Self-Driving Cars: The Next Revolution

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

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

**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)

Life augmented
Automotive & Transportation Market Trend
Light Vehicle and Automotive Semiconductor Market

### Production Light Vehicles

<table>
<thead>
<tr>
<th>Region</th>
<th>2017</th>
<th>2022</th>
<th>CAGR %</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMERICA</td>
<td>20.4</td>
<td>22.2</td>
<td>1.5%</td>
</tr>
<tr>
<td>APAC</td>
<td>49.9</td>
<td>57.2</td>
<td>2.8%</td>
</tr>
<tr>
<td>EMEA</td>
<td>24.9</td>
<td>28.2</td>
<td>2.5%</td>
</tr>
<tr>
<td>Total</td>
<td>95.1</td>
<td>107.4</td>
<td>2.4%</td>
</tr>
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</table>

### Semiconductor TAM (by SA)

<table>
<thead>
<tr>
<th>Region</th>
<th>2017</th>
<th>2022</th>
<th>CAGR %</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMERICA</td>
<td>7.9</td>
<td>11.0</td>
<td>7.0%</td>
</tr>
<tr>
<td>APAC</td>
<td>14.8</td>
<td>21.2</td>
<td>7.5%</td>
</tr>
<tr>
<td>EMEA</td>
<td>9.9</td>
<td>13.4</td>
<td>6.3%</td>
</tr>
<tr>
<td>Total</td>
<td>32.5</td>
<td>45.6</td>
<td>7.0%</td>
</tr>
</tbody>
</table>

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

CAAGR +7.4% ‘17 - '22

Safety
Power
Driver
Chassis
Body

0.0
5.0
10.0
15.0

Source: Strategy Analytics – July 2018
LMCA – June 2018

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

0
No Automation (Level 0)
Driver in control

1
Driver Assistance (Level 1)
Driver in control

2
Partial Automation (Level 2)
Driver monitors system at all times

3
Conditional Automation (Level 3)
Driver needed to be able to resume control

4
High Automation (Level 4)
Driver is not required for specific use cases

5
Full Automation (Level 5)
No Driver Required

 Adding Senses
- Accelerometers and Gyro
- Steering Wheel Angle
- Ultrasonic sensors
- Front Radar Sensor
- Blind Spot sensor
- Rear View Cameras
- Front View Cameras
- Surround View Cameras

 Learning to Drive
- Systems Networking
- Sensor Fusion
- Distance Measurement
- Traffic Sign Recognition
- Lane Reconstruction
- Free-path Definition
- Precise Positioning
- Real-time Mapping
- Driving Rules Implementation
- Critical Arbitration

Source: SAE standard J3016

Levels 0-2 Human driver monitors the driving environment

Levels 3-5 Automated driving “system” monitors the driving environment
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

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

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

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

Autonomous Driving Opportunity

Autonomous Driving Content increase by ADAS levels

Source: Strategy Analytics and ST
Camera and radar coupled with V2X, Telematics and GNSS* – Sensor Fusion
## Crash Avoidance Technologies & Effectiveness

<table>
<thead>
<tr>
<th>% Incidence</th>
<th>Automatic brake</th>
<th>Lane departure</th>
<th>Blind spot</th>
<th>Headlight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rear end (29%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crossing (24%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Off road (19%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lane (12%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Animal 6%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wrong sense (2%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reversing (2%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ped/cyclist (2%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: NHTSA
Benefits of Collision Avoidance

% Change with same vehicle with technology fitted

- Forward Collision Warning & Lane Departure Warning
- Autonomous Emergency Braking
- Autonomous Emergency Braking & Lane Departure Warning
- Adaptive cruise control & Forward Collision Warning

Source: IHS
Autonomous Driving : ST Inside
Vision Based Systems

• 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
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

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

**Market Driver**

- Sensing & Viewing Camera
  - Front-Facing
  - Rear & Surround View
  - eMirror

- In-Cabin Optical Sense
  - Driver monitoring

- Digital LiDAR
  - Autonomous Driving

**Positioning**

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

- Optical System for 2D sensing
  - Global Shutter Sensor

- Digital LiDAR SoC Receiver
  - Cost optimized
  - Scalable vs today’s solution(s)
  - Embedded ToF digital processing

**ST Product Offer**

- Rolling Shutter sensor
  - VG6640 1.3MP HDR
  - VG6768 2.5MP HDR LED Flicker-Free

- ISP
  - STV0991 for Ethernet
  - STV0971 for LVDS

- Global Shutter sensor
  - High Dynamic Range
  - 1.6Mp and 2.3Mpixels

- 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
  - Flicker Free

- Global Shutter
  - FSI, 3.2um
  - 145dB
  - No Memory
  - Low Noise
  - High Sensitivity
  - Flicker Free

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

In-Cabin Optical Sense

LiDAR

#1 ToF supplier >450M units 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)

System description
- Thermal imagery based Advanced Driver Assistance System (ADAS) for avoidance of forward collisions with 3rd 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)
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

- Rear Cross Traffic Alert
- Lane change assist
- Blind Spot Exit Assist Function
- Parking Slot Measurements
- Self-Parking
- SRR
- Rear Cross Traffic Alert
- Front Cross Traffic Alert
- Front Collision Warning
- Emergency Break Assist
- Pedestrian Detection
- Stop & Go
- Adaptive Cruise Control
- 180m - 250m → 13 dBm
- Rear pre-crash
- Back aid
- Lane change assist
- Rear Cross Traffic Alert

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

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

Available now, CRATON2

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

Future Developments

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

V2X Complete Standalone Solution
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

Valens and ST join forces to revolutionize in-car connectivity.

Unprecedented Bandwidth
- Tunneling of up to 6Gbps of simultaneous streams of high-definition video & audio, data, USB, and power, over a 15m (50ft) single, unshielded twisted pair (UTP) cable.

Designed for Networking
- Multistream & multi-hop capabilities for the whole-car backbone network infrastructure, for optimized sensor fusion, ADAS and infotainment.

EMC - Resistant Solution
- Highly robust, with adaptive mechanism to deal with EMC, cable aging, temperature changes, and more, with no need for cable grounding.
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°C < Tj < 125°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.

Packaged in a small module

- Rear View Camera
- Overhead View
- Basic Lane Detection
- Obstacle Detection
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 <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 and More Secure

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

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

- **V2X**
  - V2X Partnership
  - Leading V2X technology
  - Embedded Security

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

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**ST** - life augmented
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