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Emerging Technology Investment Opportunities:
CleanTech at Michigan

NEXT GENERATION MACHINING FLUIDS

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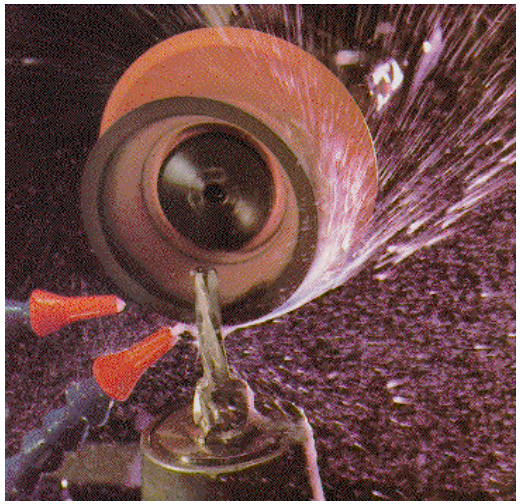
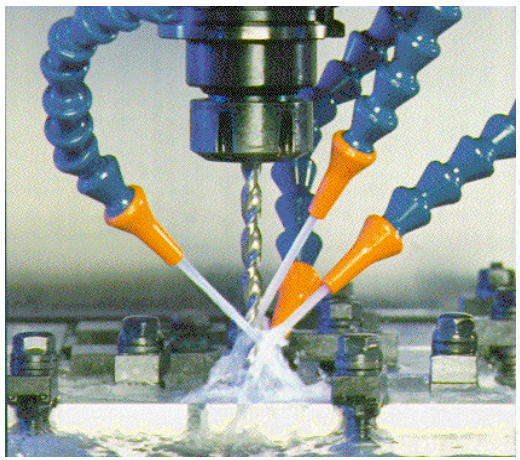
Aqueous Machining Fluids are…

- **Essential**
- **Expensive**
- **Unstable**
- **Hazardous**
- **Polluting**
- **Unchanged for 50 years**





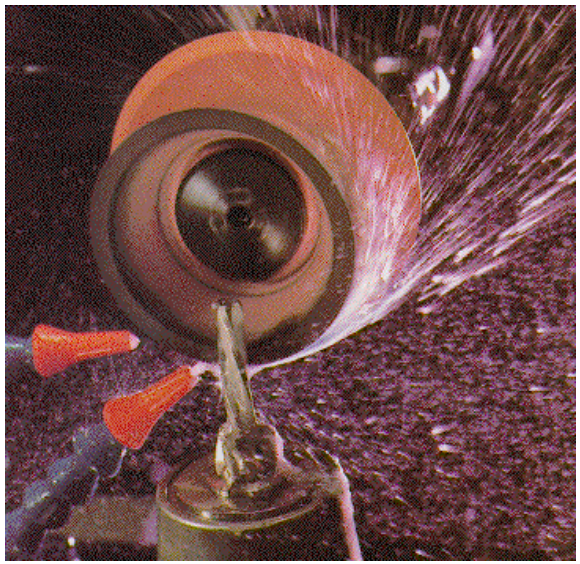

Machining Fluid Improvements

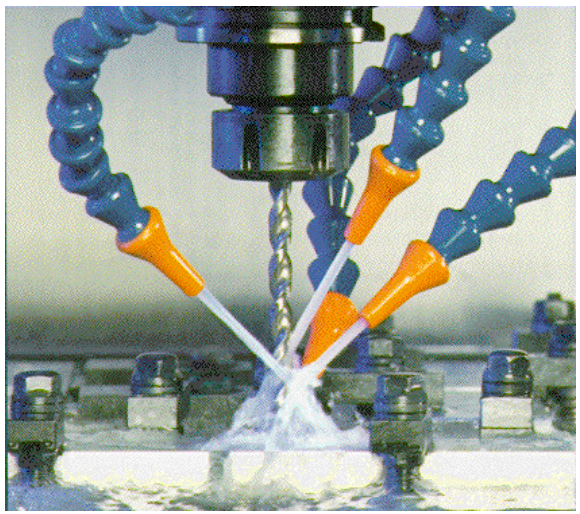
Who cares?

- Workers who get sick
- Environmentalists / U.S. EPA
- Academics

Who doesn't care?

- Most U.S. Manufacturing Engineers
- Most U.S. Lawmakers (today)
  - *The two most important change agents!*





Machining Productivity Improvements

Who cares?

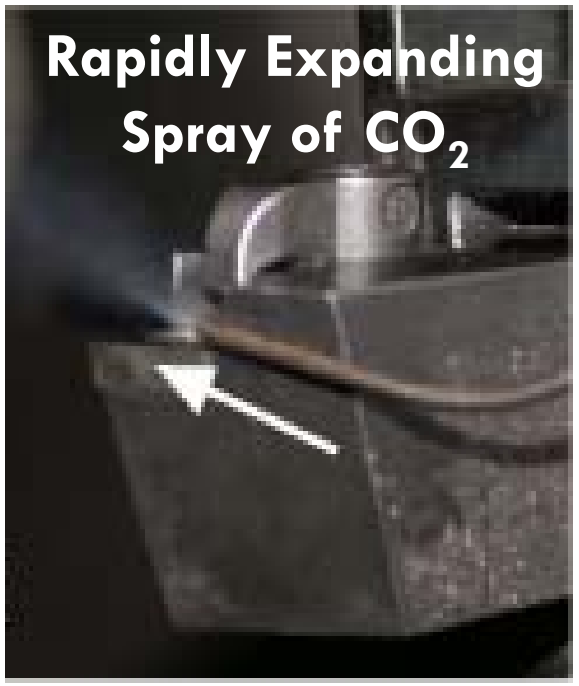
- Everyone making a profitable metal product!
  - Machining fluids impact: revenue generation rate, tool costs, labor costs, machine tool costs

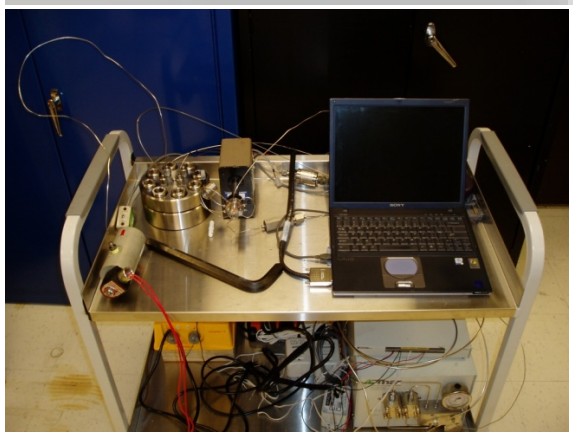
New Materials = New Machining Challenges

- Ford: Flex-fuel and clean diesel vehicles
- Boeing: 787 aircraft
- Caterpillar: Fuel efficient construction equipment

CO_2-Based Machining Fluids are Better than Aqueous:

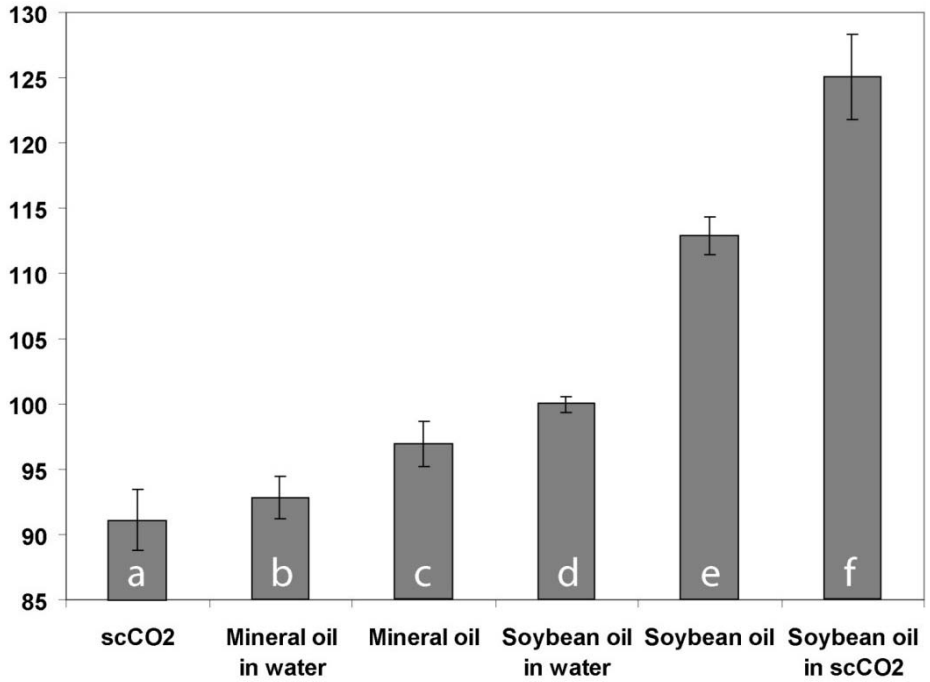
- Increase productivity
- Increase revenue
- Reduce costs
- Have only 2 components
- Can be retrofit to existing systems
- Eliminate health hazards
- Reduce environmental impact
- Developed @ UM



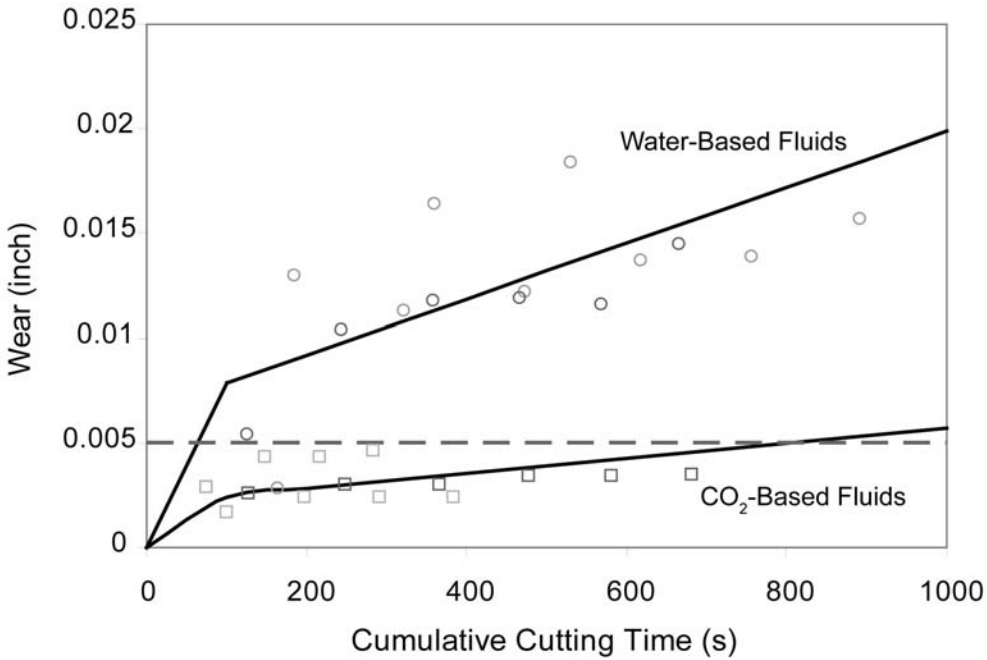


CO_2-Based Machining Fluids are *the best ever invented!*

25% Increase Lubrication Performance

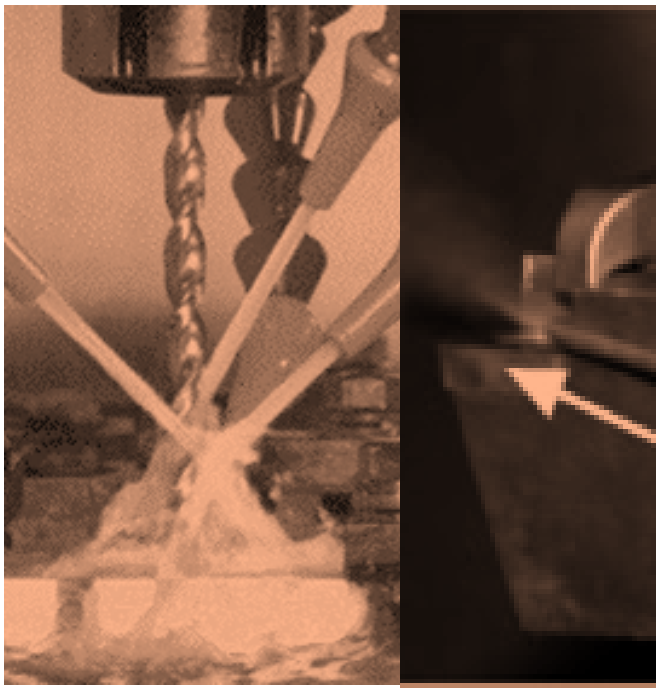


Enormous Increase in Tool Life (4-25x in Titanium Machining)



CO_2-Based Machining Fluids are *CLEAN TECH*

- ***Lower Life Cycle Greenhouse Gas Emissions***
  - *CO_2 is captured from ammonia production waste*
  - *CO_2 use rate is low*
  - *Process energy not increased*
  - *Soybean oil is renewable*
- ***No aqueous waste***
- ***No hazardous chemicals***
- ***No biological growth***
- ***No need to clean parts afterward***



CO_2 fluids are *profitable* for companies that are…

… ***production-rate limited***

- defense and aerospace

… ***switching to advanced materials***

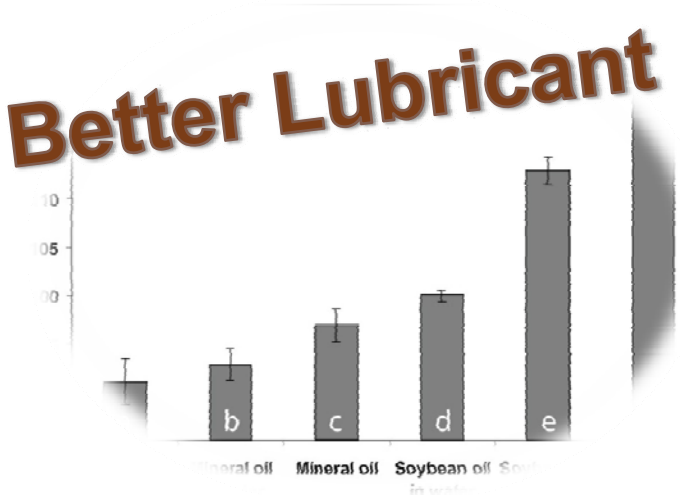
- automotive and heavy industrial

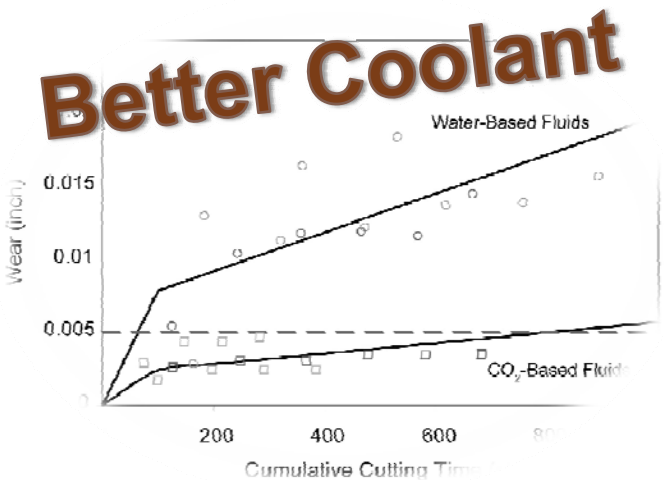
… ***strictly regulated***

- bio-compatible for implants, etc.

… ***making very small parts***

- watch making, etc.





Even automakers can profit !

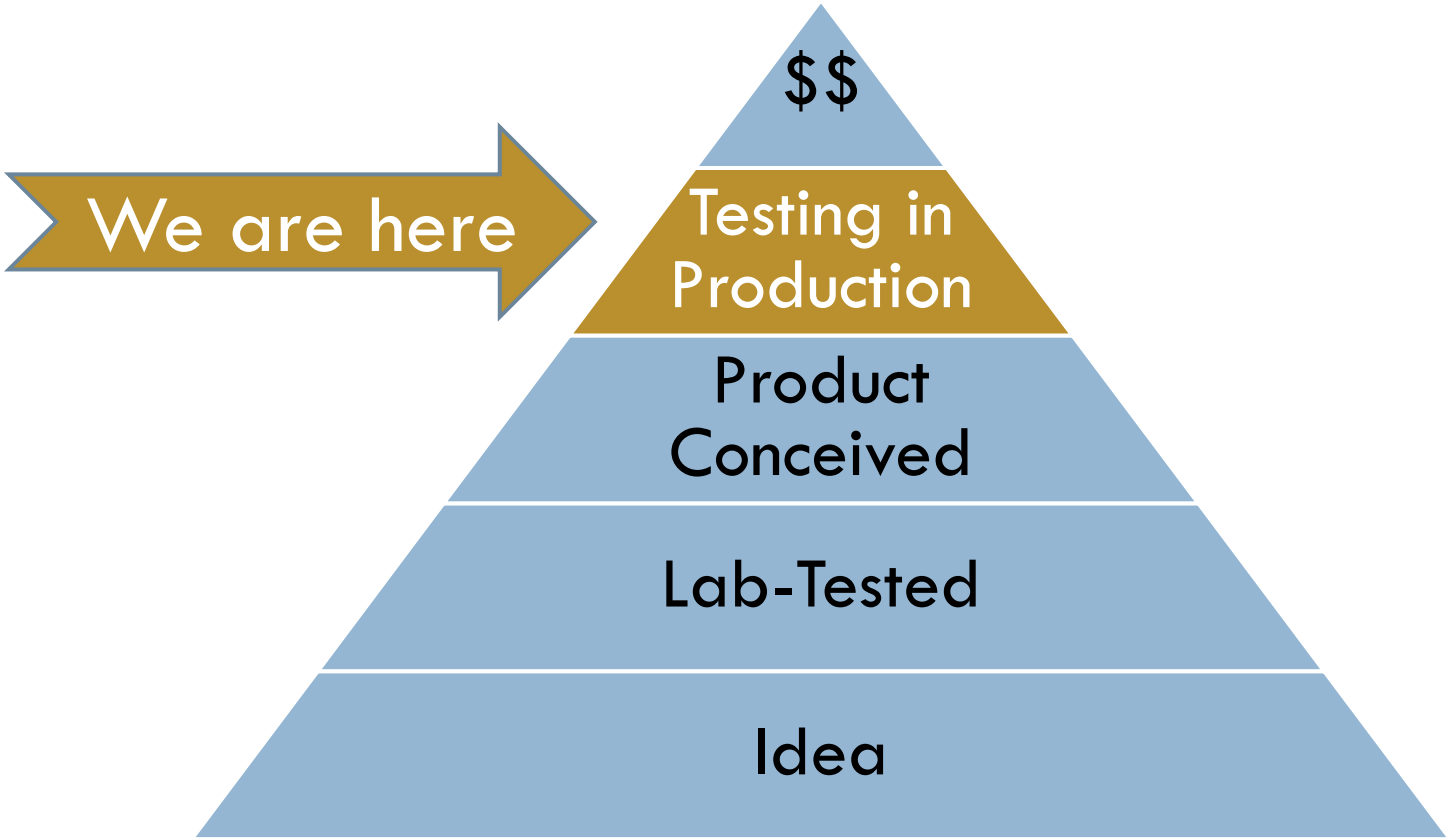
Expected Results from Ford Research (~$5M/yr):

- Valve seat production: (1.5$M/yr)
- Cylinder blocks: ($3.5M/yr)
  - Avoided future tool/labor costs
  - 5% of the opportunities

- ***Profit for Boeing could be much larger***
  - *787 starts with 200,000 lbs of titanium*
    - *Only 25,000 lbs fly away!*

Sizable Market; Patent Pending

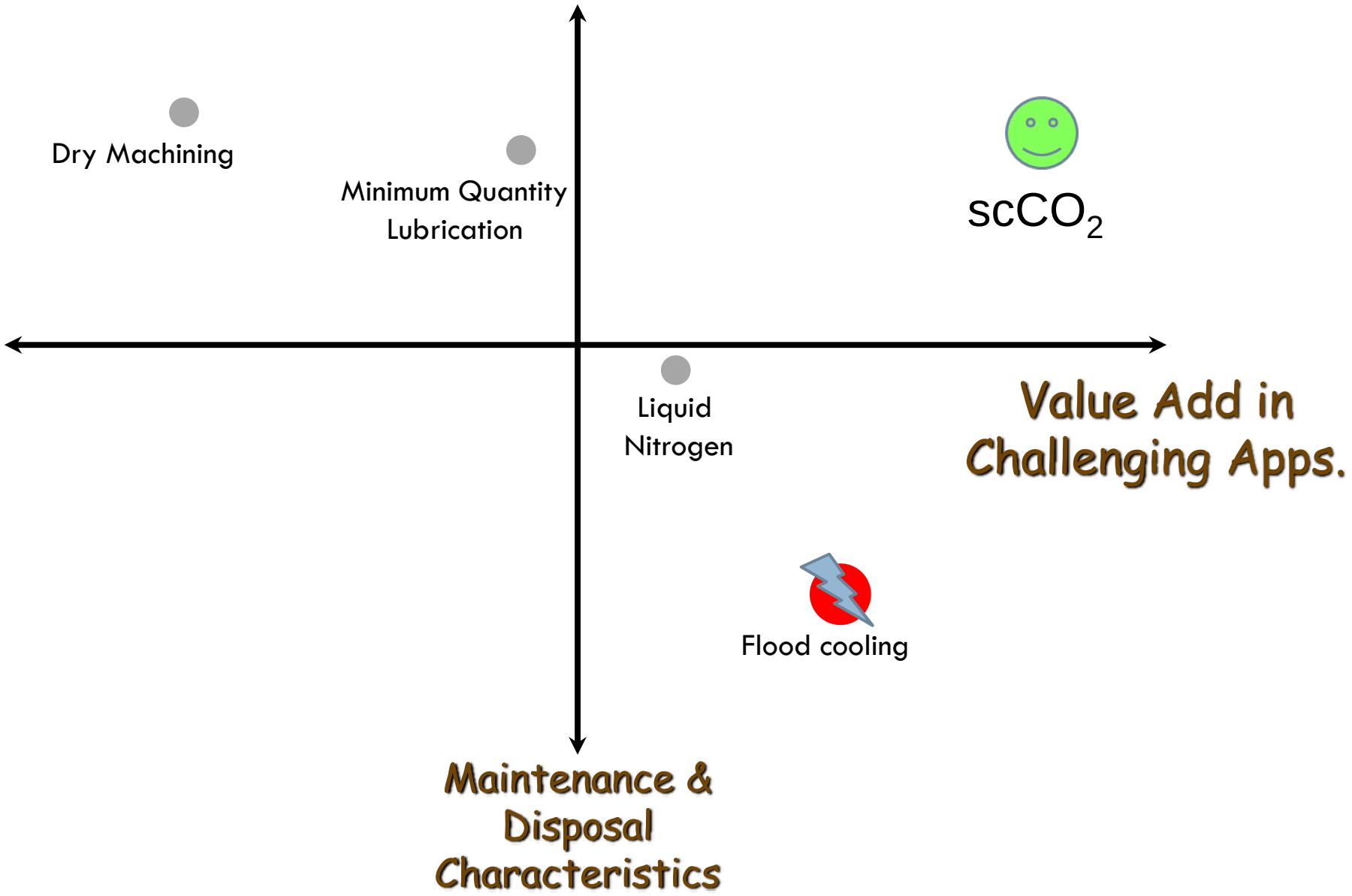
- Machining Fluid Market: $1B (North America)
- Maintenance and Disposal: $1B
- Metal Fabricated Products Industry: $300B



The Supercritical CO_2 Competitive Advantage

Customer Needs	Increase/Decrease Flowrate; Change Chemistry	$scCO_2$
Faster machining	Steady state with only incremental performance gains since 1950	**Breakthrough increase in machining speeds (>20%)**
Fewer Tool Changes	1 tool change every 120 min.; change might take 30 min. (Titanium)	**Increase tool life above 1000 min.**
Eliminate Disposal & Health Risks	Only modest gains possible	**No disposal** **No health risks**

$scCO_2$ in the Competitive Landscape



We have a business opportunity; **We need a business plan**

There are many directions this technology could go…

1. **Start-up company: sell equipment and consumables**
2. **License to machine tool builders;**
   - **Start-up would sell consumables**
3. **License to fluid suppliers**
4. **License to OEM on application-specific basis / consult**

- Funding for specific applications needed to expand proven applications outside of automotive.
- For more : Dan Broderick, Director of Tech Transfer in CoE
  - danbrod@umich.edu, 734-615-5386

Next Generation Machining Fluids

THANK YOU

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