

# What it Takes to Develop New MEMS Products: Reality Check

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AMFITZGERALD  
& ASSOCIATES

# Overview

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

# Mission

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## MEMS Product Development

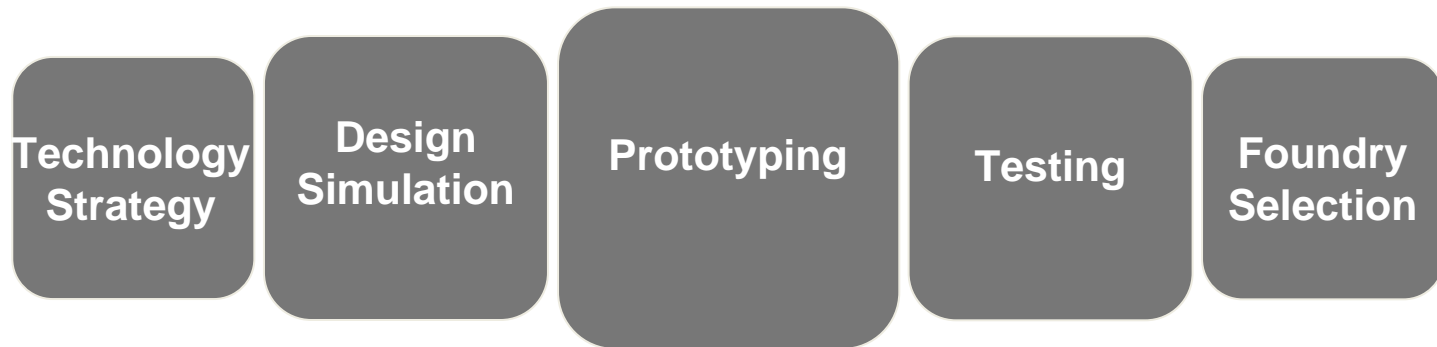


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**We turn your ideas into silicon.**

# Fully integrated services: concept to foundry

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- 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

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## 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:

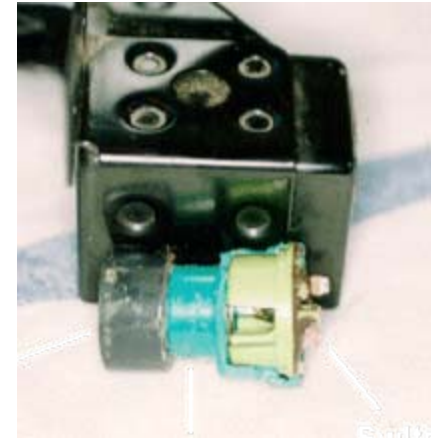
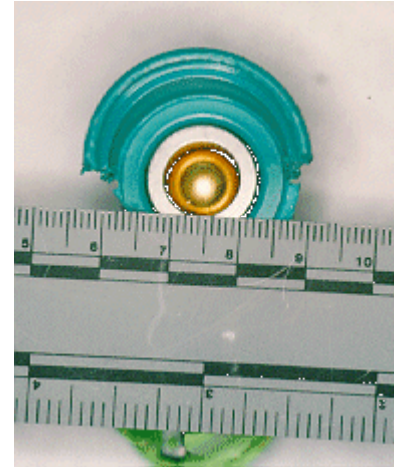
- **Consumer electronics**
- **Medical implant**
- **Medical diagnostics**
- **Infrared imaging**
- **Industrial safety**
- **System health monitoring**
- **Ultrasound imaging**
- **Optical telecom**
- **Solid state lasers**
- **Chip cooling**
- **Cell culture**
- **Drug discovery**
- **Gas flow metering**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

# What are MEMS?

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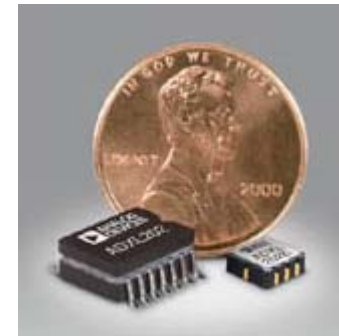
- **Micro Electro Mechanical Systems**
  - Not a platform *device* technology
  - But a powerful manufacturing technology for miniaturization
- **Semiconductor process heritage**

Airbag sensors (1980)



Source: Ed Phillips

Airbag sensors (2005)



# Challenge of MEMS development

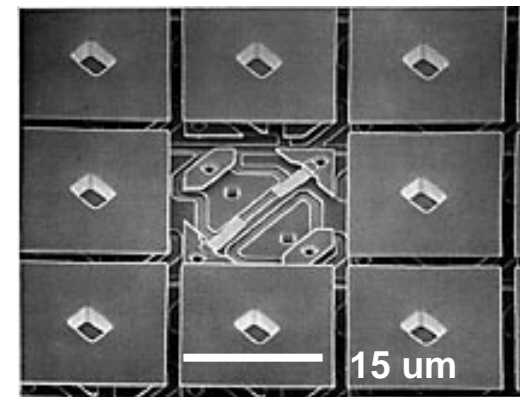
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- **High technical complexity**
  - Coupled physics
  - Moving parts
  - Environmental exposure
  - Test and packaging challenges

Microvision Pico-P



TI DLP pixels

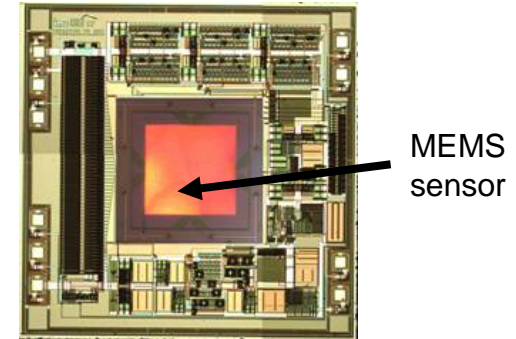


# Why MEMS are exciting for so many applications

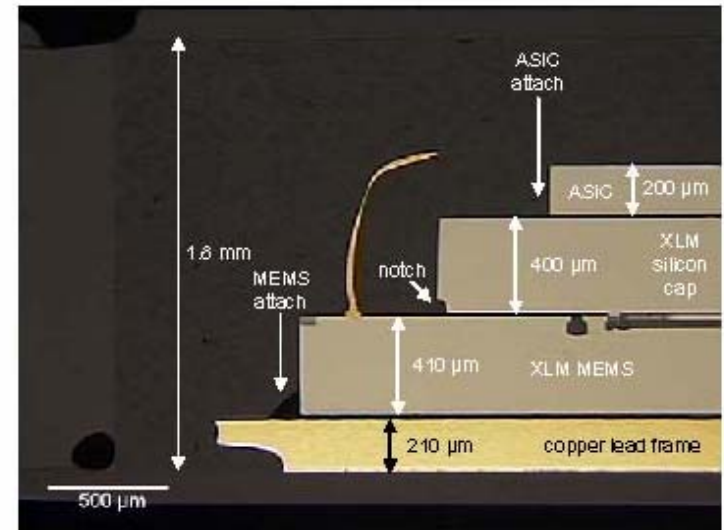
- **Smaller, better, cheaper**
  - But not always all three
- **Ease of electronics integration enables sophisticated capabilities in small form factor:**
  - Multiple sensors
  - Signal processing and analysis
  - Telemetry capability
  - Low power

**Stacked  
MEMS and  
ASIC chips,  
wirebonded**

## Integrated Pressure Sensor



Source: IMD



Source: Chipworks/Kionix

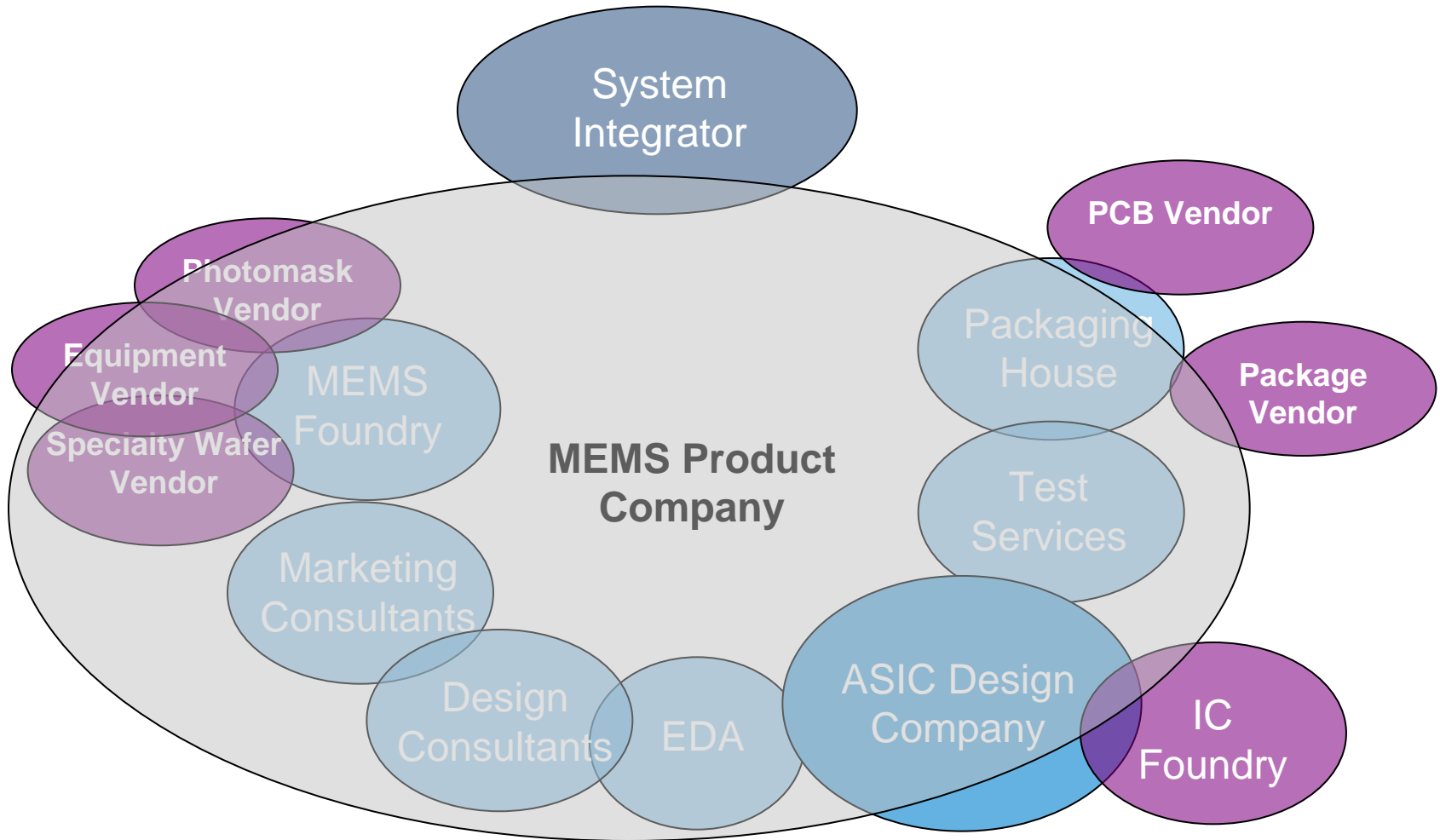
# MEMS are not ICs

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- **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)

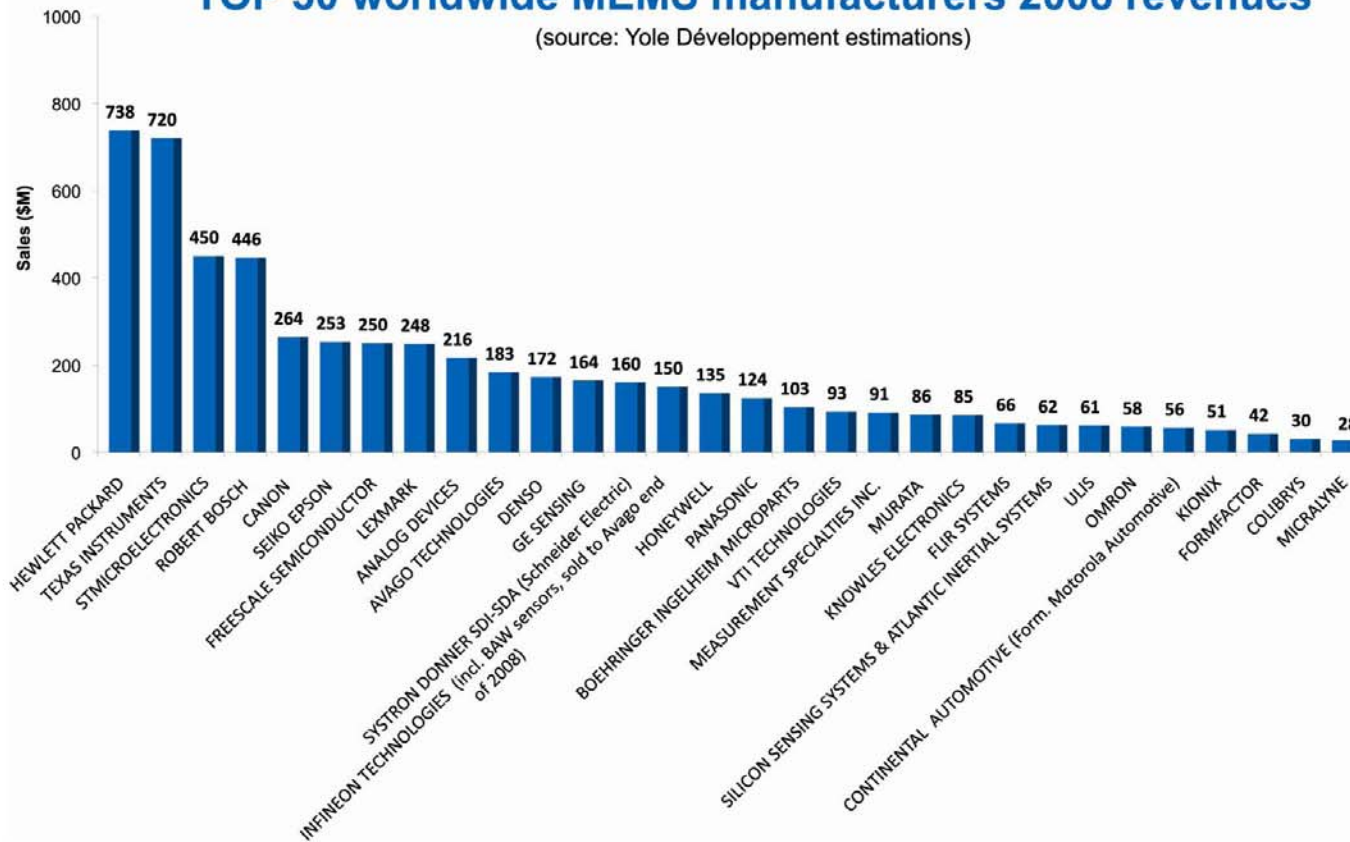


# Large companies dominate industry today

## TOP 30 MEMS Manufacturers 2008 sales

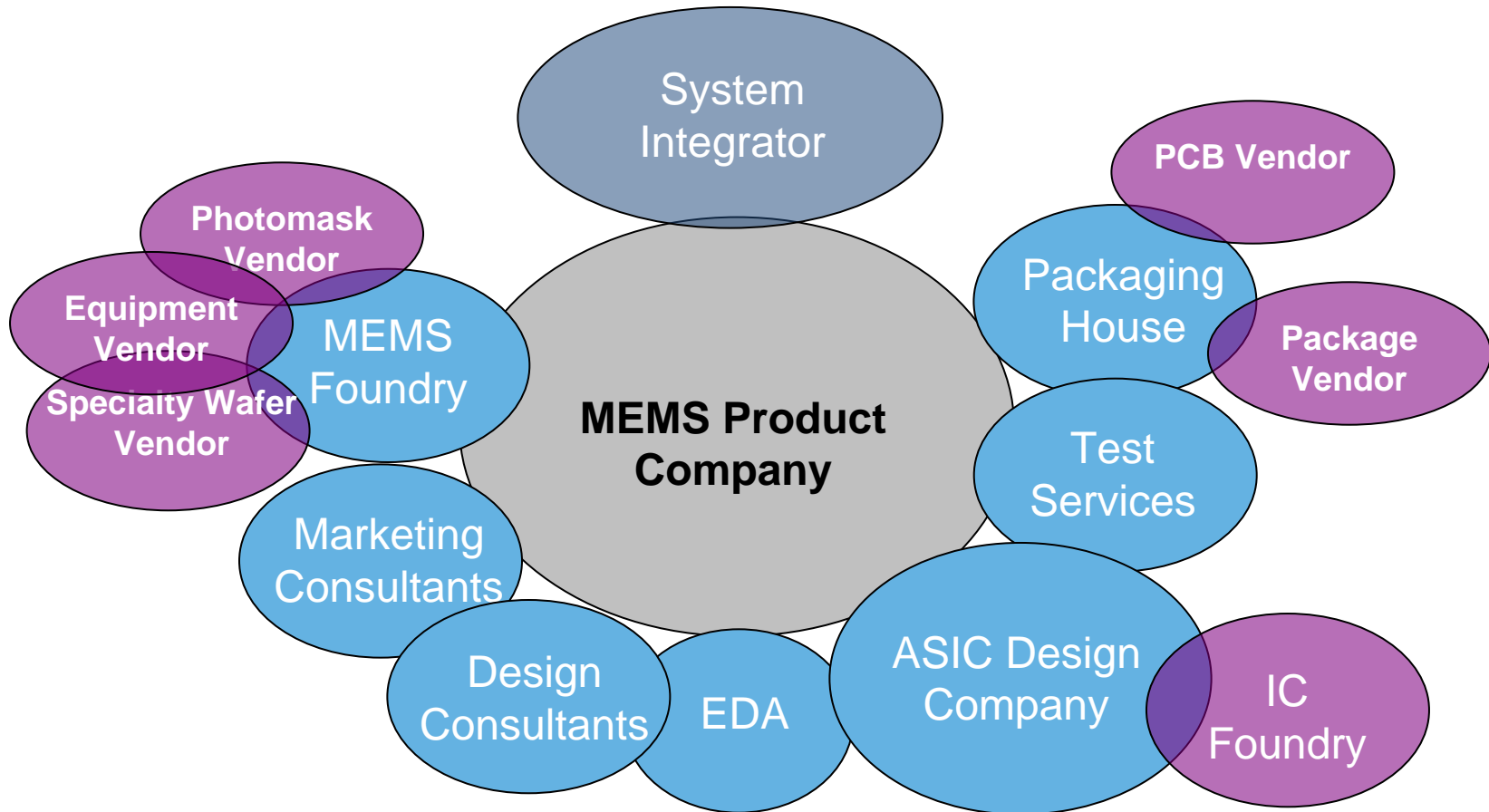
### TOP 30 worldwide MEMS manufacturers 2008 revenues

(source: Yole Développement estimations)

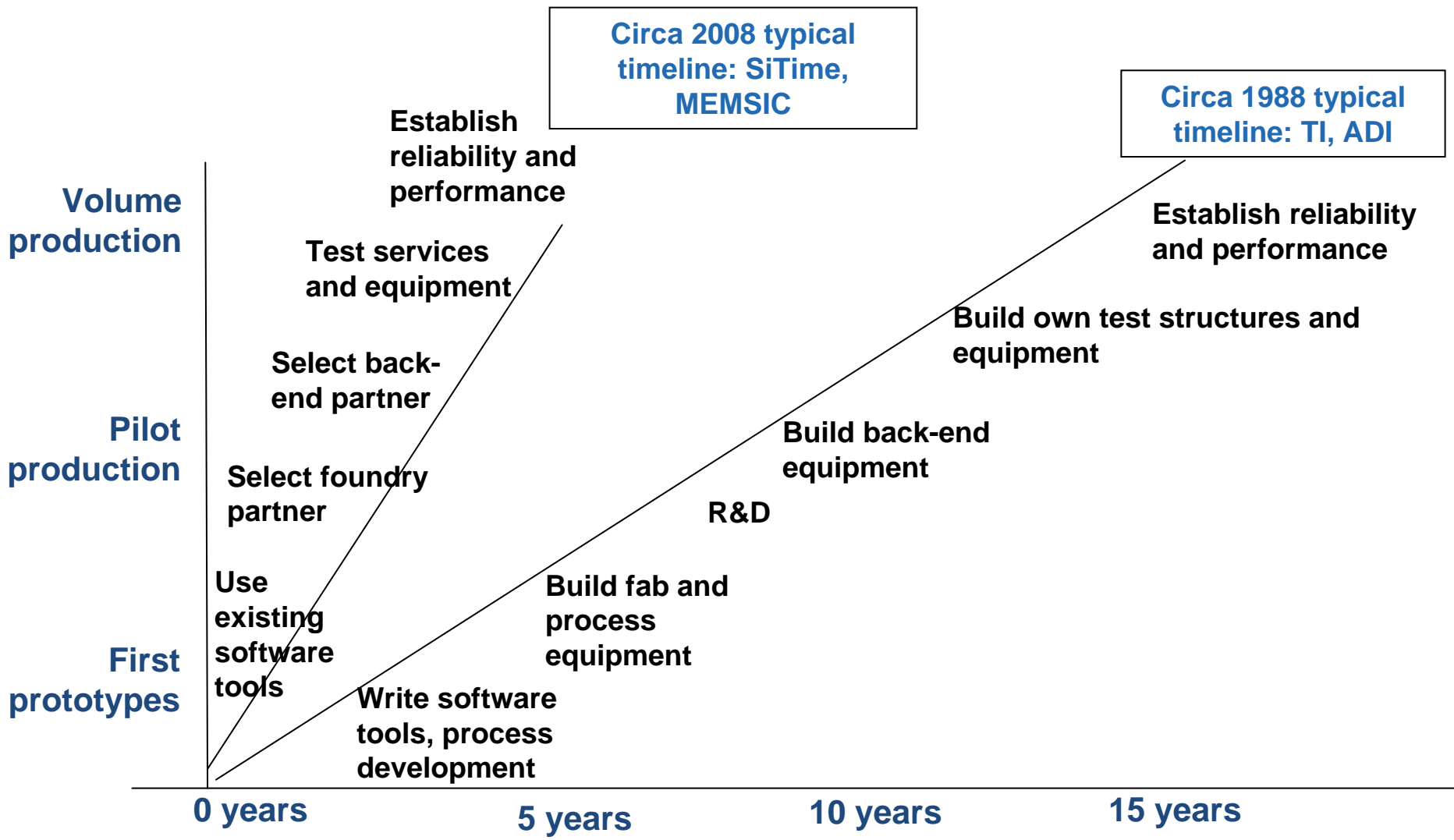


# MEMS Supplier Ecosystem: 2010

- **Specialization reduces resource requirements**



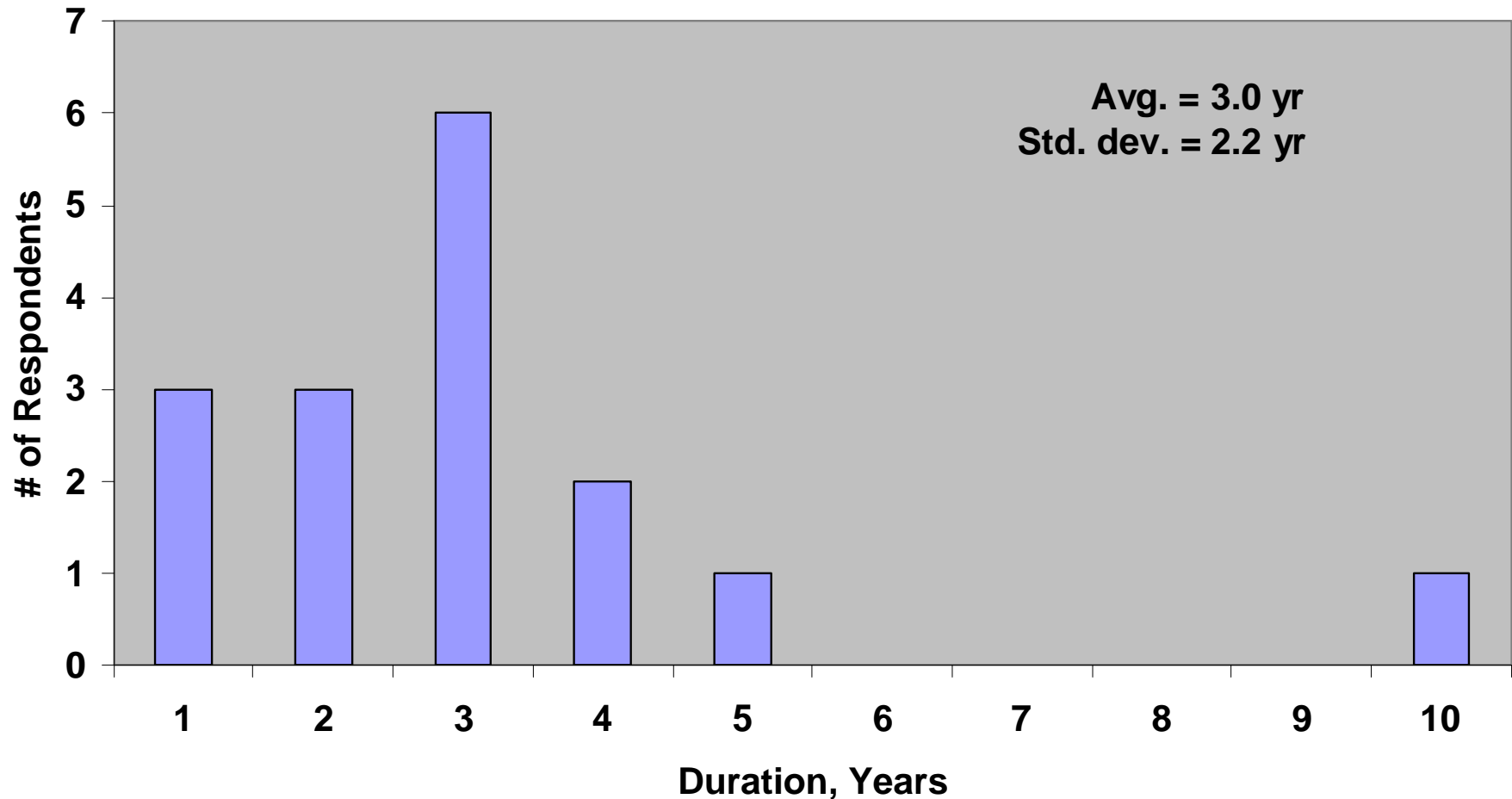
# Development timelines have improved significantly



# 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

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*“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

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- **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)**

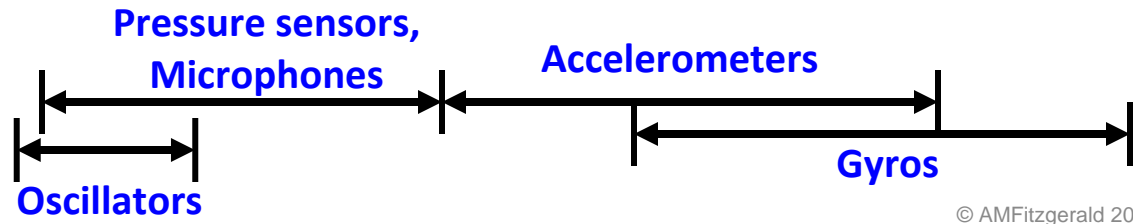
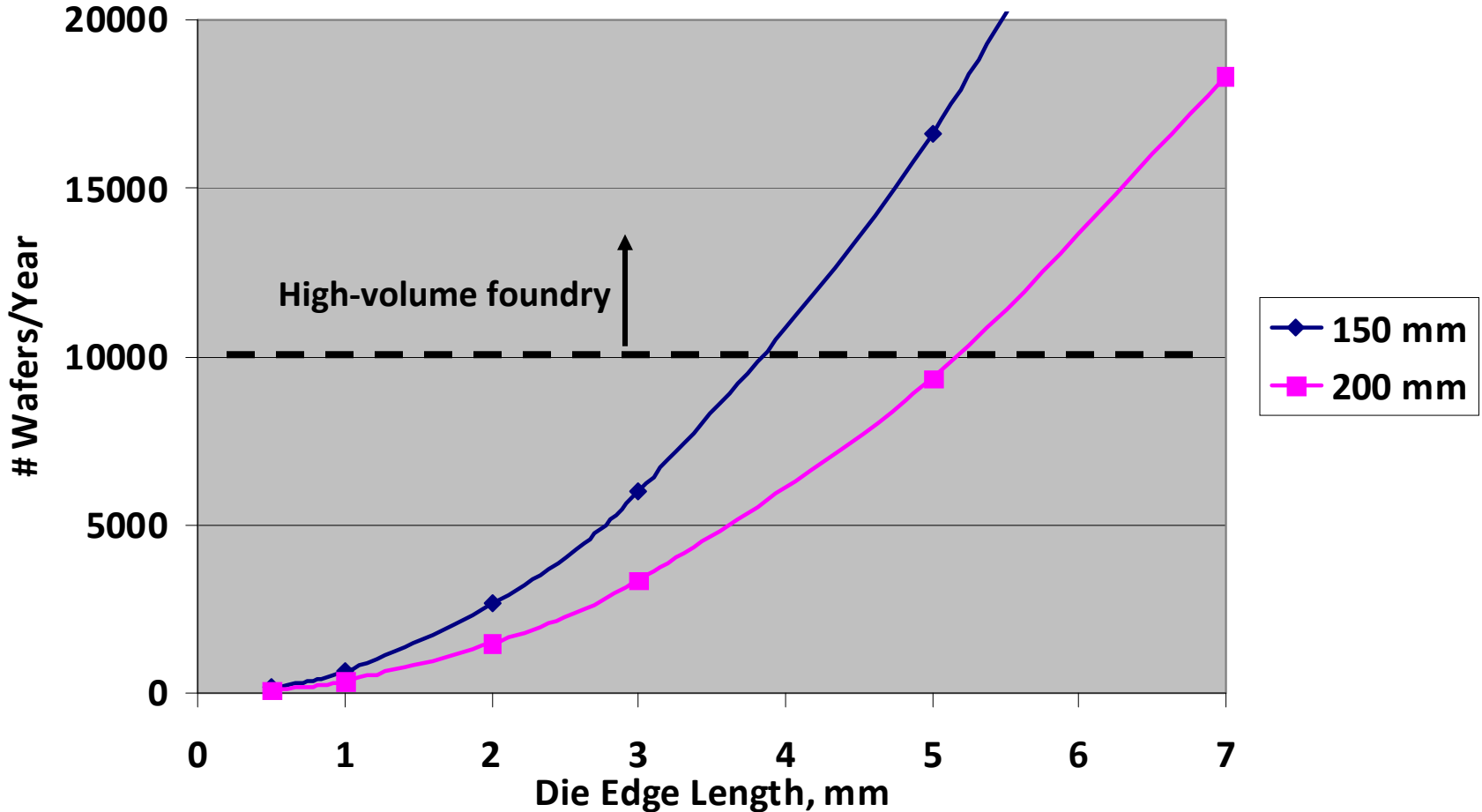
# Foundry selection

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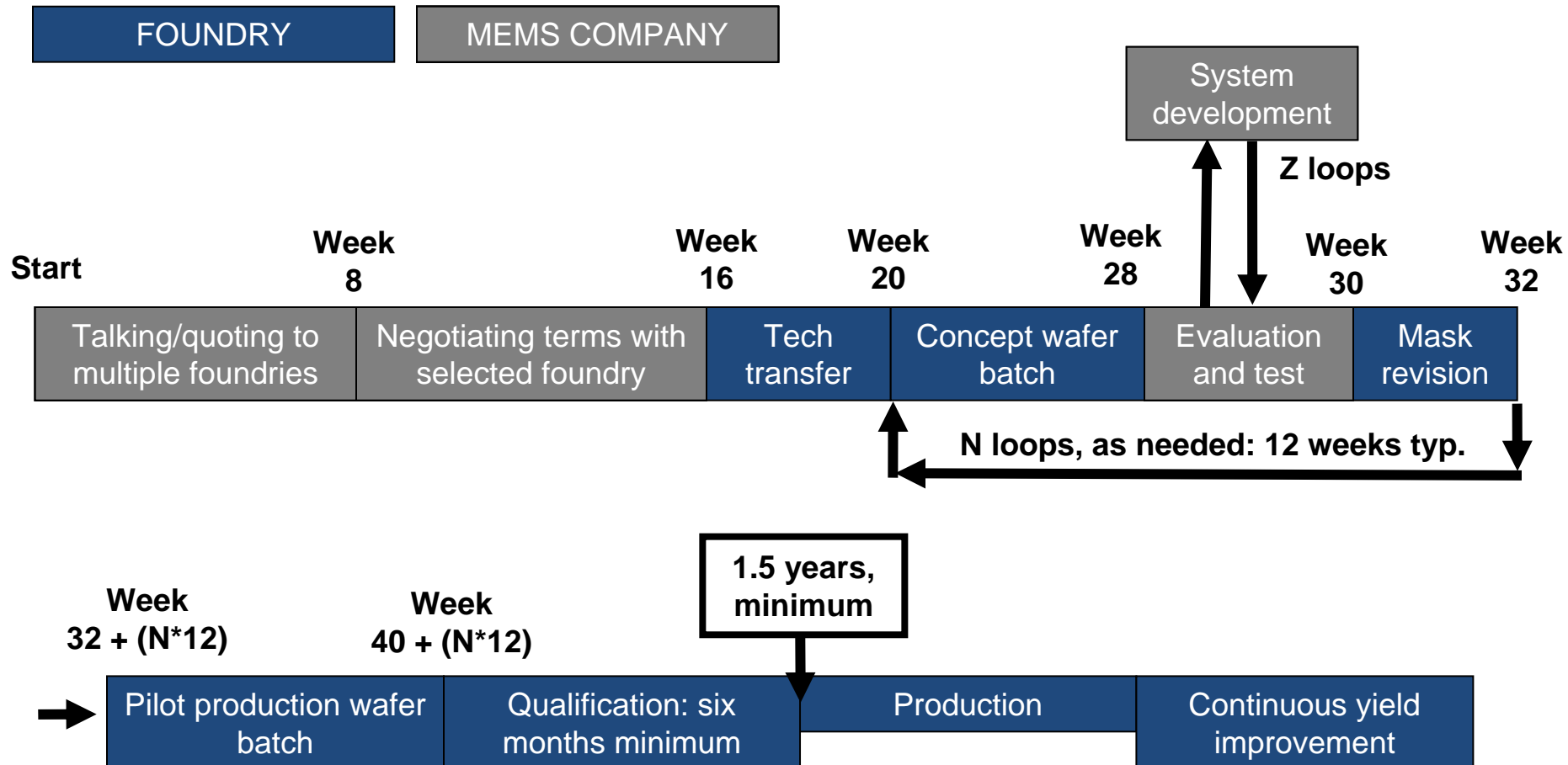
- **Evaluate process capability, experience with your type of product**
- **Make sure you have compatible:**
  - **Business models**
  - **Timelines**
  - **Expectations**
  - **Quality standards**
  - **Product volumes – ideally, don't want to be smallest or largest customer**

# Not all MEMS will need 200mm wafers

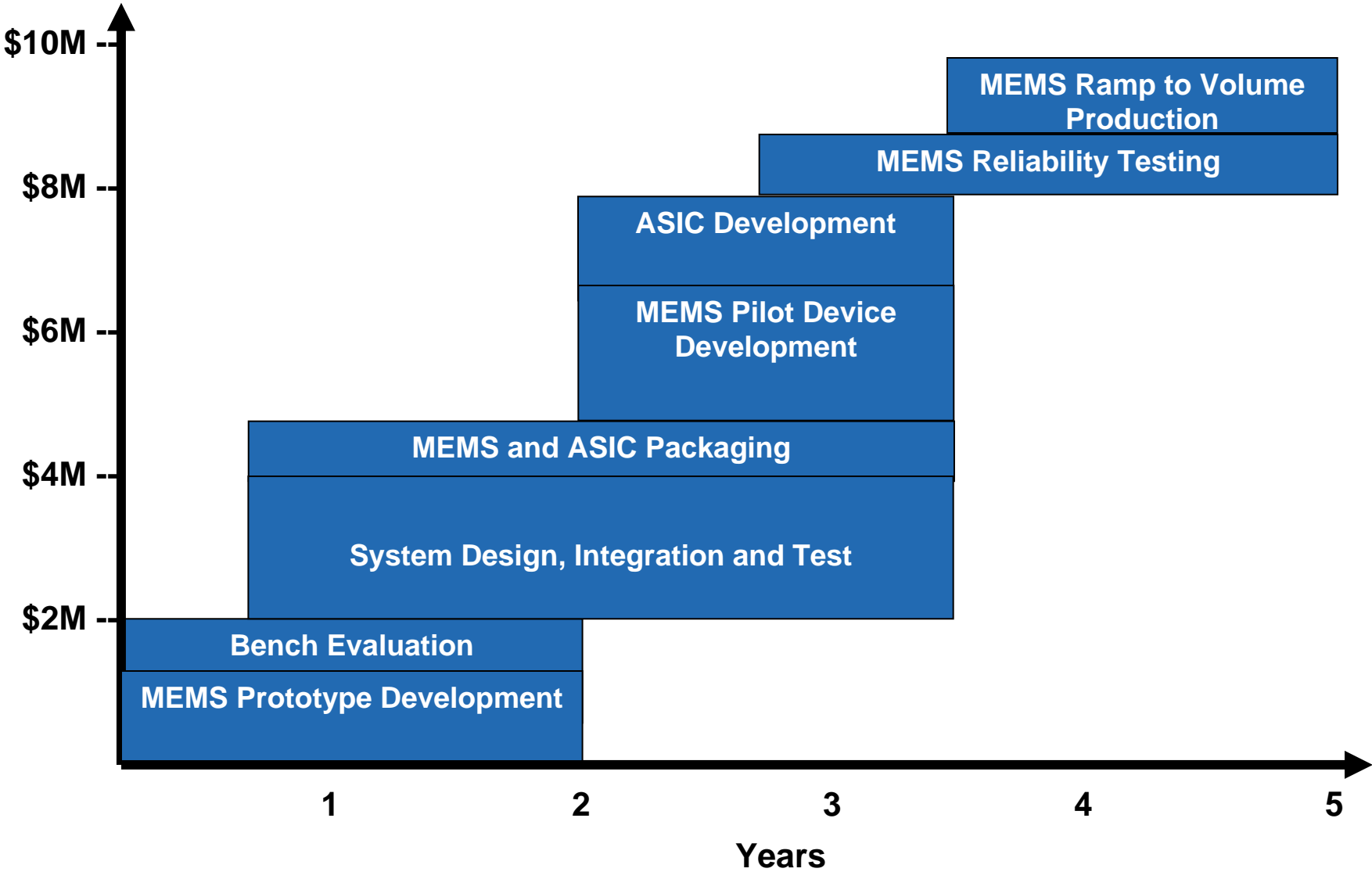
Number of Wafers Needed to Produce 10M Units (85% yield)



# Typical timeline: Always longer than you expect



# Cost of New Device (Fabless) Development: Minimums



## Development challenges: Process know-how

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- **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

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- **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

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- **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

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- **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

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- **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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