What it Takes to Develop New MEMS Products: Reality Check

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AMFITZGERALD
& ASSOCIATES

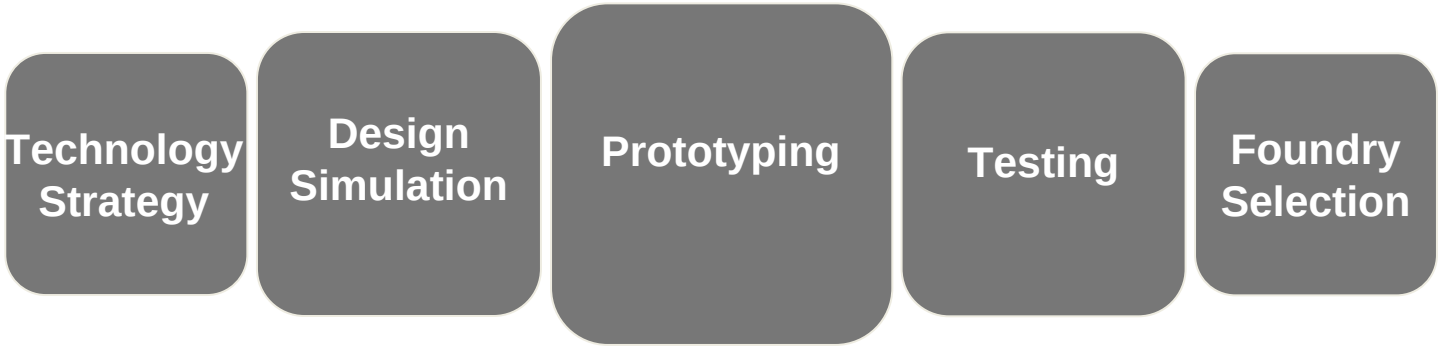
Overview

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

Mission

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

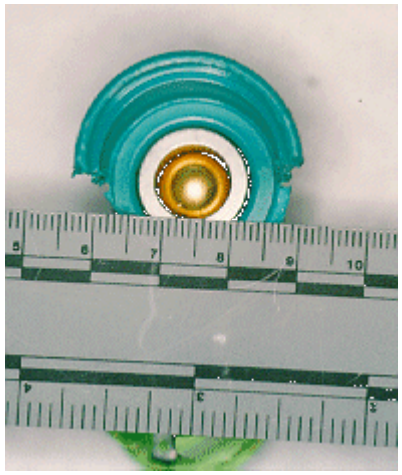
Application areas:

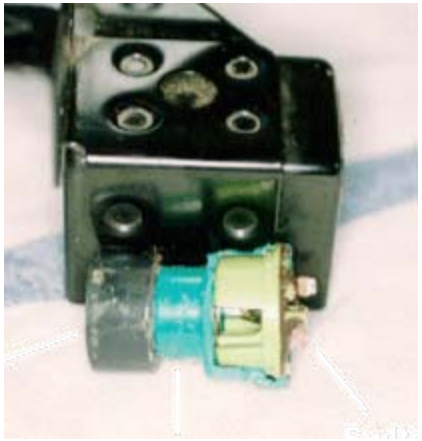
- **Consumer electronics**
- **Medical implant**
- **Medical diagnostics**
- **Infrared imaging**
- **Industrial safety**
- **System health monitoring**
- **Ultrasound imaging**
- **Optical telecom**
- **Solid state lasers**
- **Chip cooling**
- **Cell culture**
- **Drug discovery**
- **Gas flow metering**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

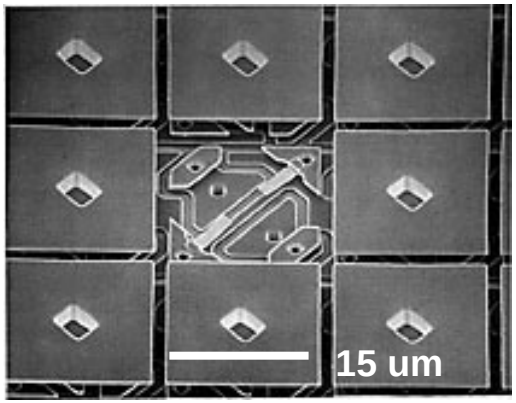
Airbag sensors (2005)

Challenge of MEMS development

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

Microvision Pico-P

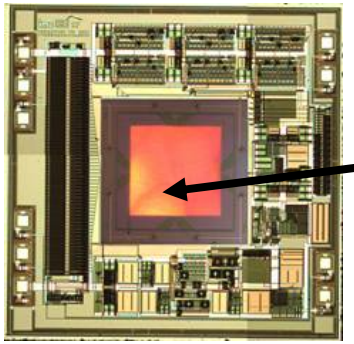
TI DLP pixels



Why MEMS are exciting for so many applications

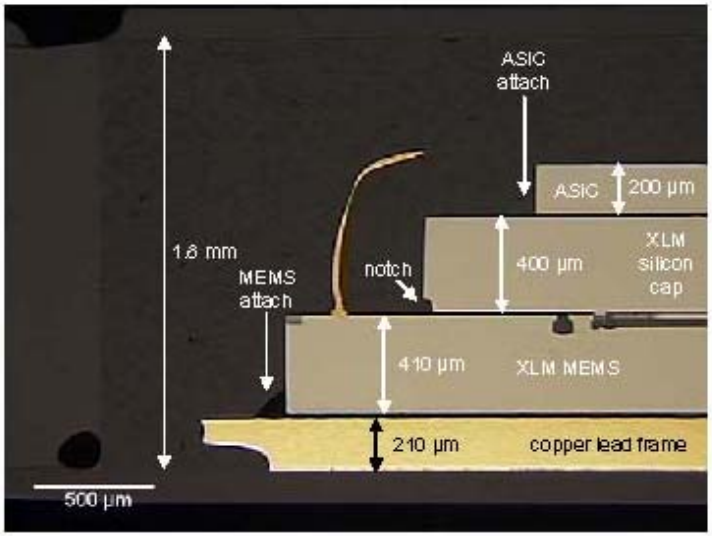
- **Smaller, better, cheaper**
  - **But not always all three**
- **Ease of electronics integration enables sophisticated capabilities in small form factor:**
  - **Multiple sensors**
  - **Signal processing and analysis**
  - **Telemetry capability**
  - **Low power**

Integrated Pressure Sensor



Source: IMD

Stacked MEMS and ASIC chips, wirebonded



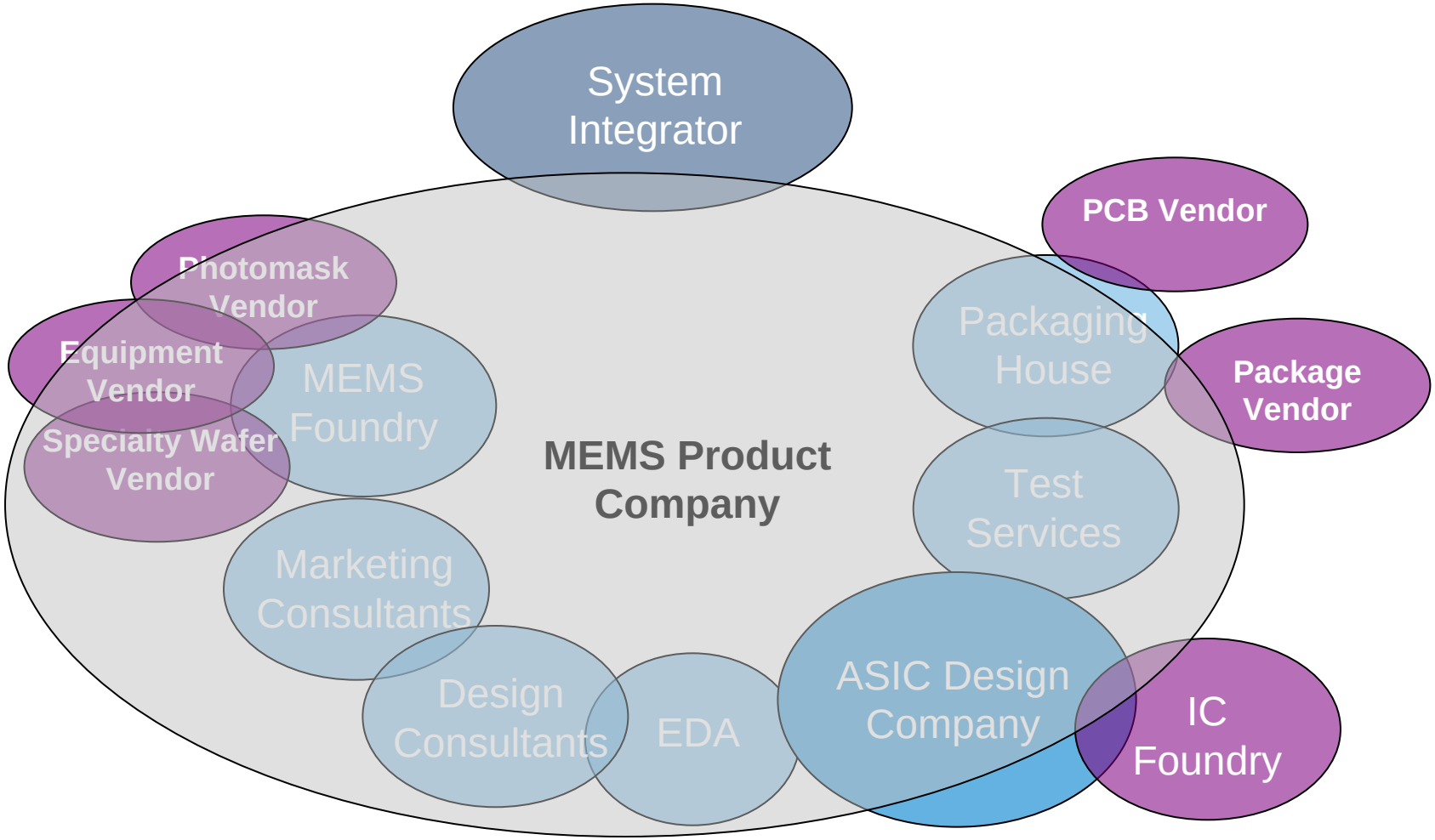
Source: Chipworks/Kionix

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)**



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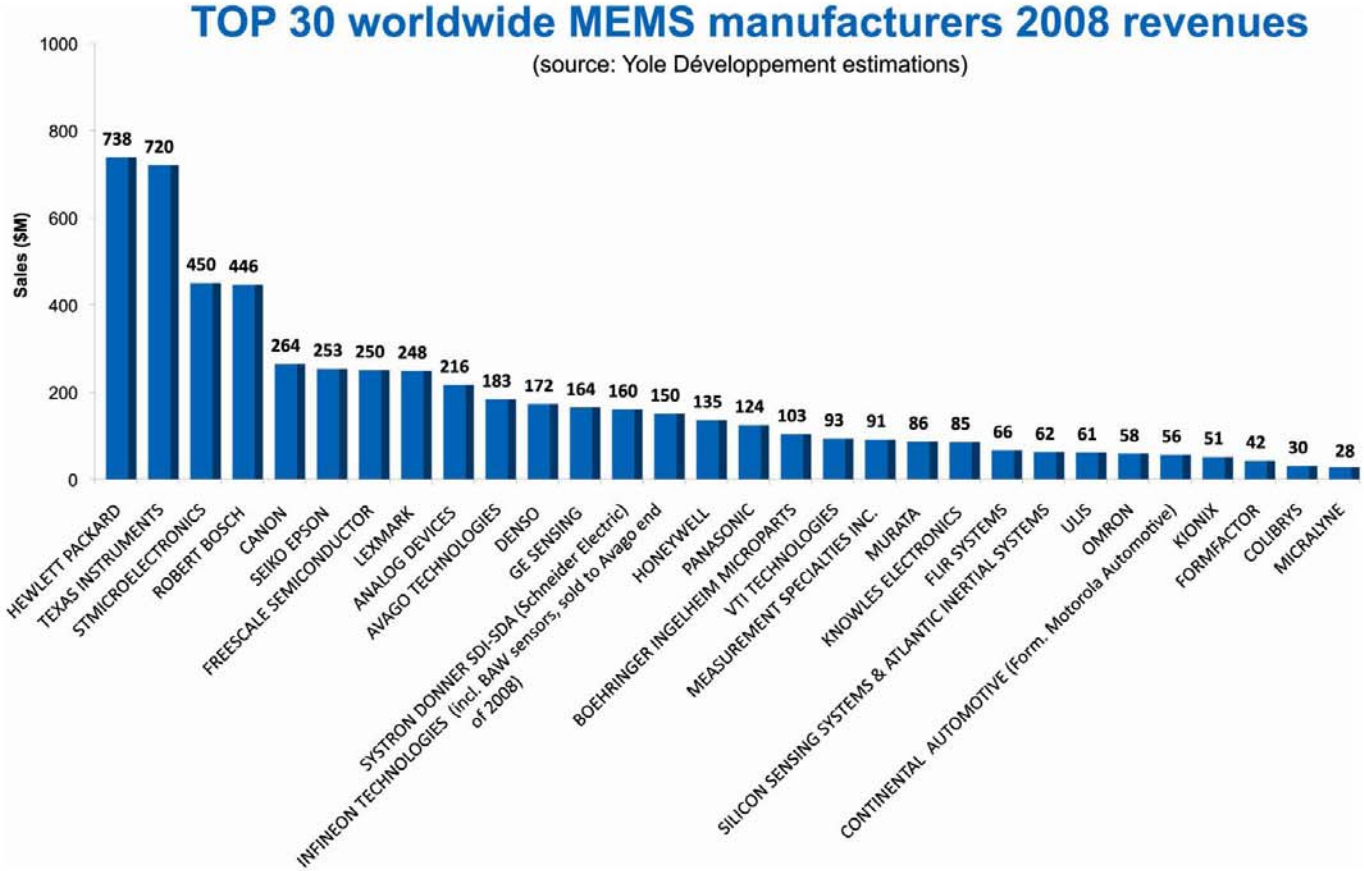
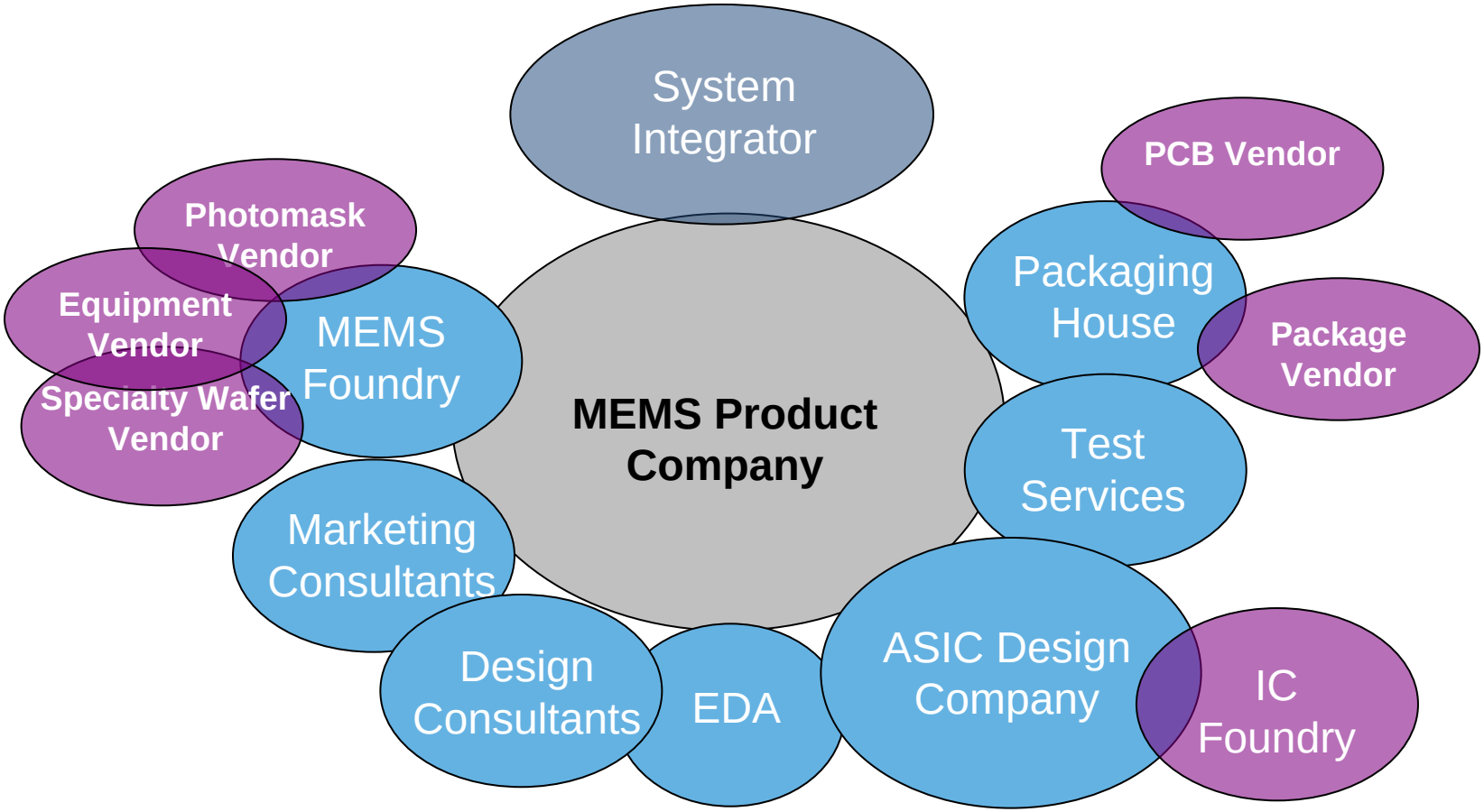
Large companies dominate industry today

TOP 30 MEMS Manufacturers
2008 sales

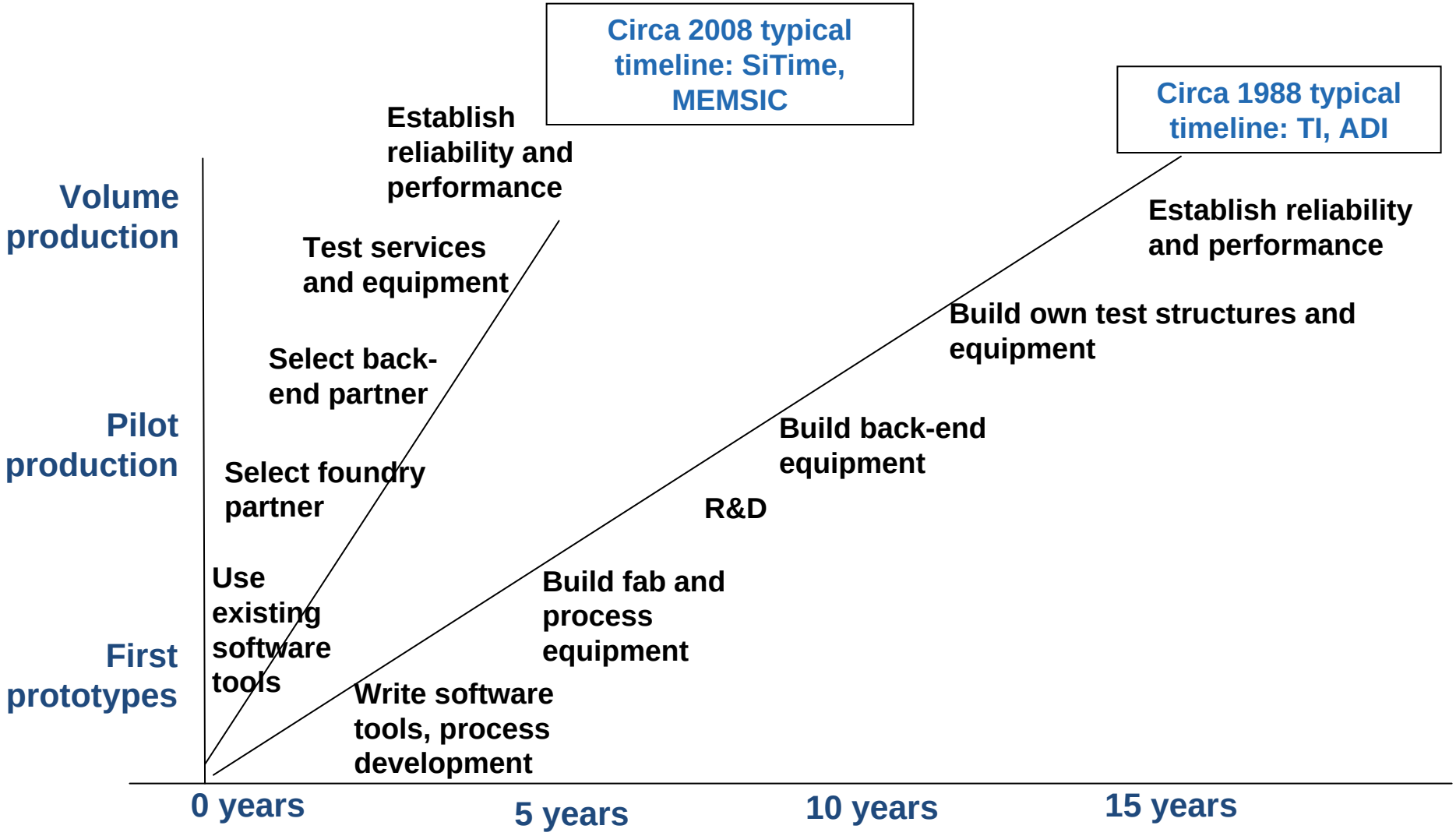


MEMS Supplier Ecosystem: 2010

- **Specialization reduces resource requirements**



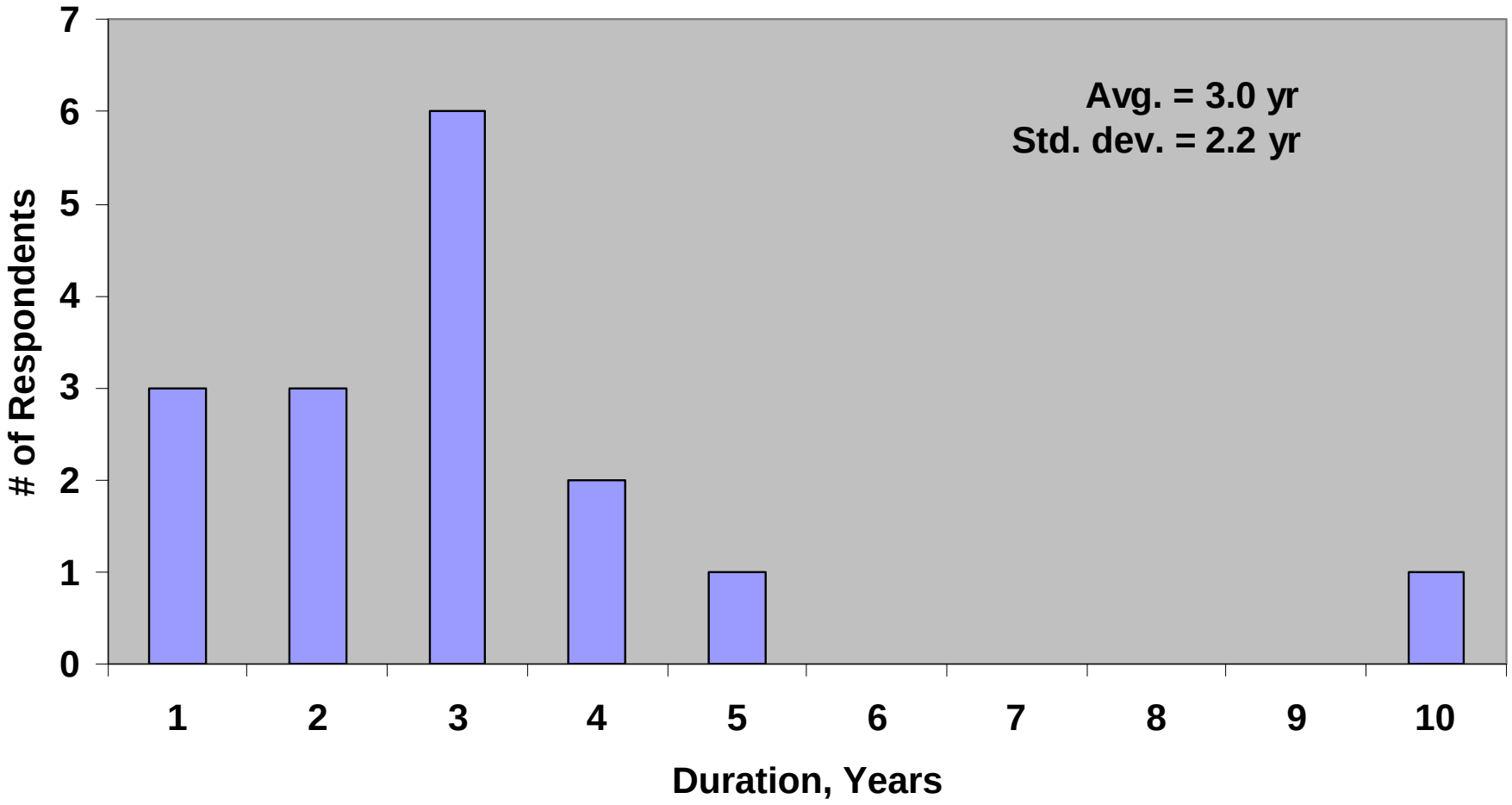
Development timelines have improved significantly



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"**

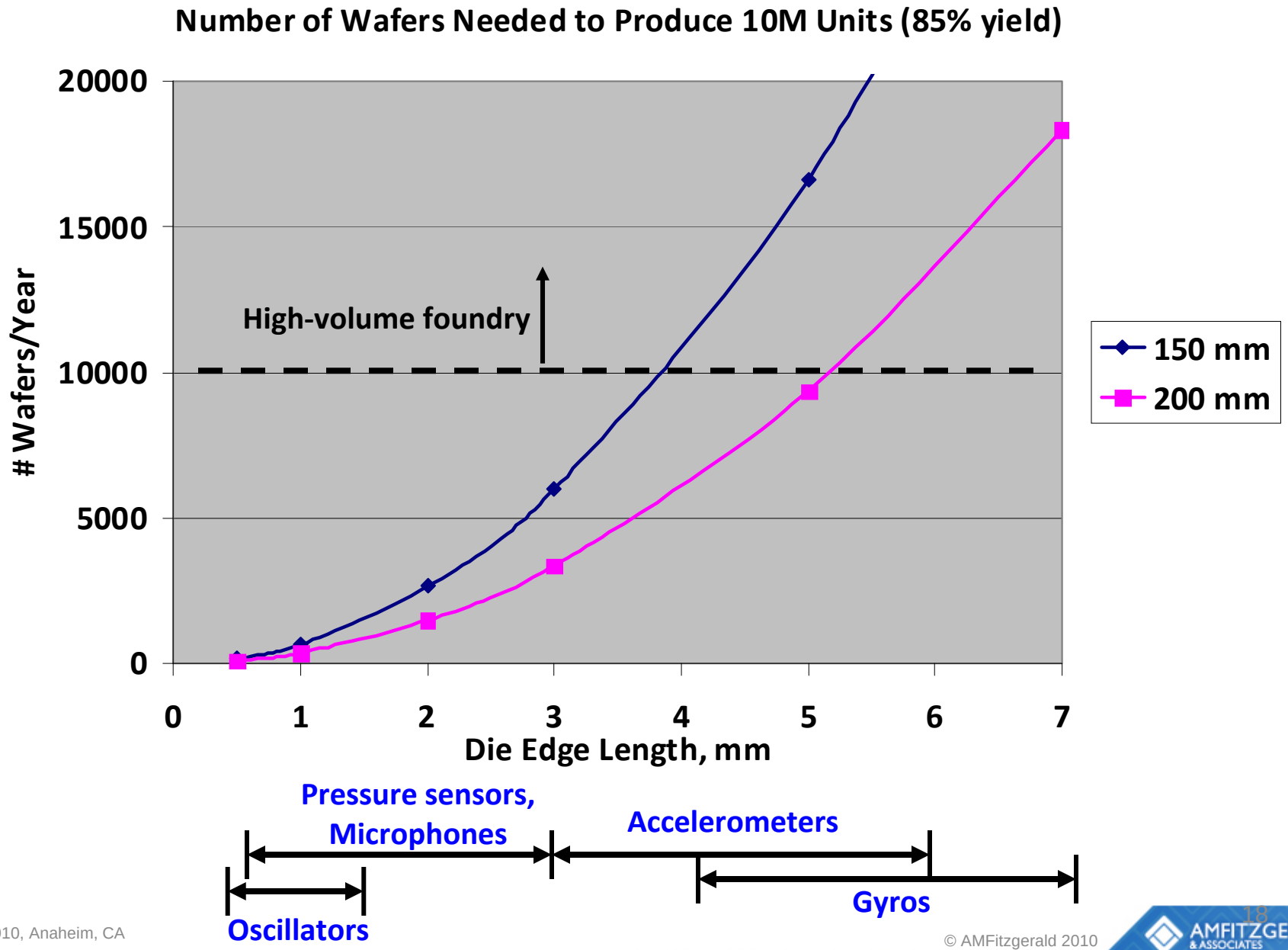
Working with foundries

- **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)**

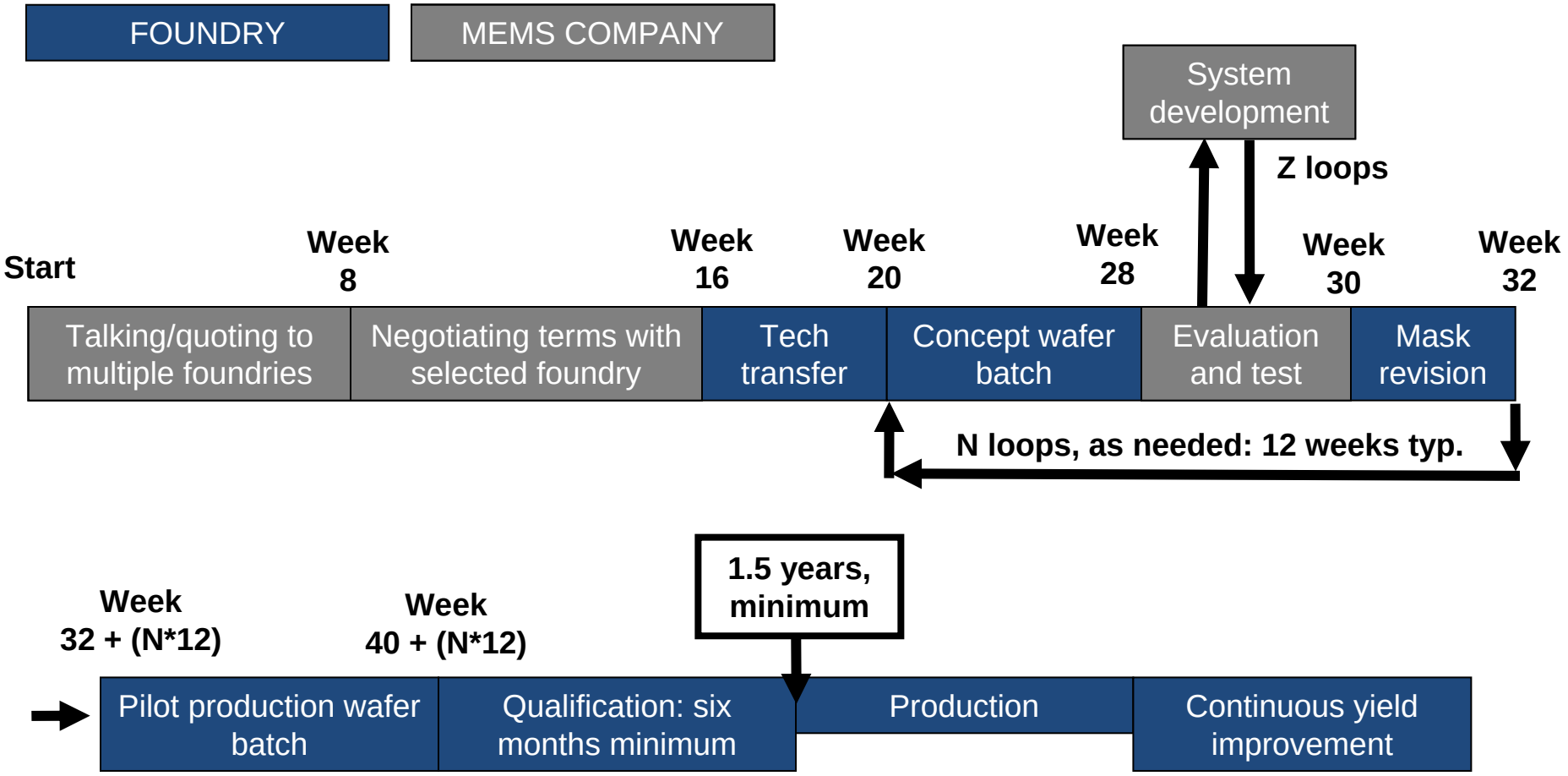
Foundry selection

- **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**

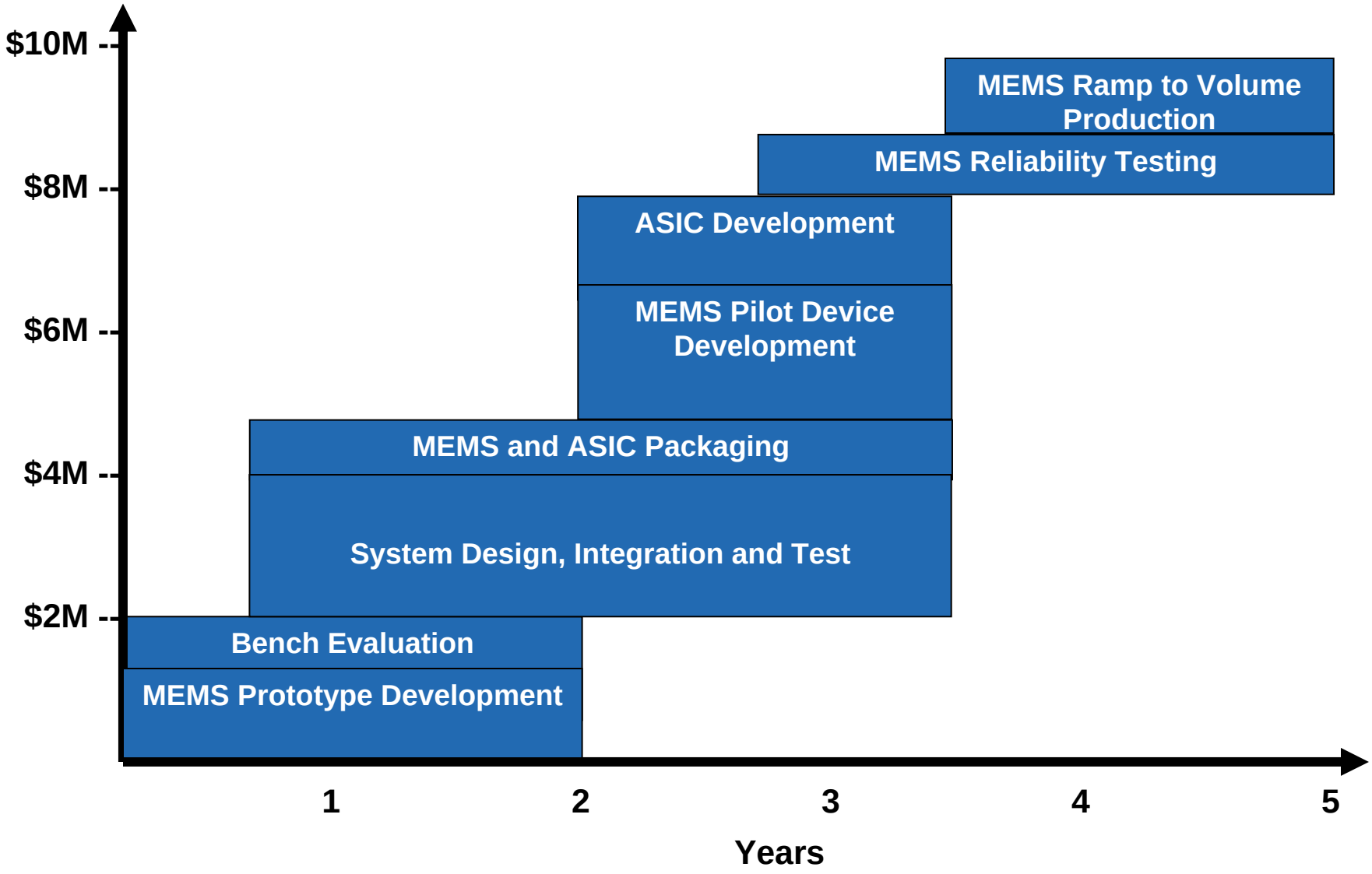
Not all MEMS will need 200mm wafers



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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