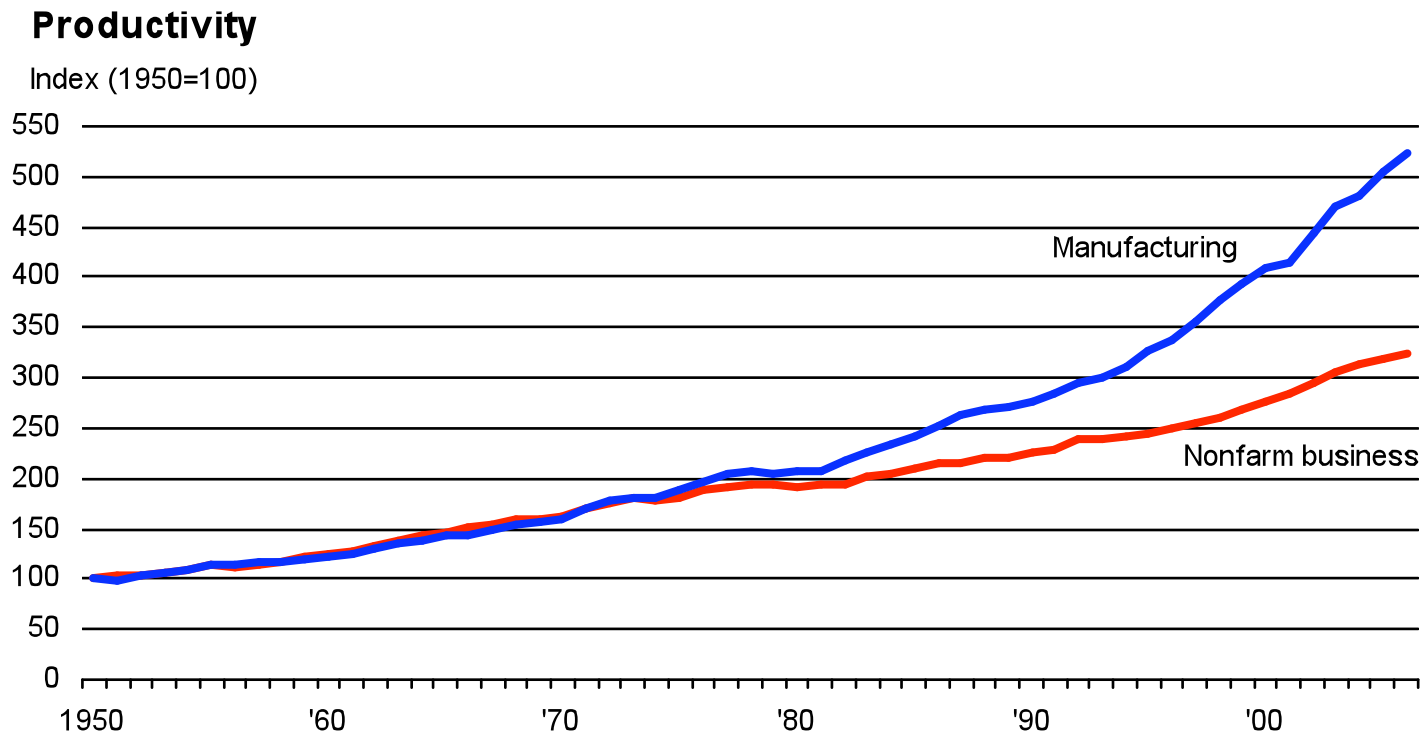


Extremely Agile, Adaptive, Responsive and Robust Manufacturing

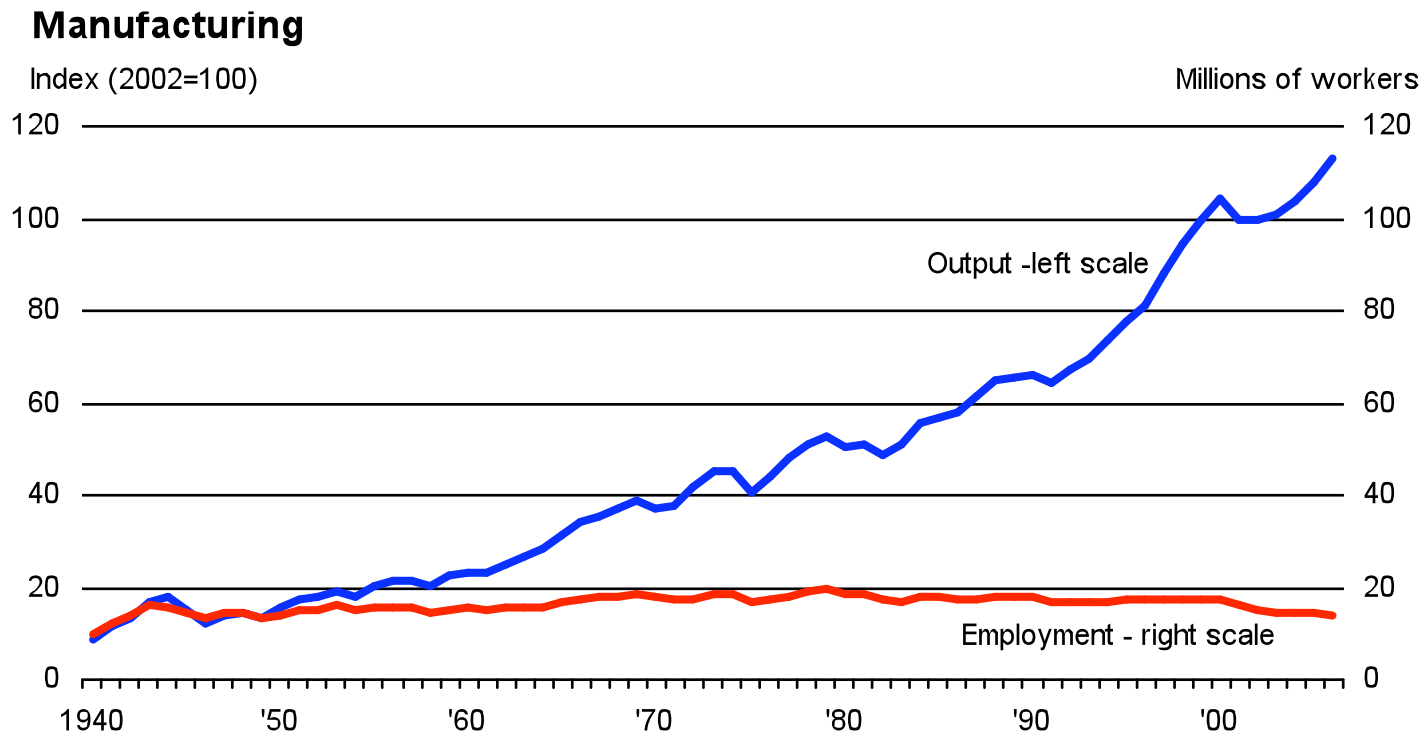
Rodney Brooks
Heartland Robotics
(formerly iRobot & MIT)

US Manufacturing Productivity Has Increased Faster Than Other Productivity



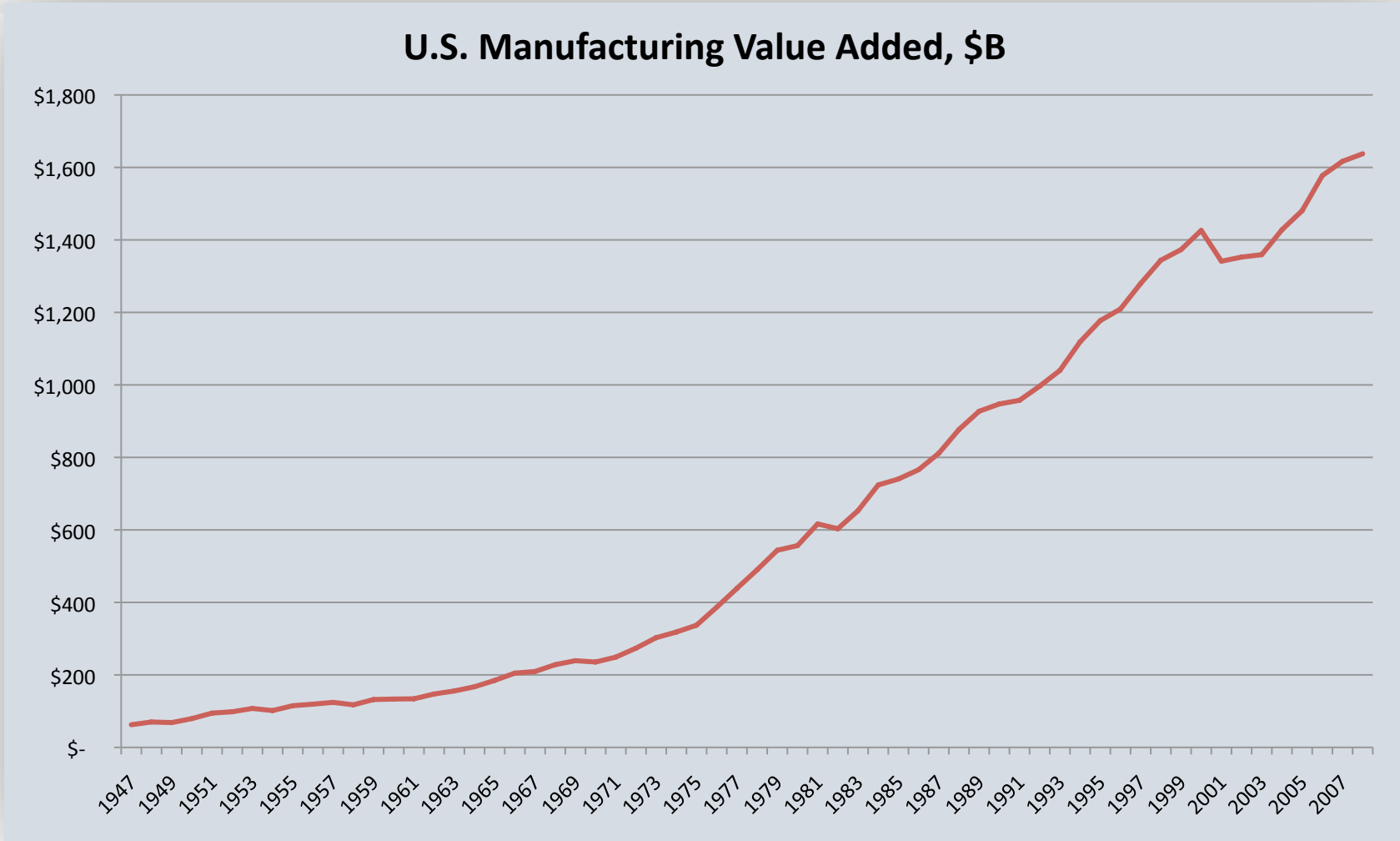
Source: Federal Reserve Bank of Chicago, Oct. 2007

US Manufacturing Output Increased 3.7% per Year with 60 Year Mostly Flat Employment

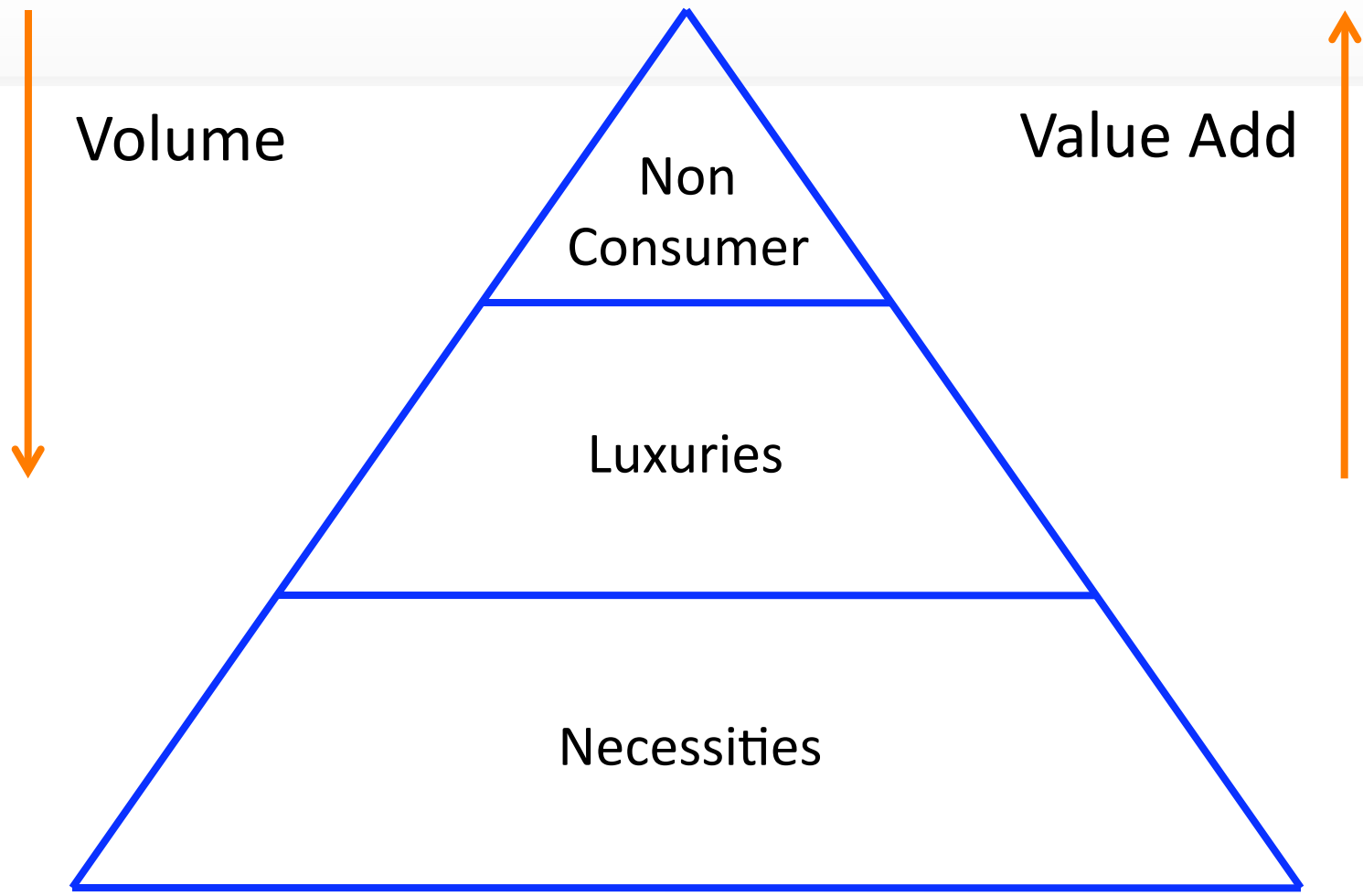


Source: Federal Reserve Bank of Chicago, Oct. 2007

U.S. Manufacturing Value Added Remains World's Largest, But Growing Slowly



Source: U.S. Bureau of Economic Analysis

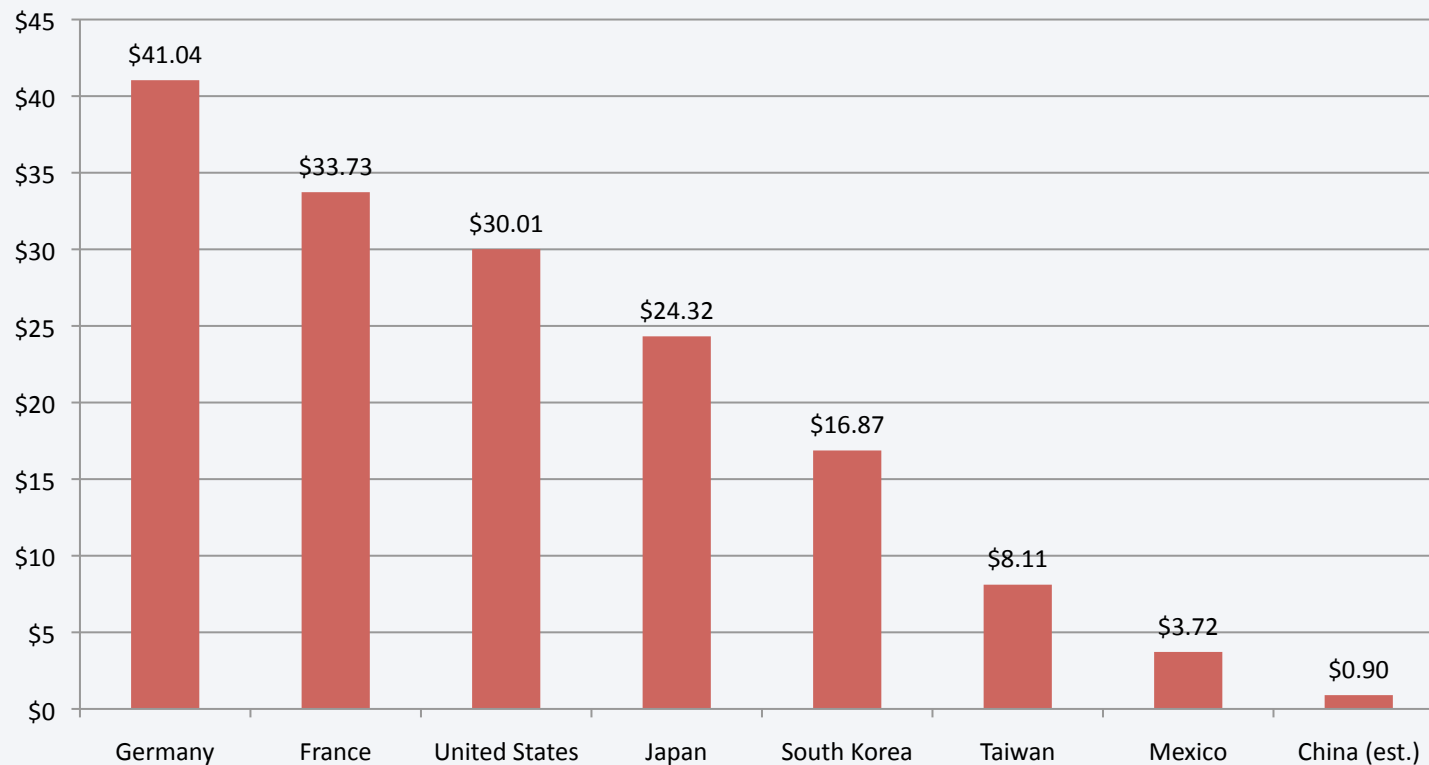


US Manufacturing Since WW2



Labor Cost Increases Move Low Value Goods

2006 Hourly Manufacturing Compensation Cost, all NAICS
ex. Petro/Coal, US\$



Sources: U.S. Bureau of Labor Statistics; China est. from Lett and Banister, U.S. BLS, "Labor Costs of Manufacturing Employees in China: an Update to 2003-04"; Deloitte & Touche survey of North American manufacturers

Low Cost Goods, E.g., Wal-Mart

- 2007: Direct Wal-Mart imports from China, \$32B
(Financial Times Apr 7, 2008)
 - Approx 10% of all Chinese imports to the US, \$321B (US Census Bureau)
- Hard to account exactly, but many other indirect imports sold by Wal-Mart not counted in this number
 - e.g., \$900M by Hasbro (2008 Hasbro 10K with SEC)
 - many other US brand names, e.g., Black and Decker
- Leaves US with a significant trade deficit with China; \$259B in 2007 (US Census Bureau)
- Trade is a driver of strategic pressures

Low End Manufacturing



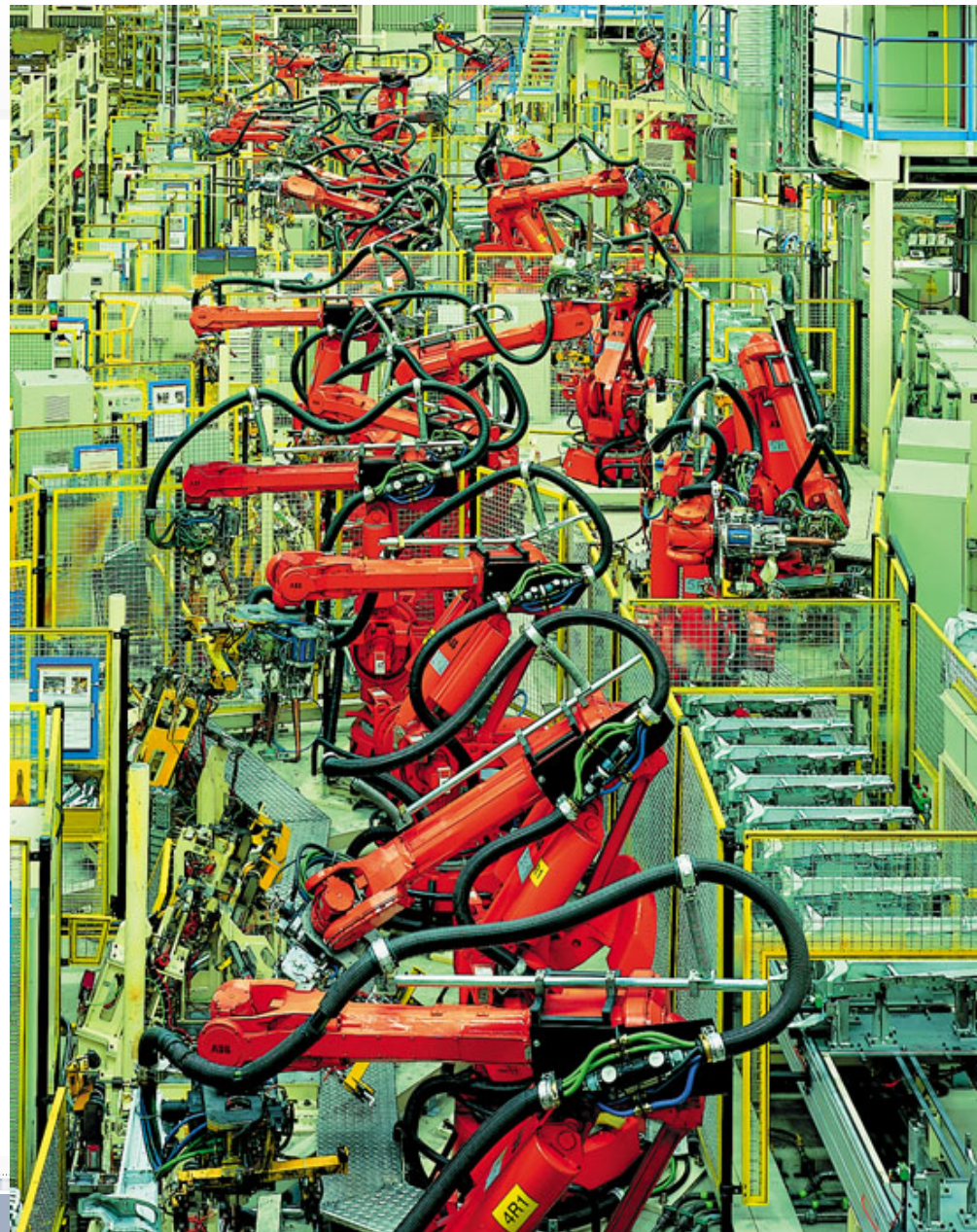
Workers are “Robotic”



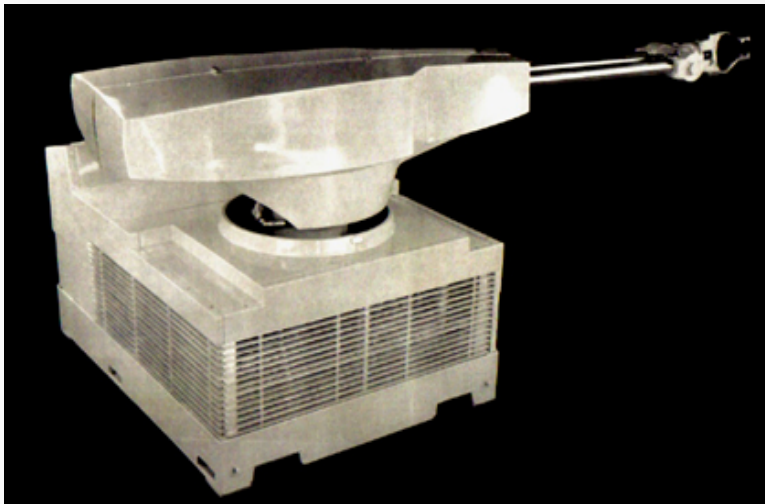
Each Does Simple Task



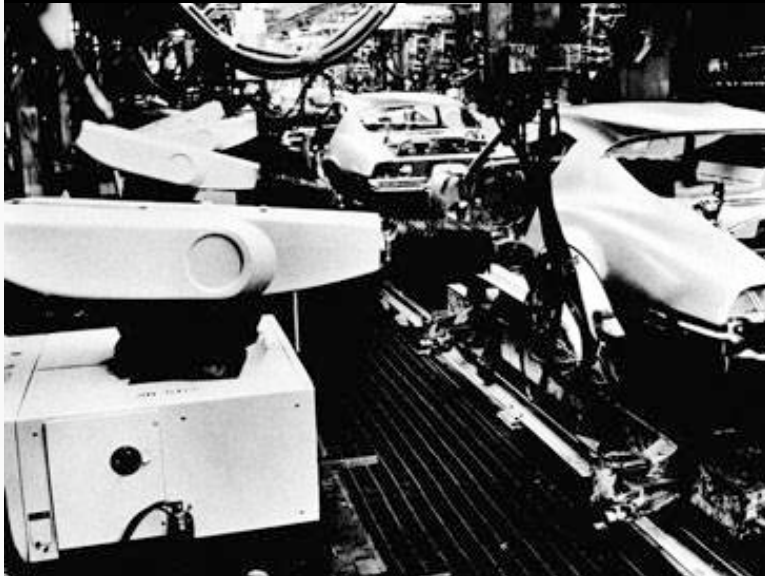
Robots?



World's First Industrial Robot

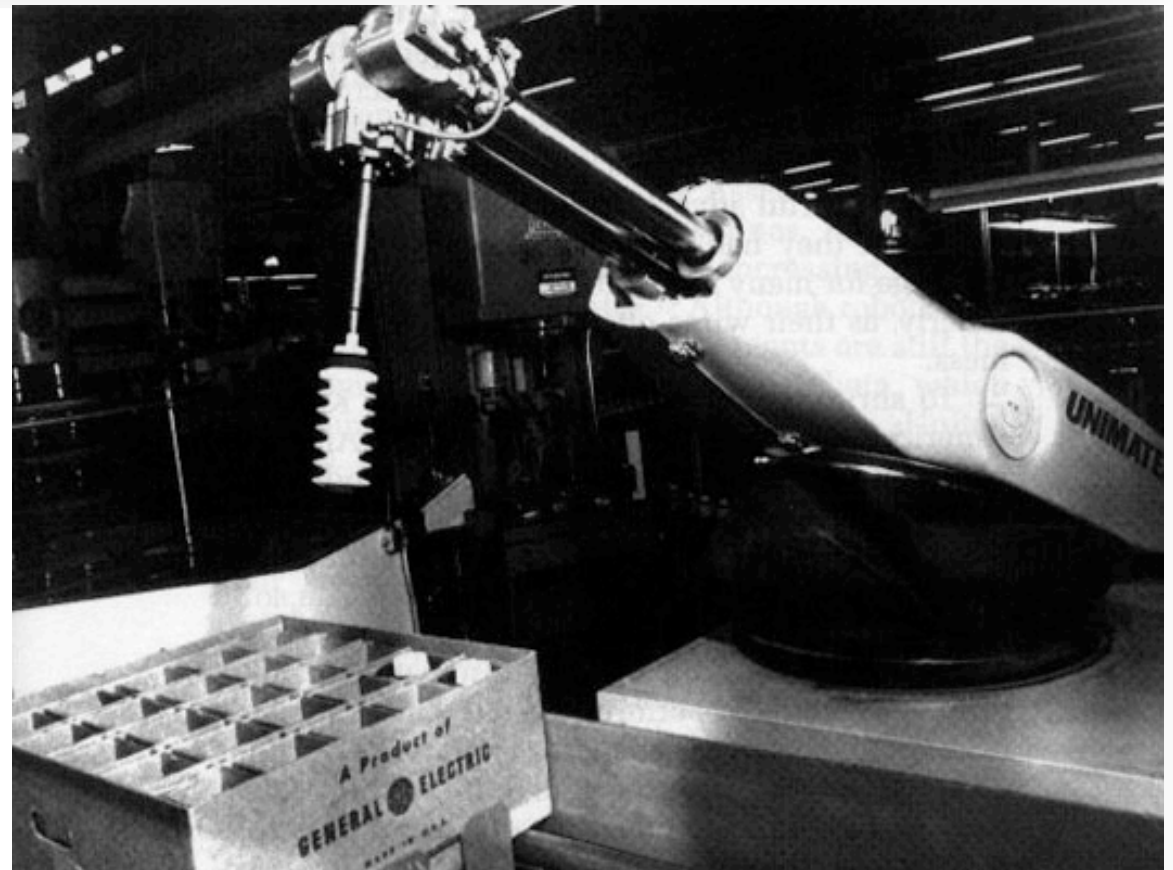


- The Unimate (Unimation)
 - by Joe Engelberger
- First installed in a GM factory
 - 1961
- Later bought by Westinghouse
 - then sold to Kawasaki



Computation and Sensing Expensive

- No computer
- No sensors
- Same motions repetitively
- Cost of systems integration is 10 times robot cost



Today's industrial robots are much the same; they have not yet exploited the microprocessor/network revolution

Today's Manufacturing Robots

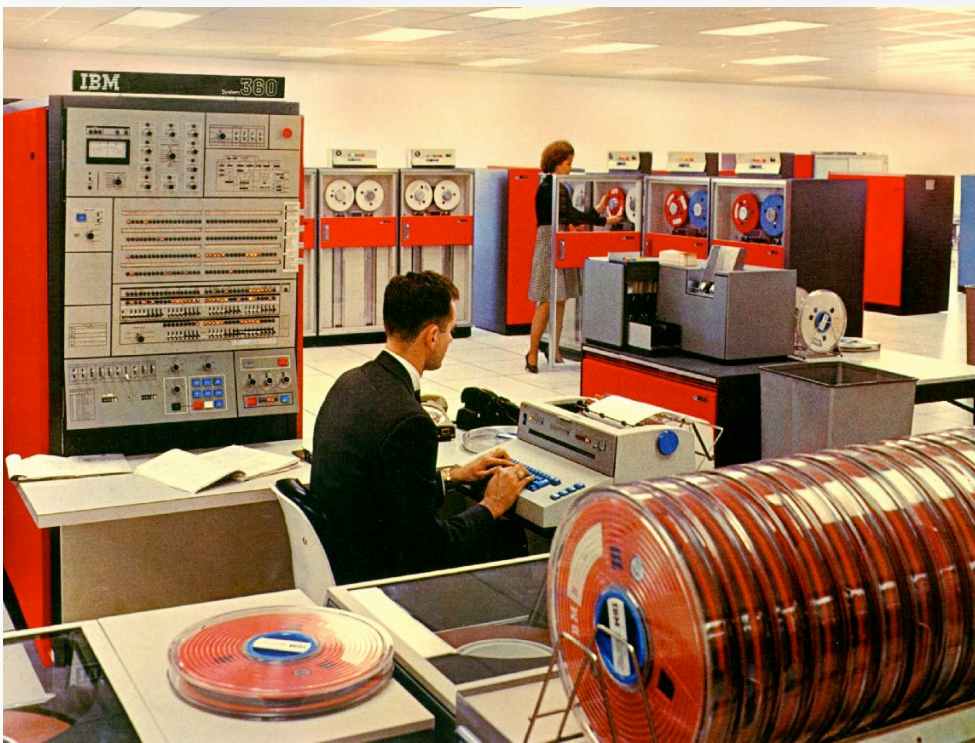


- Unsafe for people to be around
- Engineered to be precise and repeatable, not adaptable
- Can only operate in very structured environments
- Their application is limited
- Integration cost is 5 to 10 times capital cost

Distribution of # of US Manufacturing Companies By Revenue

Min	Max	# of Companies
\$0	\$500,000	158,129
\$500,000	\$1,000,000	56,553
\$1,000,000	\$10,000,000	108,029
\$10,000,000	\$100,000,000	31,712
\$100,000,000		44,294
		398,717

Transformation of Computers



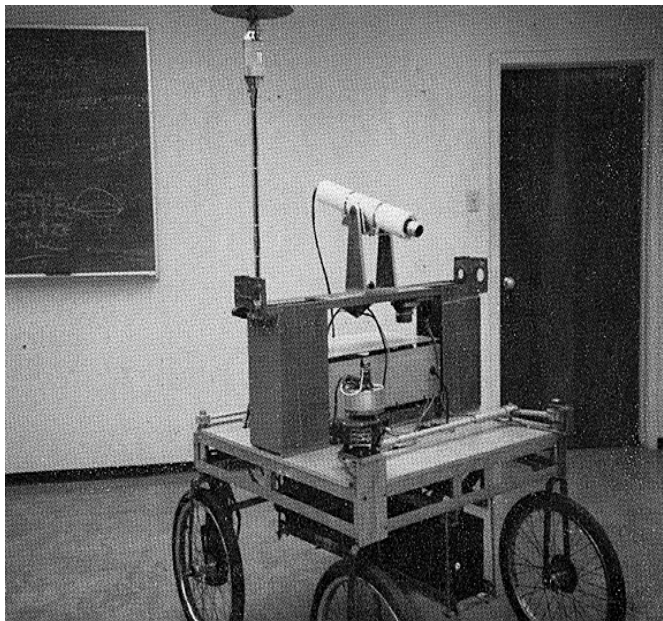
Went from top-down
model to bottom-up
empowerment of
individuals

Personal Computer and Internet Empowers

- Newer, nimbler, local services with global reach, e.g.,
 - graphics production
 - publishing (Web, and even paper)
 - language translation services
 - movie editing
 - music production
- Large scale decimation of existing models, being replaced by new
 - retailing
 - music recording
 - newspapers

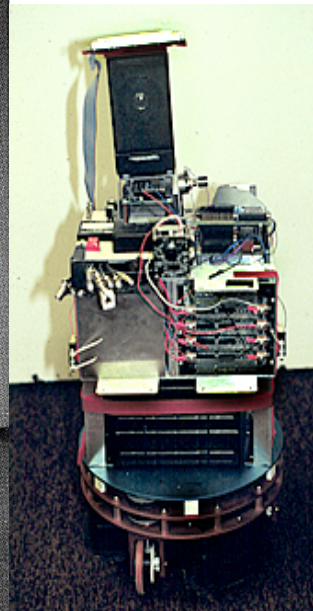
Robotics Exponential Growth

1979
20m/6hrs



The Cart, Stanford

1992
2000m/6hrs



Polly, MIT

2005
200km/6hrs



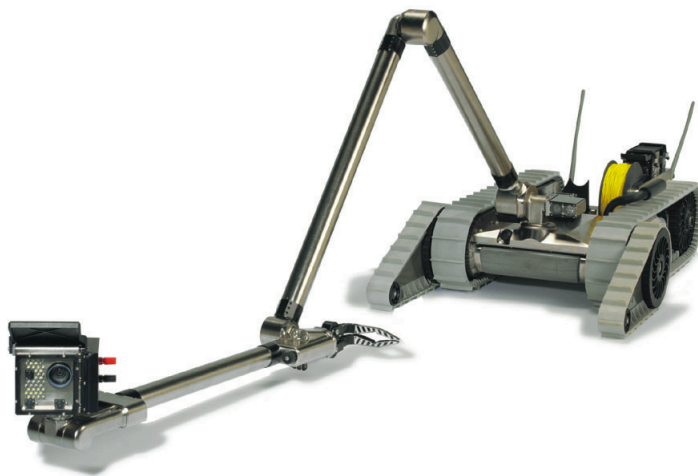
Stanley, Stanford

Robots In Unstructured Environments



Uptake in Unstructured Environments

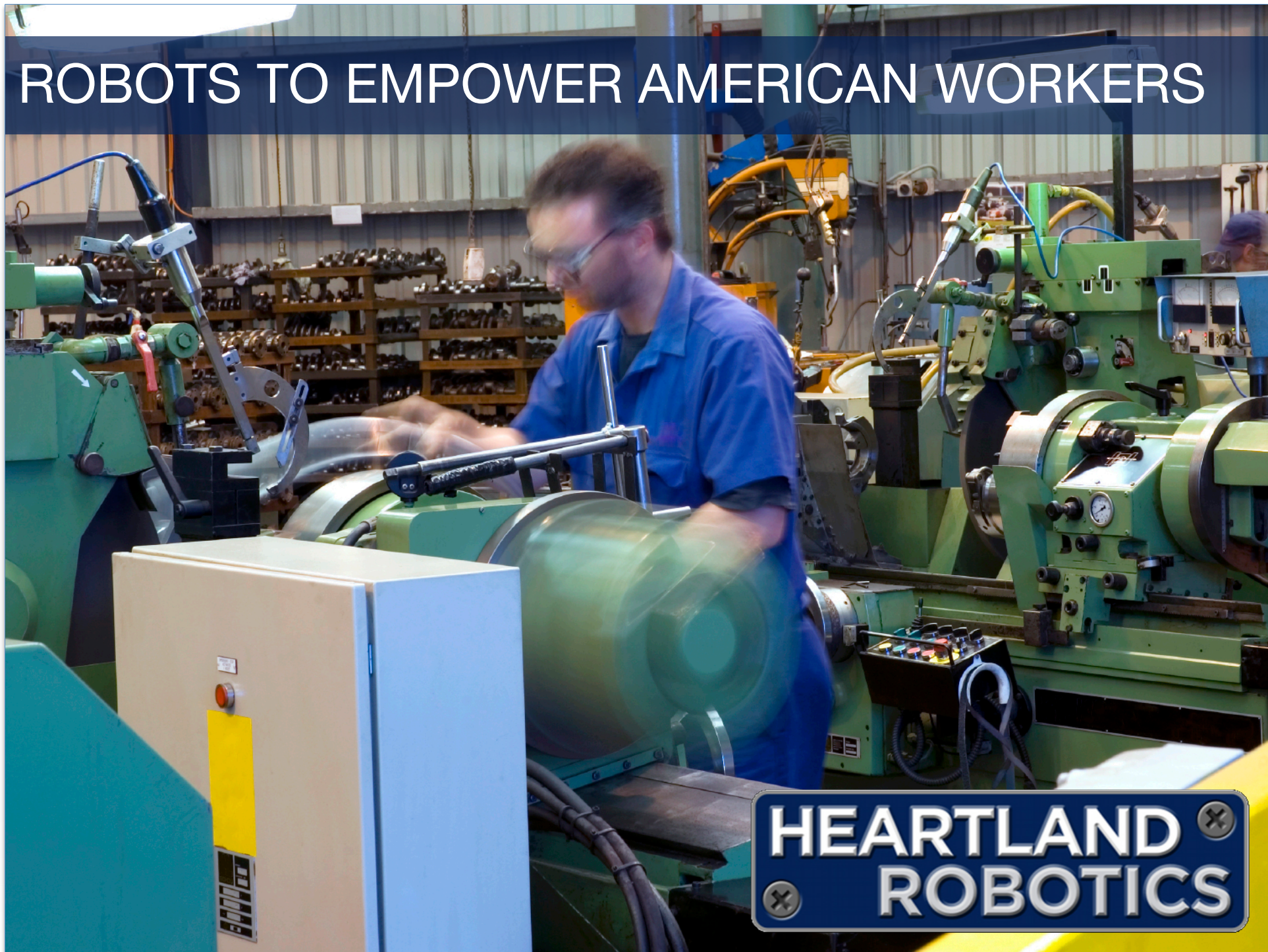
	June 2002	January 2010
Ground robots in US military	0	> 7,000
Robots in people's homes	0	> 5,000,000



Why Have Things Taken Off?

- Computation and sensors have gotten exponentially cheaper for the last 50 years
- Research in computer vision and in simultaneous localization and mapping have made major strides in the last ten years
- For certain tasks robots have passed a usability threshold that makes them useful to untrained people

ROBOTS TO EMPOWER AMERICAN WORKERS

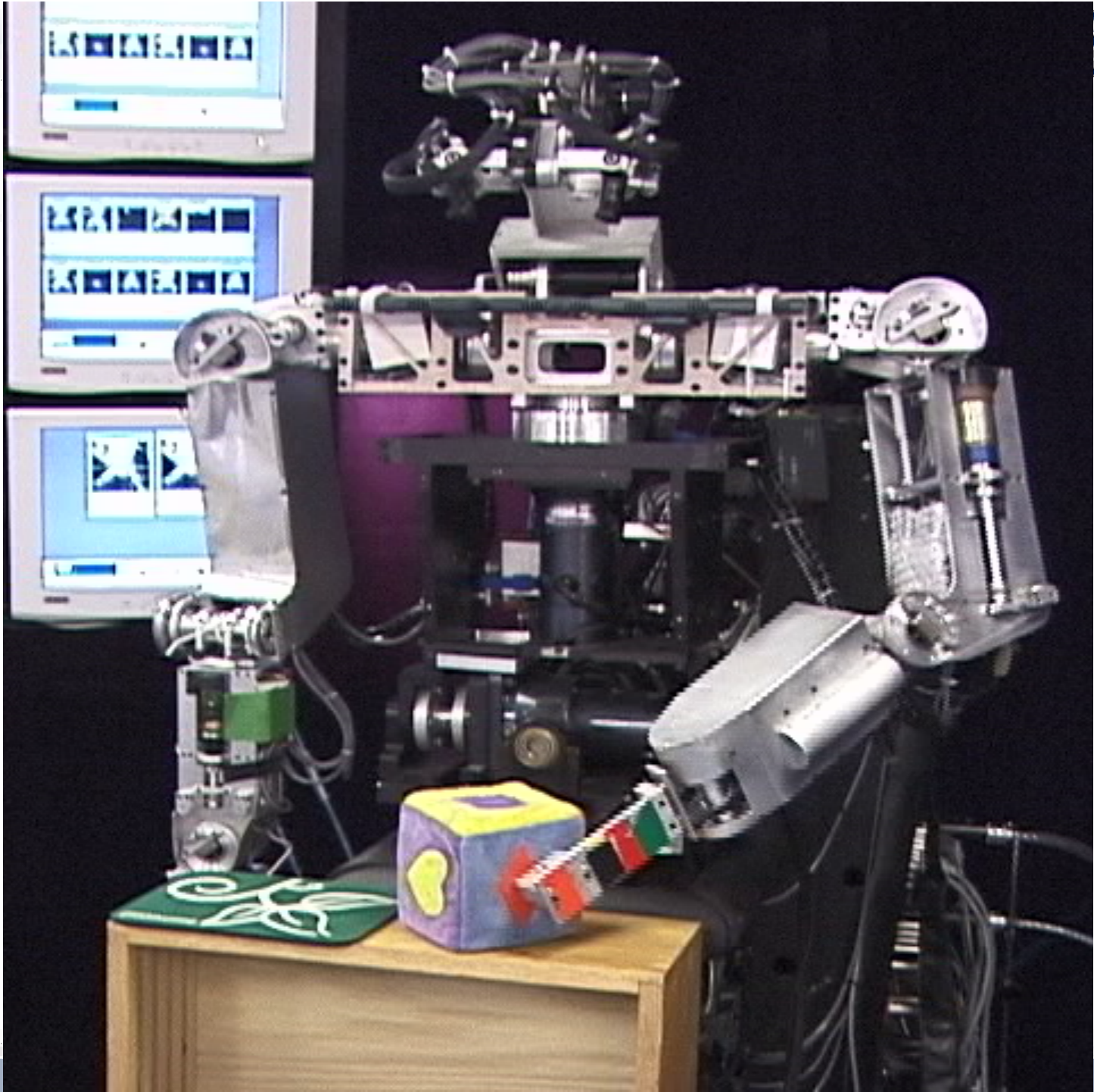


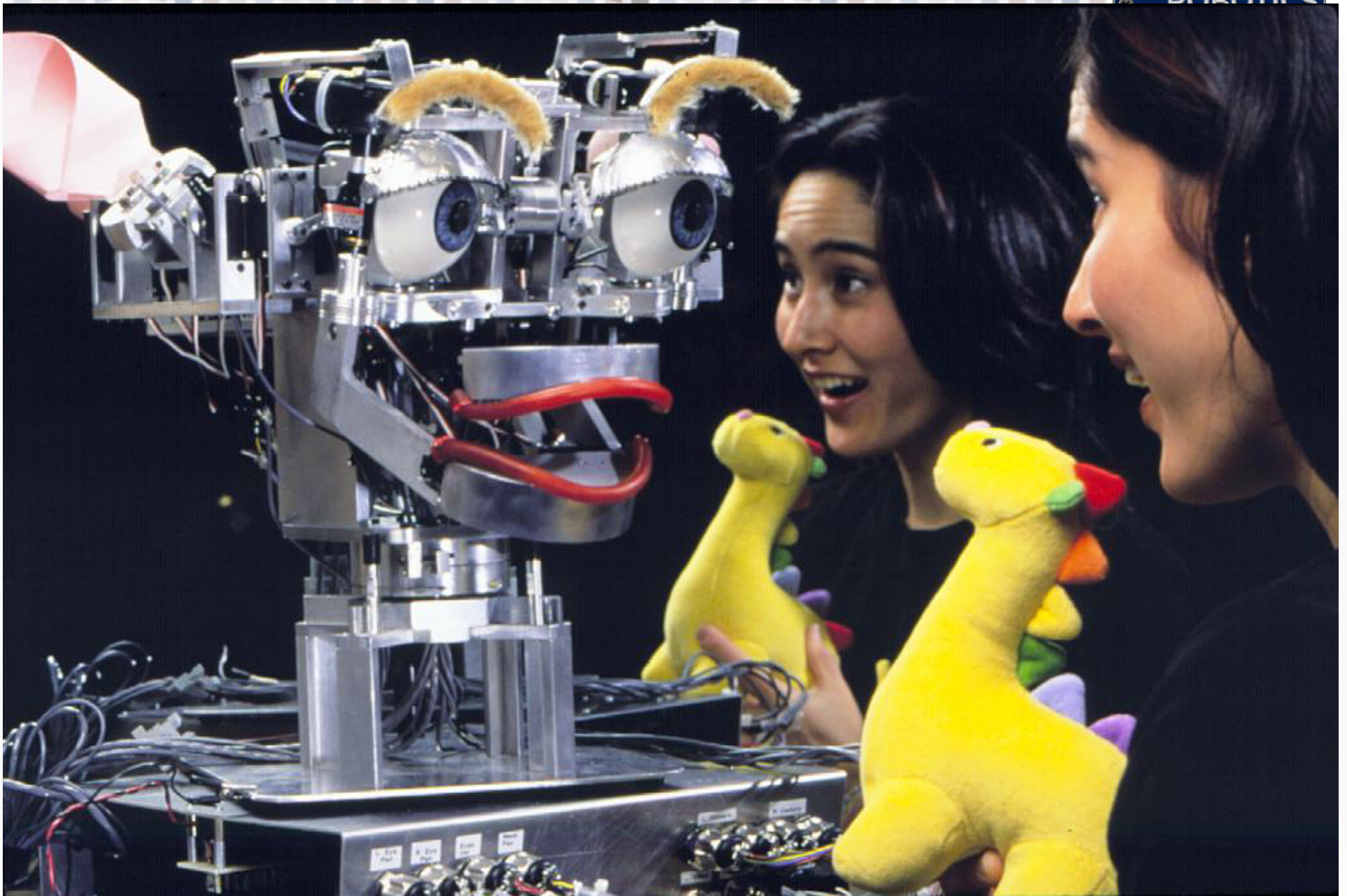
HEARTLAND 
ROBOTICS 

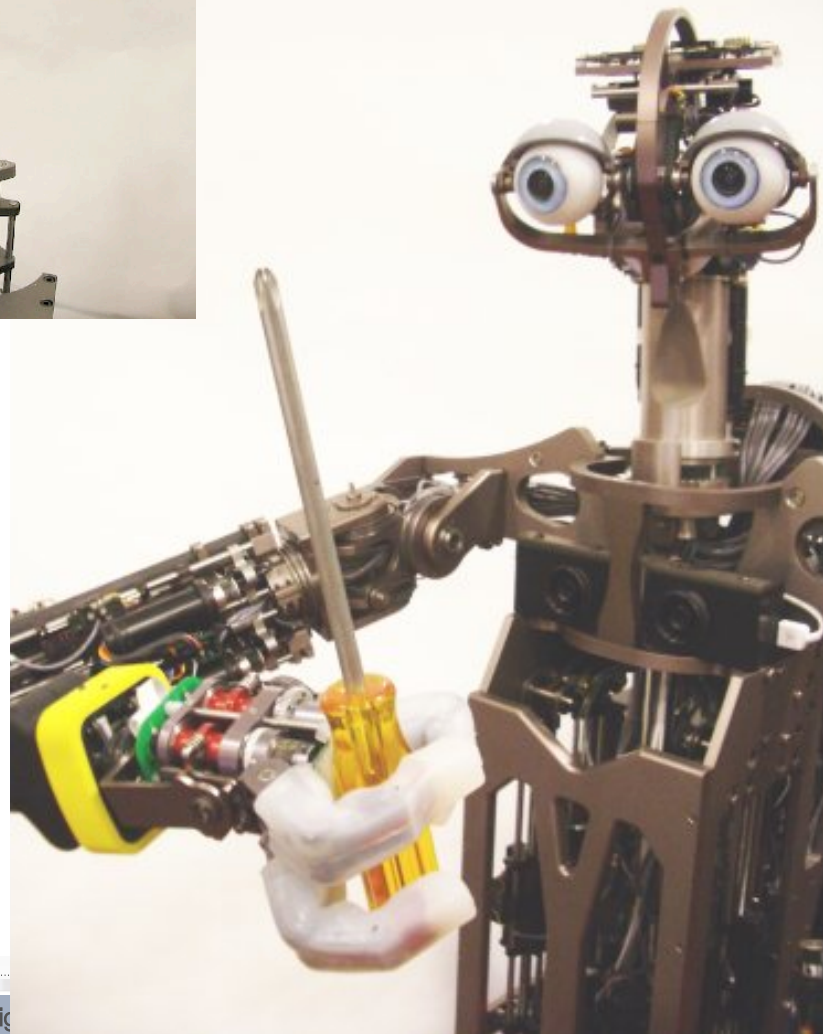
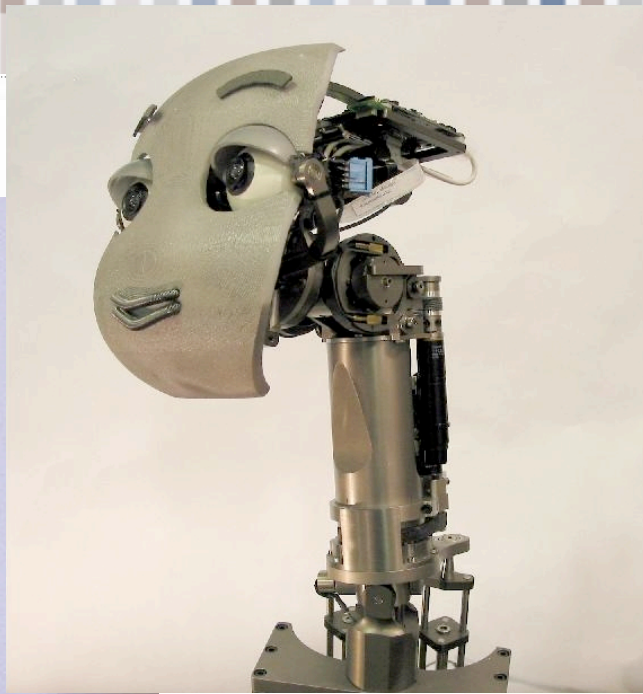
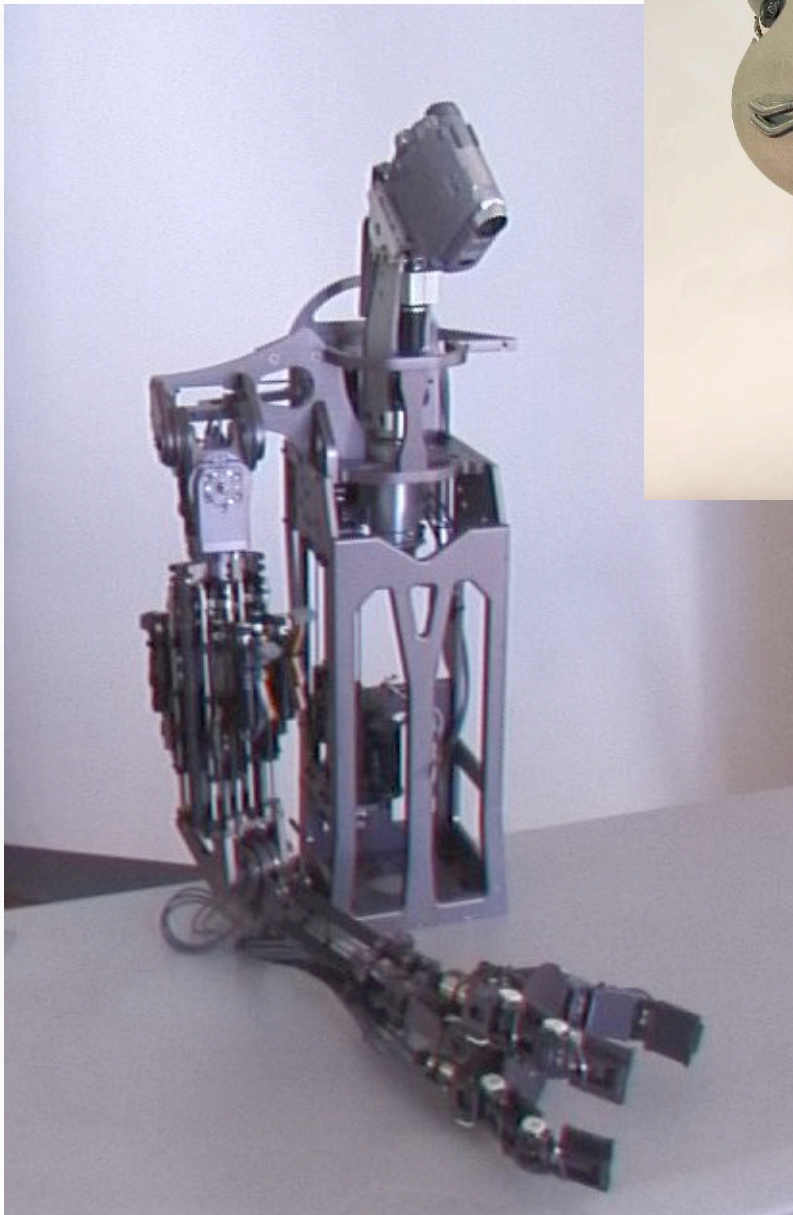
Robots for Manufacturing Workers

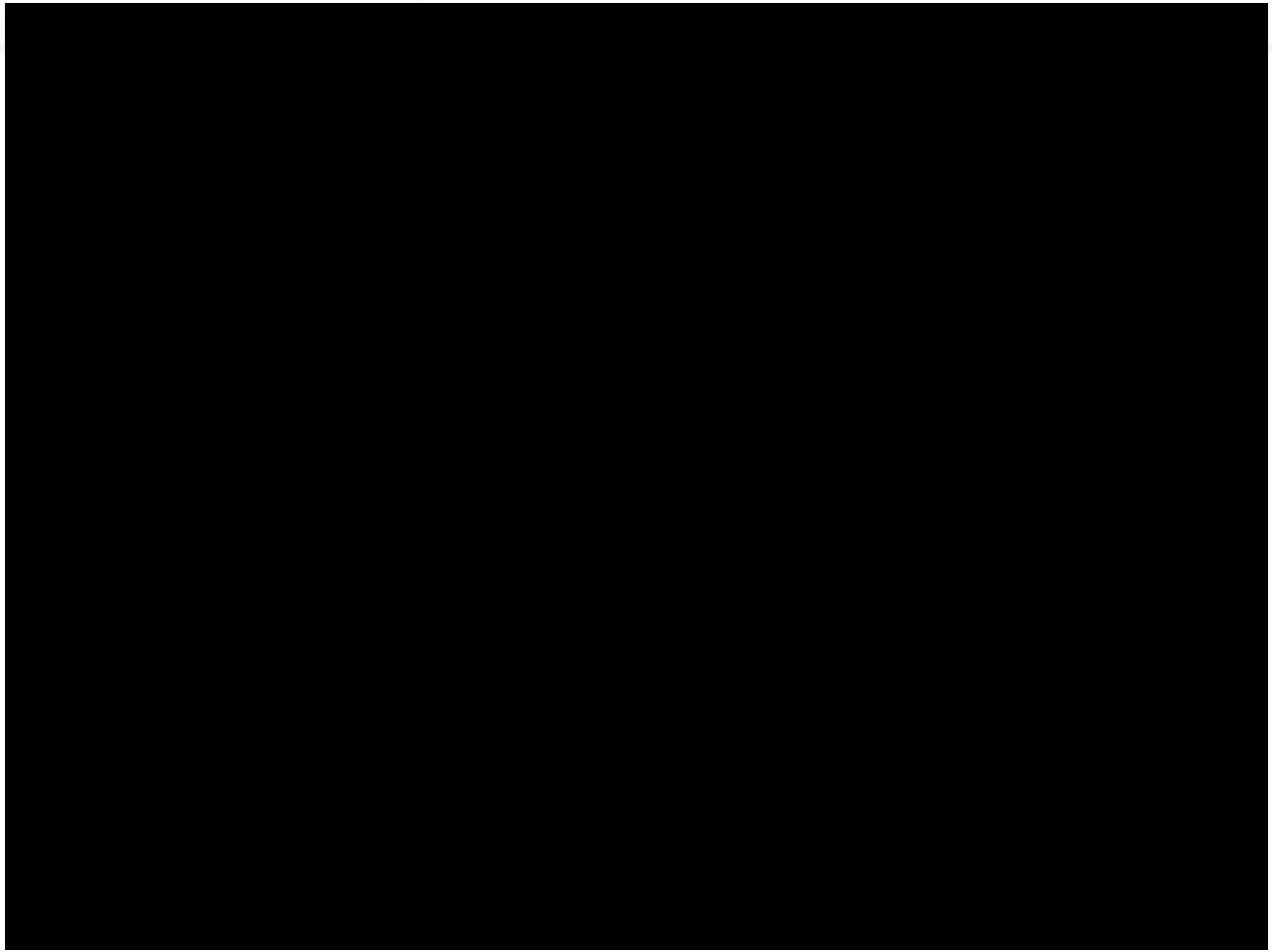
- Safe to interact with at close quarters
- Easy and intuitive to control
- Robust and reliable
- Empower people to do things faster, easier, and better











New Robotics Capabilities...

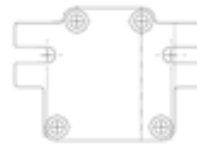
- Will revolutionize low end manufacturing and change
 - balance of payments
 - who the manufacturing powers can be
 - how the supply chain works
 - what the nature of manufactured goods are like
- Will trickle up to high end manufacturing
 - provide better and more dependable low end components
 - change the nature of high end manufacturing

This is a partial listing of recent awards

[See Thousands More Awards](#) ▶

Analogy: MFG.COM

Monday, January 10, 2011; Open RFQs



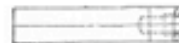
Telecommunications buyer in Carpinteria, California United States of America to a **Stamper** in Deerfield, Illinois United States of America
January 7, 2011 11:05 PM

[Award Details](#) | [Source Parts Like This](#) | [See More RFQs Like This](#)



Consumer Products buyer in La Canada, California United States of America to a **Machine Shop** in Mentor, Ohio United States of America
January 6, 2011 7:17 PM

[Award Details](#) | [Source Parts Like This](#) | [See More RFQs Like This](#)



Government Military buyer in Warrington, Pennsylvania United States of America to a **Machine Shop** in Nunica, Michigan United States of America
January 5, 2011 10:41 PM

[Award Details](#) | [Source Parts Like This](#) | [See More RFQs Like This](#)



Automotive buyer in Atascadero, California United States of America to a **Machine Shop** in Palmetto, Florida United States of America
January 4, 2011 7:49 PM

[Award Details](#) | [Source Parts Like This](#) | [See More RFQs Like This](#)



Government Military buyer in Roseland, New Jersey United States of America to a **Machine Shop** in frederick, Maryland United States of America
January 4, 2011 4:37 PM

[Award Details](#) | [Source Parts Like This](#) | [See More RFQs Like This](#)



Oil & Gas buyer in Houston, Texas United States of America to a **Machine Shop** in Clarksville, Tennessee United States of America
December 27, 2010 4:52 PM

[Award Details](#) | [Source Parts Like This](#) | [See More RFQs Like This](#)

Today's Total	77,047,396 USD
Machining	44,079,452 USD
Home Textiles	11,431,188 USD
Assembly	9,529,887 USD
Casting	2,705,277 USD
Stamping	1,962,198 USD
Molding	1,933,214 USD
Fabrics & Trim	1,290,046 USD
Extrusions	1,174,859 USD
Fabrication	1,153,028 USD
Apparel	1,148,559 USD
Pumps, Valves & Fittings	201,738 USD
Forging	169,911 USD
Tube Modification	109,475 USD
Tool, Die & Mold Making	86,925 USD
Industrial Equipment	47,427 USD
Fasteners & Hardware	21,011 USD



Only Possible Now

Enablers

- Universal availability of Internet
- Web standards and browsers
- High-end 3-D CAD and spreadsheets for personal computers
- Overnight shipping services

Result

- Tiny (1 person & up) entrepreneurial companies (high school level education often) can engage in national marketplace
- Small run prototyping and manufacture can turn around complex projects from office in 48 hours

What would worker empowering robots lead to, besides bringing low-end manufacturing back to US?

E.g., Plausible New Manufacturing Process

- Franchised “factory pavilions”, all over the country
- Entrepreneurial “micro companies” lease space
- Name brand franchise bids on building multi-10K lots of goods for national product brand
 - standardized drawings and manufacturing documents
 - requestor actually wants multi-100K but also wants to minimize warehousing and cross country transport
- Within pavilion micro companies bid on supplying parts, assembly services, packout, etc.
- Locally manufactured goods get to distribution center/retailer within days

E.g., Another Plausible Trend

- Like locavore food, locavore style & production
- Revitalization of craft
 - with appropriate flexible automation, craftspeople could manufacture at scale
 - craftspeople could become the champions of local community, and leaders in local style
- Regional strengths and craft communities could grow and become regional identities
- International airports worldwide could have unique stores!!!

A New Vision For American Manufacturing

Smart and productive:

- skilled workers producing *both* high value and mass market products
- robots take over the simple cases of the simple tasks freeing workers to be smart
- robotics and STEM education intertwine to support each other

Industrial revolutions:

1. muscles replaced by mechanically distributed power (UK - 1780)
2. electrical power allowing redistribution (USA - 1900)
3. computational intelligence between workers and work (USA?? – 2010)

HEARTLAND
ROBOTICS

