The State of AV/ADAS at Mobileye/Intel
Today’s presentation contains forward-looking statements. All statements made that are not historical facts are subject to a number of risks and uncertainties, and actual results may differ materially. Please refer to Intel’s most recent earnings release, Form 10-Q and 10-K filing available for more information on the risk factors that could cause actual results to differ.

If any non-GAAP financial measures are used during the presentation, you will find on Intel’s website, intc.com, the required reconciliation to the most directly comparable GAAP financial measure.
Vehicle models with advanced functionalities
- 38 with ACC support (fused or vision only)
- 26 lane centering
- 20 traffic jam assist / pilot
- 15 road profile
- 2 newly designed EV (Audi E-Tron, NIO ES8)

Programs launches with 78 vehicle models
- 16 OEMs
- 5 Tier 1s

Vehicle models launched with EyeQ4
- EyeQ4 Mid Mono
- EyeQ4 High Tricam

New design wins
- 24 OEMs
- 8 Tier 1s

2018 In Numbers
- 28 New design wins
- 20 Programs launches with 78 vehicle models
- 7 Vehicle models launched with EyeQ4
- 56 Vehicle models with advanced functionalities
EyeQ® Shipped 2014-2018

- **EyeQs shipped to date**: 32M
- **YoY growth from 2017**: 42%
- **CAGR from 2014**: 46%
## Euro NCAP 5-Star 2018 Models

<table>
<thead>
<tr>
<th>Make and Model</th>
<th>Mobileye inside</th>
<th>Safety Equipment</th>
<th>Overall Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volvo XC40</td>
<td>✅</td>
<td>Standard</td>
<td>★★★★★</td>
</tr>
<tr>
<td>Lexus ES</td>
<td>✅</td>
<td>Standard</td>
<td>★★★★★</td>
</tr>
<tr>
<td>Peugeot 508</td>
<td>✅</td>
<td>Standard</td>
<td>★★★★★</td>
</tr>
<tr>
<td>Mercedes Benz A-Class</td>
<td>✅</td>
<td>Standard</td>
<td>★★★★★</td>
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<tr>
<td>Audi A6</td>
<td>✅</td>
<td>Standard</td>
<td>★★★★★</td>
</tr>
<tr>
<td>Volvo S60</td>
<td>✅</td>
<td>Standard</td>
<td>★★★★★</td>
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<tr>
<td>Volvo V60</td>
<td>✅</td>
<td>Standard</td>
<td>★★★★★</td>
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<tr>
<td>Audi Q3</td>
<td>✅</td>
<td>Standard</td>
<td>★★★★★</td>
</tr>
<tr>
<td>Mazda 6</td>
<td>✅</td>
<td>Standard</td>
<td>★★★★★</td>
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<tr>
<td>Hyundai NEXO</td>
<td>✅</td>
<td>Standard</td>
<td>★★★★★</td>
</tr>
<tr>
<td>Hyundai Santa Fe</td>
<td>✅</td>
<td>Standard</td>
<td>★★★★★</td>
</tr>
<tr>
<td>VW Touareg</td>
<td>✅</td>
<td>Standard</td>
<td>★★★★★</td>
</tr>
<tr>
<td>Jaguar I-PACE</td>
<td>✅</td>
<td>Standard</td>
<td>★★★★★</td>
</tr>
<tr>
<td>BMW X5</td>
<td>✅</td>
<td>Standard</td>
<td>★★★★★</td>
</tr>
<tr>
<td>Nissan LEAF</td>
<td>✅</td>
<td>Standard</td>
<td>★★★★★</td>
</tr>
<tr>
<td>Ford Focus</td>
<td>✅</td>
<td>Standard</td>
<td>★★★★★</td>
</tr>
</tbody>
</table>
Launched in 2018 with 2 OEMs – Mobileye’s TriFocal & EyeQ® 4

Wider FOV and further range FOV enabling:
- Enhanced detection capabilities/ranges for all features
- Red Light warning, Stop sign/ no entry warning
- Cross traffic/ peds/ cyclist warning
- AEB turning scenarios- TAP

EyeQ® 4 features for the first time:
- 3D VD, 3D motorbikes
- Hazard detection
- REM harvesting

Leading the Way With High-end ADAS Features

BMW X5: First Ever Maximum AEB VRU Score (12/12)
VW and Mobileye are continuing their efforts to materialize a L2+ proposition combining the front camera and Roadbook™ technologies.

- Leveraging the harvested data from VW series production vehicles
- The ongoing development activity is targeting a broad operational envelope L2+ product addressing mass market deployment
- Enhancing ACC & LKA by HD maps:
  - Foresight of road geometry and road semantics used to optimize control decisions
  - Navigation through unmarked/ill-marked road sections, including junctions
  - A redundant road-geometry source under adverse visibility conditions

Engaging in a strategic collaboration with Great Wall Motors

- Great Wall Motors, a leading domestic automaker in China, to fit ME based L0 to L2+ ADAS systems
- Targeting SOPs in the next 2-6 years; lifetime volume of 7.3M over 6 car models
- Joint development of higher autonomy (L3 and above) systems
- Deepening our footprint in China- 16 programs sourced in 2018
Growing Emphasis on ADAS in Safety Ratings

% of points awarded for ADAS features in EuroNCAP evaluation

Global Trends
- EU ADAS mandate (General Safety Regulation)
- Introduction of ADAS in undeveloped markets
- Increased HFOV & new technologies needed to meet new scenarios & object types - AEB motorbikes, crossing & turning cars/VRUs, AES
The AV/ADAS Strategy

The Building blocks of Autonomous Vehicles
- Sense / Plan / Act
- Perception computer vision
- Other sensors processing
- Mapping

The Building blocks of ADAS
- Front sensing
- Wide-angle front sensing
- Surround perception
- Mapping

Revolution in Transportation

Making “Vision Zero” a reality
Revolution in Saving Lives
Integrated Solution
Mobileye/Intel Core Assets

Visual Perception and Sensor Fusion

Compute platform

Driving Policy and RSS

Dynamic mapping- REM
Mobileye Solutions Portfolio

ADAS/ Autonomous Platforms

Open EyeQ5
- Plug & Program
- Silicon

Closed EyeQ5
- Plug & Integrate
- Silicon
  + Perception Software
  + Mapping - REM

Surround Vision
- Plug & Integrate
- Silicon
  + 360 Vision Perception Software
  + Mapping - REM

AV Series
- Plug & Drive
- Silicon+ Multi domain control
  360 Vision Perception Software
  + Mapping - REM
  + Policy & Control
  + Fusion
  + Fail Operation
  + Other sensors
  Optional subsystems

AV Series + MaaS platform
- Plug & Move People
  Silicon+ Multi domain control
  360 Vision Perception Software
  MaaS Software Platform

Autonomous Platforms

Mobileye Solutions Portfolio
Visual Perception
Visual Perception Approach

- **The Goal**
  - To achieve True Redundancy for AVs:
    - Cameras enable a comprehensive end-to-end operation
    - Other sensors added for redundancy

- **The Means**
  - Pushing computer-vision sensing envelope
    - To empower cameras to deliver end-to-end AV performance

- **The Challenge**
  - Extracting 3D information from cameras
    - The easiest thing to do - using indications from other sensors already in the low-level stage

- **The Outcome**
  - “The right AV”
    - With true redundancy
  - Cost-optimized ADAS
    - Relying on cameras - cheap and versatile
Current AV Setup

End-to-End AV powered by Camera-only

Separate sub-system of Radar/Lidar ("true redundancy") will be added in the future
Compute Platform
2.5 TOPs @ 6W

0.25 TOPs @ 3W

24 TOPs @ 10W

6 x VMP + 2 x PMA + 2 x PMC + 4 x CPU, 28nm, series prod from 3/2018 launches by 4 OEMs in 2018, 12 OEMs in 2019 & onwards

EyeQ® 3
4 x VMP + 4 x CPU, 40nm, series prod since 11/2014

EyeQ® 4

EyeQ® 5
7nm, 1st silicon 12/2018

Tight co-design of SW and HW yields cutting edge capabilities
The EyeQ® 5
Enabling high-end functionalities for ADAS and AV

- The EyeQ® 5 chip was sampled in December
- Successfully passed all functional tests
- Design wins by 4 OEMs from 2021, volume above 8M
- Designed to support 3rd party programmability
- Series prod from 3/2021
The EyeQ® 5
Enabling high-end functionalities for ADAS and AV

Boards for BMW 2021 series production with Aptiv
Driving Policy and RSS
Fundamental Issues

Safety
- Nominal (design should not cause accidents)
- Functional (FuSa) (secondary channel, fail operational, ASIL)
- Safety vs. Agility?
- Acceptance by Society?
- How to define and Validate?

Scalability
- Tech that is transferrable for generating new markets
- Agents of Proliferation (across geographies):
  - HD-mapping
  - Generalizable and Agile Driving Policy
  - Cost of system in volume
  - Scalable test & validation across geographies
A mathematical model, formalizing a “common sense” interpretation of what it means to drive “cautiously” while being agile.

- What is a dangerous situation?
- What is the proper response to a dangerous situation?
- What does it mean to be reasonably cautious?
- What assumptions a driver can make on the unknown behavior of other road users?

- RSS is designed to optimize three axes: (i) sound, (ii) useful, and (iii) efficiently verifiable.
Driving Policy Logic

**Strategy**
Long term Semantic decision/planning
e.g. change lane, overtake

**Tactics**
Short term Semantic Decision/planning
e.g. how/when to overtake, give/take way

**Path Planning**
Plan the Trajectory to execute the Tactics decision

**Control**
Machine learning and classical control low level throttle and torque control

- Reinforcement Learning
- Semantic Space
- “Self Play” in reinforcement learning

RSS
Proper Response
The Challenge of Autonomous Driving
The Challenge of Autonomous Driving

SAFE AGILE
The Challenge of Autonomous Driving

SAFE AGILE
The RSS is gaining global acceptance as an Automated Vehicle Safety Standard

Auto technology supplier Valeo is the latest company to publicly embrace the RSS model for safe automated vehicle (AV) decision-making.

Baidu - who earlier this year announced plans to adopt RSS for Project Apollo – reported the first open source implementation of the model.

China ITS approved proposal to standardize RSS for the China market under “Technical Requirement of Safety Assurance of AV Decision Making” with RIOH, Tsinghua University, NIO, Autonavi, Huawei.

We continue on getting momentum among governments and regulators.
REM®
Mobileye’s Mapping Technology
REM Process

1. **HARVESTING**
   Collecting road and landmarks through EyeQ-equipped vehicles

2. **Anonymising & encrypting REM data**

3. **AGGREGATION**
   Generating HD crowdsourced road-book for the autonomous vehicle

4. Map tile distributed to the car

5. **LOCALIZATION**
   Localizing the car within 10cm accuracy in the road book.
REM Process

RB data projected onto image space.
Road edge, lane marks, lane center, landmarks (in Yellow).

RB data projected onto Google Earth.
Mapping Japan Highways - Now Completed

Production at scale
Entire Japanese highway system map was produced in less than 24 hours

Map production is automatic
With the push of a button

25,000 km of Roads
Mapping Japan Highways - Now Completed

10 kb per km compressed harvested data:
- Final map weighs only 400 MB
- Each purple map tile represents 1 sq. km
- Average tile size weighs only 30 KB
Mapping Japan Highways- Now Completed

Each tile contains relevant HD map features
Accuracy < 10 cm
In total > 1.1 Million map features:

320,000 signs
300,000 poles
250,000 lane marks
190,000 road boundaries
50,000 crowdsourced drivable trajectories
This coverage was achieved during testing of a production fleet that will hit the roads in 2019.
REM Utilizations

**AV Maps**
- Scalable solution for HD maps
- Ultra-high refresh rate with real-time updates

**L2+/3/4**
- Enhancing today’s ADAS with minimal cost

**Non-Automotive**
- Realtime data for “smart cities”
- Automatic infrastructure survey to aid city planning
L2 Enhancement Through REM

**Lane Centering**
- Areas without lane marks or with low quality lane marks, junctions, roundabouts, urban scenarios, newly paved roads
- Availability in challenging weather conditions: fog, heavy rain, reflecting road, low sun, heavy snow
- Late detection nearby unmarked highway exits
- View range and availability on very sharp curves

**ACC**
- CIPV decision at areas with low quality lane marks
- Precise roadway elevation model for better control
- Continuing ACC at areas with traffic lights and stop signs: REM supports traffic lights relevancy and accurate position, high quality stop line detection
- Map data on merges and exits for better planning and control
Open-EyeQ platform promotes an eco-system of automotive technologies, integrated as part of Mobileye’s AD/ADAS portfolio.

- Minimizing/Avoiding hardware overheads and its automotive integration and validation processes.
- Leveraging Mobileye’s market access to proliferate cutting-edge AD/ADAS capabilities
- As an example – Eyesight Technologies have recently showcased a driver monitoring system running on EyeQ4, interfacing to ME’s L2+ proposition.
REM in the Aftermarket

Mobileye 8 Connect | Project Status

Government
3 mapping agreements signed

Smart Cities
3 projects signed

Major Fleets
Europe, US

20,000 vehicles
First RSD collected via Mobileye 8 Connect™

Passengers Waiting Near a Bus Station
First RSD collected via Mobileye 8 Connect™

First Deployment Snapshots From Around the World

Manchester
Dusseldorf
Munich
New York
Israel
Mapping the UK by Ordnance Survey and Mobileye® An Intel Company
Moving beyond automotive with REM data

- Partnership with Ordnance Survey to collect and share UK local map data to help utilities manage infrastructure

- Prime example of how Mobileye’s unique mapping capabilities can extend the value of location data to businesses in new market segments, such as smart cities

- Utilities can leverage the service to maintain the precise location of their assets on the ground, such as manhole covers, lamp posts, telephone poles, etc.
Mapping the UK with Ordnance
# The Type of Data being Collected

<table>
<thead>
<tr>
<th>Priority</th>
<th>Gas</th>
<th>Electricity</th>
<th>Water</th>
<th>Power Supply</th>
<th>Telco</th>
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<tbody>
<tr>
<td>1</td>
<td>Manholes</td>
<td>Manholes</td>
<td>Drain covers / grates</td>
<td>Overhead foliage</td>
<td>Telco cabinet</td>
</tr>
<tr>
<td>2</td>
<td>Pavement Service Covers</td>
<td>Pavement Service covers</td>
<td>Manholes</td>
<td>Overhead cable</td>
<td>Telegraph pole</td>
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<tr>
<td>3</td>
<td>Overhead foliage</td>
<td>Overhead foliage</td>
<td>Pavement Service covers</td>
<td>Power distribution pole</td>
<td>Manholes</td>
</tr>
<tr>
<td>4</td>
<td>Sign post/sign</td>
<td>Power distribution pole</td>
<td>Overhead foliage</td>
<td>Trees</td>
<td>Overhead cable</td>
</tr>
<tr>
<td>5</td>
<td>Trees</td>
<td>Overhead cable</td>
<td>Trees</td>
<td>Manholes</td>
<td>Pavement Service covers</td>
</tr>
<tr>
<td>6</td>
<td>Bushes</td>
<td>Trees</td>
<td>Sign post/sign</td>
<td>Street light</td>
<td>Overhead foliage</td>
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<tr>
<td>7</td>
<td>Drain covers / grates</td>
<td>Street light</td>
<td>Bushes</td>
<td>Sign post/sign</td>
<td>Trees</td>
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<tr>
<td>8</td>
<td>Sign post/sign</td>
<td>Bushes</td>
<td>Sign post/sign</td>
<td>Bushes</td>
<td>Street light</td>
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<td>9</td>
<td>Traffic light</td>
<td>Drain covers / grates</td>
<td>Traffic light</td>
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<td>10</td>
<td>Bushes</td>
<td>Latex</td>
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<td>Sign post/sign</td>
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<td>11</td>
<td>Drain covers / grates</td>
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<td></td>
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</tbody>
</table>

Front-facing camera is an “intelligent agent”
Mobileye store

Ingestion store

GCP store

Fleet of Vehicles

Finds: Lampposts, Traffic lights, signs, road edges, road lanes etc...

Raw Data Convertor

Cloud

Relative coordinates

Geographic coordinates

Working Prototype

Matching > Transform > Aggregate

OS Datastore “SOR”

Surveyed control points
Mobileye, Volkswagen, and Champion Motors bring Mobility-as-a-Service to Israel
Project Overview

Project PINTA is to create a JV with VW-group, Champion Motors and Mobileye for launching MaaS in Israel with commercial deployment in 2022.

Service Summary

- **Pilot Commercialization of Full-Stack MaaS offering**
  SDS, Vehicles, Fleet Operations & Fleet Control Center, Mobility Platform & Services, Content
- **Operational fleet of Self-Driving EVs until 2022**
- **First deployment in Tel-Aviv**
- **Scale up to cover all of Israel**

Project Timeline & Phases

- **1. Development & Testing**
  - 2019
- **2. Pre-Commercialization**
  - 2020
- **3. Commercialization**
  - 2021
- **4. Scaling**
  - 2022
  - 2023+
**Collaboration Layers**

The project consortium partners across all layers of the layer model of Mobility-as-a-Service with self-driving electric vehicles.

<table>
<thead>
<tr>
<th>Layer 5</th>
<th>Content Providers</th>
<th>VOLKSWAGEN</th>
<th>CHAMPION MOTORS</th>
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<tbody>
<tr>
<td>Layer 4</td>
<td>Mobility Platform &amp; Services</td>
<td>VOLKSWAGEN</td>
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<tr>
<td>Layer 3</td>
<td>Fleet Operations &amp; Fleet Control Center</td>
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<tr>
<td>Layer 2</td>
<td>Self-Driving Vehicles</td>
<td>VOLKSWAGEN</td>
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<tr>
<td>Layer 1</td>
<td>Self-Driving System</td>
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</table>
Project Phases

The service covers the most relevant urban area of Israel by 2022

2019 Phase 1
- Pre-Development
- 15 km

2020 Phase 1.1
- Development
- 33 km

2021 Phase 2 2022
- Phase 3 Pre-Commercial
- 111 km
  (13.4 km²)

2023 Phase 4 Scaling

Scaling approaches

- Scale into Metropolitan area
- Increase granularity of existing area
- Add additional special routes
Collaboration with Beijing Public Transport corporation and Beijing Beytai to commercially deploy autonomous public transport services in China

Utilizing Mobileye’s AV Series – a full turn-key hardware and software self-driving system validated for level-4 driverless

Deployment expected 2022
The Revolution of ADAS
Unlocking “Vision Zero” with RSS for Humans
ADAS Evolution

**ADAS Today**

- **AEB, LKA** | Emergency driven
- **ESC/ ESP** | Prevention driven

Application of brakes longitudinally & laterally

**ADAS Future Potential**

- **AEB, LKA, ESC** | All in one
- **Prevention** driven system
- **Formal Guarantees**
Vision Zero: Can Roadway Accidents be Eliminated without Compromising Traffic Throughput?

Shai Shalev-Shwartz, Shaked Shammah, Amnon Shashua

Mobileye, 2018

Abstract

We propose a new economical, viable, approach to challenge almost all car accidents. Our method relies on a mathematical model of safety and can be applied to all modern cars at a mild cost.

1 Introduction

In 1997 the Swedish Parliament introduced a “Vision Zero” policy that requires reducing fatalities and serious injuries to zero by 2020. One approach to reduce the number of serious car accidents, which has been advocated by the “Vision Zero” initiative, is to enlarge the tolerance to human mistakes by combining regulative and infrastructure changes. For example, installing speed bumps in urban areas, which reduces the common speed from 50 kph to 30 kph, may make the difference between a mild injury and a fatality when a car hits a pedestrian. Another example is not allowing a green light for two routes at the same time (like “turn right on red” scenarios). The disadvantage of this approach is that it compromises the throughput of the road system — for example, reducing the speed limit from 50 kph to 30 kph increases traveling time by 66%.

Another approach to reduce the number of car accidents is to rely on Advanced Driving Assistant Systems (ADAS)
1 RSS
   - Braking profile of a robotic system
   - Definitions of “dangerous” based on “safe distance” arguments
   - Formal guarantees for zero accidents if:
     - Perception is correct
     - All road users follow “Proper Response”

2 Braking profile
   - Generalize RSS to hold for ANY braking profile
   - Propose a specific jerk-bounded braking profile
   - Jerk-bounded braking profile prevents the car from entering a “Dangerous Situation” by longitudinal & lateral braking

3 Surround sensing
   - If car is equipped with surround sensing (cameras) + REM, then if all cars have APB and perception is correct, there will be no accidents
   - Definitions of “dangerous” based on “safe distance” arguments
Thank You!

Drive Safe