

What are the business and technology trends that are impacting the MEMS business for the next 5 years?

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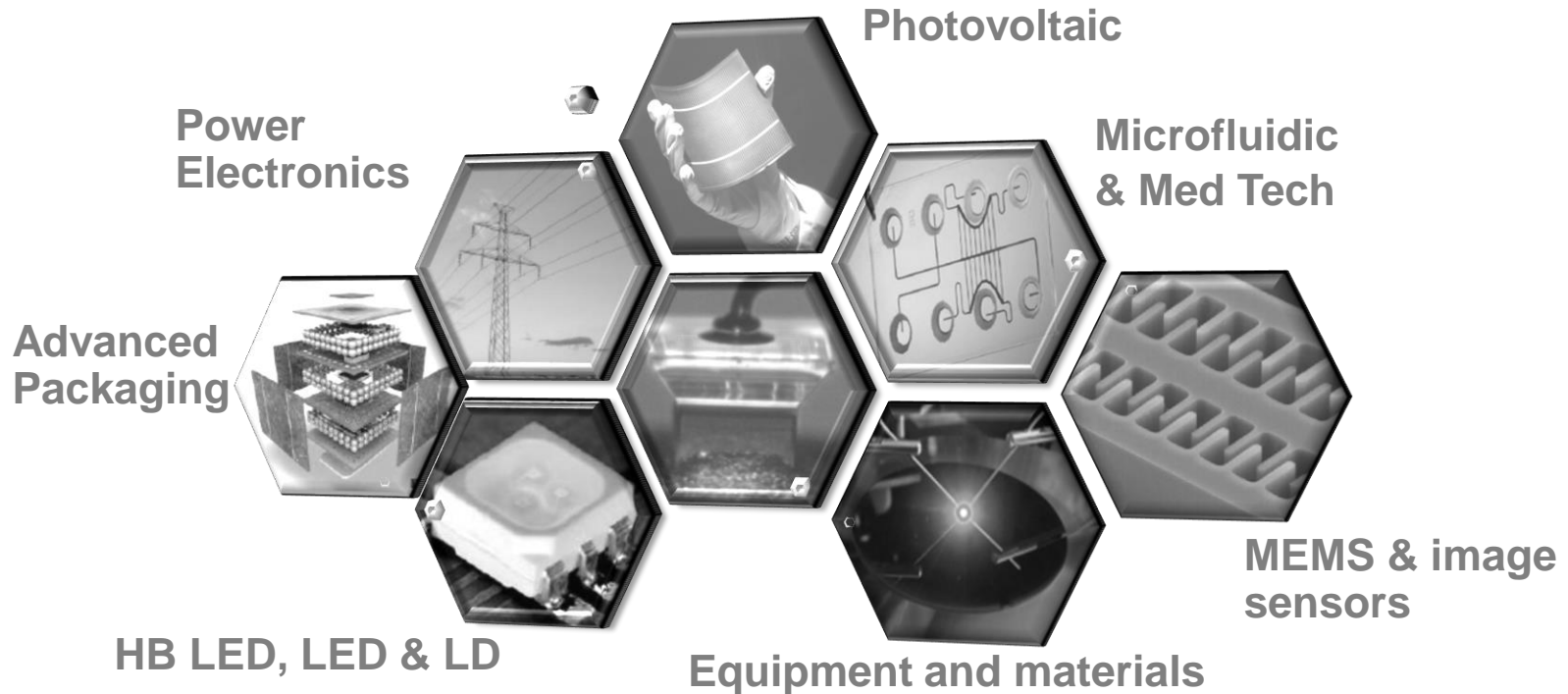
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YOLE presentation

- Yole Développement is a market, technology and strategy consulting company, founded in 1998. We operate in the following areas:



- Our expertise is based on research done by our in-house analysts, conducting open-ended interviews with most industry players.
 - 30 full time analysts with technical and marketing degrees
 - Primary research including over 3,500 interviews per year

4 business models

- **Custom Analysis:**

- Largest part of Yole activities
- Covered by NDA agreement
- A few days to several months of work, depending on objectives

- **Published Reports:**

- An average of 40 reports published every year
- Available individually or through Annual Subscription Program
- Market and technology reports, Patent analysis, Reverse Engineering/Costing reports and Reverse Costing tools

- **i-Micronews Media:**

- Newsletter and webcasts on 3D, MEMS, Power electronics, LED and imaging
- 45 000+ subscribers...

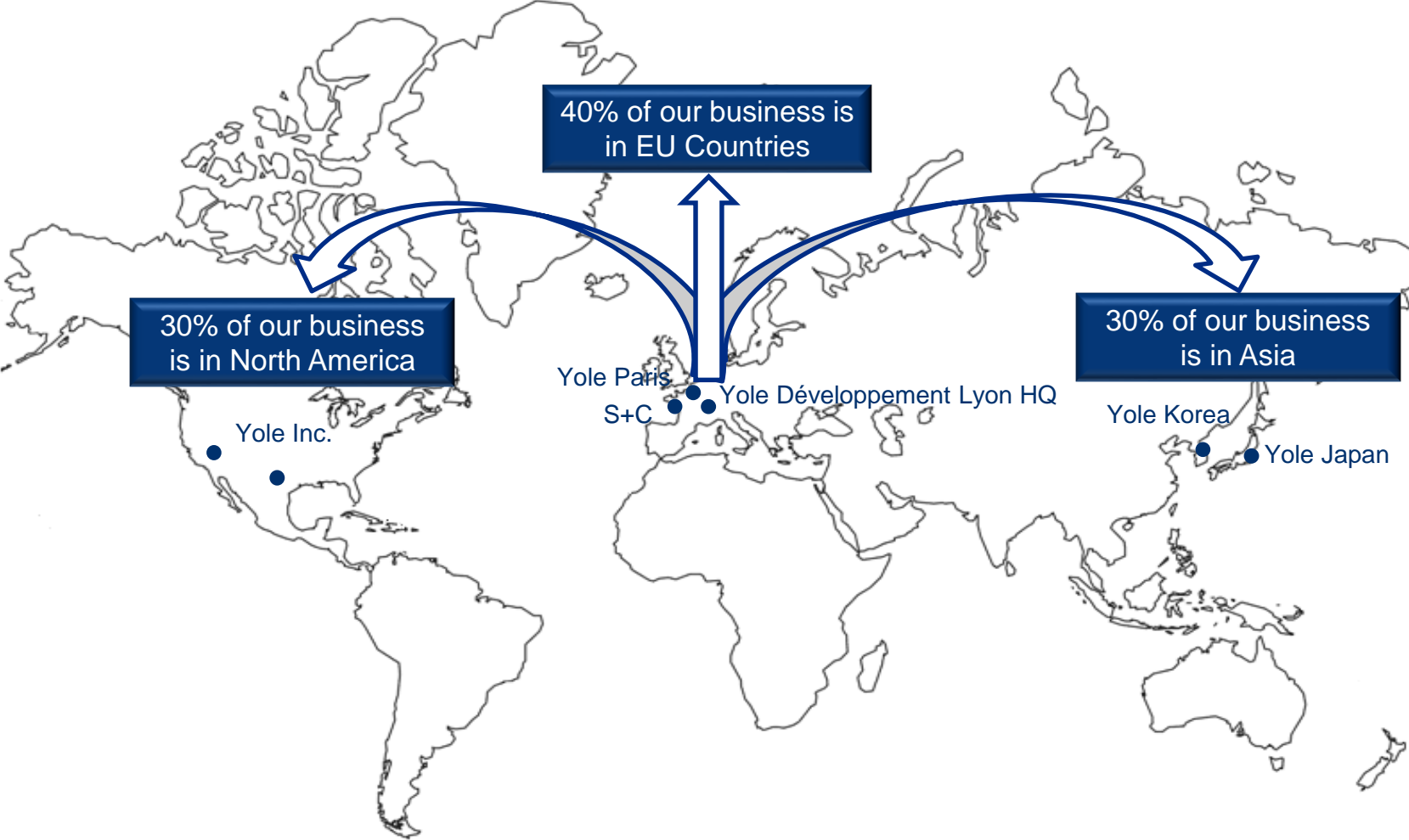
- **Yole Finance services:**

- M&A (buying and selling)
- Due diligence
- Fund-raising services

Last YOLE reports on MEMS

- **Permanent Wafer Bonding for Semiconductor: Application Trends & Technology**
- **MEMS Microphone: Market, Applications and Business Trends 2014**
- **Inertial MEMS Manufacturing Trends 2014 - Volumes 1 & 2**
- **Market & Technology Trends in Materials & Equipment for Printed & Flexible Electronics**
- **Status of the CMOS Image Sensor Industry**
- **Sensors for Home Healthcare Applications: Market & Technology Analysis**
- **Thin Film PZT for Semiconductor Application Trends & Technology Update**
- **6 and 9 axis sensors: consumer inertial combos report**

Global activities



Some of our customers

Financial investors & industry advocates



R&D Organizations



Suppliers (equipment, wafers, materials)



Component manufacturers



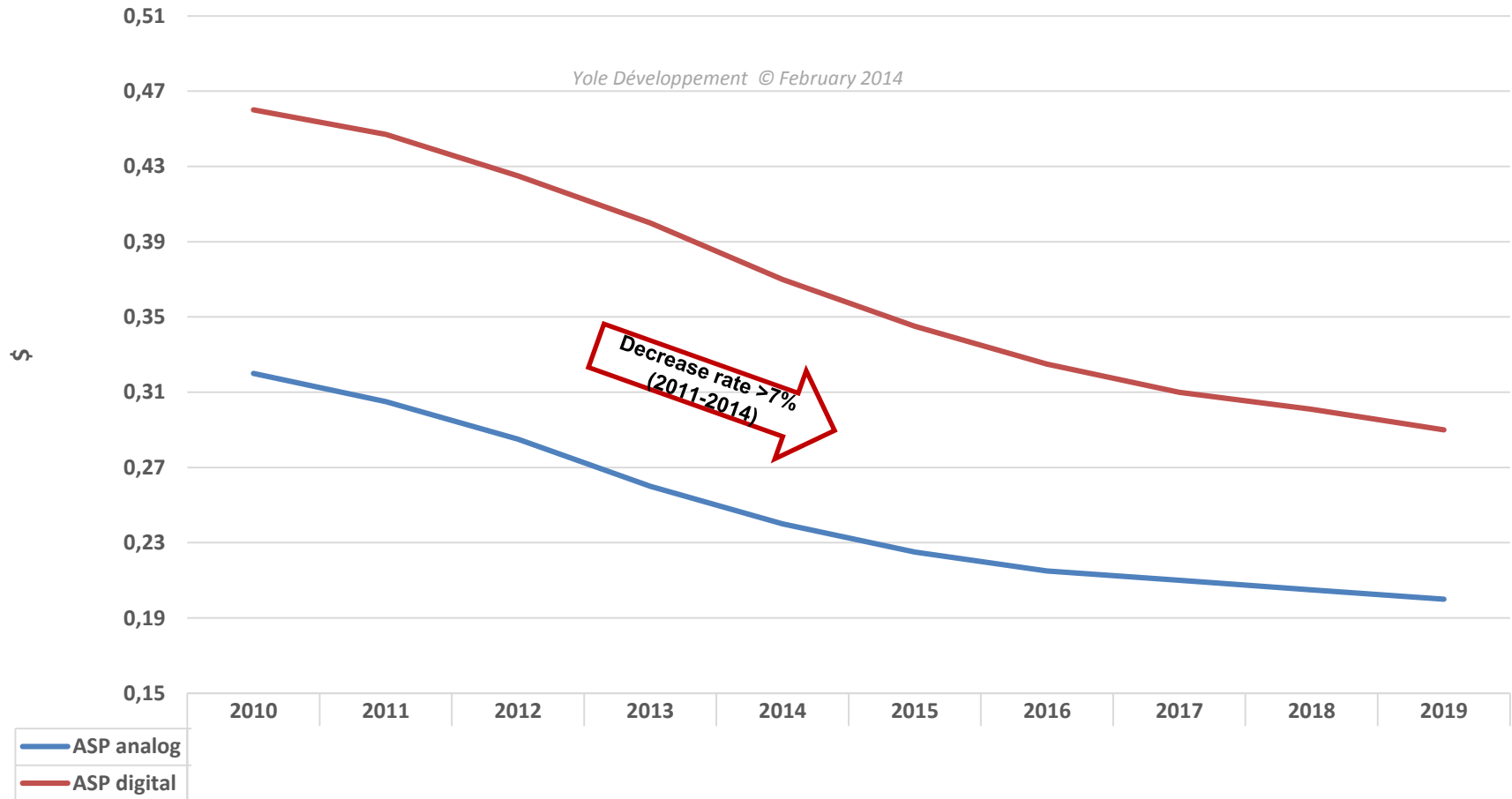
Integrators, system suppliers & end users



**FEW TRENDS ARE IMPACTING THE MEMS
BUSINESS...**

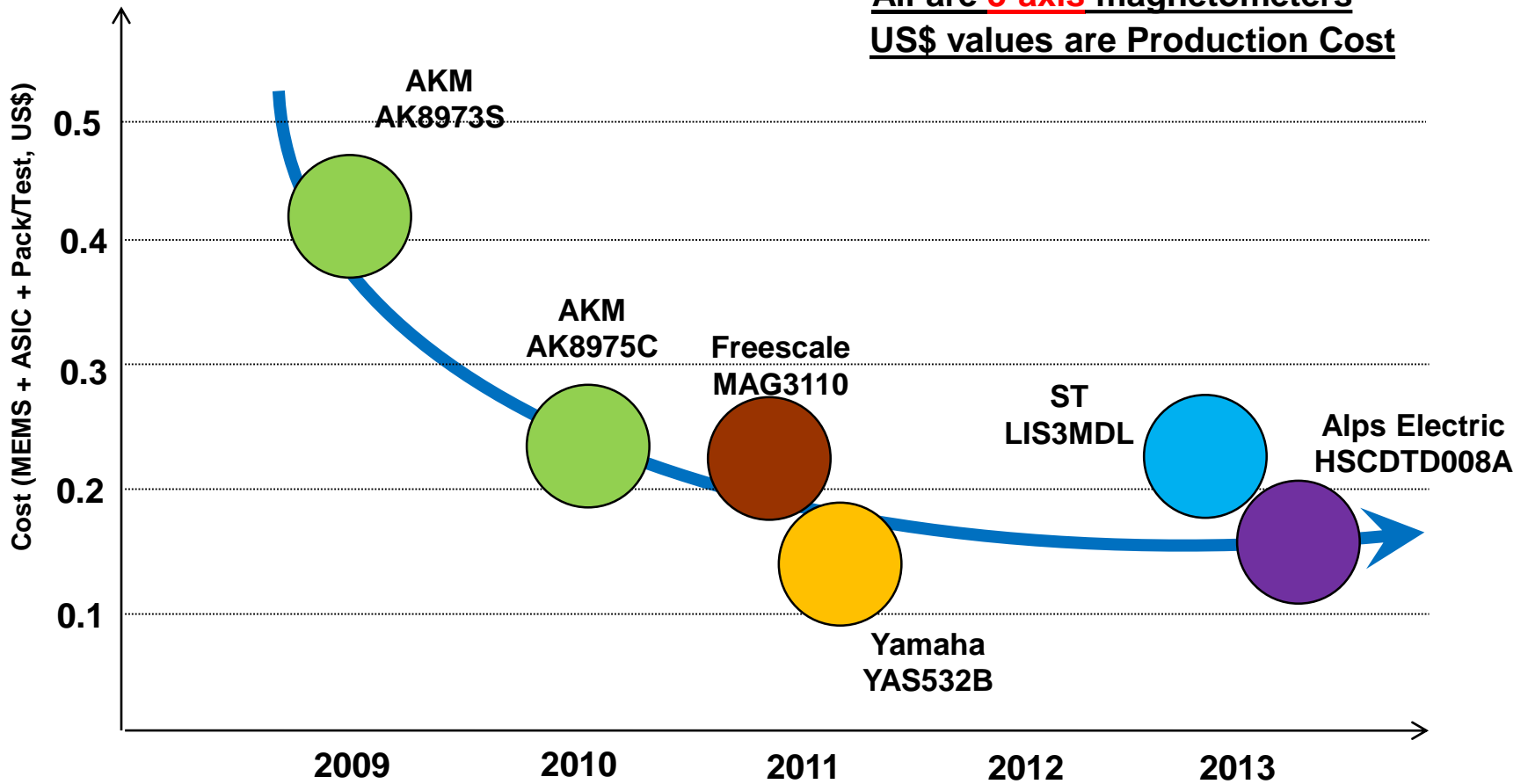
Decrease of price... ASP of MEMS microphones

Global ASP Evolution of MEMS Microphone
2010-2019

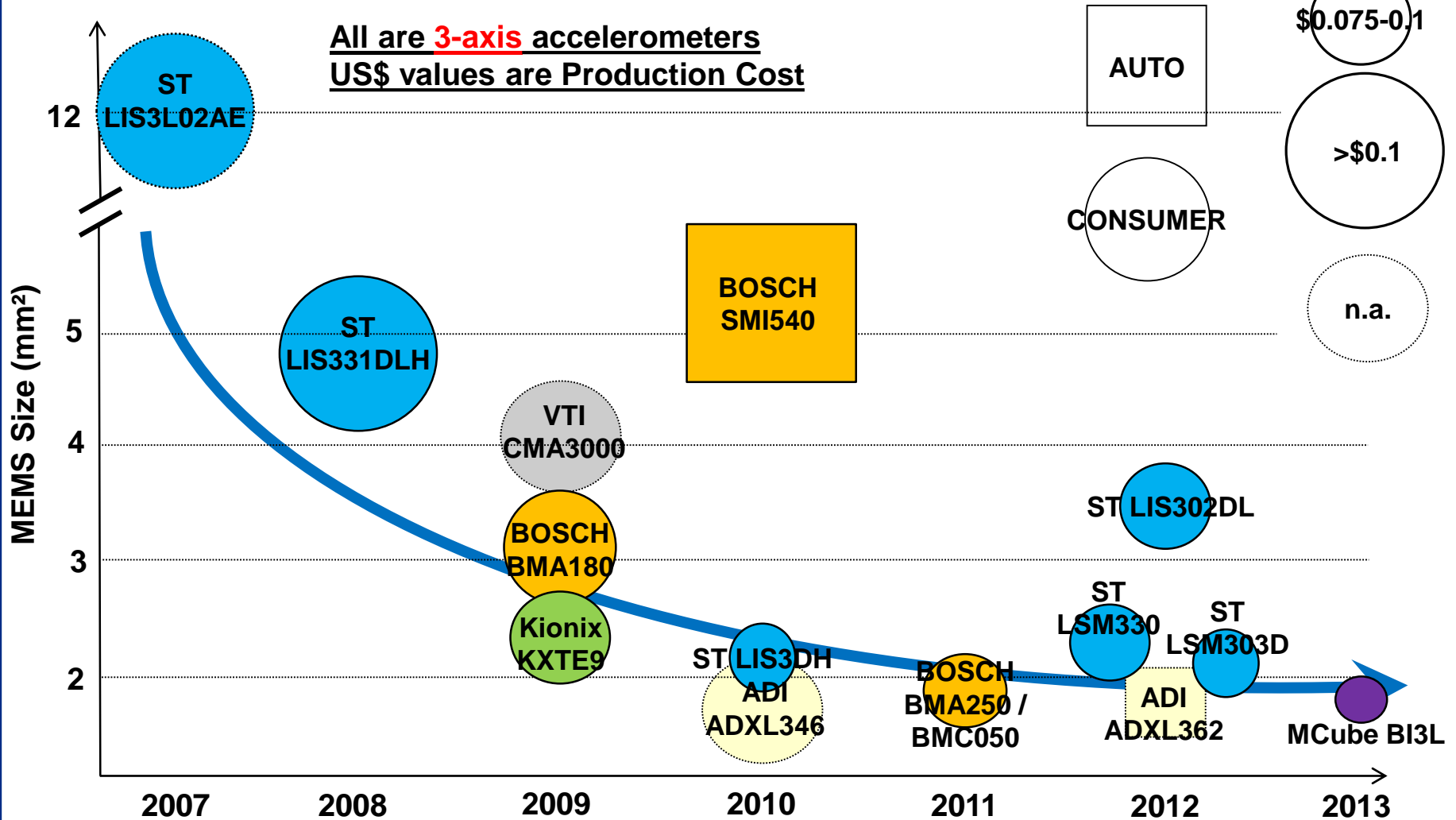


Decrease of price... Magnetometer cost evolution

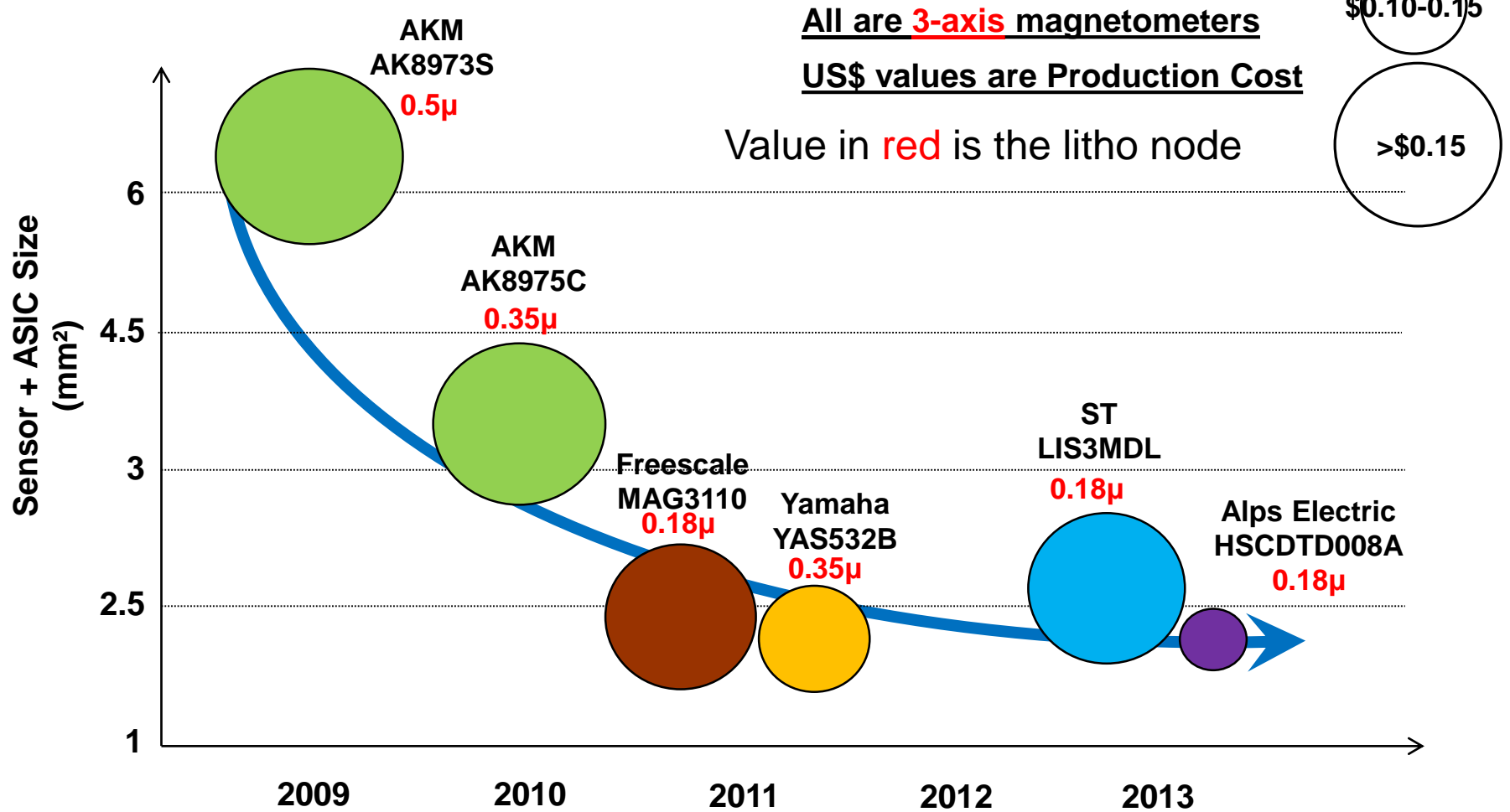
All are 3-axis magnetometers
US\$ values are Production Cost



Decrease of size... Accelerometer MEMS size evolution

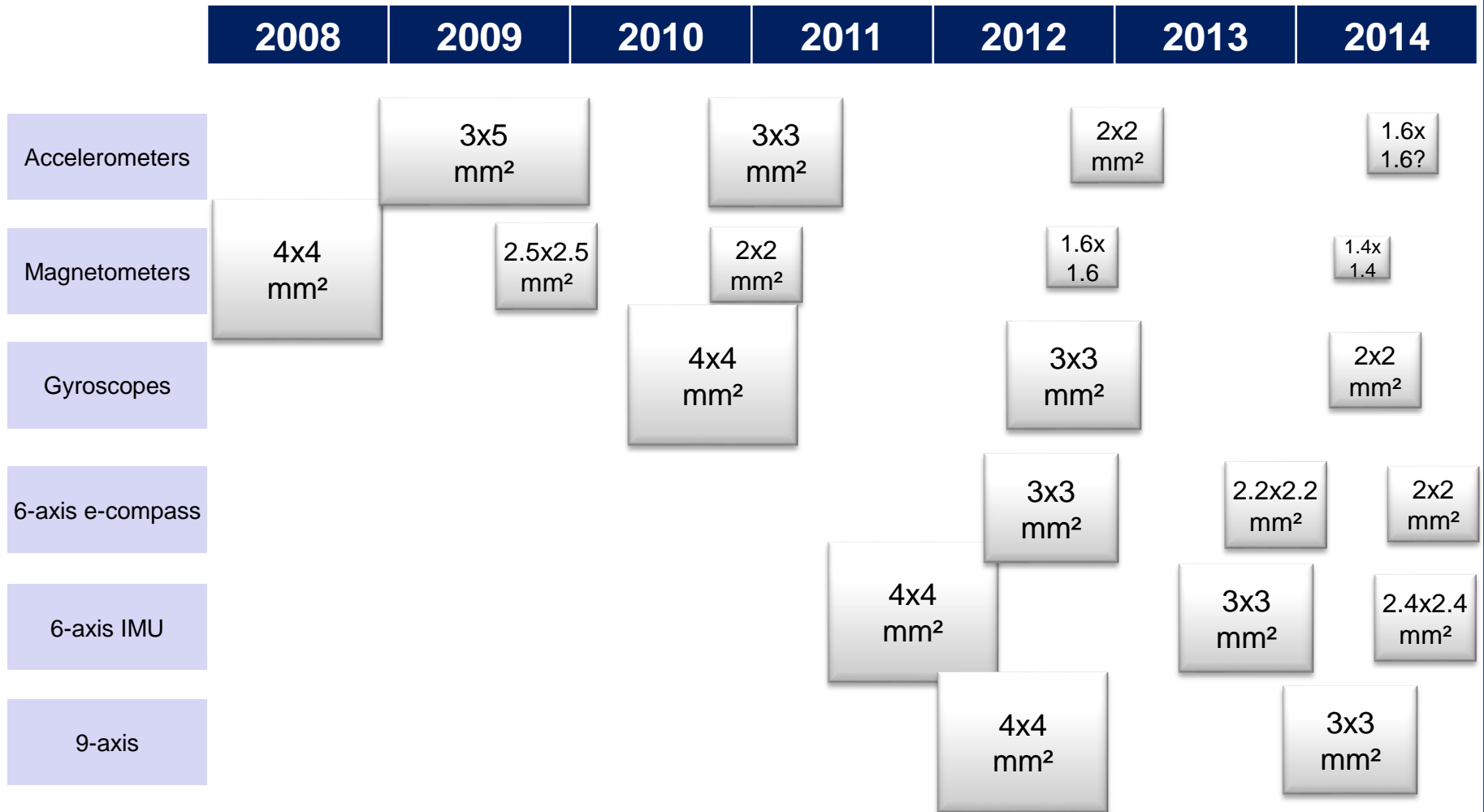


Decrease of size... ASIC size evolution



Component size is still decreasing

Typical package footprint for sensors used in mobile devices

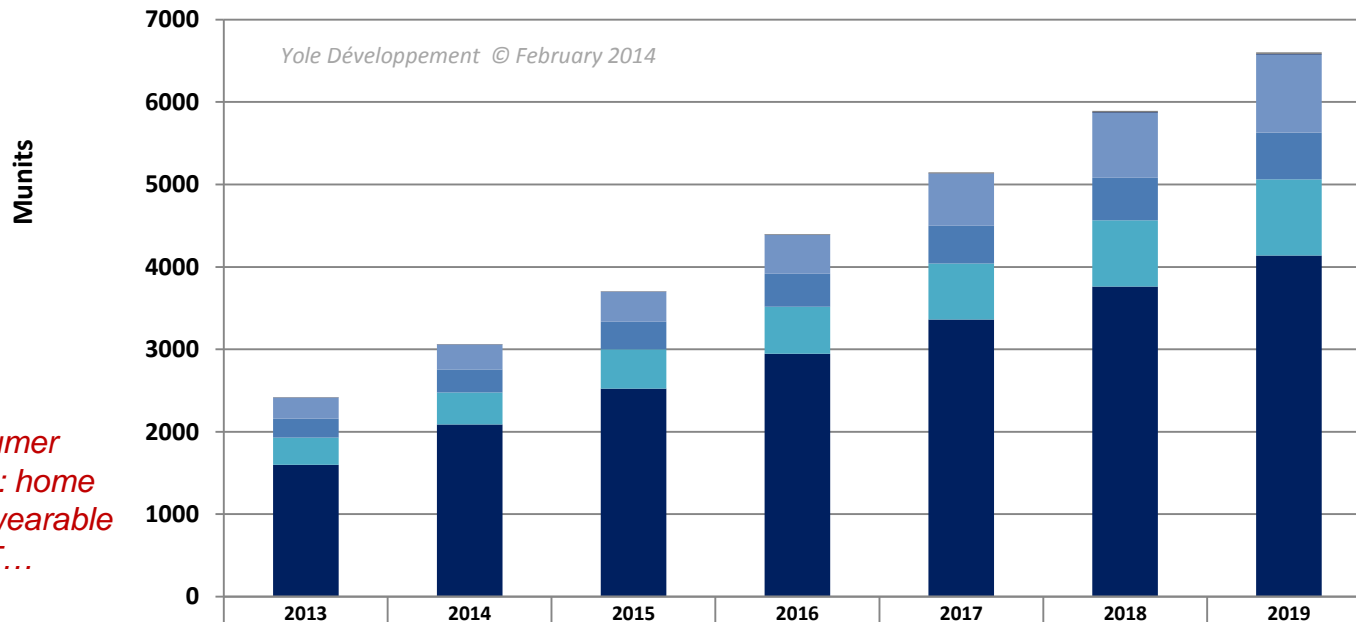


Increase of market size...

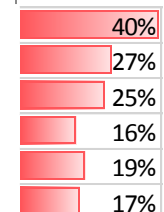
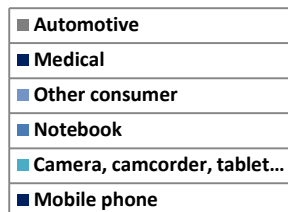
Total microphone market forecast by application

- MEMS microphone is a 2.4B units market in 2013.
 - Mobile phone application dominates but other consumer applications will grow fast as well.
 - Mobile phone and other consumer applications represent more than 90% of the total market.

MEMS Microphone Market Split by Application in Munits
2013-2019



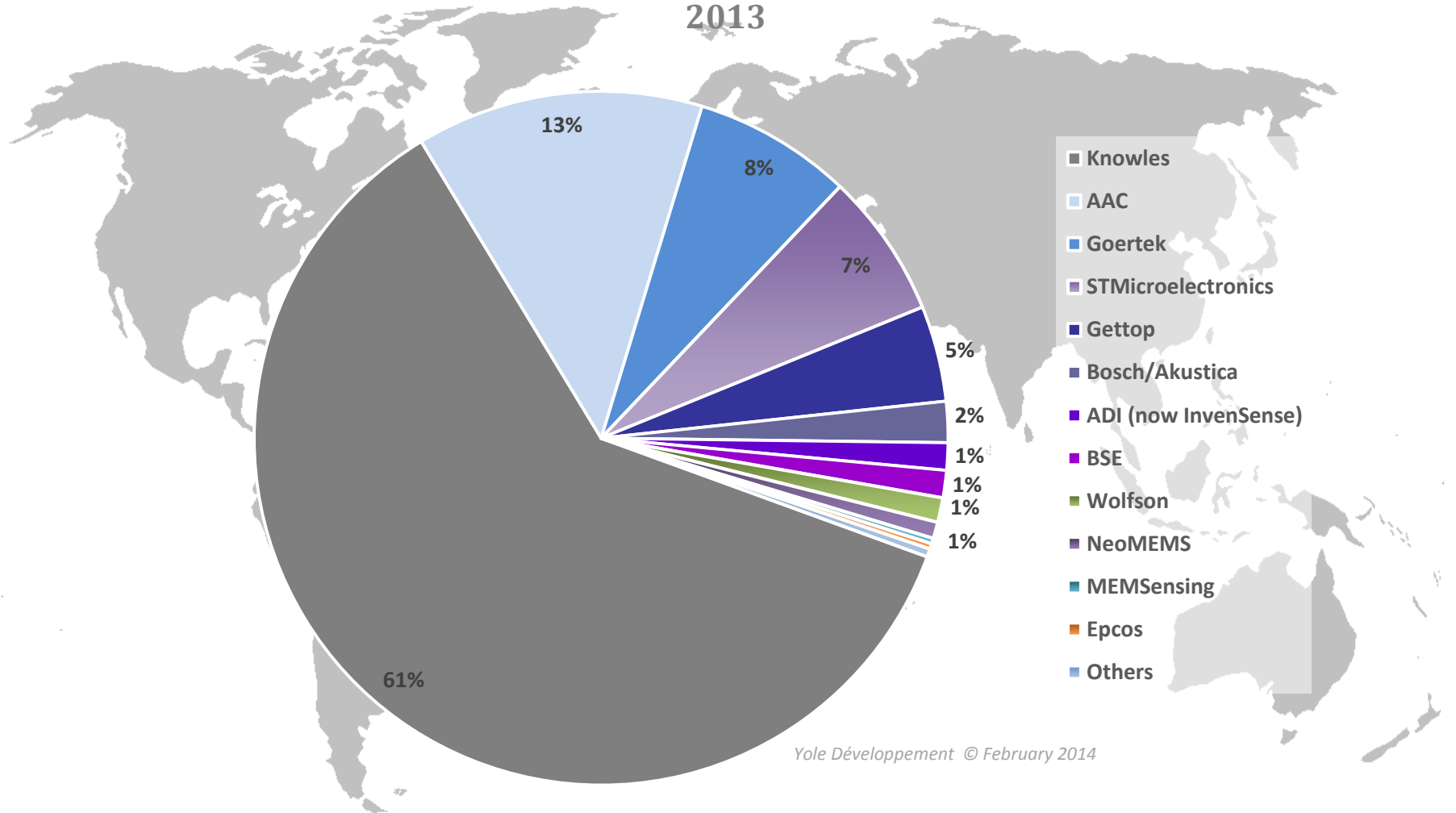
Other consumer applications: home appliance, wearable devices, IoT...



Things are different depending on what you are looking at...

Packaged microphone market share in 2013

Global MEMS Microphone Market Share in Value (\$M)
2013



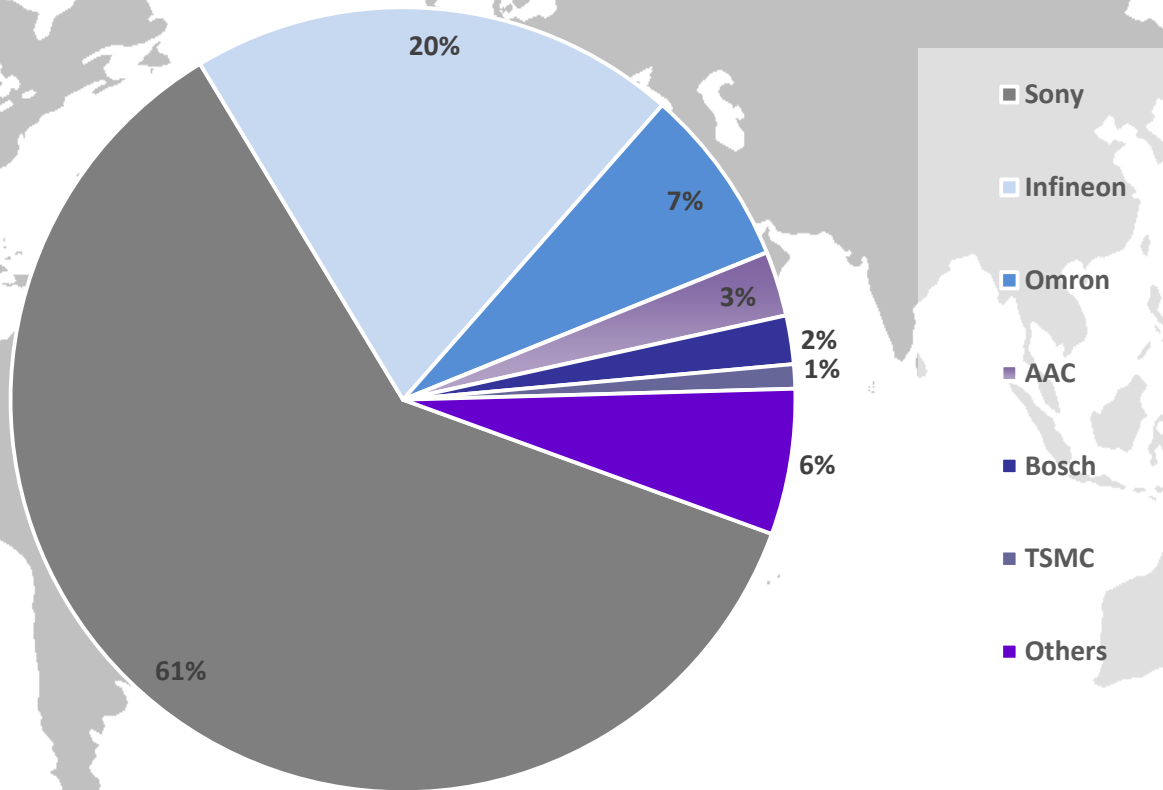
Yole Développement © February 2014

Things are different depending on what you are looking at...

Microphone die market share in 2013

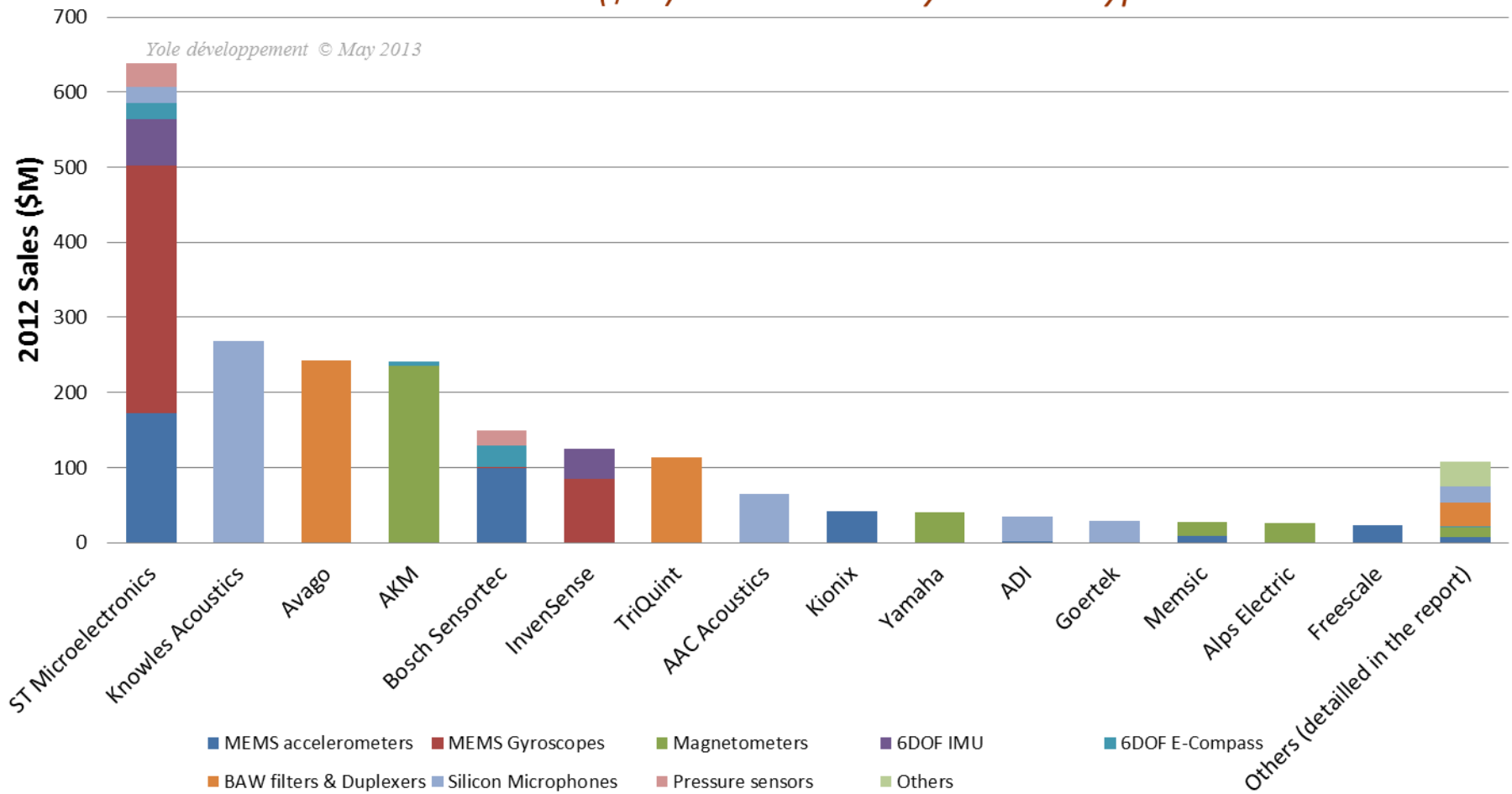
Global MEMS Die Manufacturing Market Share 2013 (in volume)

Yole Développement © February 2014



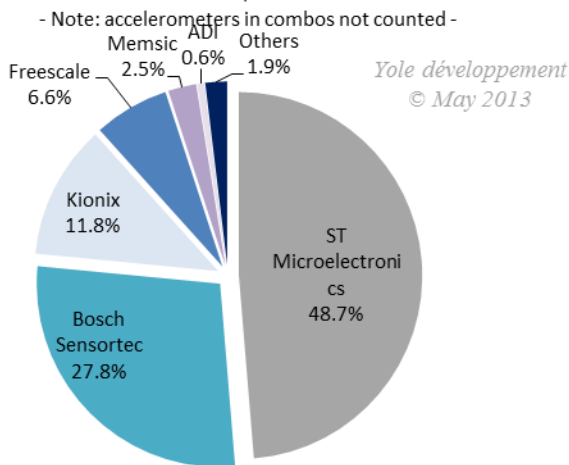
Few MEMS companies are involved in different type of devices...

Top MEMS Suppliers in the Mobile Phone and Tablet Market
- 2012 Revenue (\$M) - Breakdown by Product Type -

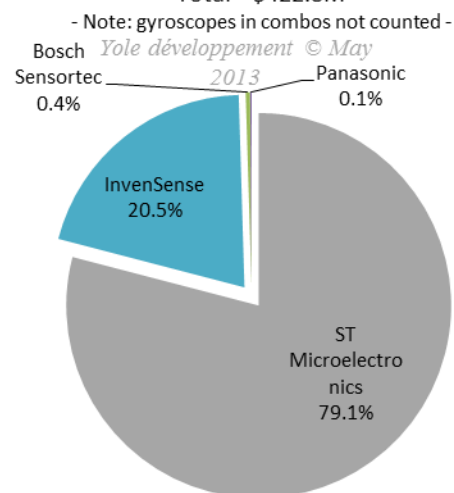


Each business is dominated by one player... But market shares are eroding step by step

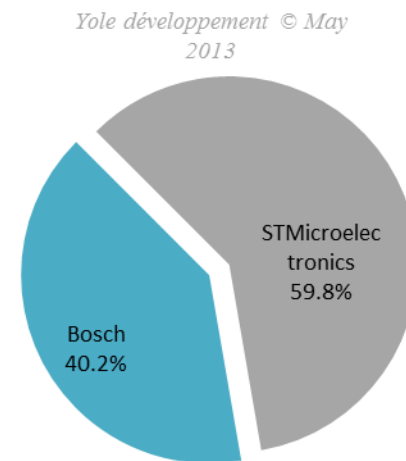
3-axis accelerometer in mobile phones and tablets -
2012 market share
- Total = \$403.1M -



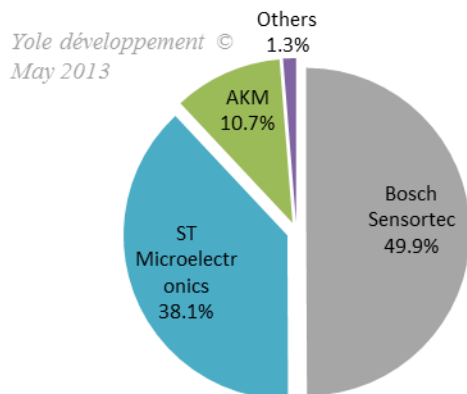
3-axis gyroscope in mobile phones and tablets -
2012 market share
- Total = \$422.8M -



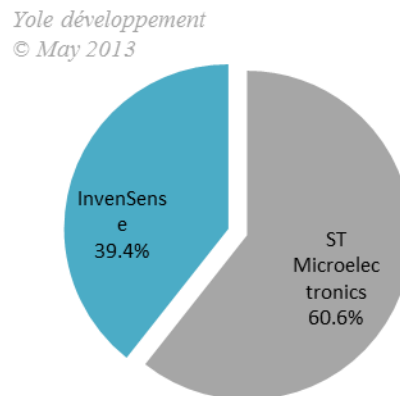
MEMS pressure sensors in mobile phones
and tablets - 2012 market share
- Total = \$52.7M -



6-DOF E-compass in mobile phones and
tablets - 2012 market share
- Total = \$57.7M -



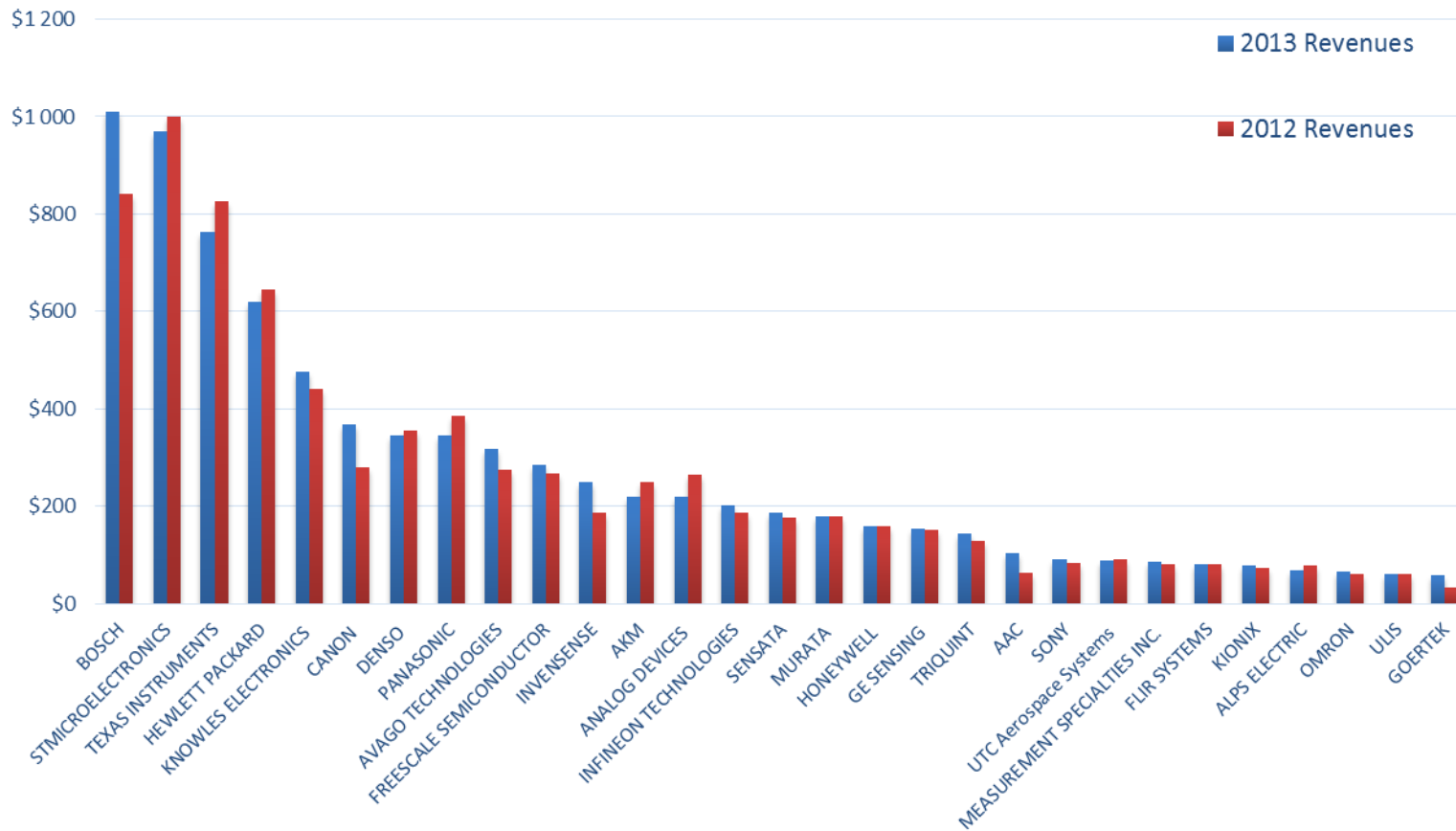
6DOF IMU combo in mobile phones and
tablets - 2012 market share
- Total = \$100.5M -



You can find any type of business models in MEMS...

TOP MEMS Ranking

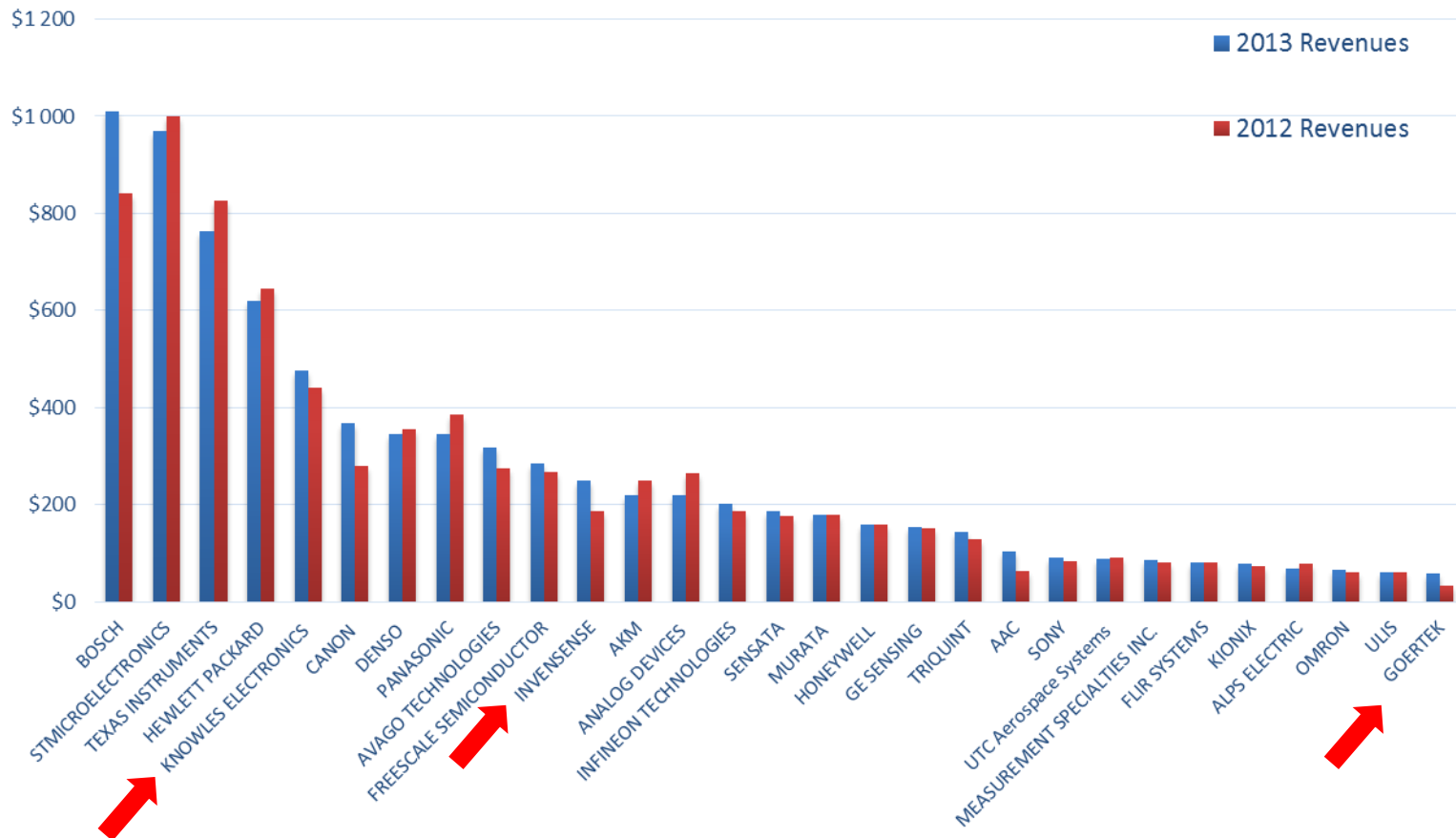
2013 MEMS Ranking
April 2014



You can find any type of business models in MEMS...

TOP MEMS Ranking

2013 MEMS Ranking
April 2014

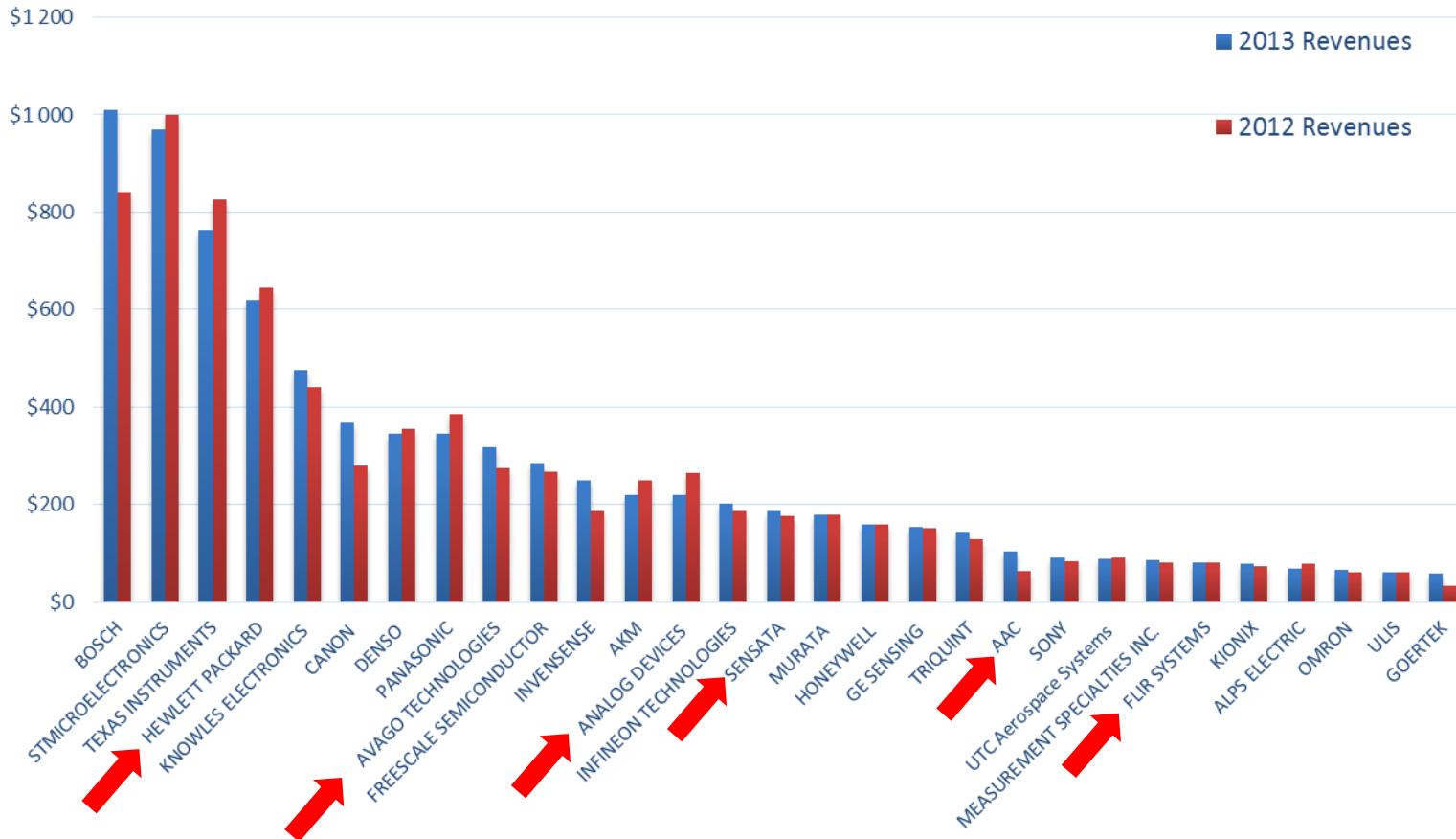


Fabless companies

You can find any type of business models in MEMS...

TOP MEMS Ranking

2013 MEMS Ranking
April 2014

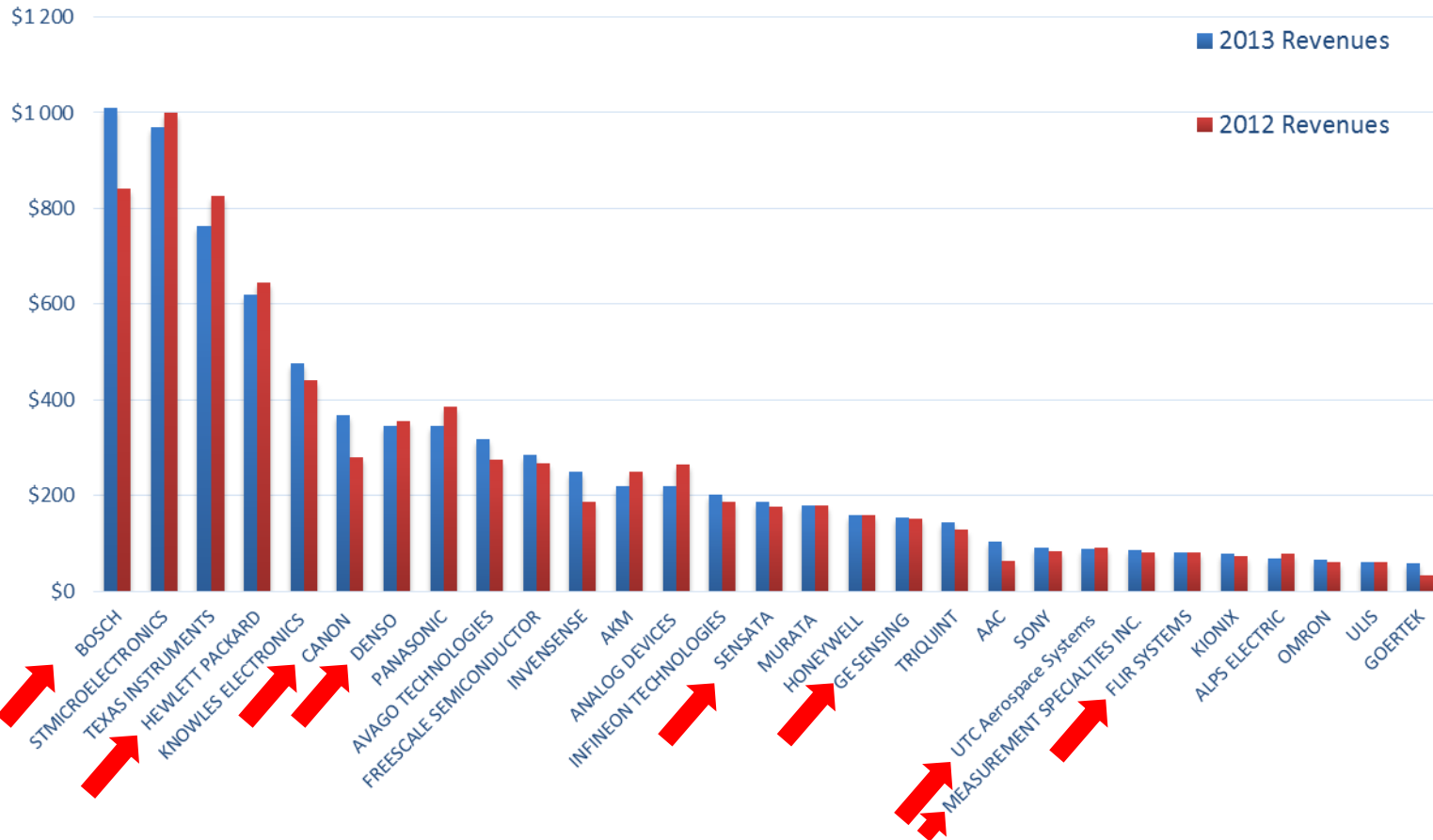


Fabligh companies

You can find any type of business models in MEMS...

TOP MEMS Ranking

2013 MEMS Ranking
April 2014



System makers with fabs

You can be successful with different business models...

- **STMicroelectronics:**

- A business model of IDM, focusing on delivering devices to its main customers (Apple, Samsung...)
- Use its semiconductor infrastructure to start price war and kill the competition

- **InvenSense:**

- A business model of fabless, using external suppliers for the MEMS die, the ASIC and the packaging
- InvenSense has created its own test facility because it is strategic

- **Bosch:**

- A sensor and system manufacturer, addressing both the automotive and the consumer applications
- A main business: delivering sensors to Bosch Automotive system units
- A second (large) business: delivering sensors to automotive system makers, competitor of Bosch
- A very smart move:
 - Creation of Bosch Sensortec to address the consumer applications, with dedicated team
 - Work as fabless, using Bosch as foundry
 - Allocation of wafer from Bosch to Bosch Sensortec, if wafers are available... with a strategy of filling the fab
 - Bosch automotive competitors in sensors are step by step no longer competitive in term of production costs

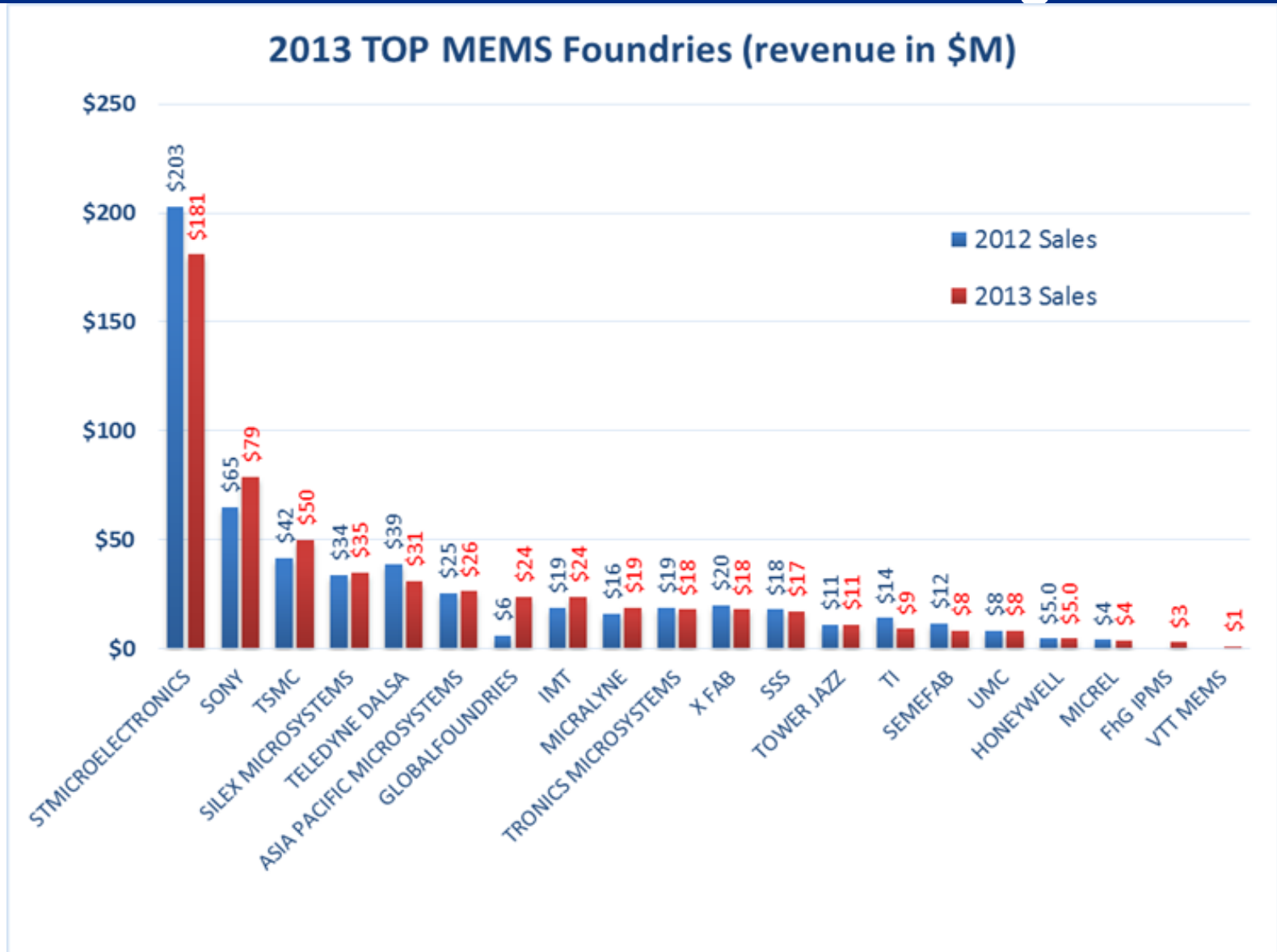
With different approaches...

Technological Choices and progress Expected for 6&9DOF

	STMicroelectronics		InvenSense		Bosch Sensortec	
	<i>Today</i>	<i>Possible evolution</i>	<i>Today</i>	<i>Possible evolution</i>	<i>Today</i>	<i>Possible evolution</i>
MEMS design	<ul style="list-style-type: none"> Reduced sensing area 	<ul style="list-style-type: none"> 6-axis on single die soon (already in LSM330?) Au-Au sealing frame soon Still reduced sensing area 	<ul style="list-style-type: none"> 6-axis on single die Reduced sensing area 	<ul style="list-style-type: none"> Still reduced sensing area 	<ul style="list-style-type: none"> - 	<ul style="list-style-type: none"> 6-axis on single die not immediately Reduced sensing area
MEMS front end	<ul style="list-style-type: none"> 8-inch internal 	<ul style="list-style-type: none"> Project to go to 12-inch internal (not launched yet) 	<ul style="list-style-type: none"> TSMC, 8-inch 	<ul style="list-style-type: none"> 2nd source (GF), easier transfer to new fabs if needed 	<ul style="list-style-type: none"> Bosch Automotive Fab, 8-inch 	<ul style="list-style-type: none"> Need to invest or need to have external partners
ASIC	<ul style="list-style-type: none"> 180 nm node Several dies 	<ul style="list-style-type: none"> 130 nm node in development? Single die ASIC as a cap 	<ul style="list-style-type: none"> 180 nm node Single die 	<ul style="list-style-type: none"> Partners could transfer to 130 nm ASIC as a cap 	<ul style="list-style-type: none"> 180 nm node Several dies 	<ul style="list-style-type: none"> Need new partner to go to 130 nm? Internal low power ASIC design Single die ASIC as a cap
Magnetometer	<ul style="list-style-type: none"> Strong partnership with Honeywell AMR, 2 dies 	<ul style="list-style-type: none"> New technology for better integration? (Freescale) 	<ul style="list-style-type: none"> Partnership with AKM (low cost but lower perf than STMicroelectronics / Bosch) 	<ul style="list-style-type: none"> Working with another Hall sensor supplier (Melexis probably → smaller cost and similar performance as AKM expected) 	<ul style="list-style-type: none"> Internal FlipCore technology 	<ul style="list-style-type: none"> Already very optimized
Assembly	<ul style="list-style-type: none"> Wire bonding 	<ul style="list-style-type: none"> TSV soon 	<ul style="list-style-type: none"> Wafer level / Nasiri process 	<ul style="list-style-type: none"> NA 	<ul style="list-style-type: none"> Wire bonding 	<ul style="list-style-type: none"> TSV not immediately
Test	<ul style="list-style-type: none"> Internal (partnership with SPEA) 	<ul style="list-style-type: none"> Optimization 	<ul style="list-style-type: none"> Internal 	<ul style="list-style-type: none"> Off the shelf tools? 	<ul style="list-style-type: none"> Now using SPEA tools 	<ul style="list-style-type: none"> Optimization
Software	<ul style="list-style-type: none"> Internal + partnership with PNI 	<ul style="list-style-type: none"> More applications not expected (semiconductor view) 	<ul style="list-style-type: none"> Internal mostly 	<ul style="list-style-type: none"> Could develop more applications (sensor view) 	<ul style="list-style-type: none"> Internal 	<ul style="list-style-type: none"> More applications not expected

Foundry business is growing step by step...

TOP MEMS Foundries Ranking

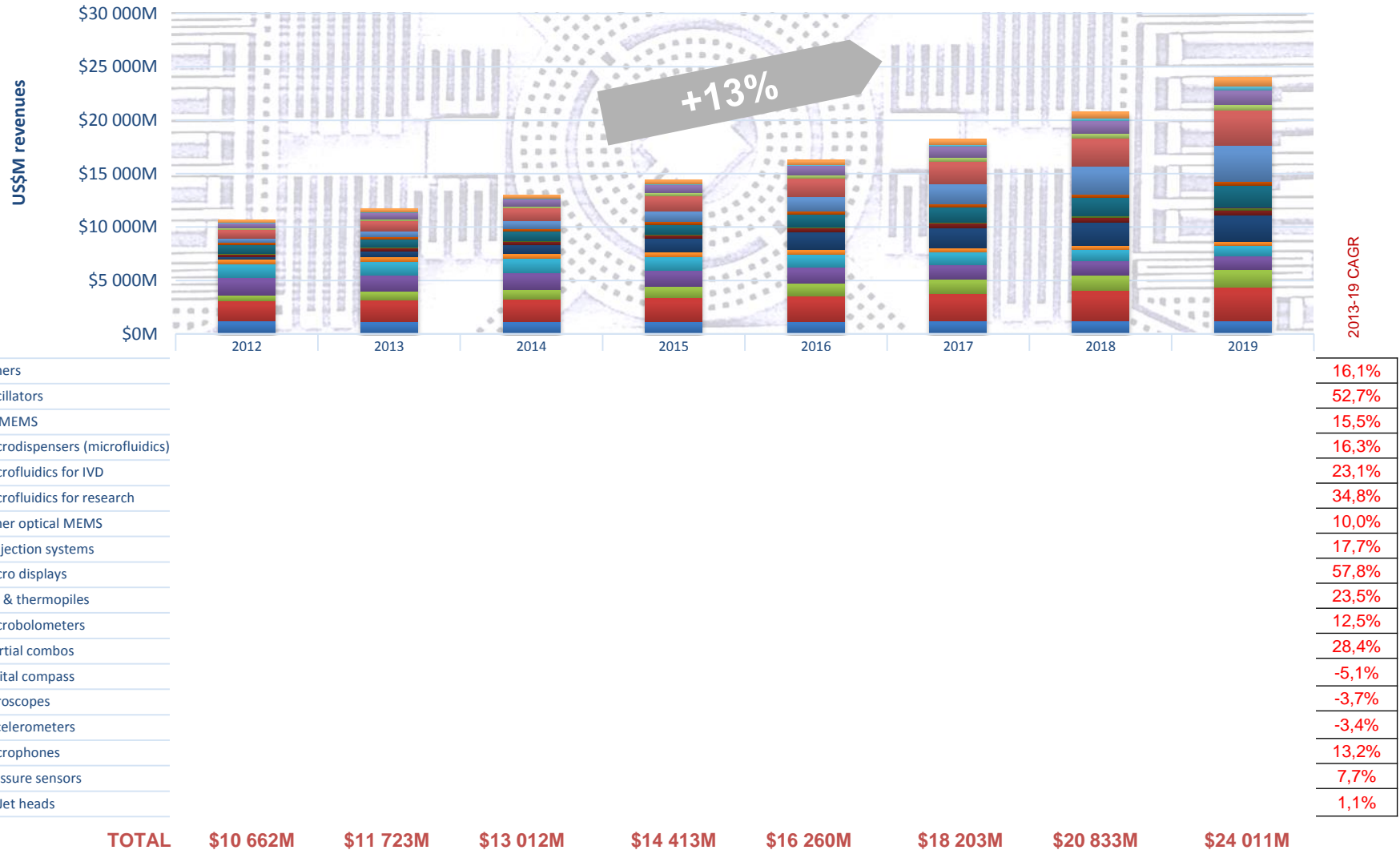


SO WHAT WILL HAPPEN?

Business is growing everywhere... 2012-2019 MEMS Markets (US\$M)

MEMS market forecast 2012-2019 value (in M\$)

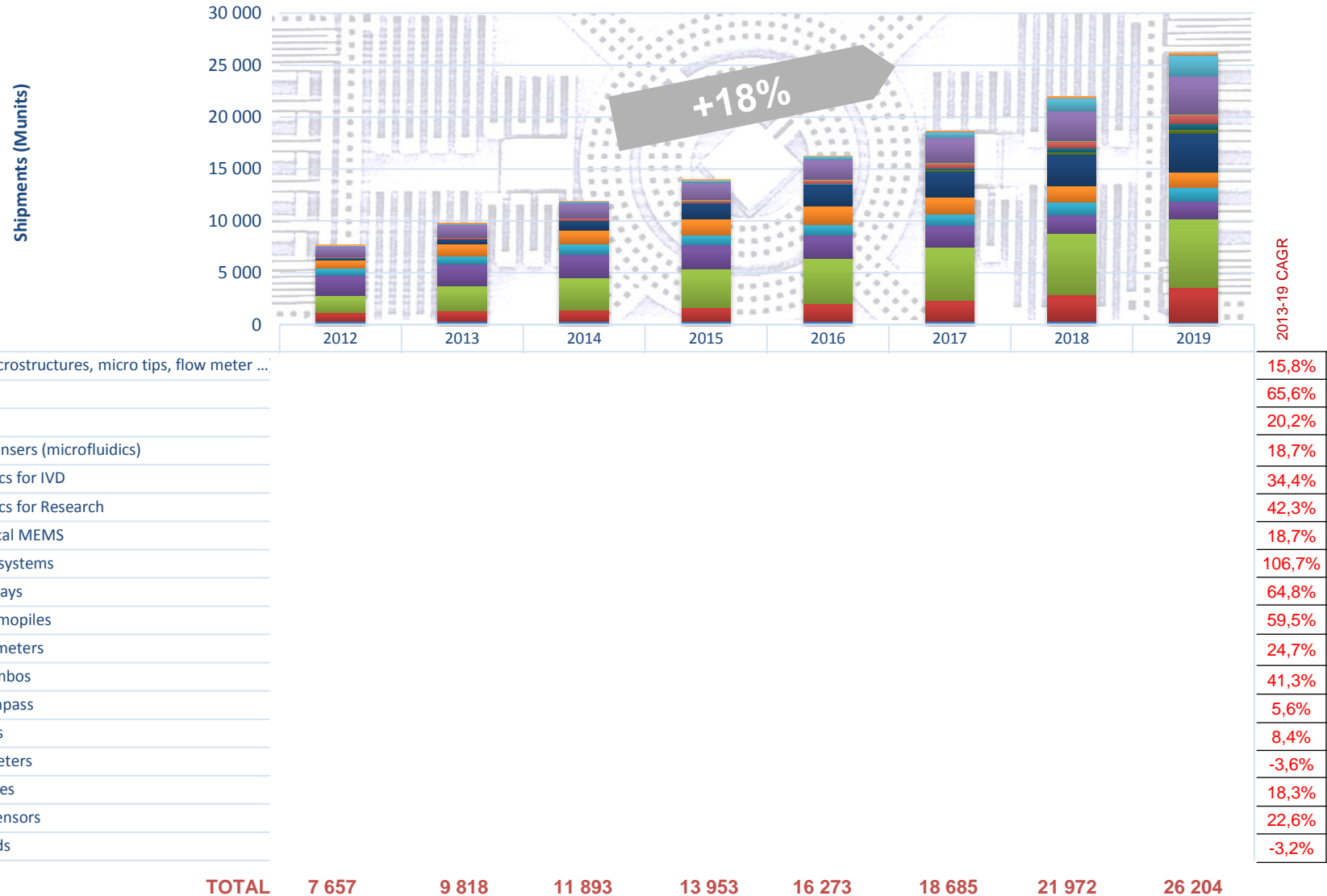
April 2014



Business is growing everywhere...

2012-2019 MEMS Markets (Munits)

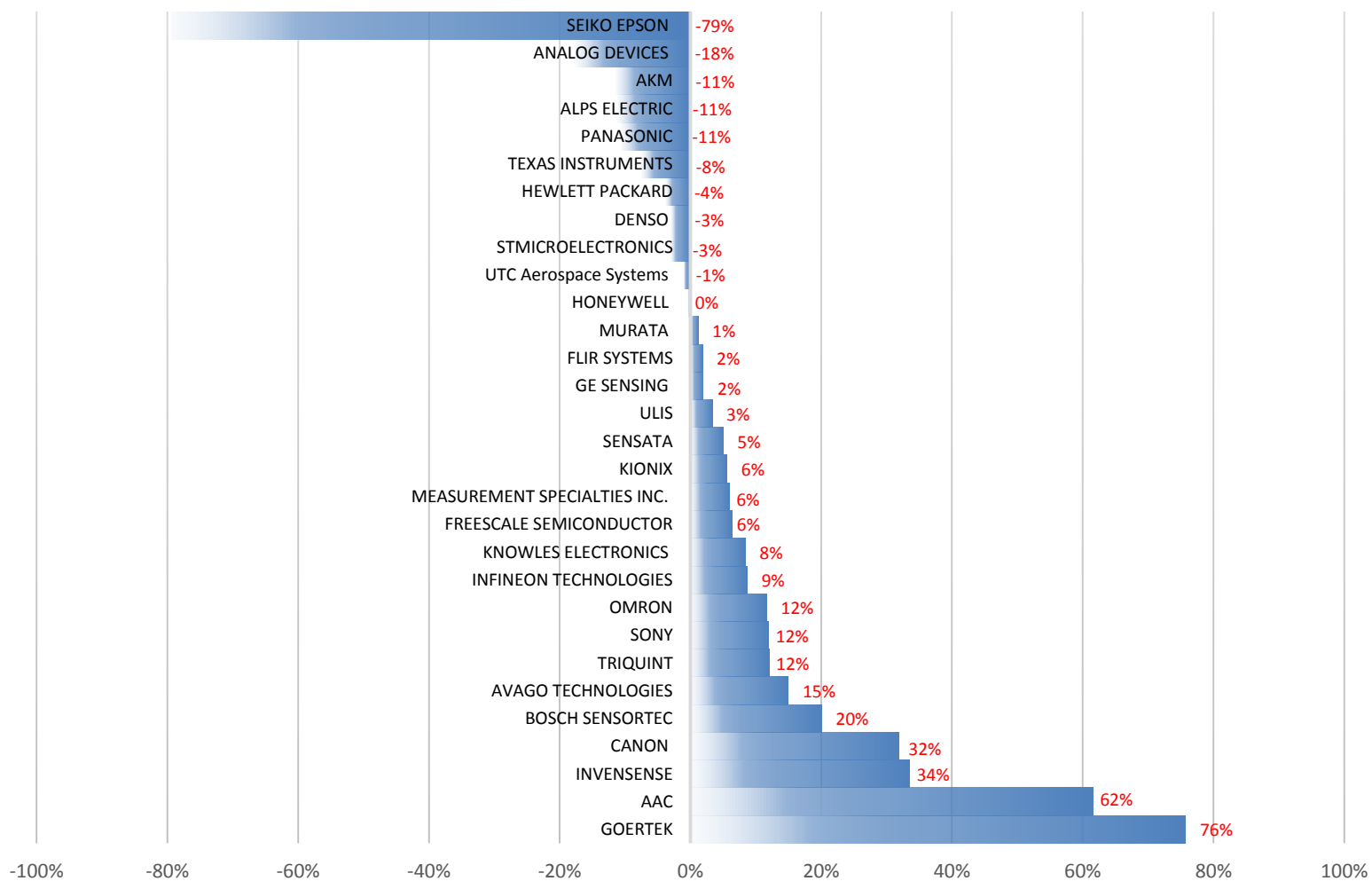
MEMS market forecast shipments (in Munits) April 2014



Business is growing everywhere...

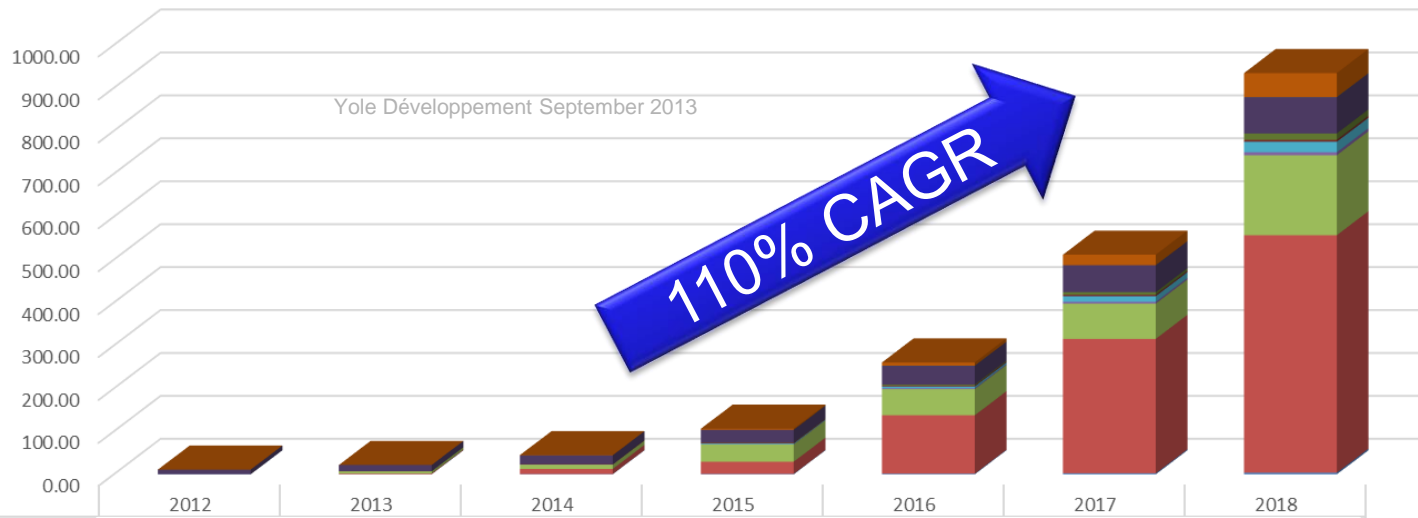
Growth of Mems companies 2012-2013

RELATIVE DIFFERENCE IN MEMS SALES 2013/2012



New devices are coming... Emerging MEMS Market in Units

Emerging MEMS Market 2012-2018 in Million Units



- Touch Screen
- Switches
- Silicon microfluidics
- Scanning mirrors
- RF ID
- Radiation sensors
- Micro-fuel cells
- Micro speakers
- Energy harvesting
- Chemical sensors
- Autofocus
- AOC MEMS

Total

10.97

21.81

44.83

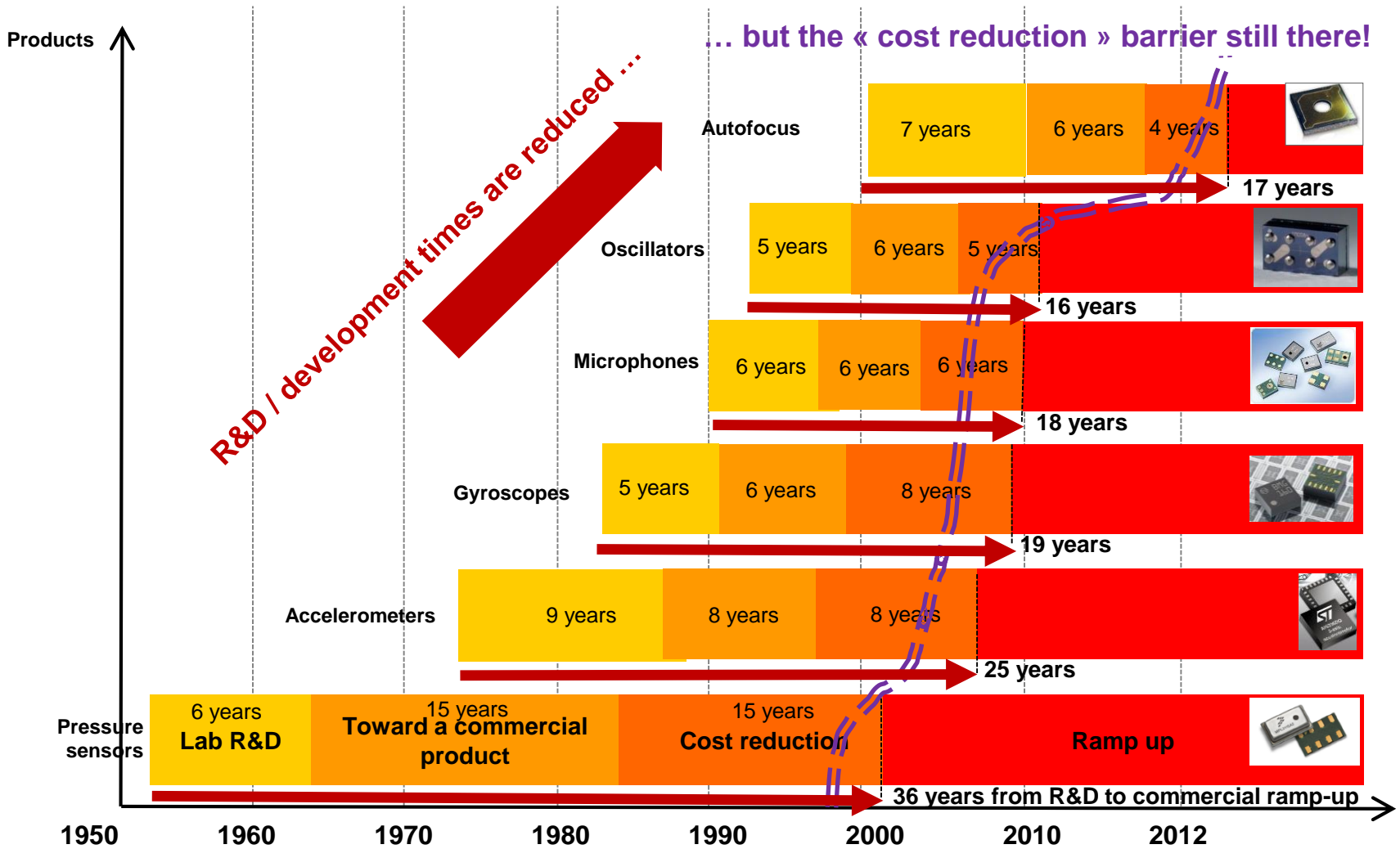
106.35

260.63

511.65

934.62

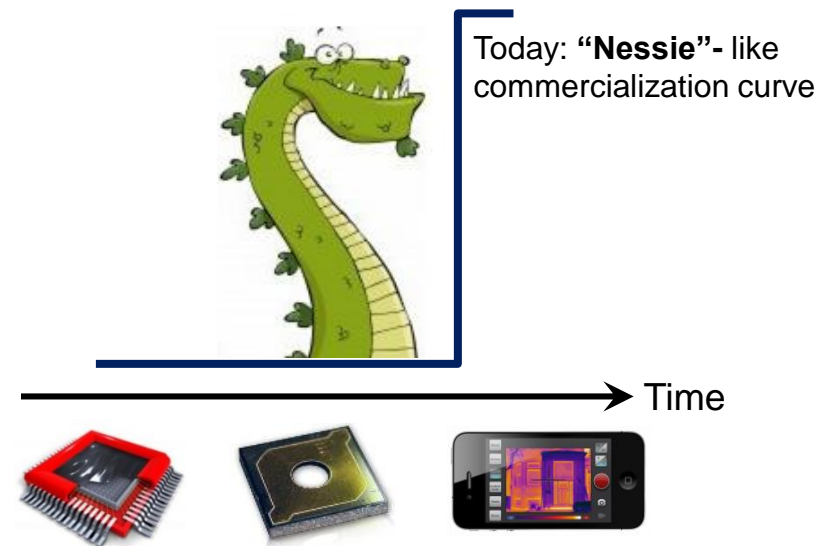
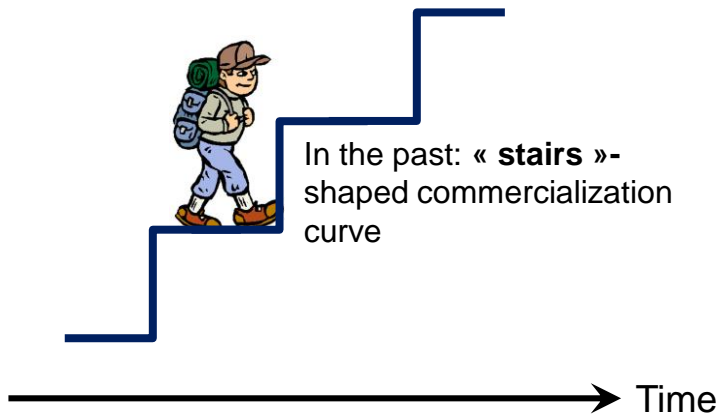
But commercial ramp-up is still a big issue...



But commercial ramp-up is still a big issue...

The « Nessie curve » law

- We note the difficulty to reach the commercialization phase: we have not seen new types of MEMS entering production for years!
 - Delayed production for Auto-Focus, Micro speakers...
- A major change in the industry linked to the importance of mobile applications can explain that:



So...

- **MEMS industry is big and growing. Strong market pull observed for sensors and actuators in cell phones, automotive, medical, industrial...**
- **Not limited to few devices. A new wave of MEMS is coming!**
- **Component and die size are still being optimized while combo approaches become mainstream. And several disruptive technology approaches are now in development to keep going in term of size and price decrease**
- **But the MEMS industry has not solved a critical issue: how to increase the chance of new devices to enter the market?**
 - **RF switch, autofocus... are example of devices still under development after more than 10 years of effort**
 - **How to help companies to go faster and safer on the market with new devices?**

Thank You for your Attention!

Q&A

Please give me or to Mr. Katano your business card in order to get an electronic copy of my presentation.

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