SOI Consortium – IOT, 5G, ADAS and AI Market Update

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IoT has been happening for years, solutions today are more sophisticated

Devices have been getting smarter and more connected for decades

Key IoT Drivers

INNOVATION AND COMPETITIVENESS

BUSINESS MODELS

STANDARDIZATION AND SECURITY

WIRELESS TECHNOLOGY INNOVATION
Measuring progress through connected devices

Internet of Everything
Includes (in theory) every electronic and non-electronic object in the world. Then branches into increasingly smaller divisions, differentiated by connectivity type and device function.

Non-electronic vs. electronic: 1st major divide. Is object powered—by electricity, batteries or solar?
- Non-electronic: Tagged objects are identified by RFID labels or QR codes
- Electronic: splits into more specific subsets and categories

Connected vs. Unconnected: 2nd big divide
- Non-IP-addressable: DVD players with no internet connectivity
- Tethered: wearables that don’t link up directly to the internet but connect instead to smartphones to share data

IP-addressable vs. Closed: 3rd and final divide
- IP devices: PCs, smartphones, tablets connecting directly to the internet
- Closed network: nuclear launch systems, military drones and other devices never to be connected to the open internet
Tracking IoT through the „THINGS“

IHS Markit segments IoT devices by 6 markets and 27 applications and 228 end devices.

**Automotive & Transportation**
- 0.7B ICs
  - Aerospace and military
  - Automotive – ADAS & Others
  - Automotive – other
  - Infotainment

**Commercial & Industrial Electronics**
- 3.3B ICs
  - Commercial electronics
  - Industrial automation
  - Lighting
  - Other Commercial and industrial electronics
  - Power and energy
  - Security and building automation

**Computers**
- 1.0B ICs
  - Desktops
  - Portable computers
  - Servers

**Consumer**
- 3.7B ICs
  - Consumer – other
  - Home appliances
  - Home automation
  - Home CE
  - PC peripherals and printers
  - Portable CE
  - Sports, fitness and activity

**Medical**

**Industrial automation:**
- **fixed assets**
  - Motion controller
  - Servo drive
  - Stepper drive
  - Linear Encoders
  - Process control
  - DCS
  - Process controller
  - Process measurement
  - RTU
  - Rotary Encoders
  - Pumps & Compressors
  - Sensors
  - Switchgear
  - Air Circuit Breakers
  - Circuit Breakers
  - Industrial Pushbuttons
  - Beacons
  - Low Voltage
  - Contactors
  - Low Voltage Motor
  - Control Centres
  - Low Voltage Soft

**Industrial automation:**
- **mobile assets**
  - Automated guided vehicles
  - Drones
  - Heavy vehicles
  - Service robots

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Source: IHS Markit IoT Devices & Connectivity Market Tracker; Q2 2019 – August 2019
IoT Market Growth: Connectable Device Shipments

Commercial & Industrial Electronics
- Shipments will see strong growth: 2013–2030 CAGR = 20%
- Will contribute the largest margin of installed devices in the next decade (2021–2030)
- Devices in the market will surpass the communications segment in 2023, which includes mobile handsets

Consumer & Wearables
- Shipments will see moderate growth over the long-term forecast: 2013–2030: 17.3%
- Connectable devices will double from 2015 to 2020
- Total new connectable shipments increases 10% from 2013–2030

Devices included in both shipments and installed base are “connectable” and may not end up connected.
IoT Market Growth: Connectable Device Shipments

Timeline for Growth is Steady

• **2015-2019**
  Connectivity – Phase 1 “Mission Accomplished”

• **2018-2023**
  IoT Infrastructure buildout continues in earnest
  (eg “Software Platforms” for connectivity, data and
  application management) → SW, SW, SW

• **2021 - 2025**
  AI experimentation, 5G begins to RAMP with
  Massive IoT

• **2024 - 2030**
  ADAS becomes an emerging factor, AI in
  healthcare begins to show real results, 5G
  Mission Critical deployments begin
Technology drives convergence of verticals

1.4B devices in 2018
20.5% CAGR 2017–2023
Voice and Digital Assistant as the HMI of everything
Lighting driving cost of wifi connectivity <$1usd

475 million devices in 2018
13.96% CAGR 2016–2021
Sports, fitness and personal care central to the personal IoT.- now a legitimate fashion accessory

525 million devices in 2018
>18% CAGR 2016–2021
Utilities active in smart meters expanding to mobility and charging to explore revenue streams

250 million devices in 2018
7.6% CAGR 2017–2023
The move to ADAS (L4/L5) is already having a major impact on auto manufacturers strategies.

450 million devices in 2018
19.6% CAGR 2017–2023
Asset tracking, robots and drones, predictive maintenance are new tools and changing the way products come to market as well as the competitive landscape

475 million devices in 2018
13.96% CAGR 2016–2021
Sports, fitness and personal care central to the personal IoT.- now a legitimate fashion accessory

120 million devices in 2019
11.7% CAGR 2017–2023
We now have WIFI enabled pregnancy tests that entertain you while you wait!
Signs that the IoT platform vendor landscape may be consolidating
Market development speed varies widely

FAST DEVELOPING
- Asset Tracking
  Quick ROI
- Sharing Economy
  Low investment, High re-use
- Consumer related
  Subscription model

SLOWER DEVELOPING
- Predictive Maintenance
  Heavy R&D investment
- Industrial IoT
  Industry hesitancy
- Government & Defence
  Longest sales cycle
Cellular IoT Showing Healthy Growth

> 950 million connected Cellular IoT devices in 2018

- **Automotive and Transportation**
  - 151 million devices
  - 11.0% CAGR 2018-30

- **Asset Management**
  - 583 million devices
  - 20.2% CAGR 2018-30

- **Healthcare**
  - 14 million devices
  - 23.5% CAGR 2018-30

- **Retail and Payments**
  - 73 million devices
  - 10.7% CAGR 2018-30

- **Security**
  - 36 million devices
  - 10.9% CAGR 2018-30

- **Digital Signage**
  - 847 thousand devices
  - 15.7% CAGR 2018-30

- **Energy and Utilities**
  - 76 million devices
  - 10.7% CAGR 2018-30

- For the next 4-5 years 4G products will continue to offer comprehensive technologies for different applications:
  - In 2025, 90% of global cellular IoT module shipments will support the 4G LTE standard.
  - By 2023 the 2G/3G network sunset will be complete in developed countries while 5G IoT network deployment will be at an early stage making 4G the clear dominant standard.
Importance of NB-IOT to IOT

- LTE NB-IoT and Cat-M connectivity becoming highly competitive with LoRaWan
  - CAT-M offers high-speed ~1.0-10Mbps with low latency 10-100ms
  - Low-cost power optimized NB-IoT standards for ~250-375kbps with latency of 1.6-10s

- Leading applications that drive market and volume
  - Lighting ~2X the size of home consumer electronics
  - Asset tracking, beacons larger than home appliance market
  - Security and building automation rivals home automation

- Cellular has a potential to overtake Wired market if the networks are reliable and scale drives change in the subscription economics
NB-IoT Market Drivers Dominate the Deployment Use Cases

**Energy and Utilities**

Smart Meters will have the largest install base by 2024 and is seeing explosive growth in China and India.

In North America, explosive growth in online purchases (e.g., Amazon) has created additional demand for more efficient warehousing and logistics cellular IoT solutions.

**Asset Management**

Cities are welcoming new revenue streams (Meters) as well as diversified mobility (shared bikes, scooters).

**Smart Cities and Home**

The automotive segment will be the primary consumer of the fastest high-speed 4G LTE modules.

**Automotive and Transportation**

- Smart Meters and Utilities
- Smart Cities (Parking Meters, Lighting, Shared Bikes)
- Smart Home, Personal Trackers, Consumer Wearables
- Asset Management (Logistics, Warehouse Management)
- Transportation (Fleet Management)
- Others (Agriculture, Retail, Medical)
AI is pervasive: everywhere at the Edge and at the Cloud

Cybersecurity
Monitoring diagnostic
Predictive maintenance
Quality and testing
Genome & chemistry simulation
Retail & CRM
Autonomous machine
ASP Degradation of Processors and Importance of AI

![Graph showing the ASP degradation of processors for different sectors from 2015 to 2025. The x-axis represents the years 2015 to 2025, and the y-axis represents the ASP values ranging from 0 to 1.5. The graph compares the degradation of ASP for Commercial electronics, Industrial automation, Home automation, Home CE, and Clinical care devices over the years.]
Vehicle production rises slowly

1.5% CAGR (2017 – 23)
Electrification, automated driving and connectivity
Fueling automotive semiconductor growth

8.3% CAGR (2017 – 24)
## Typical ADAS content from level 3 to 5

<table>
<thead>
<tr>
<th>ADAS Modules</th>
<th>L3</th>
<th>L4</th>
<th>L5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultrasonic Sensors</td>
<td>12</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>Long-range Radar</td>
<td>1</td>
<td>1-2</td>
<td>1-2</td>
</tr>
<tr>
<td>Short/Mid-range Radar</td>
<td>2-4</td>
<td>2-6</td>
<td>4-6</td>
</tr>
<tr>
<td>Exterior Camera</td>
<td>5-8</td>
<td>12</td>
<td>8-15</td>
</tr>
<tr>
<td>Interior Camera</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Night Vision Camera</td>
<td>0-1</td>
<td>0-1</td>
<td>0-1</td>
</tr>
<tr>
<td>Long-range Lidar</td>
<td></td>
<td>~ $2-3k</td>
<td>~ $3-6k</td>
</tr>
<tr>
<td>Short-range Lidar</td>
<td>0-2</td>
<td>0-4</td>
<td>0-4</td>
</tr>
<tr>
<td>ADAS Domain Controller</td>
<td>0-1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Autonomous Driving DC</td>
<td>1</td>
<td>1-2</td>
<td>2</td>
</tr>
<tr>
<td><strong>TOTAL (without ultrasonic)</strong></td>
<td><strong>14</strong></td>
<td><strong>22</strong></td>
<td><strong>25</strong></td>
</tr>
</tbody>
</table>

*Architectures based on existing pilot car platforms from BMW, Volvo, Audi, Nissan.*
ADAS system cost to OEM by component value on Audi A8

ADAS module type

- Domain Controller
- Night Vision System
- LIDAR
- 4x Mid-range Radar
- Mono-camera Module
- Long-range Radar
- Driver Monitoring Camera
- 5x Basic Camera
- 12x Ultrasonic Parking

Source: IHS Markit

*Price of SOC does not include software value.
Possible architecture for L4/L5 in model year 202x

**Asymmetric redundancy**

- **No Driver - Redundancy for L4/L5 is key**
  - Two identical (or nearly) Domain Controllers
    - Provides complete redundancy.
    - Expensive but comprehensive.
    - DC2 can either share normal operations with DC1 or act just a back up.
    - Redundant network and power supply
  - Limited or distributed redundancy
    - Cockpit Domain Controller (CDC) and/or Front View Camera are candidates because of their processing capabilities.
    - Lower cost than symmetric redundancy but maybe less comprehensive.

*DC= Domain Controller
Implication of AI and Deep Learning
Major advantages in comparison with traditional machine vision

- **Assumptions:**
  - New silicon solutions will be developed with focus on AI algorithm
  - The functional safety aspect will be addressed by the entire supply chain

- **Deep learning can:**
  - Allow detection and recognition of multiple object ➔ improve perception
  - Perform semantic analysis of the area surrounding the vehicle
  - Reduce development time of ADAS and IVI systems (once DL is in steady-state)
  - Reduce the power required compared to the same operation w/ traditional algorithms

- **Deep Learning needs help**
  - Recognition/Prediction of actions and Fusion - Bayesian Net and other stochastic algorithms may complement DL in the run to autonomous cars (L4-L5)

- **Required precondition:**
  - Telematics will be broadly deployed to: 1) enable gathering of “real” patterns and data for training 2) allow over the air system update and security ➔ 5G is very welcome!!
The Wheel of Fortune - Culture

Companies are still looking for value

Does your company or business line currently adopt transformative technology in production or products today?

- Yes, we have widely adopted
- Yes, we have limited adoption
- Strategy to adopt a work in progress
- No current adoption or planned strategy
- Transformative technology in proof of concept projects
- Strategy developed to test transformative technology

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What stage of maturity are your IIoT projects

Industrial IoT deployment stage
- We are not considering or implementing IIoT solutions
- We are evaluating / starting Proof of Concept (PoC) projects
- We have completed PoC project but have seen no value from this project
- We have completed PoC project and have seen value from this project
- We have moved from PoC and are deploying across our operation

Number of responses

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The biggest challenges to doing IIoT in your organization - weighted importance

- Lack of cybersecurity
- Lack of willingness to invest for the future
- Lack of co-operation between IT and OT teams
- Issues with interoperability of software solutions
- Lack of support from leadership
- Organisational culture averse to change
- Lack of employee skills and knowledge
- Ability to derive meaning from data collected
- Ability to collect data
- Legacy equipment and infrastructure

Data issued: November 2018

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Questions, comments, cheers, jeers, rebuttals?

Thanks you, Matthew Short, 512.431.7152  <matthew.short@ihsmarkit.com>