

What it Takes to Develop New MEMS Products: Reality Check

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AMFITZGERALD
& ASSOCIATES

Overview

- **About AMFitzgerald**
- **What are MEMS?**
- **Industry supply chain**
- **Captive or fabless?**
- **Challenges**
- **Summary**

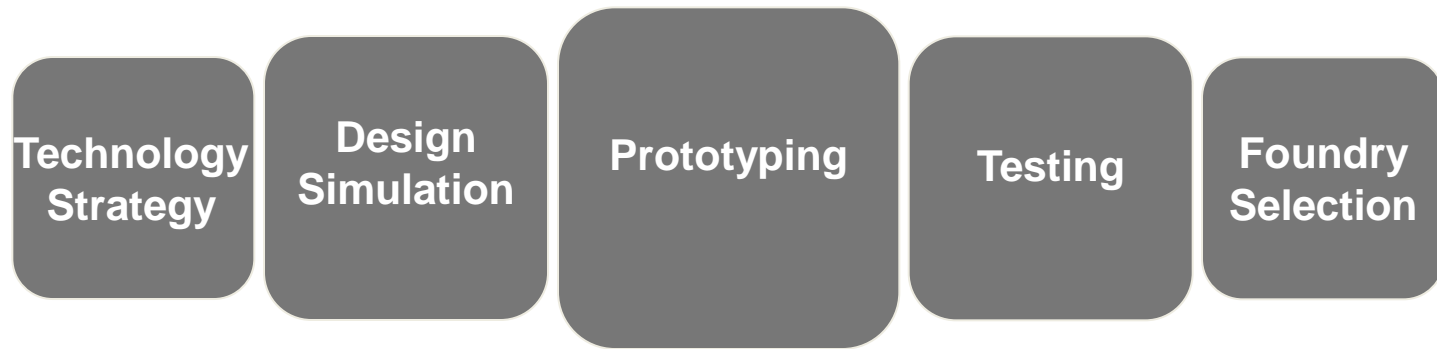
Mission

MEMS Product Development



.....
We turn your ideas into silicon.

Fully integrated services: concept to foundry



- Complete design and project management
- Feasibility and cost analysis
- Design optimization using simulation
- Process development on 100 mm or 150 mm wafers
 - Prototype fabrication with own staff engineers at UC Berkeley's Microlab
- Test system development
- Packaging, system integration
- Technology transfer to foundries for production

MEMS design and prototyping expertise

Technologies we have developed:

- **Piezoresistive sensors**
- **Piezoelectric (AlN and ZnO) sensors**
- **Capacitive sensors**
- **Electrostatic actuators**
- **Micro-cantilevers**
- **Microfluidics**
- **Mold masters**
- **Gratings and lenses (x-ray, optical, acoustic)**
- **Solar cells**

Over 60 clients served

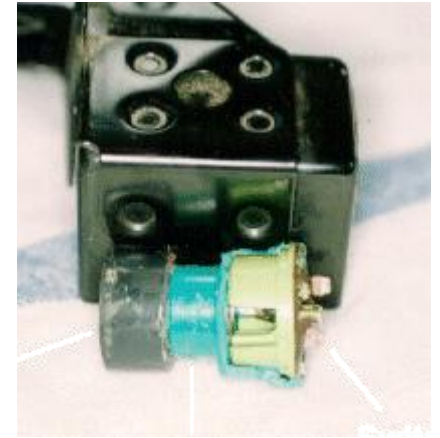
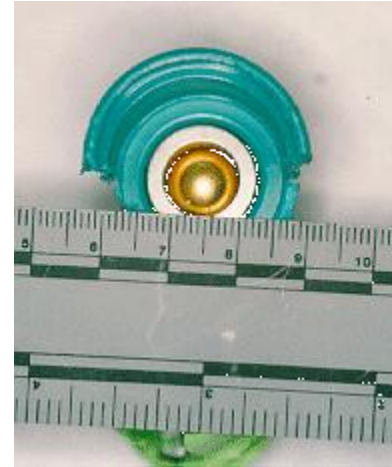
Application areas:

- **Consumer electronics**
- **Medical implant**
- **Medical diagnostics**
- **Infrared imaging**
- **Industrial safety**
- **System health monitoring**
- **Ultrasound imaging**
- **Optical telecom**
- **Solid state lasers**
- **Chip cooling**
- **Cell culture**
- **Drug discovery**
- **Gas flow metering**
- **Advanced packaging**
- **Solar**

What are MEMS?

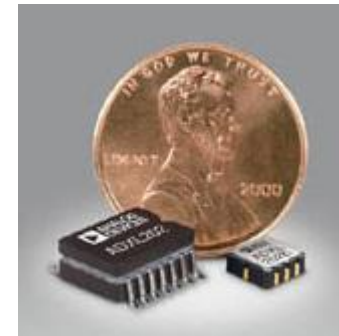
- **Micro Electro Mechanical Systems**
 - Not a platform *device* technology
 - But a powerful manufacturing technology for miniaturization
- **Semiconductor process heritage**

Airbag sensors (1980)



Source: Ed Phillips

Airbag sensors (2005)



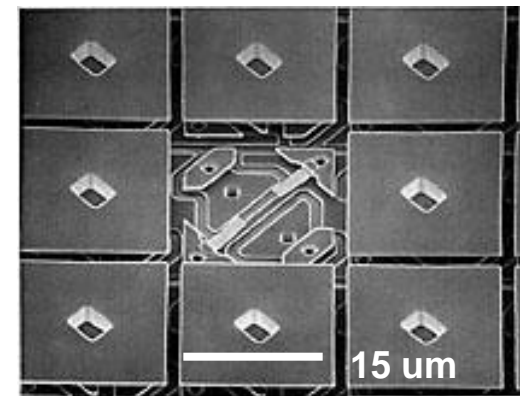
Challenge of MEMS development

- **High technical complexity**
 - Coupled physics
 - Moving parts
 - Environmental exposure
 - Test and packaging challenges

Microvision Pico-P



TI DLP pixels

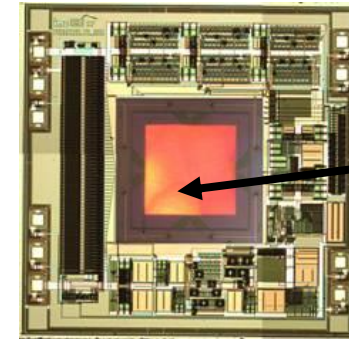


Why MEMS are exciting for so many applications

- **Smaller, better, cheaper**
 - But not always all three
- **Ease of electronics integration enables sophisticated capabilities in small form factor:**
 - Multiple sensors
 - Signal processing and analysis
 - Telemetry capability
 - Low power

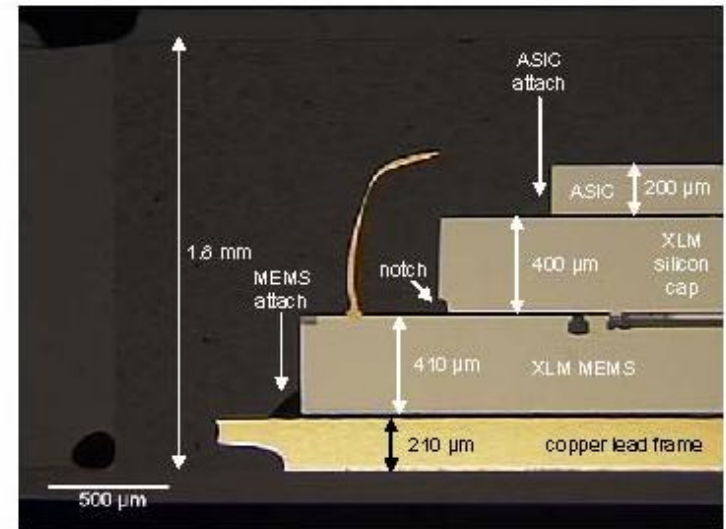
**Stacked
MEMS and
ASIC chips,
wirebonded**

Integrated Pressure Sensor



MEMS
sensor

Source: IMD



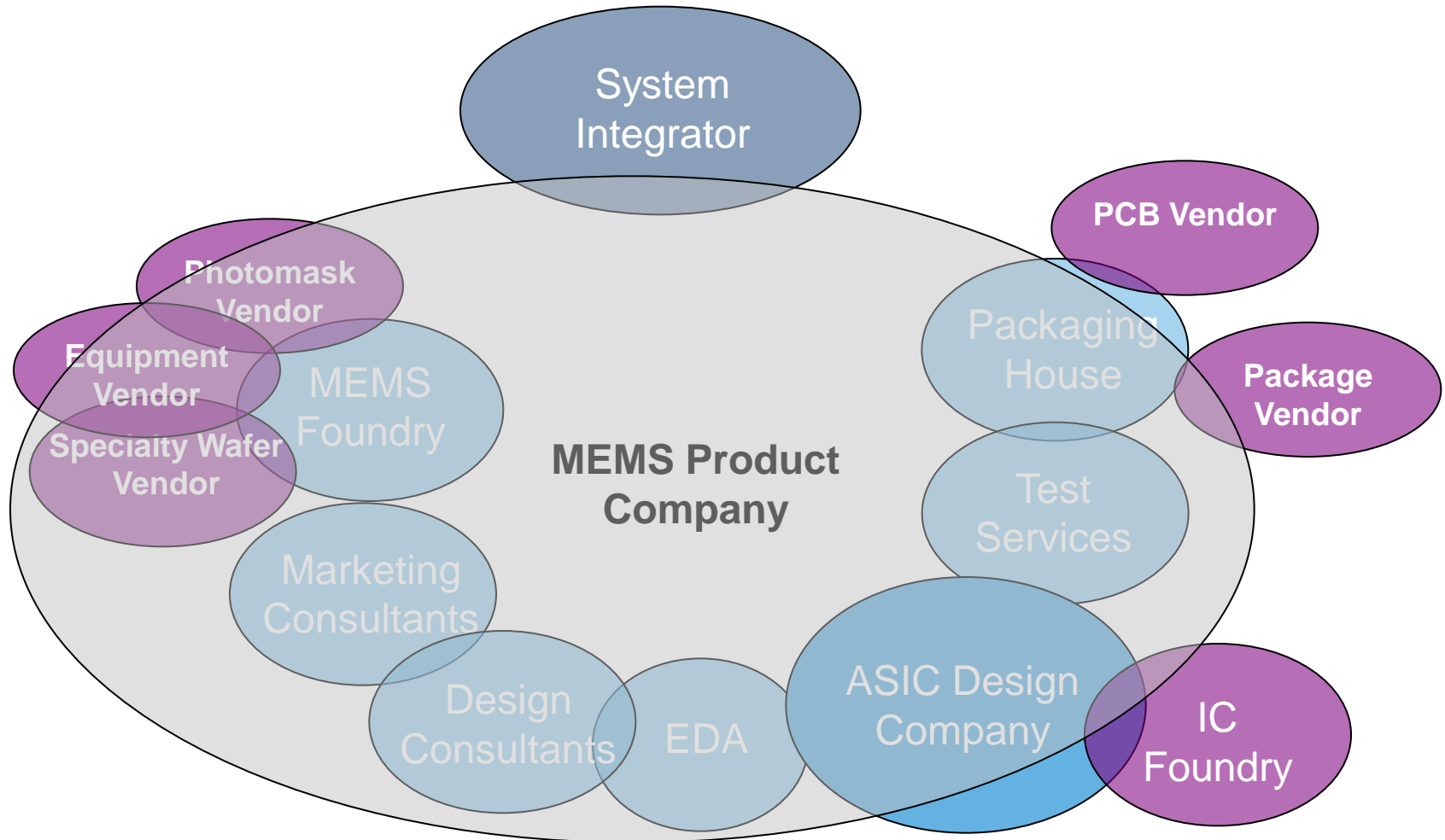
Source: Chipworks/Kionix

MEMS are not ICs

- **Parallels to IC are misleading**
 - **IC design to product < 18 months**
 - **Enabled by well established processes, design rules, sophisticated simulation software**
 - **Competitive wafer costs**
- **MEMS design to product timeline > 5 years typical**
 - **Lack of sophisticated simulation tools and process standards**
 - **Solutions evolving slowly**
 - **Wafer costs vary widely**

MEMS Supplier Ecosystem: circa 1995

- Only large, vertical companies can do this (and did)

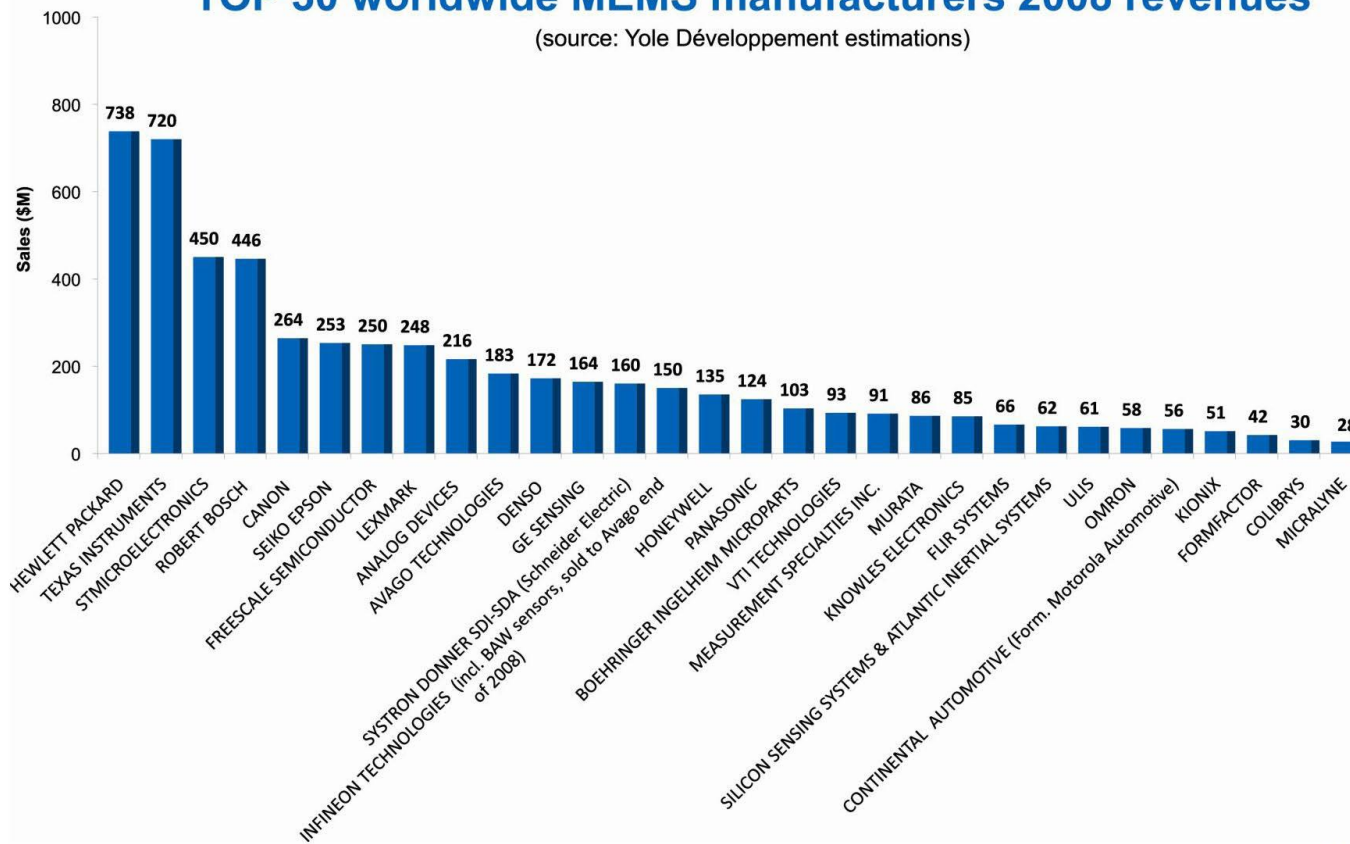


Large companies dominate industry today

TOP 30 MEMS Manufacturers 2008 sales

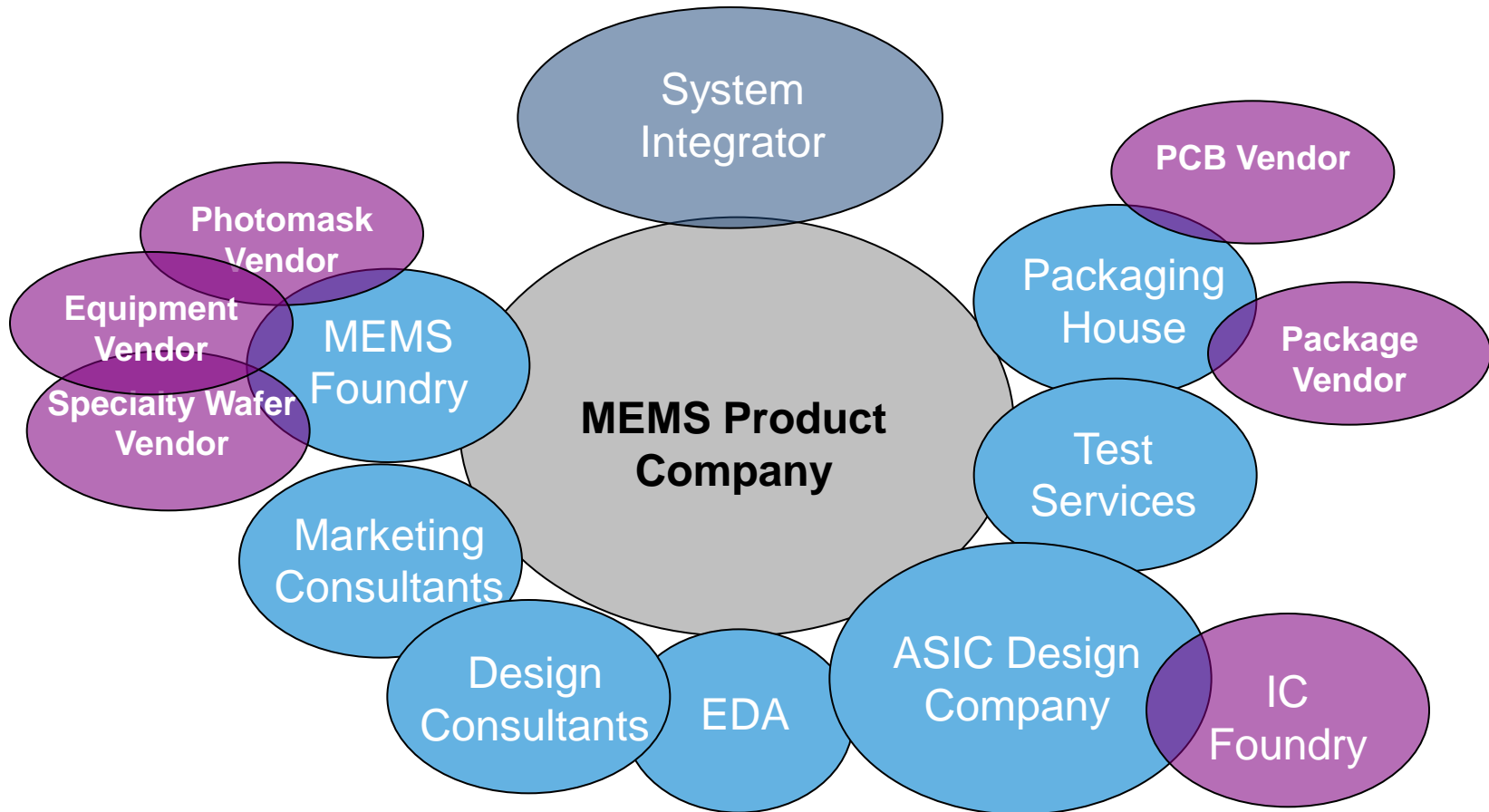
TOP 30 worldwide MEMS manufacturers 2008 revenues

(source: Yole Développement estimations)

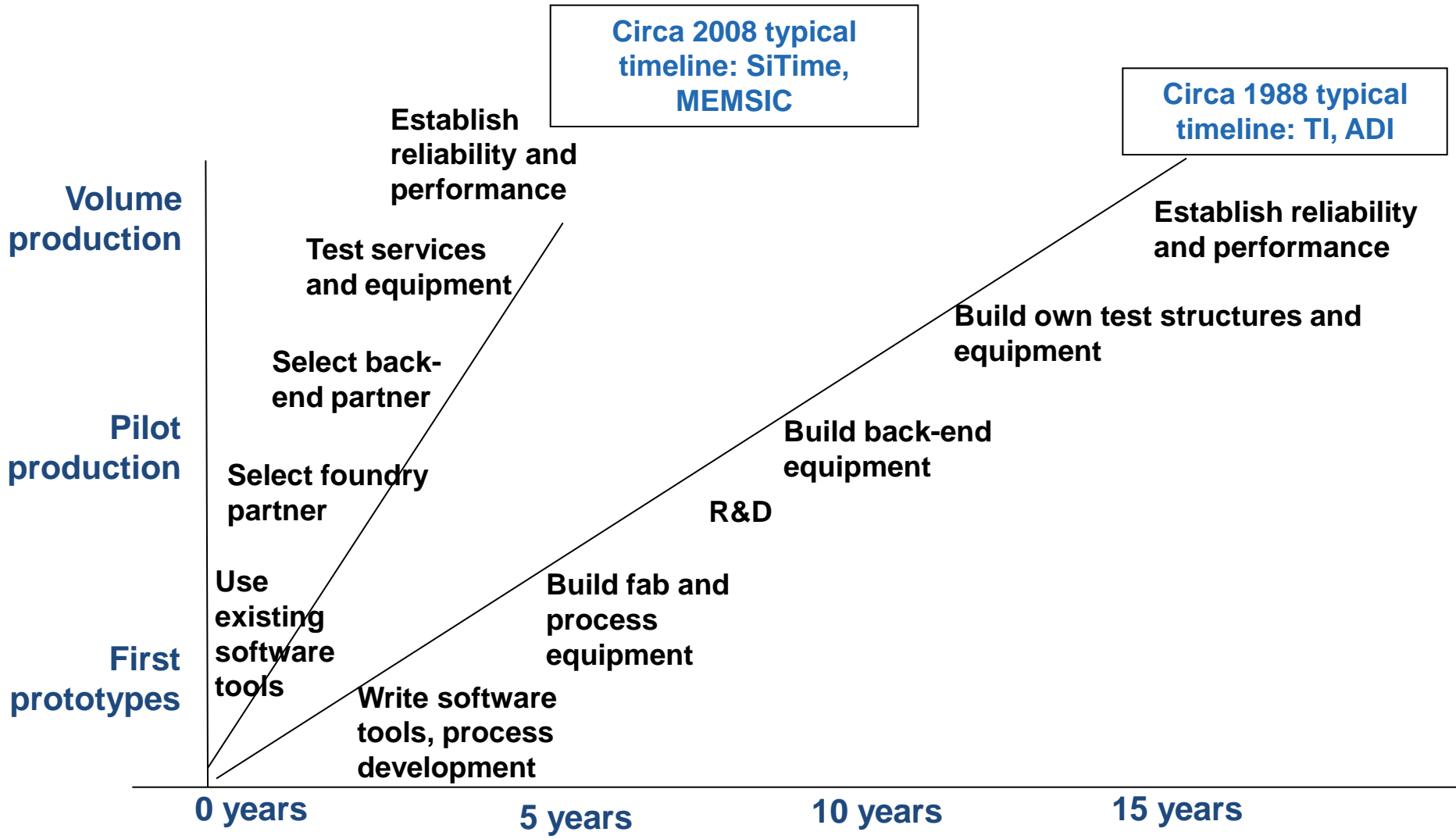


MEMS Supplier Ecosystem: 2010

- **Specialization reduces resource requirements**



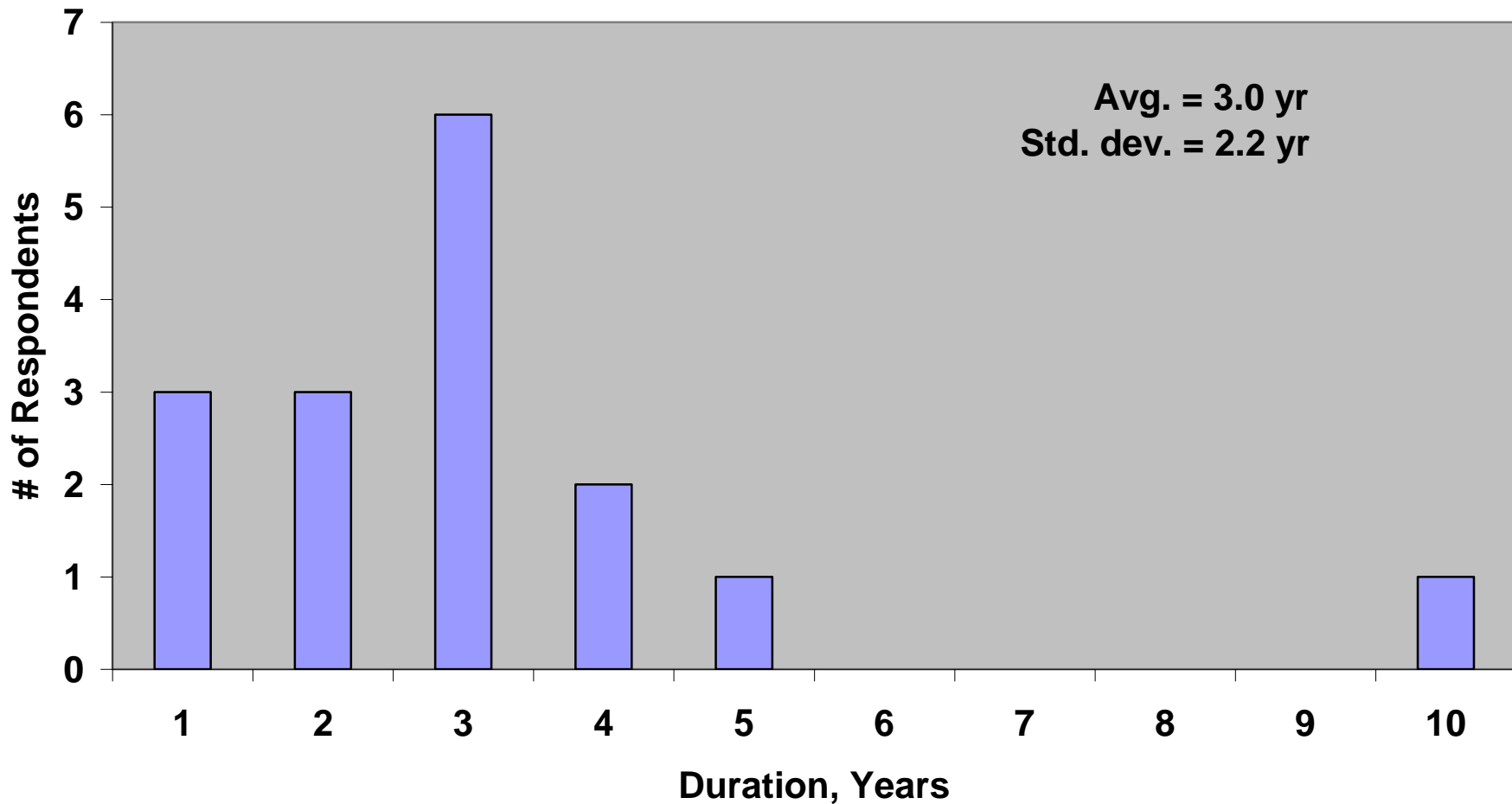
Development timelines have improved significantly



MEMS Development Timelines: Survey

How long does it take to develop new MEMS products (from existing technology)?
(N= 16)

Source: MEMS Industry Group (2009)



Viable business models for new MEMS companies

“Real men have fabs.” – Jerry Sanders, AMD

Today: **“Smart MEMS companies don’t have fabs”**

- **Fabless**
 - Plenty of capacity
- **Hybrid or Fab-Lite**
 - Adds value with specialty processes/equipment that are kept in-house
 - Release processes, calibration, integration
 - Can be an IP control strategy, especially when there is “secret sauce”

Working with foundries

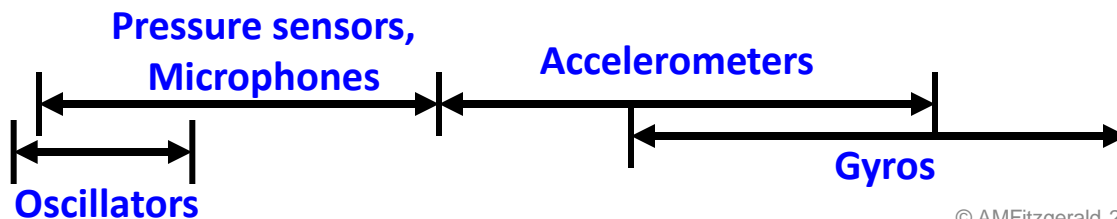
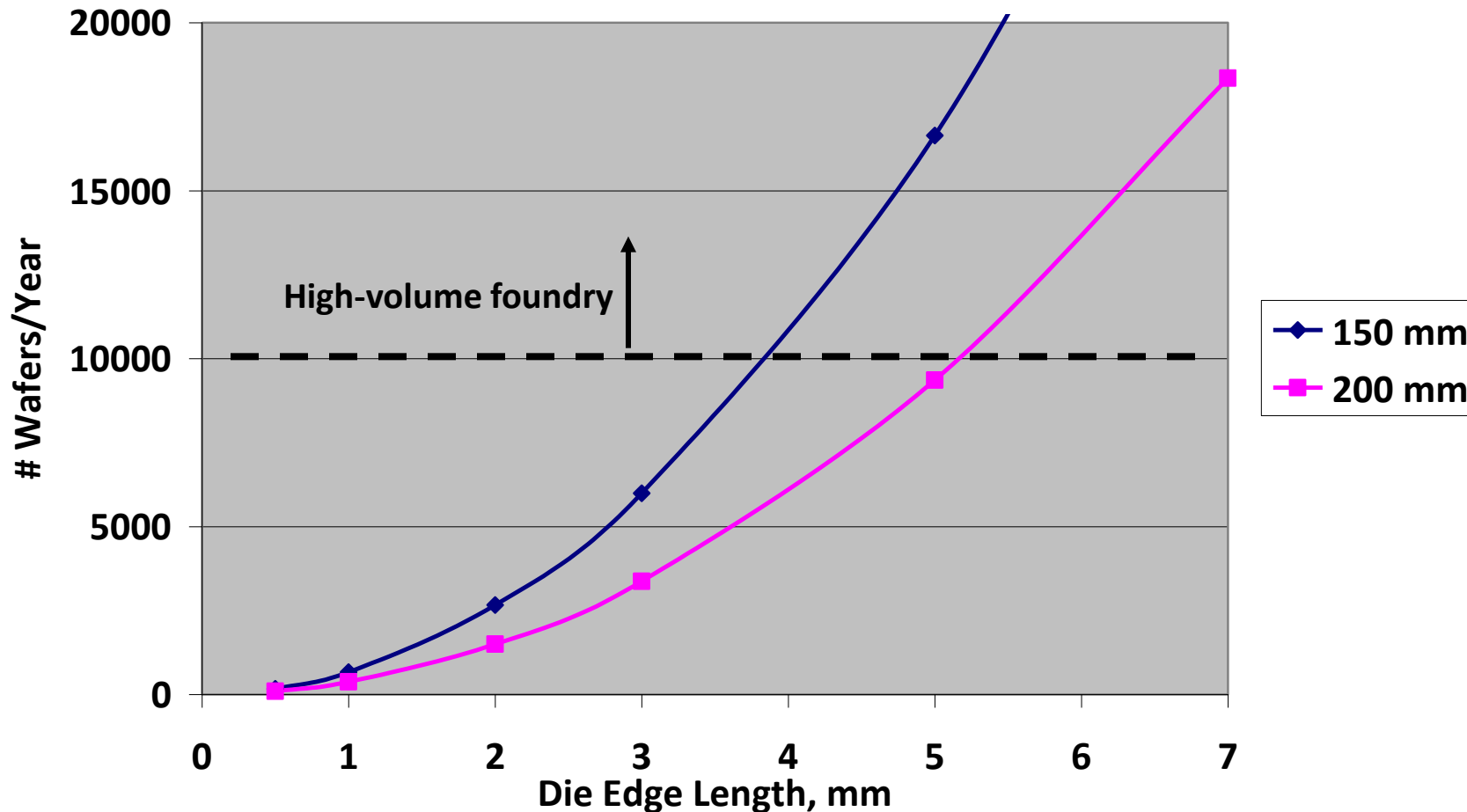
- **Choosing the right foundry partner is essential and should be viewed as a long term relationship**
 - **Partner, not vendor**
 - **Cannot just throw MEMS designs “over the fence”**
 - **Switching foundries = starting over (\$\$\$ and time)**

Foundry selection

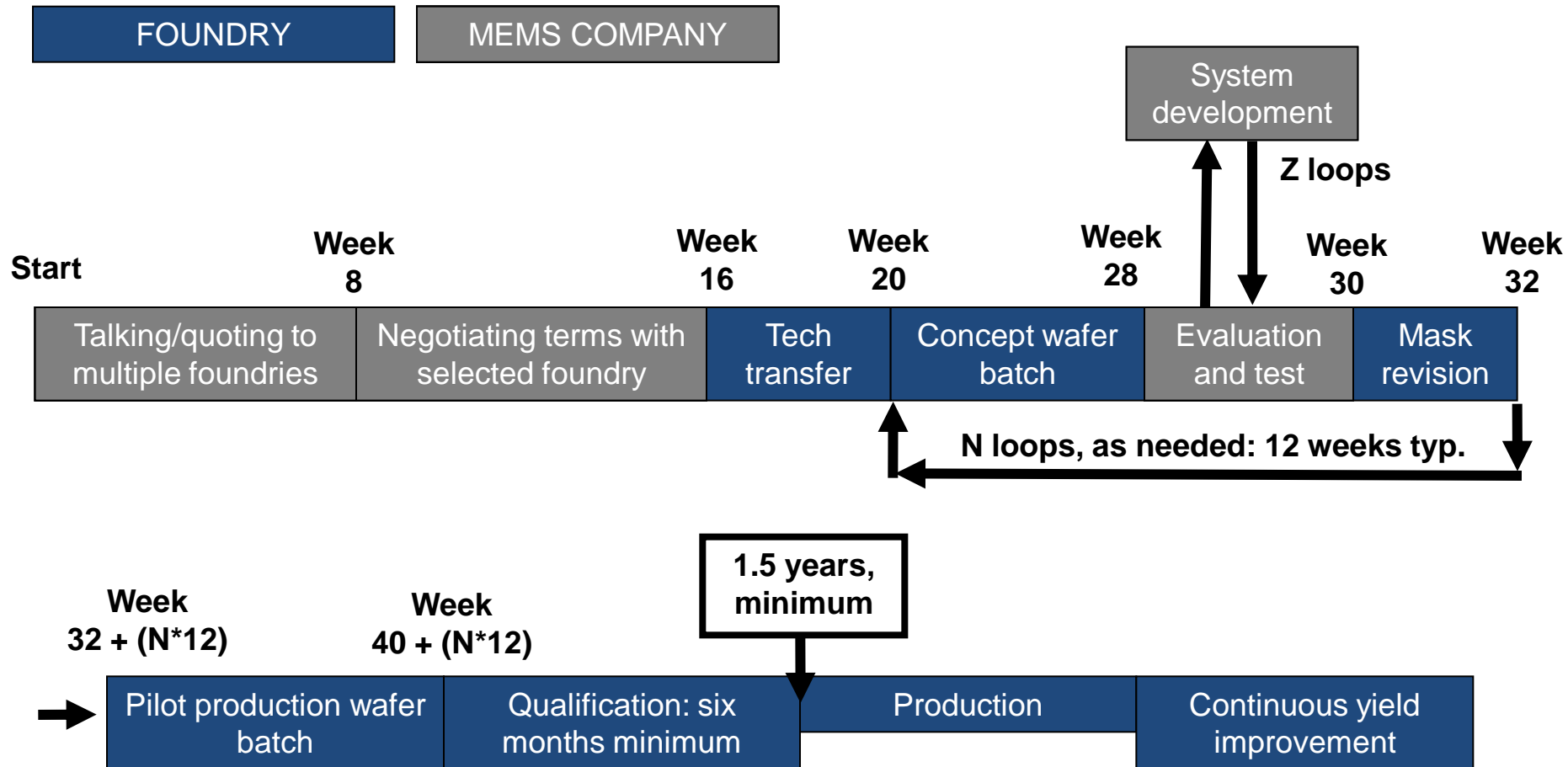
- **Evaluate process capability, experience with your type of product**
- **Make sure you have compatible:**
 - **Business models**
 - **Timelines**
 - **Expectations**
 - **Quality standards**
 - **Product volumes – ideally, don't want to be smallest or largest customer**

Not all MEMS will need 200mm wafers

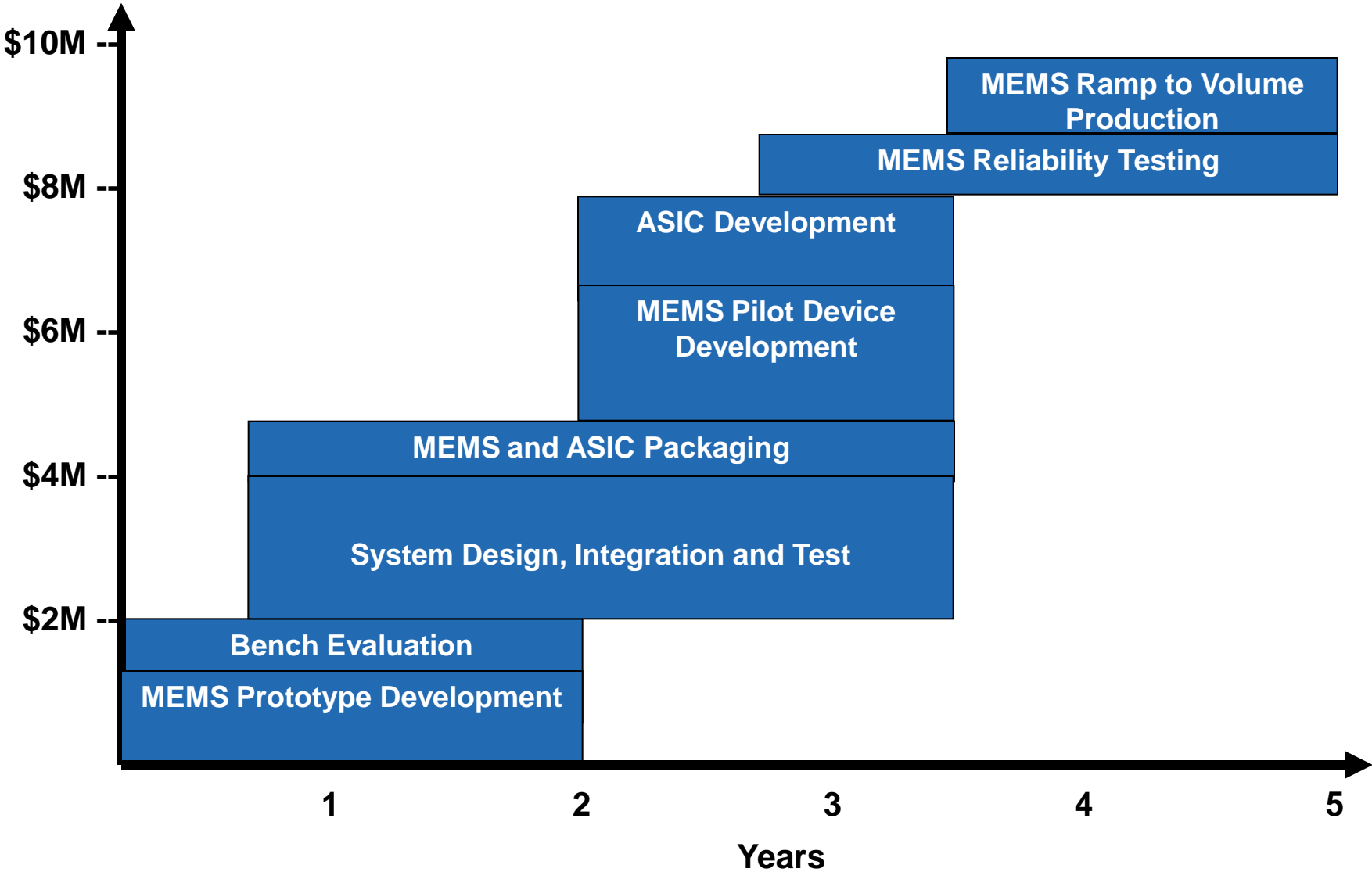
Number of Wafers Needed to Produce 10M Units (85% yield)



Typical timeline: Always longer than you expect



Cost of New Device (Fabless) Development: Minimums



Development challenges: Process know-how

- **Much of MEMS process design is still art**
 - **Few formal standards**
 - **Diverse tool set – process experience is situational**
 - **Foundry-specific design rules NOT available for existing simulation packages**
 - **No ability for end-to-end simulation prior to fab start**
 - **Good MEMS design requires having good process engineers**

Development challenges: Human resources

- **MEMS companies need skilled and experienced engineers**
 - **In the US, these skills learned in graduate school programs, at PhD level**
 - **Very few PhD grads per year, and many need visas**
- **Even fabless MEMS product companies should have experienced process engineers on staff**

MEMS patent landscape

- **USPTO grants MEMS patents very liberally (my opinion)**
 - **Many overlapping claims between patents**
 - **Need for cross-licensing between competitors, in order to achieve “freedom to operate”**
 - **Fights and deals:**
 - **Microfluidics: Caliper vs. ACLARA (lost)**
 - **Microphones: Knowles vs. Akustica (deal)**
 - **Microphones: ADI vs. Knowles (TBD)**
 - **Oscillators next?**

MEMS IP value is transient

- **Creative end-run around possible**
- **As more competitors enter market, profit margins for entire sector regress towards mean, IP value deflates**
- **Fabrication process IP protection has pros and cons**
 - **Easily defended, but:**
 - **Shackles you to a process that may prove inefficient or obsolete over time**
- **Deals, licenses, etc. should acknowledge time constant of the IP's value**

Conclusions

- **It's a tough business, but improving**
- **Be realistic about funding and R&D timelines**
- **Leverage foundries, standard tools, processes, and methods to the extent possible**
- **Consider buying/licensing existing MEMS technology before attempting to build your own**
- **Customers want system functionality, not just chips**



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