Entrepreneurship and the Commercialization of University Research in Engineering

University of Michigan, NSF ERC in WIMS
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Consider...

What is the definition of the word engineering?

*engineering, n*

- the practical application of science to commerce or industry
Consider...

What is the definition of the word research?

research, n

scholarly or scientific investigation or inquiry
Consider...

So what is engineering research?

**engineering research, n**
- scholarly or scientific investigation or inquiry into the practical application of science to commerce or industry
Consider...

**Possible outcomes of engineering research**

- Advancement of the field through new discoveries or better understanding of relevant phenomenon
- Determination of concepts, methods, or approaches that have low or little utility (i.e. the null result is a result)
- Determination of concepts, methods, or approaches that have high utility and should be developed for widespread use (i.e. commercialization)

**Engineering research and commercialization are inextricably linked**
Outline

About Mobius Microsystems, Inc.
- Technology overview
- History

New Venture Development
- Overview
- Prototype development, IP protection and licensing, business planning
- Where to begin and university resources
- Challenges

New Venture Spin-out
- Financing and fundraising
- Infrastructure development and recruiting, M&S for a new technology
- Challenges

Closing Remarks and Advice
About Mobius Microsystems, Inc.
Technology Overview

Mobius Microsystems (Mobius) is a semiconductor component and IP company specializing in clock/timing products

- Flagship technology is high accuracy and low jitter all-Si clock/timing integrated circuitry in standard CMOS
- Tech. based on research in the UMICH NSF ERC in WIMS
- 1 patent issued and 6 pending
- Full custom IC design center in Detroit, MI
- Management, governance, and technical M&S in N. CA
Entrenched Technology in Typical Application

Master Timing Socket
- ICS95022
- 14.318MHz XTAL
- 2 dedicated pins
- 2 capacitors
- 1 precision resistor
- 5 insertions
- ±300ppm accuracy

Intel 925 PC Motherboard
Entrenched Technology vs. Mobius’ Technology

Obviously valuable, but can Mobius demonstrate the required signal integrity without the external frequency reference?

YES

Mobius all-Si clock generation technology…

- eliminates the XTAL, but retains the required accuracy (as low as ±150ppm)
- eliminates 2 package pins, 2 capacitors, 1 precision resistor, and 5 insertions
- enables clock start-up latency and scaling in ns, not ms
- can serve applications in harsh environments (high $T$, $G$, etc.)
Mobius Technology

- USB to RS-232 bridge controller for cables and thumb drives
- Mobius replaced the XTAL + PLL with an all-Si clock generator and reduced the clock module cost to pennies and size by over 1,000X
- 2M units/month

- Mobius is the first to build a USB-compliant all-Si clock
- 0.18mm² in 0.35μm CMOS
History of Mobius

- **2000**
  Brown and McCorquodale initiate work on Monolithic RF TC-LCO clock generators for MCU, µP, and digital interface applications

- **2001-2002**
  McCorquodale enrolls in UofM B-school entrepreneurship & IP law classes

- **2000-2002**
  Fundamental research pursued under fellowship

- **2002**
  Prototype development begins through MOSIS MEP and with IBM

- **2002**
  Disclosure filed with UMICH TTO and provisional IP filed with USPTO

- **2002**
  Mobius is incorporated through start-up program with Perkins-Coie LLC
History of Mobius

- **2002**
  - Wilkins and Rushing (MBA candidates) and Vincke (veteran entrepreneur) recruited for business plan development through ZLI and OTT

- **2003**
  - Full utility IP filed with USPTO
  - First publications appear including 1st place DAC/ISSCC design award

- **Summer 2003**
  - Mobius’ first office established in Ann Arbor with $180k in grants/awards

- **2002 - 2004**
  - Mobius team wins 9 national and international business plan competitions

- **April 2004**
  - Final prototypes complete, license executed, McCorquodale defends and serves as Mobius’ CEO and CTO
History of Mobius

- **April 2004**: Mobius closes $1M in financing with angels and Waypoint Ventures & WVF
- **July 2004**: Mobius acquires first design win for USB application
- **August 2004**: Mobius acquires next design win for \( \mu \)P application
- **November 2004**: State of MI awards Mobius with the High-Tech MEGA to move to Detroit
- **March 2005**: First customer project completes USB qualification
- **May 2005**: Governor awards Mobius for largest high-tech job creation in MI
- **June 2005**: Industry veteran L. David Sikes becomes Mobius’ CEO
History of Mobius

- **January 2006**
  - New members of Mobius’ management team hired for next phase

- **January 2006**
  - Mobius’ 1st customer moves to high volume production

- **November 2005**
  - Mobius raises $8.1M from tier-1 Si Valley VCs (Foundation and Menlo)

- **November 2005**
  - Mobius 1st customer begins sampling of new product in prep. for production

- **April-August 2005**
  - Mobius closes $1M in additional angel and local VC investment

- **August 2005**
  - Mobius 2nd customer project a success and moves to next phase
New Venture Development
Overview

1. Win an IP clean research grant
2. Pursue fundamental research
3. Disclose inventions to OTT
4. File provisional patent application with USPTO
5. Develop functional prototypes
6. Publish results
7. File full utility patent application with USPTO
8. Develop business plan and build team
9. Negotiate and execute license option?
10. Negotiate and execute license
11. Incorporate and spin-out
12. Financing

Prototype Development

For any venture to be financed from university research the technology must be demonstrable.

Prototype development pertinent to WIMS
- Prototypes from the MNF
- MOSIS MEP

Grant programs funding prototype development
- Engineering Technology Development (GAP) Fund
- Office of the Vice President for Research (OVPR)
IP Protection and Licensing

Patent application overview for the researcher

1. File formal IP disclosure with OTT
2. OTT reviews interest in IP (e.g. is there a corporate or start-up licensee for the technology?)
3. Work with university IP attorney to develop and file provisional or full utility application with USPTO
4. File with PCT and choose nationalization strategy
5. Wait for review, amend claims, resubmit
6. USPTO grants patent to research institution
7. Research institution can license IP (Bayh-Dole Act, 1980)
IP Protection and Licensing

Patent licensing overview for the entrepreneur

- License option
  - Licensee is granted limited time rights to IP for exploratory purposes
  - IP unavailable to other interested licensees during option period
  - Licensee has “option” to execute formal license

- License
  - IP is licensed to a specific company under a specific set of terms
  - Terms vary from agreement to agreement

A business plan is required for any license
Team Building and Business Planning

Difficult to move a venture forward without a team

- Faculty + student
- Researcher + local professionals
- Leverage resources and network to source teammates
- Mobius sourced local professionals through OTT and MBA students through ZLI, business development courses, and MBA student groups

Business planning

- Technology venture concepts can be presented to MBA students in business plan writing courses for development
- For students, business plan competitions provide an excellent resource for deadline-oriented plan development and critical feedback (e.g. local competitions include GLEQ and Pryor-Hale)
Where to Begin and University Resources

Office of Technology Transfer
- IP development support
- Business development support
- Grants: GAP, OVPR, MUCI, MI TTC
- Licensing

Zell Lurie Entrepreneurial Institute
- Prep./sponsorship for business plan competitions
- MBA internship program (Marcel Gani)
- Business development support
- Dare to Dream grant program
- Pryor Hale, Michigan Innovators competitions
Academic Courses

UMICH Ross School of Business

- 23 entrepreneurial courses
- Business plan writing course particularly useful
- Entrepreneurial Multidisciplinary Action Project (EMAP)

UMICH CoE

- No courses on entrepreneurship for graduate credit
- Challenges electing business school courses
- EECS 495: Patent Fundamentals for Engineers
Student Organizations

UMICH Ross School of Business
- Entrepreneur and Venture Club (EVC)
- High Tech Club (HTC)
- Wolverine Venture Fund (WVF)

UMICH CoE
- Michigan Entrepreneurs (UME)
Challenges

The UMICH CoE...

- does not have academic offerings in entrepreneurship
- does not have student-led organizations in entrepreneurship
- is decoupled from the UMICH Ross School of Business
- does not have an entrepreneur-friendly culture
- has a poor track record in research commercialization
- does not have access to sufficient professional business development resources
Addressing Challenges

The UMich CoE...

- students can drive demand for better access to entrepreneurial education and resources
- can create organizations or leverage existing organizations
- can work more closely with the Ross School of Business
- students and faculty can improve the entrepreneurial culture
- can focus faculty searches on those with entrepreneurial experience
- can develop incentives for faculty and students to pursue entrepreneurial interests
New Venture Spin-out
Overview

1. Recruit start-up team
2. Raise money
3. Execute business plan
4. Recruit engineering and M&S teams

- Get design win or sale and deliver
- Refine M&S strategy
- Achieve milestones before next round
- Raise next round
Non-Equity Financing Sources

Government programs

- **SBIR/STTR**
  - Grants through federal agencies (e.g. NSF, DoD) for new research only
  - 2-phase award (~$100k + ~$1M) with long review cycle
  - Marginally successful
  - Decreasing in popularity with both legislators and awardees

- **Congressional “Defense adds”**
  - Direct additions to defense budget for any project
  - Requires direct lobby in D.C. to congressional representative and senators
  - Requires a defense agency champion; not a review process like SBIR
  - Amounts to ~$1-5M “added” as pork to the defense budget
  - Now very popular, but award cycle tied to defense budget cycle

- **Local loan and grant programs**
Non-Equity Financing Sources

Banks

- Collateralized loans
  - Must have collateral (unlikely for a new technology venture)
  - Difficult to secure loans for high-risk ventures
  - Difficult to secure sufficient capital
  - Great resource for subsidizing capital equipment expenditures

- Personal credit
  - High personal risk associated with default
  - For the “confident” or “crazy”; you decide
Equity Financing Sources

Private accredited investors or angels

- Difficult to source without close personal relationships
- Substantial legal overhead to manage several individual investors
- Becoming very common (nearly mandatory for technology ventures) as VC moved to later stages post-bubble
- Some now organized into networks (e.g. Great Lakes Angels)

Professional equity investors

- Venture capitalists
- Private equity funds
Comments on Financing Sources

Non-equity financing
- Government financing cycles are too long and are riddled with red tape
- Bank financing can be difficult and is high risk for the entrepreneur
- Founders maintain ownership of the company, though it may be worthless

Equity financing
- The typical route for a technology venture
- Amounts to selling ownership of the company to investors
A Typical Equity Financing Cycle

Angel and founder round or seed round
- Sources: private accredited investors and founders
- Size: ~$100k - $1M
- Typical milestones: development of a commercially viable prototype, customer references or letters of intent
- Goal: attract professional investors

Series A round
- Sources: professional venture funds
- Size: ~$2M - $10M
- Typical milestones: management team, final product development, design wins, first few customers
- Goal: maximize valuation for next round
A Typical Equity Financing Cycle

**Series B round**
- Sources: professional venture funds
- Size: ~$10M - $20M
- Typical milestones: Growth, ramp sales rev., increase GM, profitability
- Goals: Ramp sales and possibly achieve profitability

**Series C round**
- Sources: professional venture funds and financial institutions
- Size: >$20M
- Typical milestones: Continued growth and profitability
- Goals: IPO or acquisition
The Art of Fundraising

Not all technologies are appropriate for venture backing

- The entrepreneur must determine this prior to proceeding

Key parameters VCs consider in a new tech. venture

- Proven and demonstrable technology with significant differentiation to entrenched technology (e.g. 10X power, form factor, cost reduction)
- Technology addresses a TAM >$1B
- Served market is attractive (e.g. large CAGR, not disrupted recently)
- Barriers to entry: Patents, trade secrets, etc.
- Competent or replaceable management team
- Large potential ROI

Financing decisions are analytical, not subjective
The Reality of Investment Capital

Top 10 Colleges of Engineering in the U.S. in 2006

1. Massachusetts Institute of Technology (MIT)
2. Stanford University
3. University of California Berkeley (UC-Berkeley)
4. Georgia Institute of Technology (Georgia Tech.)
5. University of Illinois at Urbana-Champaign (UIUC)
6. University of Michigan (UMICH)
7. University of Southern California (USC)
8. California Institute of Technology (Cal. Tech.)
9. Carnegie-Mellon University (CMU)
10. Purdue University

3 in the Midwest, 2 in N. Cal., 2 in S. Cal.

## The Reality of Investment Capital

<table>
<thead>
<tr>
<th>University</th>
<th>Region</th>
<th>CoE Research Expenditures</th>
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<tbody>
<tr>
<td>Stanford</td>
<td>N. CA</td>
<td>$178M²</td>
</tr>
<tr>
<td>UC-Berkeley</td>
<td>N. CA</td>
<td>$110M³</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>$288M</strong></td>
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<tr>
<td>UMICH</td>
<td>Midwest</td>
<td>$132M⁴</td>
</tr>
<tr>
<td>UIUC</td>
<td>Midwest</td>
<td>$214M⁵</td>
</tr>
<tr>
<td>Purdue</td>
<td>Midwest</td>
<td>$130M⁶</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>$476M</strong></td>
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The Reality of Investment Capital

Total U.S. post-bubble VC investment from Q1/02 – Q3/05
$79B and 11,060 deals

Si Valley
$27B and 3,189 deals
- Emerging $4.86B and 479 deals
- Semiconductors $3.6B and 339 deals
- Emerging semiconductor $686M and 102 deals

Midwest
$2.9B and 636 deals
- Emerging $473M and 186 deals
- Semiconductors $147M and 41 deals
- Emerging semiconductor $27M and 12 deals

# The Reality of Investment Capital

7% **Total U.S. post-bubble VC investment from Q1/02 – Q3/05**

$79B and 11,060 deals

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<th><strong>Michigan</strong></th>
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<td>$27B and 3,189 deals</td>
<td>$363M and 75 deals</td>
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- **Emerging**
  - $4.86B and 479 deals
- **Semiconductors**
  - $3.6B and 339 deals
- **Emerging semiconductor**
  - $686M and 102 deals

- **Emerging**
  - $25M and 21 deals
- **Semiconductors**
  - $39M and 7 deals
- **Emerging semiconductor**
  - $2.8M and 4 deals
  (Mobius is $2M of this)

Mobius’ Financing Experience

Capital requirements
- Mobius launched in ‘04 with SIP model to prove tech. on minimal capital
- By ‘05 Mobius required >$5M to grow and move to component model

Midwest investors
- Mobius raised a nearly unprecedented $2M from over a dozen angels and 2 local VCs (Waypoint and WVF)
- Spoke with nearly every single Midwest VC over 6 mo. and could not raise next round due to size (>5M), space (semis.), and stage (early)

Si Valley investors
- Mobius received multiple term-sheets and raised over $8M in just a few months after engaging only a few VCs in CA
- Headquarters to move to CA due to recruiting and governance
Infrastructure and Recruiting

Office Establishment

- Proper consideration of resources needed and recruiting is mandatory
- Difficult balance between growth opportunities and cash
- Possibly consider some local incubators and accelerators
- Consider local incentives: Mobius only start-up ever to receive MEGA
- Mobius started in Ann Arbor and moved to Detroit

Recruiting and compensation

- Very difficult to recruit without sufficient capital
- Founding technologists and team likely to be grossly underpaid at first
- Determine capitalization table sooner rather than later
- Mobius hired many personnel already known or referred
The Art of Securing the First Customer

Must solve a very “painful” problem

- Mobius’ first customer was won in a bloody price war
- Mobius’ other customers were won with customer’s performance challenges (e.g. power)

Credibility and transparency critical to tech. M&S

- Competency of the customer’s application builds credibility
- Transparency of the technology provides comfort and increases the likelihood that a customer will take a risk on a small company
Regional Challenges

Lack of investment capital
- Only $25M in MI in emerging business for the past 4 years
- Poor local and state leadership to recognize this as a problem
- Local entrepreneurial initiatives off in tangential directions

Recruiting
- Difficult to build a management team with tech. start-up experience
- Difficult to recruit engineering talent due to concerns over lack of other local opportunities if the venture fails
- Midwest engineers tend to be risk adverse
Regional Challenges

N. CA is a success as an entrepreneurial region
- Technology from the East Bay (Berkeley) to the Peninsula (Stanford)
- Financial institutions from SF to Sand Hill Rd.
- Companies throughout the entire region from SJ to SF to Livermore

SE MI lacks regional cooperation and proper leadership
- Ann Arbor: Spark and IT Zone
- Detroit: TechTown
- Oakland County: Automation Alley

What SE MI needs
1. Capital
2. Capital
3. Entrepreneurial leadership from its premiere research institutions (i.e. you)
4. Better leadership that understands the importance of tech. to the economy
Closing Remarks and Advice
Putting the Pipeline Together

- Fundamental research
- IP development
- Business planning
- Team building

- Licensing and spin-out
- Financing
- Go to market
- Achieve goals and seek follow-on financing

Go to market
Putting the Pipeline Together

The next successful technology venture
Common Questions

Was launching Mobius easy?
- It was the hardest endeavor I have ever pursued in my life
- Prof. Brown and others provided endless encouragement
- MI made the endeavor unnecessarily challenging

Was it worth it? Would I do it again?
- Absolutely; it has been the greatest experience of my professional life

For what do I aspire in the future?
- That Midwest research institutions (e.g. UMICH, UIUC, Purdue) become synonymous with successful technology start-ups
- That the Midwest becomes a technological leader in the private sector
- That the economies of the great Midwest cities (e.g. Chicago, Detroit) diversify through a focus on new technologies
Closing Thoughts

Commercialization of research is a simple pipeline
- Follow the protocol, leverage university resources, succeed

Midwest entrepreneurs face formidable challenges
- Large gaps in the commercialization pipeline
- Limited educational and professional resources
- Poor culture and enthusiasm
- Dearth of capital
- Lack of regional cooperation and proper leadership
Advice

Prudent for Midwest entrepreneurs to leave the region
- Remaining in the region delays inevitable fundraising challenges
- Infrastructure/personnel in the region are expensive/difficult to relocate
- Small workforce with start-up management experience

Generally steer clear of local entrepreneurial orgs.
- For those not in university, education through orgs. may be useful
- Else if it is not helping you raise money or win customers, it is useless
- Stick to UMich resources: Only CoE, OTT, and ZLI ever helped Mobius

MI and Midwest still offer opportunities
- Cost is substantially lower than VC-rich regions of the U.S.
- Quality of life in Midwest perceived as high
- Large skilled workforce in science in engineering
- Substantial research resources at world class institutions
Acknowledgements

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Questions welcome