rates between 1Gb/s and 12Gb/s has to meet stringent automotive EMC and temperature requirements



Hi-Speed Connectivity: ST & Valens



System content

- 6Gbps full-duplex link on UTP cable
- Gigabit Ethernet
- USB 2.0, I2S, I2C protocols

Silicon implementation

- 28nm CMOS bulk
- 20M logic gates
- 13x13 225pin FlipChip BGA
- Max Total power < 7W
- $-40^{\circ}\text{C} < T_j < 125^{\circ}\text{C}$

Assisted Driving Solutions

Active Safety differentiated offer

2017/18

- Mobileye 4th Gen
- 2nd Gen 24 GHz
- 1st Gen 77 GHz
- Auto Parking MCU
- Surround View Video Processor & Camera (open market)



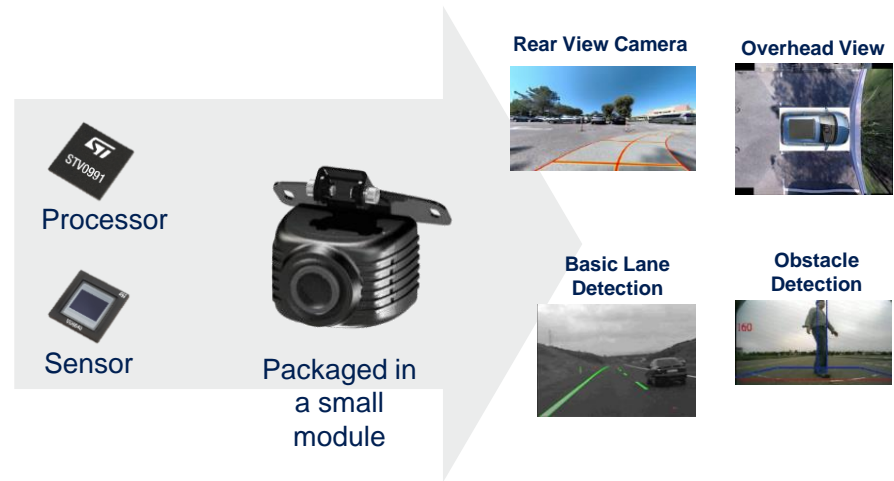
2020

- Mobileye 5th Gen
- Radar FD-SOI28
- 360° ASIC Vision Processor
- ADAS Power Management

ADAS solutions for mass market

New

10+ Projects engaged in China/Taiwan
Lead project already in production.



From Assisted to Autonomous Driving

\$400 of Additional Silicon Content to Enable Level 4/5 Cars

- ADAS Video Processor
 - FinFET 7nm
- Production 2020
- ADAS level 4

EyeQ5
Partnership with
Intel/Mobileye

EyeQ6
Partnership with
Intel/Mobileye

- Autonomous Driving Processor
- FinFET 7nm
- ADAS level 5

V2X
Partnership with
Autotalks

- DSRC (ITS-G5 - WiFi 11.p) V2X
- CMOS 40 nm
- Production 2019
- ADAS level 4

**Precise
Positioning**
Teseo

- Teseo <30 cm multi-constellation GNSS
- CMOS 40 nm RF
- Production 2020
- ADAS level 4

**360° ASIC Vision
Processor**

- Vision Processor
- FinFET
- Production 2020
- ADAS Level 4

2019

2020

202X

ST is Making Driving More Connected

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and More Secure



- Automotive MCUs with security features
- Extended temp range
- Zero defect strategy
- High performance, safety critical and low power SPC5 families



- Automotive Multi-core MPUs
- Embedded security
- Wide Connectivity
- Best-in-class Perf / Power ratio
- Temperature 105C
- Posix OS support



- V2X Partnership
- Leading V2X technology
- Embedded Security



- ST33 Secure Element
- Protection against physical and logical attacks
- Automotive Grade

Conclusions

Autonomous Vehicle User Benefits

- Roads will be safer
 - It is estimated that if about 90% of cars on American roads were autonomous, the number of accidents would fall from 6 million a year to 1.3 million
- Roads will be greener
 - Autonomous vehicles not only react better to potential accidents they drive more economically as well
 - Autonomous vehicles will reduce car ownership and hence numbers of vehicles on the road, meaning less fuel, lower emissions, lower pollution and less natural resources needed for their manufacture
- More Free time
 - Commuting in an autonomous vehicles will be “free time” for those previously at the steering wheel
 - Traffic congestion will be reduced, meaning shorter journeys





life.augmented