Electronic systems for the automobile of the future

Dr. Martin Duncan, Berlin, 7th July 2015

life.augmented

Talk outline

- Introduction
- Technological & application challenges
- The path towards autonomous driving
- Conclusions

life.augmented

The car of today is becoming an electronic technology hub…

- ✓ *Zero casualties*
- ✓ *Active & Passive Safety*
- ✓ *ADAS*
- ✓ *ISO26262 compliancy*
- ✓ *Autonomous Drive*
- ✓ *Data Management*
- ✓ *Data Security*
- ✓ *…*

- ✓ *Mobility for Everyone*
- ✓ *Electrification of the Car*
- ✓ *48V Board Net*
- ✓ *CO2 Reduction*
- ✓ *Entertainment Fun*
- ✓ *Connectivity*
- ✓ *Intelligent mobility*
- ✓ *….*

Innovation driven by Automotive Mega Trends

life.augmented

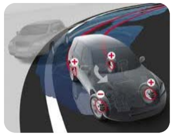
Electronics & Semiconductors dominate today's car

The mechanics are **evolving** but **slowly** and mostly driven by **weight reduction**

Evolution of **electronics** makes the **interaction** with the mechanics **more efficient**

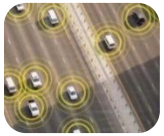
Power Train

Safety



Body and accessories

Infotainment and connectivity



Sounds good so far but………..

life.augmented

Talk outline

- Introduction
- Technological & application challenges
- The path towards autonomous driving
- Conclusions

life.augmented

Automotive Semiconductor Market

Major Trends and Challenges

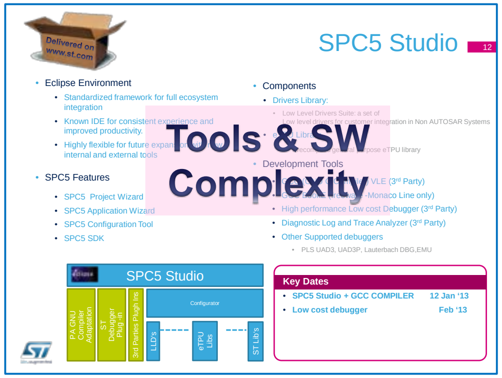
- Complexity increase vs. ASP pressure
  - Strong price pressure during the last years

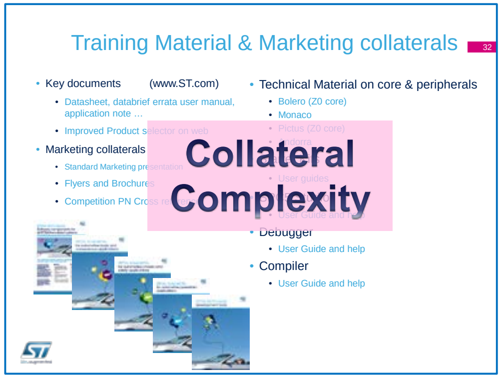
> Example: 4cyl GDI Powertrain MCU 2005 vs. 2015
> - **price down of ~40%**
> - **product complexity increase of factor >10**
> - **factor >10 gate density increase / ~20% die size cut**
>
> SPC5

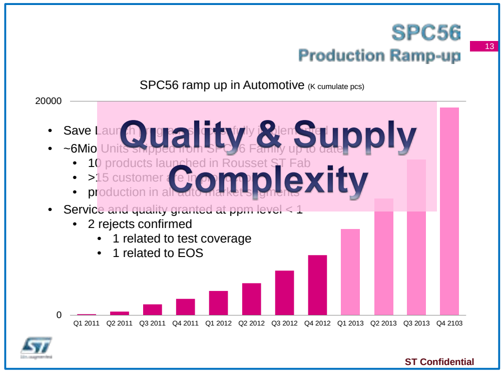
  - Tremendous complexity increase during last years
    - Product complexity (scalability, multicore, safety, security,..)
    - EcoSystem complexity (Tools, SW, Collaterals,..)
    - Increased demand for supply security and quality (dual source, long term delivery, DFx, Safe Launch,..)
- Overall R&D cost increase
  - Technology and product development cost increase

90nm Technology 0.18µm² Flash cell → 55nm Technology 0.13µm² Flash cell → 40nm Technology 0.08µm² Flash cell

  - Test and validation cost increase
  - Material cost increase (wafer, mask, tools,..)







life.augmented

Security Needs in Automotive?

Use cases? Which ECUs ? Model Year?,..

Modification of Mileage

Anti-Tuning
(HW/SW functionality activiation,

V2x Infrastructure
Intelligent traffic management V2V & V2I for further reduction of the number and severity of car

Conclusion

- Protect
  - few dedicated critical functionalities (eg. immobilizer, milage)
  - and the car network entry points

(so high-end module/MCUs)

- from SW attacks

➢ Isolate security function from the application function > HSM Concept

Driver Info / Multimedia /..

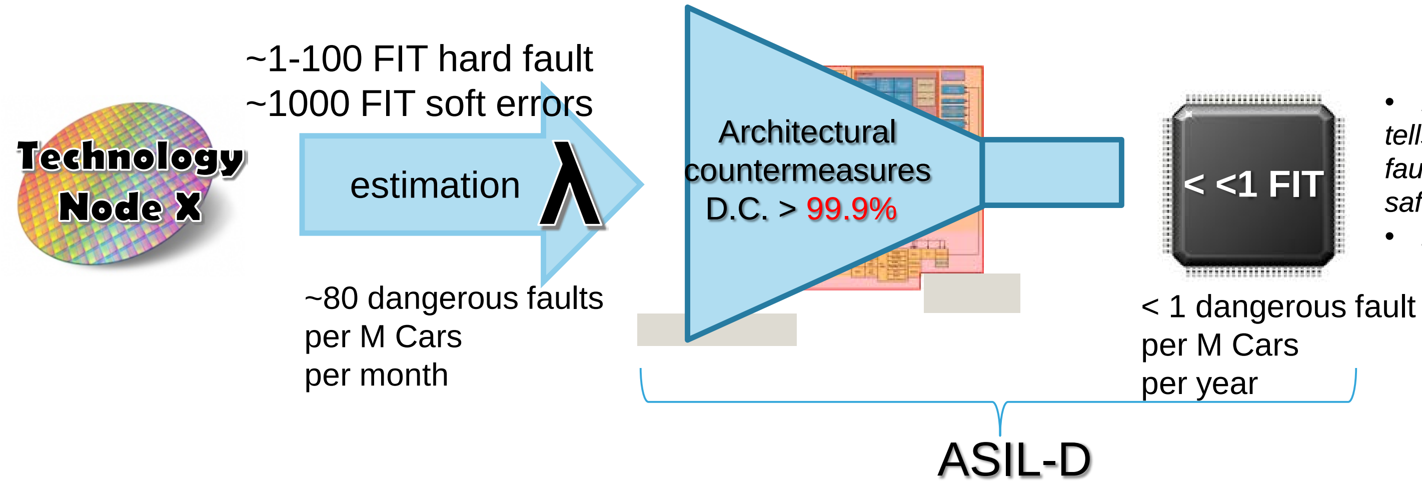
Privacy Protection

Anti-Fraud
(Illegal after market ECUs – Security Master ECUs -requires a full HSM Network-)

Anti-Fraud
(impersonate –e.g. electronic license plate)

To FIT or not to FIT….

Random Hardware Faults Computation

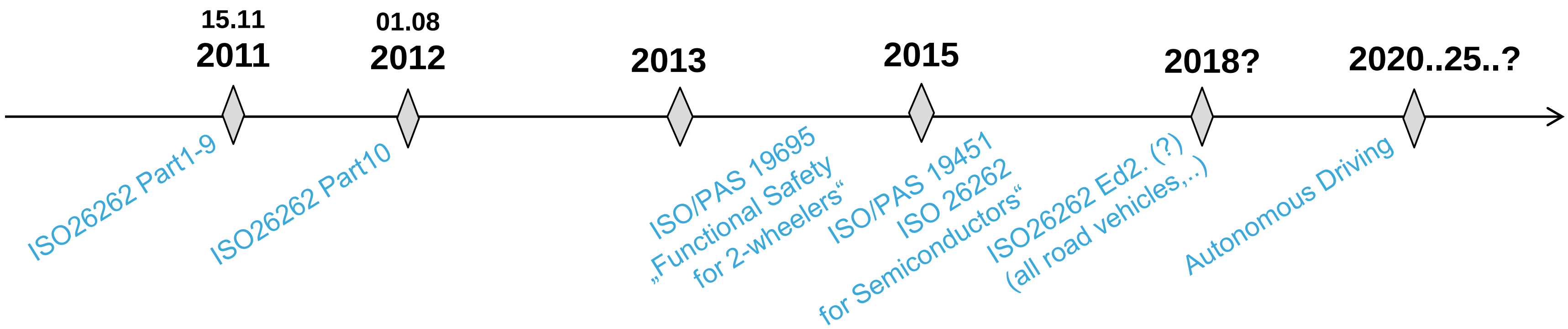


- *D.C.: Diagnostic Coverage tells how many dangerous faults are being detected by safety countermeasures*
- *Different targets given by Tier1s*

- High focus on random faults (can be quantified and easily assessed during safety audits)
- Today complexity (and probably overdesign) is built based on
  - *Fault rates (λ) on hard faults measured either on non mature technologies or coming from fault rate handbooks (SN29500, IEC62380…), quite pessimistic on both cases*
  - *Fault rates (λ) on on soft error measured in lab only*
- Systematic faults are still the primary source of reported accidents today, though.
  - *Complexity does not help prevention of systematic faults*

life.augmented

Roadmap of Safety in Automotive



Adressing the **increasing risk** associated to **soft errors**
+
Reducing system safety **cost** impact by introducing single MCU solutions

System shutdown/restart acceptable wrt. safety (system unavailability remains an potential risk for quality/image)

Addressing **unavailability** induced by safety measures
+
Reducing cost of MCU safety

System shutdown/restart acceptable wrt. safety with few exception (driving situation) and up to a certain unavailability risk

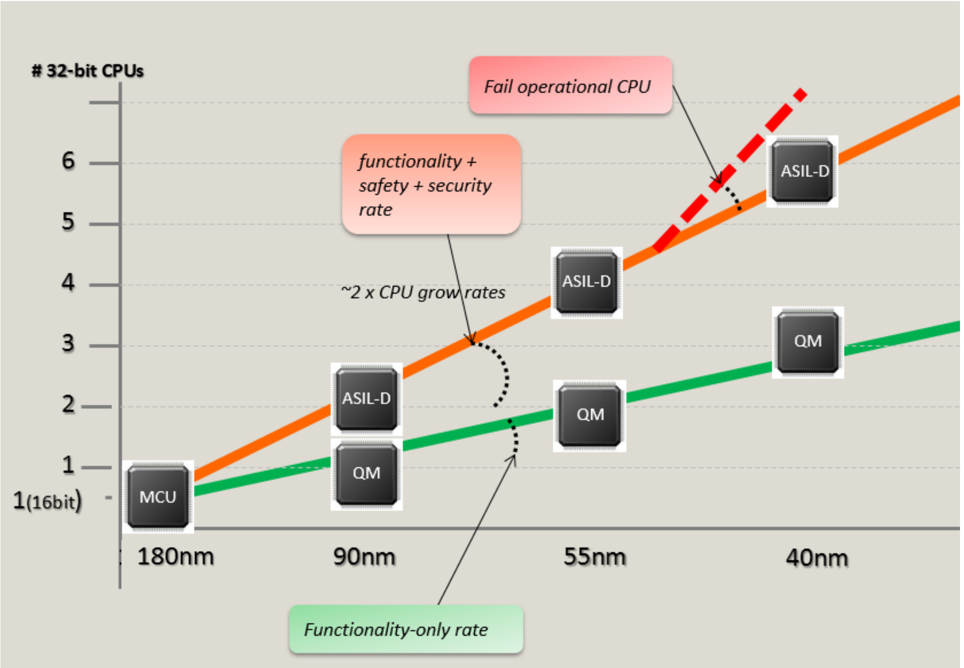
Solution for **very high availability** requirement
Autonomous driving

Loss of a (minimum) support of the E/E system is not acceptable from safety pespective

And new challenges...

- *semiconductor cost trend inversion*
- *number of available parts for automotive (possible consumer parts in automotive despite safety/availability concerns?)*
- *...*

Complexity Trends: Safety impact



functional area   fail-silent area (real case estimation)   fail-operational area (real case estimation)

Impact from Safety Measures on silicon area is relevant:

- Area allocated to Fail-Silent weights more than 100% on CPUs and more than 50% on total Digital
- On Analog impact is more limited, but almost no technology shrinking applies
- Introduction of Fail-operational is worsening the scenario

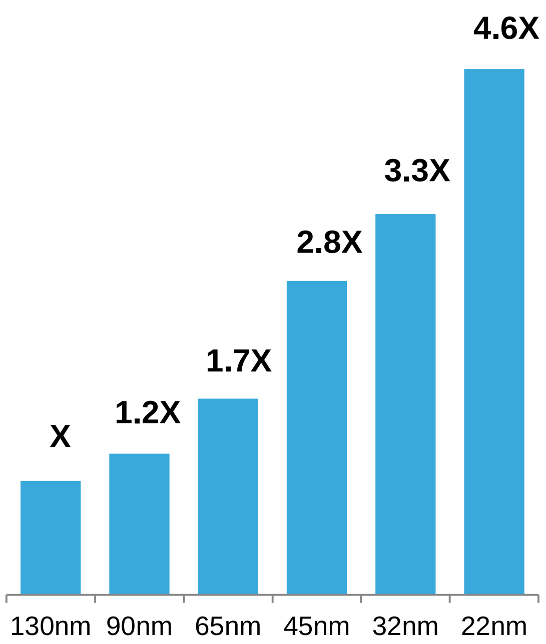
life.augmented

Source: ST elaboration

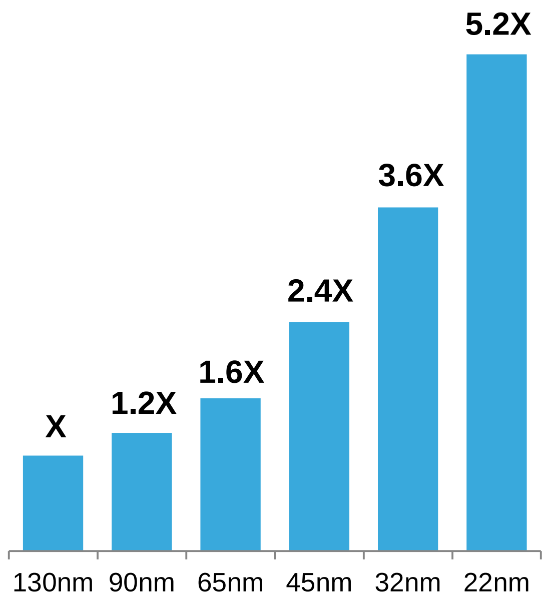
Silicon Technology Perspectives – Scaling

Semiconductor industry scaling pattern is at the basis of a challenging EXPONENTIAL COST GROWTH PATTERN at 360º

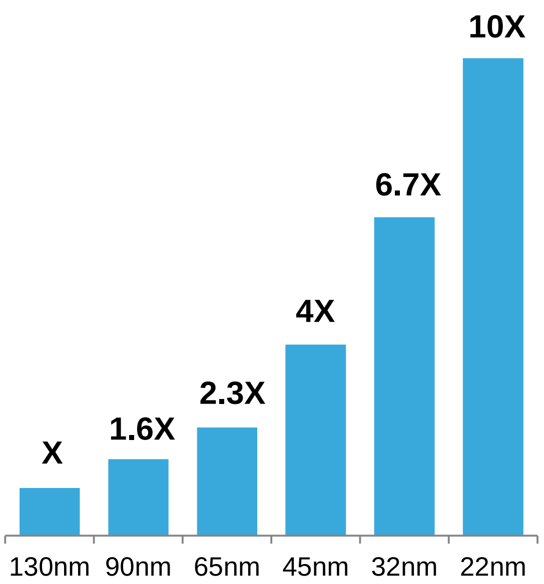
Fab cost by node



Process development cost by node



Chip design cost

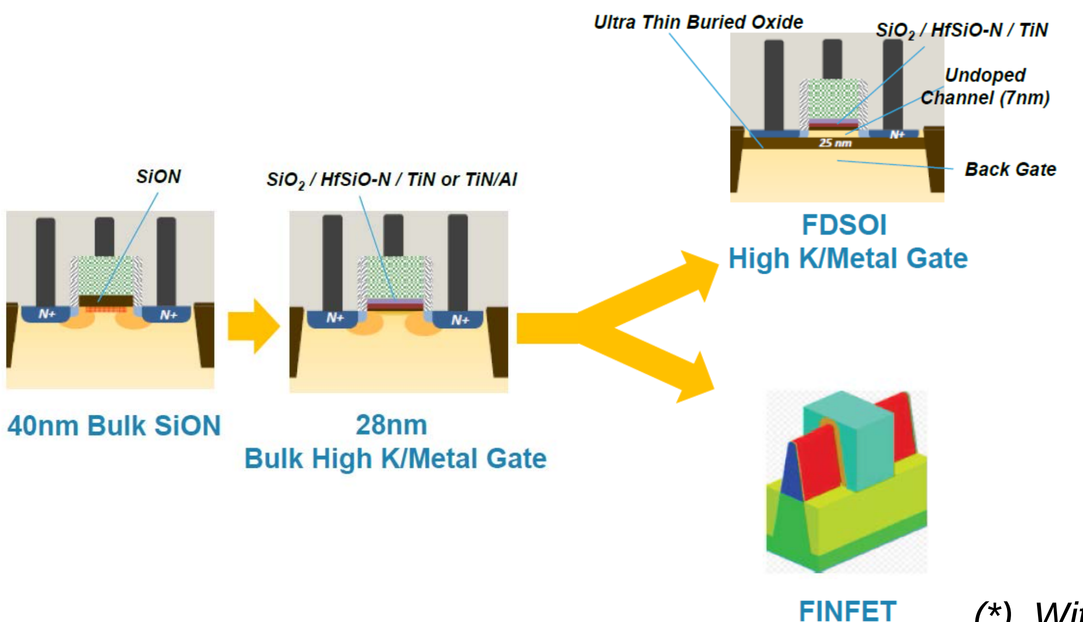


life.augmented

Source: TCX Inc.

28nm challenges summary

Techno	(*) Leakage Consumption	(*) Dynamic Consumption	Ability to embed FEOL memories	5V Analog & IO's	(*) CMOS reliability NBTI, HCI, TDDB	Supply voltage scaling	Radiation Immunity
28nm SiON	–	+	+	+	–	– –	–
28nm HKMG	+	+	– –	–	–	–	–
28nm HKMG FDSOI	+ +	+	– –	–	–	+	+



(*) With respect to 40nm base line

Talk outline

- Introduction
- Technological & application challenges
- The path towards autonomous driving
- Conclusions

What is driving the ADAS field

Two Major Trends

Evolution

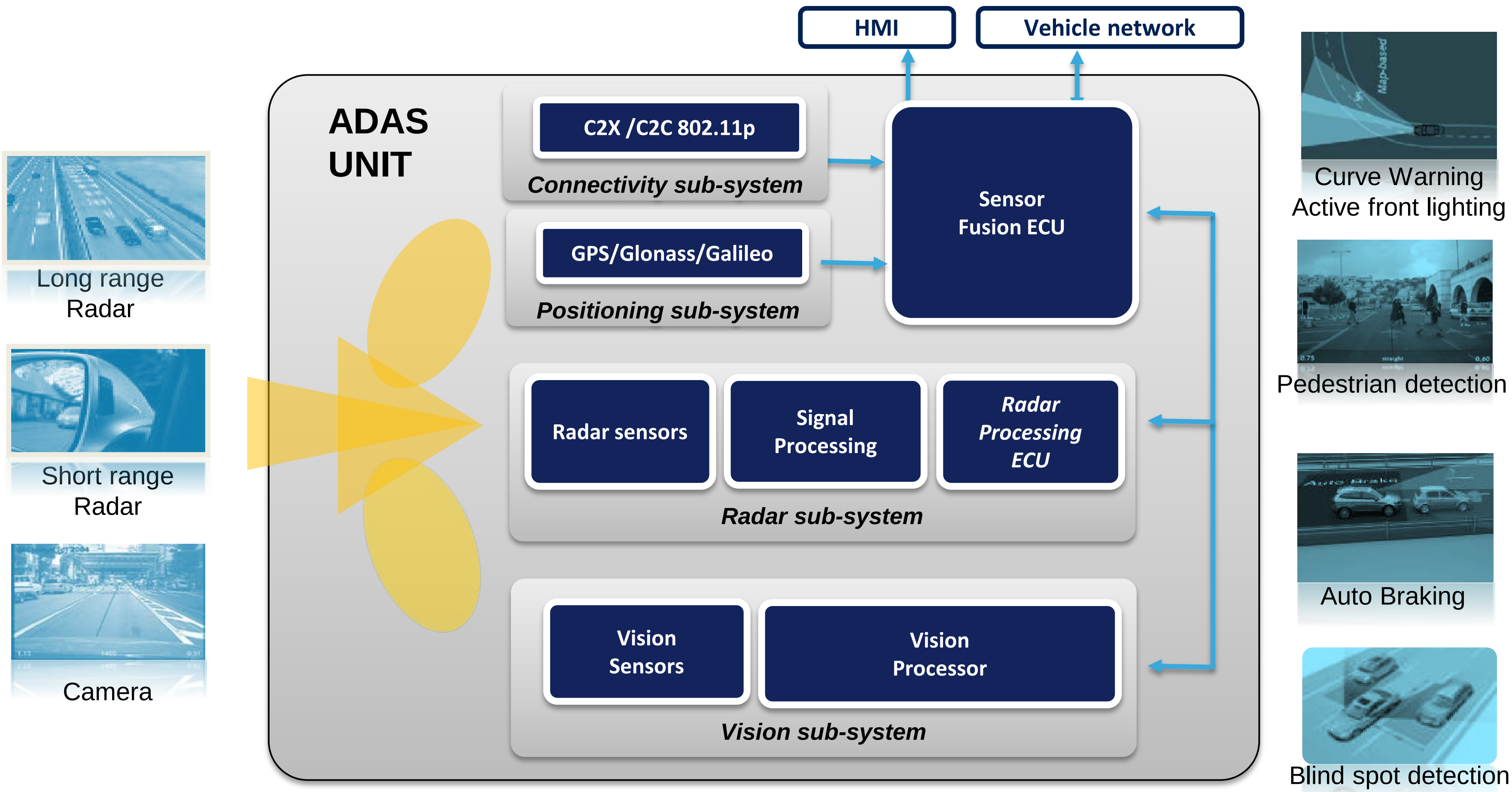
Revolution

New Safety Rating Regulations

Autonomous Driving Megatrend

life.augmented

Example of an ADAS System



Multiple Technologies Leading to Enhanced Safety

Trend is that Vision will drive future systems

- The functional territory taken by the camera is rapidly increasing:
  - 2011: warning against collisions
  - 2013: ACC, partial brake AEB, TJA
  - 2015: full brake AEB

WHY?

- 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

Radars/Lidar/Ultrasonic: for redundancy, robustness

life.augmented

MOBILEYE®

But we must find a safe way

Don’t compromise NCAP points, compromise reputation when “tested in the wild”

- False Negative: miss fires, late fires, inaccurate measurements..
- False Positives: unexplained braking, inaccurate firing, nuisance braking…

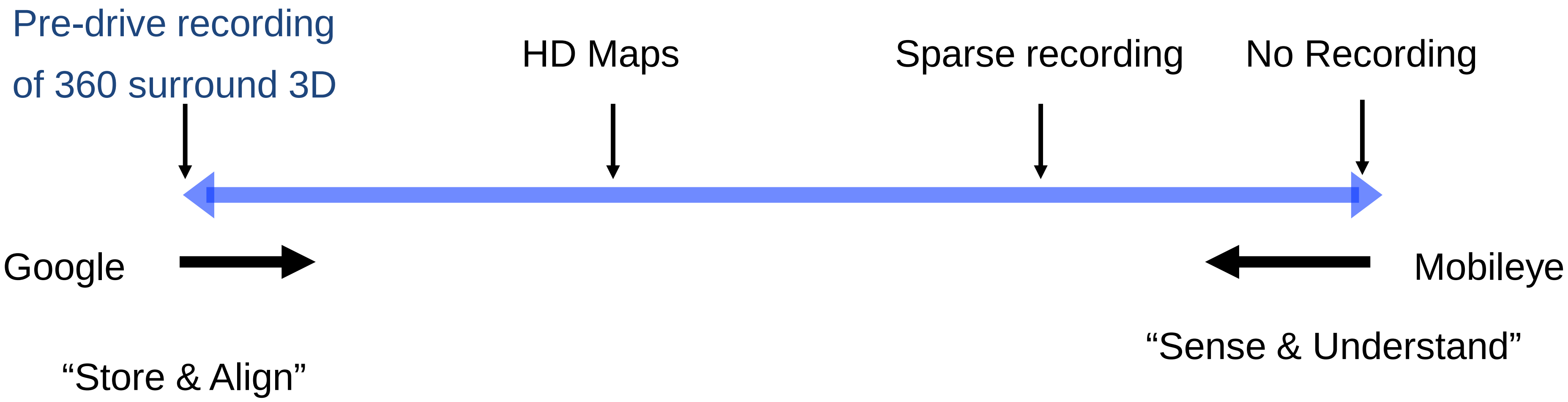
compromise reputation, recall

Evolution : Incremental Growth

- Animal Detection
- Left Turning Across Path (LTAP)
- Road Profile: Bumps, Potholes
- TSR Evolution
- Traffic Light Detection
- Stop Line Detection
- Brake and Turn-light detection
- Early cut-in detection
- Road Signs detection
- General Objects detection

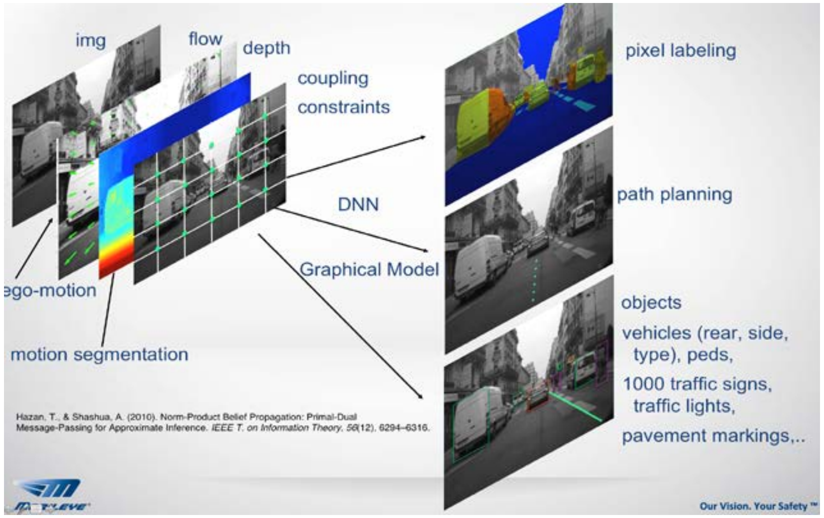
life.augmented

Two approaches to autonomous driving



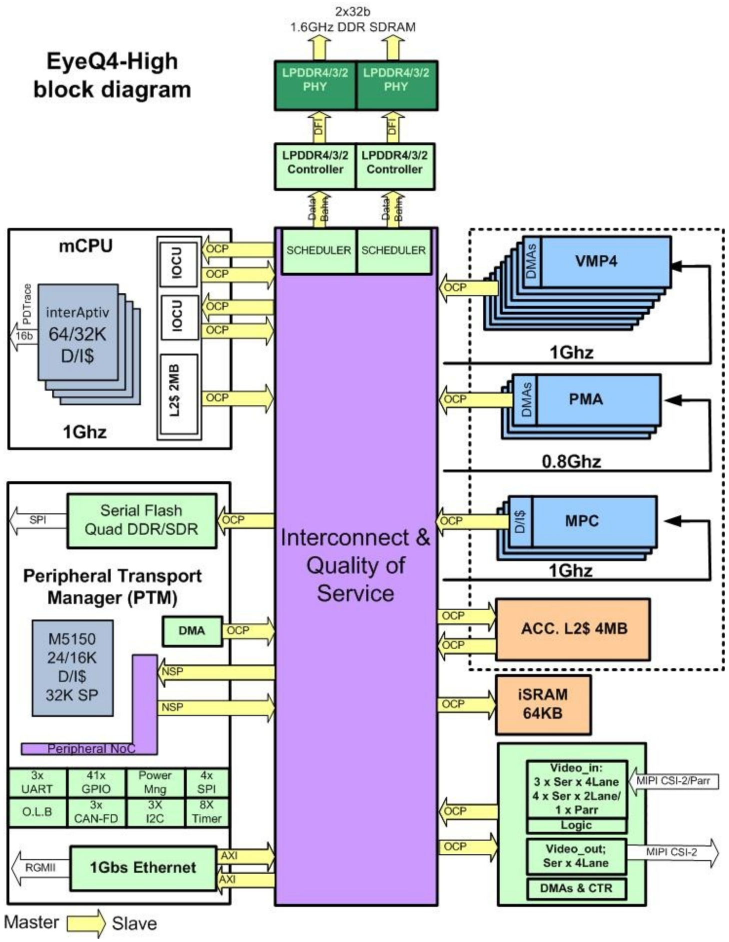
Revolution : Growth by leaps and bounds

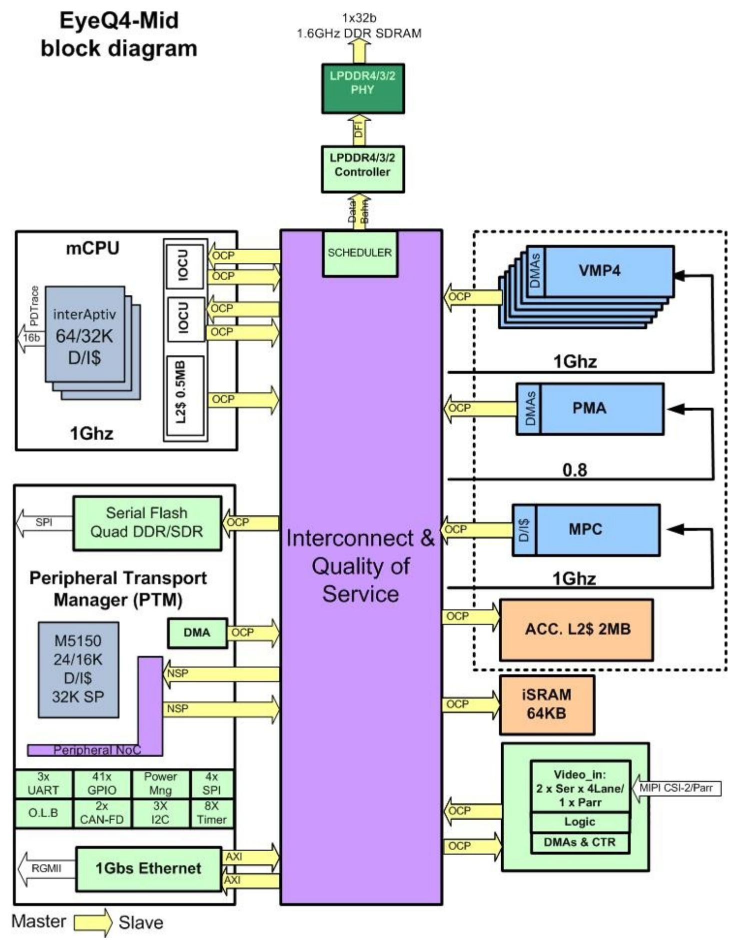
- From sensing to comprehensive perception
- Machine learning used already for object sensing (decomposing video)
- Autonomous driving needs
  - Path planning based on holistic cues
  - To dynamically follow the drivable area
- Deep learning is being used by Mobileye for
  - Free space
  - Path planning
  - General objects
  - 1000 traffic signs
  - Classical object enhancement



life.augmented

Hardware : Family of Computer Vision processors





PMA-Programmable Macro Array
VMP-Vector Microcode Processor
MPC-Multithreaded Processor Cluster

28nm FD-SOI process. Engineering Samples 10/2015

life.augmented

Talk outline

- Introduction
- Technological & application challenges
- The path towards autonomous driving
- Conclusions

Conclusions 1/2

- ADAS is to be dominated by cameras.
- The primary sensor for automated driving would also be the camera - multiple cameras.
- Radars and Lidars would be used for redundancy and for additional robustness when cost allows.

- Visual interpretation is difficult if done at high quality - requires huge validation data over multiple geographies and OEMs.
- Automated Driving requires Environmental modeling and path planning which in turn require a leap-frog technological jump (if done at high quality and low cost).

Conclusions 2/2

- Electronics are fueling the innovation in the car
- Cost, complexity and technology are changing the rules
- The safety bar is getting high and mandates complex techniques
  - Functional safety
  - Security
  - Virtualization
- Partially autonomous driving needs all of the above and is coming to a road near you sooner than you may think
- Watch this space, it may be a bumpy ride but it will be fun

life.augmented