Past, Present, and Future of ISE in Manufacturing

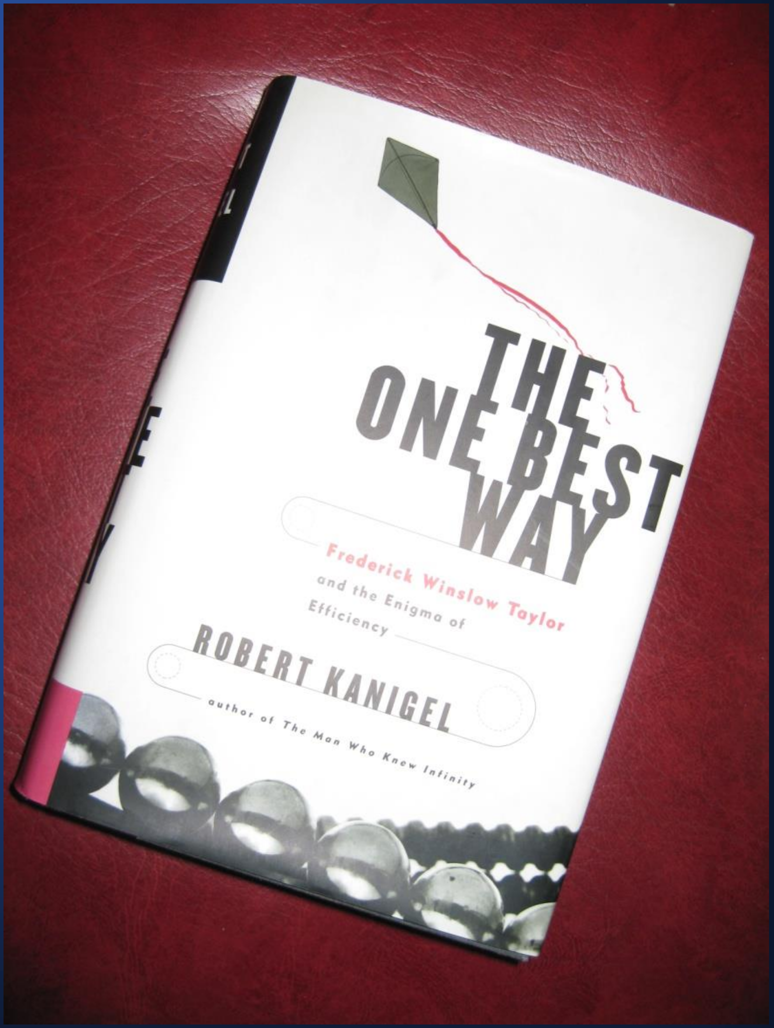
Leon McGinnis
Gwaltney Professor of Manufacturing Systems
Professor of Industrial and Systems Engineering
Professor of Mechanical Engineering
Georgia Institute of Technology

Abstract

ISE was born in Taylor's designed experiments with manufacturing processes. ISE grew into a mature discipline in the manufacturing heyday of the late 40's and 50's. Today, ISE is one of the fastest growing disciplines in developing economies of Asia and South America. But is the role of ISE in manufacturing beginning to diminish in the US and other developed economies? What are the modern manufacturing challenges that should be inspiring ISE researchers and practitioners, and how should we respond to those challenges?

The Past

Frederick W. Taylor



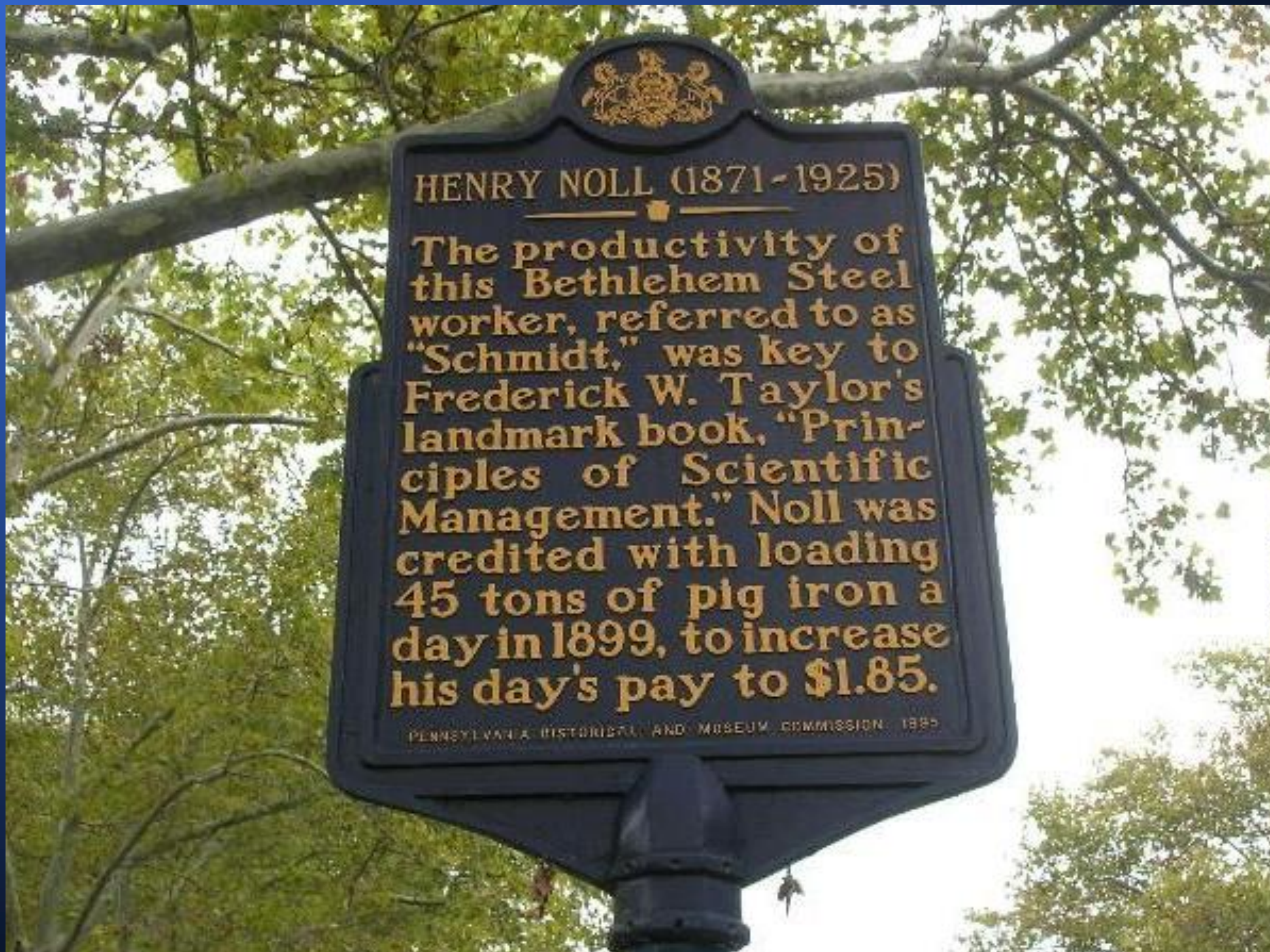
http://en.wikipedia.org/wiki/Lillian_Moller_Gilbreth

http://en.wikipedia.org/wiki/Frank_Bunker_Gilbreth,_Sr.

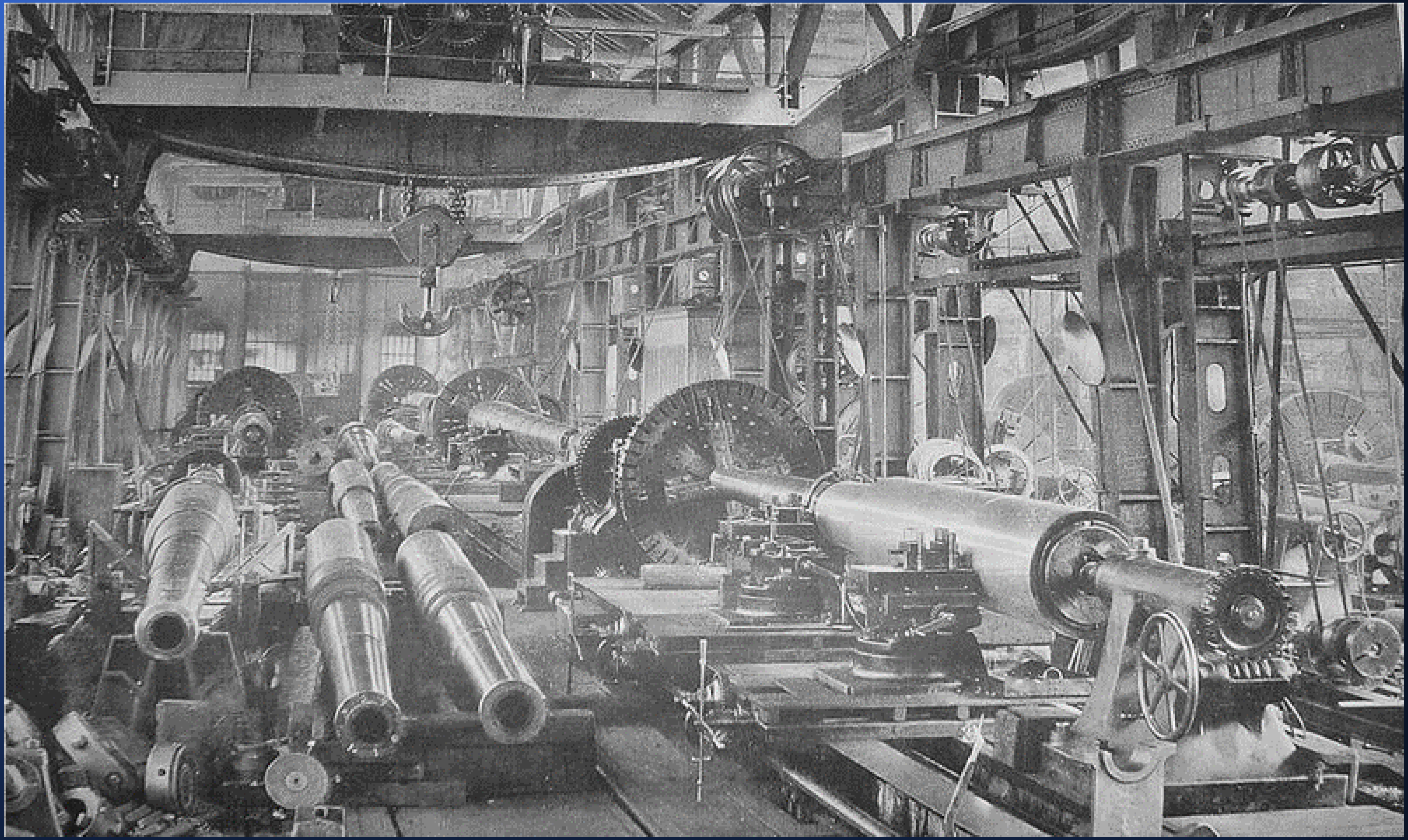
A brief summary of Taylor's beginnings

- Pig iron
- Cannon boring
- Maunsel White
- Carl Barth

Pig Iron


HENRY NOLL (1871-1925)
The productivity of this Bethlehem Steel worker, referred to as "Schmidt," was key to Frederick W. Taylor's landmark book, "Principles of Scientific Management." Noll was credited with loading 45 tons of pig iron a day in 1899, to increase his day's pay to $1.85.
PENNSYLVANIA HISTORICAL AND MUSEUM COMMISSION

Canon Boring



Maunsel White

Taylor-White process

() A process (invented about 1899 by Frederick W. Taylor and Maunsel B. White) for giving toughness to self-hardening steels. The steel is heated almost to fusion, cooled to a temperature of from 700¡ to 850¡ C. in molten lead, further cooled in oil, reheated to between 370¡ and 670¡ C., and cooled in air.

THE METALLOGRAPHIST

A Quarterly Publication devoted to the Study of Metals, with Special Reference to their Physics and Microstructure, their Industrial Treatment and Applications

Edited by ALBERT SAUVEUR

VOL. V

1902

THE TAYLOR-WHITE PROCESS OF TREATING TOOL-STEEL *

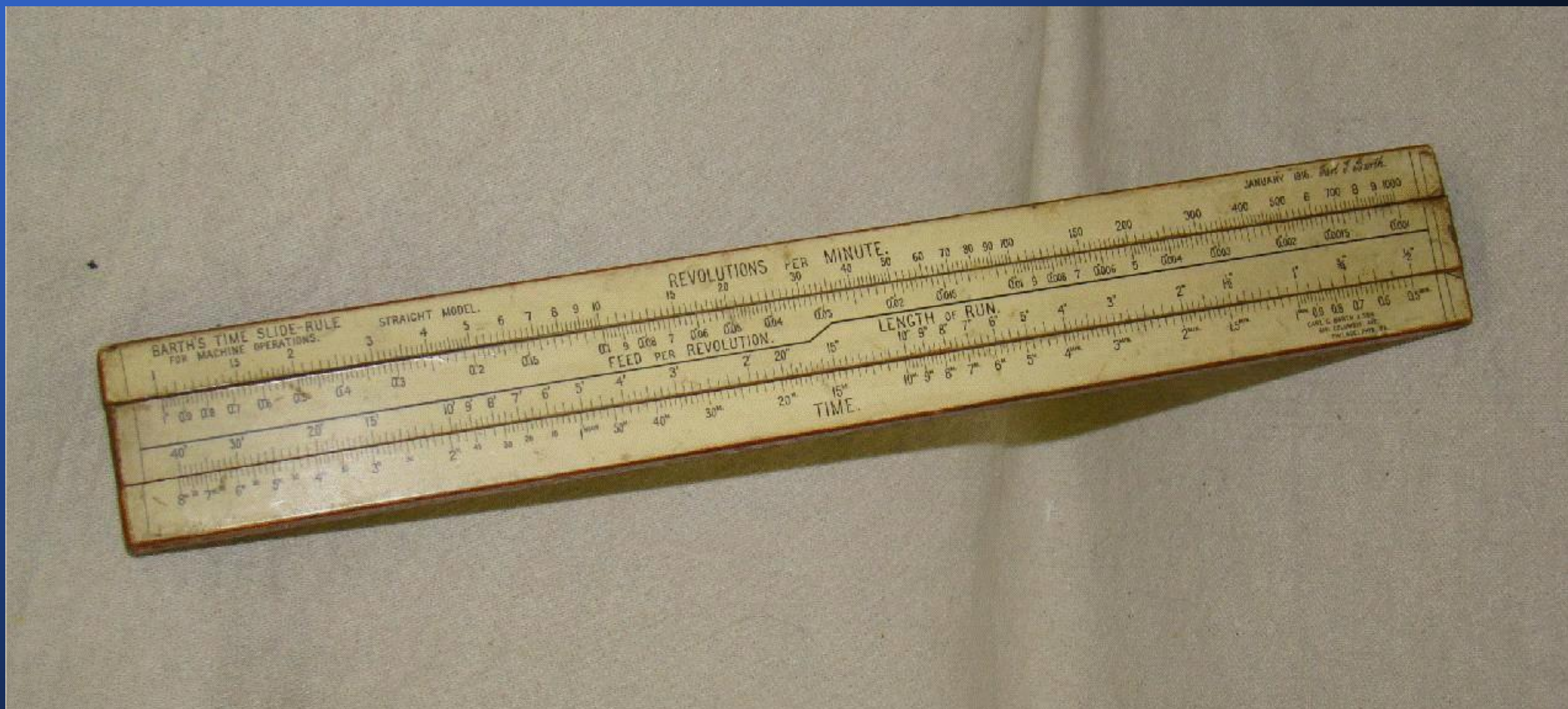
[Being the Report of the Committee on the Invention of Maunsel White and Fred W. Taylor. Sub-Committee: Charles Day, James Christie, Coleman Sellers, Arthur Falkenau, Wilfred Lewis.]

YOUR Sub-Committee submits the following report on the Taylor-White process of treating tool-steel.

About three years ago an extensive series of experiments were undertaken at the Bethlehem Steel Works, by Messrs. Taylor & White, in order to determine the relative efficiency of various brands of tool-steel on the market at that time.

There are two distinct classes of tool-steel, namely, carbon and air or self-hardening. The latter brand, the result of Mushet's work, has completely replaced the carbon steel for roughing, its comparative efficiency approximately being 1.5 to 1.0. Mushet discovered that by the addition of manganese and tungsten to tool-steel it maintained its cutting edge at much higher temperatures and consequently much higher speeds were possible. The general introduction of this steel did not, however, take place as rapidly as one would suppose, the manufacturers failing to appreciate the great economy realized by using it. In fact, very few of the shops that did use it obtained the greatest effi-

Carl Barth


BARTH'S TIME SLIDE-RULE
FOR MACHINE OPERATIONS.
STRAIGHT MODEL.
REVOLUTIONS PER MINUTE.
FEED PER REVOLUTION.
LENGTH OF RUN.
TIME.

Taylor saw opportunities

- Identify the best way of loading pig iron
  - ***And teach it to the workforce***
- Identify the best way of treating steel tools
  - ***And treat all tools the same way, in a centralized tool shop***
- Identify the best way of computing speeds and feeds
  - ***And develop tools that automated the calculations for machinists***

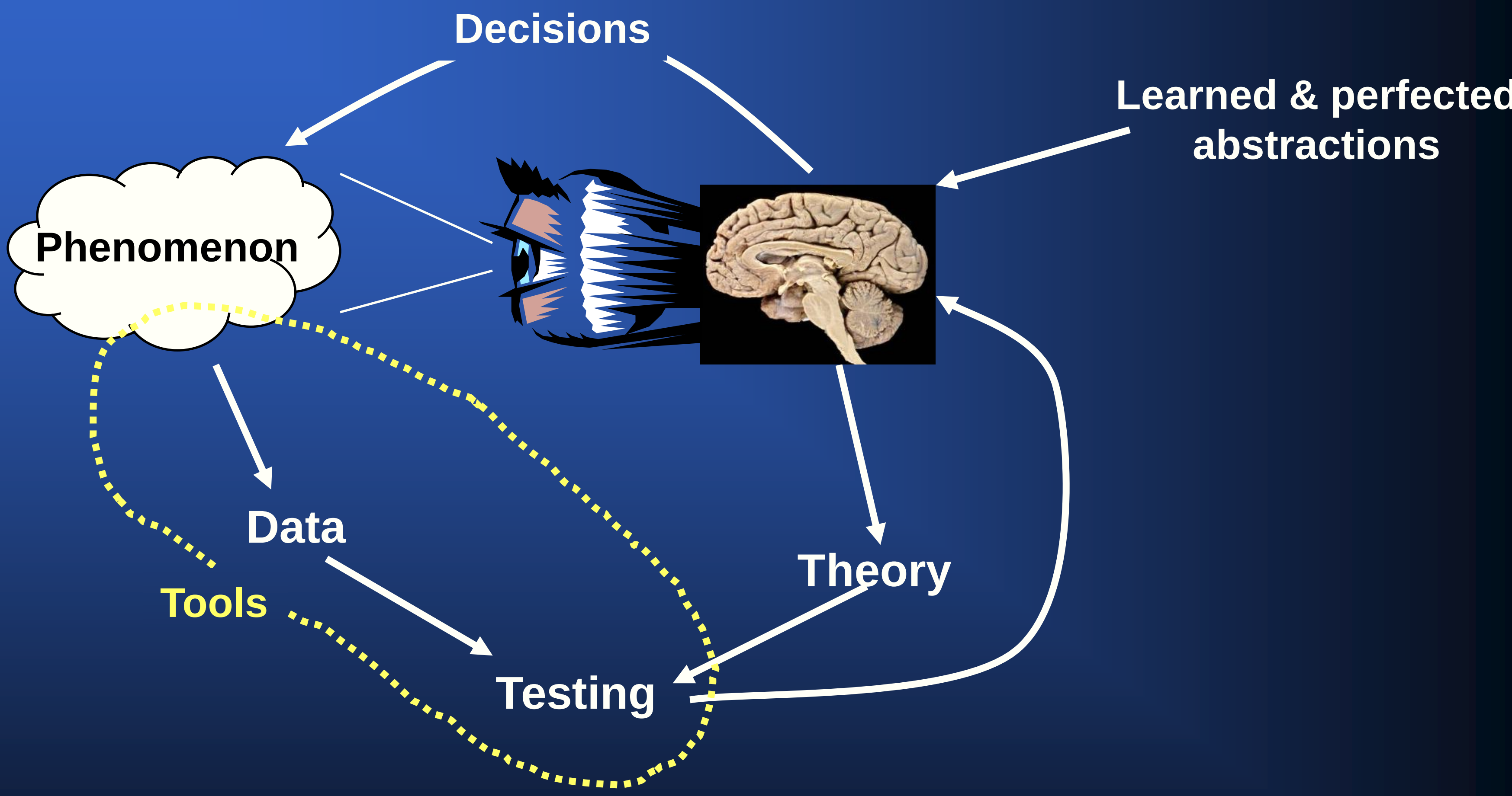
Taylor saw opportunities

- Identify the fundamental work elements
  - ***And reuse them everywhere***
- Decompose any task into its constituent elements
  - ***And optimize the worker's "trajectory"***
- Develop an engineering method for designing work
  - ***And teach it to others***

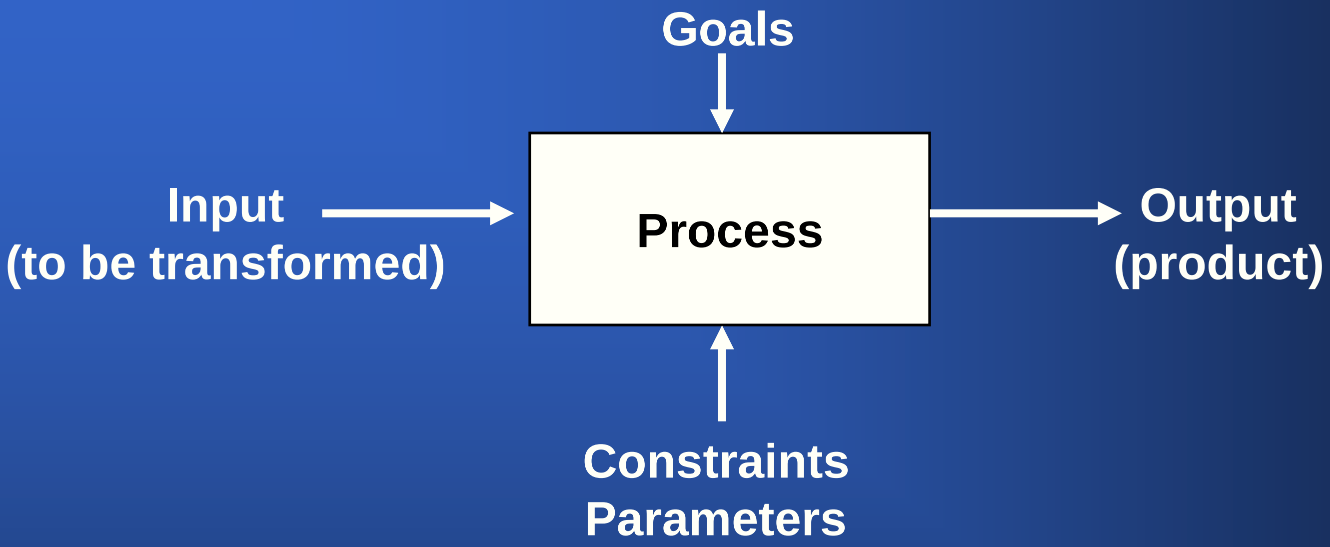
Taylor's work

- Evidence based
- Analytical
- Multi-disciplinary

Scientific (engineering) method



Taylor's (process) abstraction



Pig iron: pigs to be loaded; minimizing the effort required; selecting men

Tool steel: tools to be hardened; effect of heating/cooling; specifying the protocol

Speeds & Feeds: job descriptions; algorithm for computing S&F; tool for executing algorithm

The "Taylor Process"

- Limited in:
  - Space
  - Time
  - Scope
  - Interactions
  - Number of "internal" entities involved
- Characterized by "efficiency"
- Subject to improvement

Peter Drucker, 1974

On Taylor's 'scientific management' rests, above all, the tremendous surge of affluence in the last seventy-five years which has lifted the working masses in the developed countries well above any level recorded before, even for the well-to-do. Taylor, though the Isaac Newton (or perhaps the Archimedes) of the science of work, laid only first foundations, however. Not much has been added to them since - even though he has been dead all of sixty years.

1899 - 2009

How has ISE evolved?

How has manufacturing evolved?

ISE changes: 1899 – 2009

- More tools, better tools
  - Statistics, Simulation, Optimization
  - Ergonomics, org psych
  - Economics, decision theory
  - Info & computing technology
  - …
- Expanding scope of phenomena
  - Unit Processes → Homogeneous Systems
  - Manufacturing → Discrete Event Logistics
  - …
- Learned abstractions
  - Flow networks
  - Activity networks

ISE changes: 1899 – 2009

- More tools, better tools
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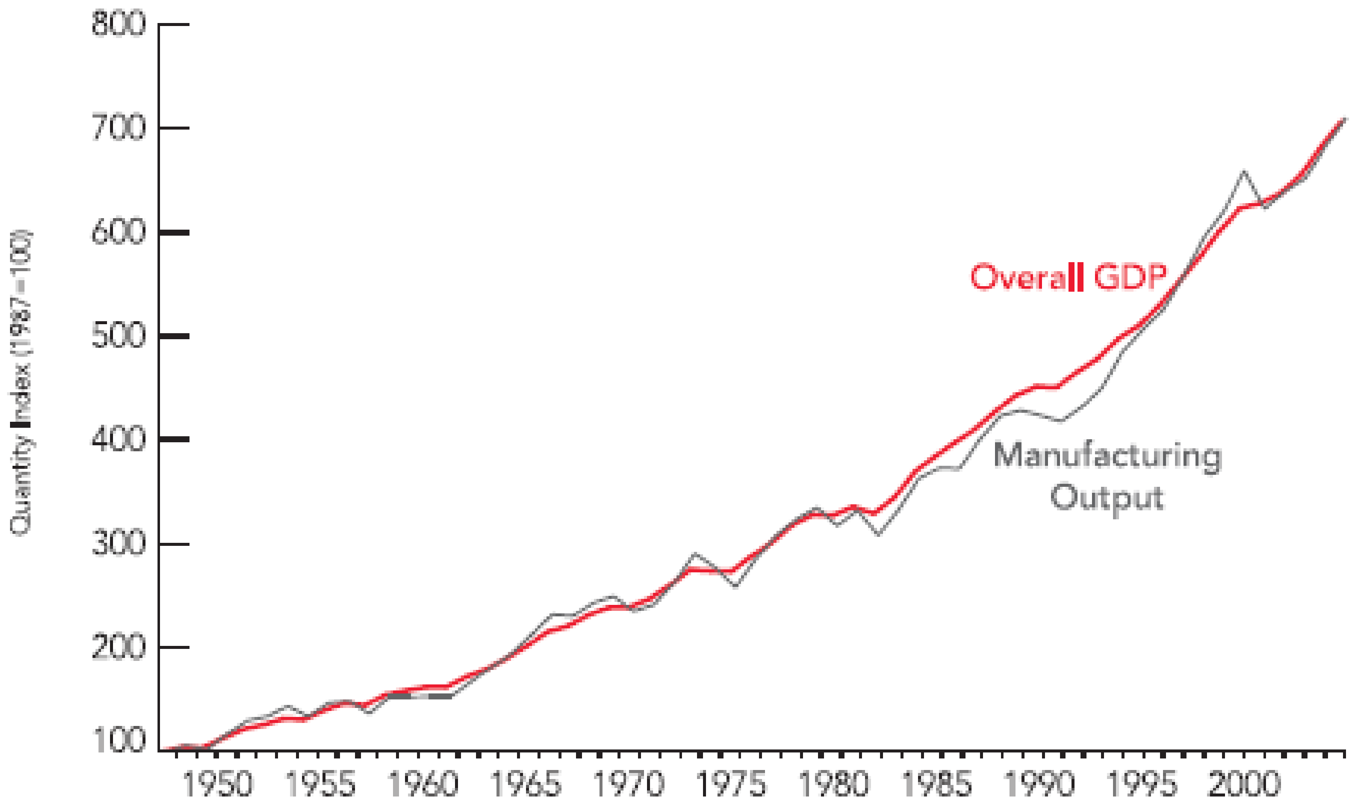
  - Activity networks

Our graduates today are very well equipped to solve “Taylor process” improvement problems.

But do they go into manufacturing?

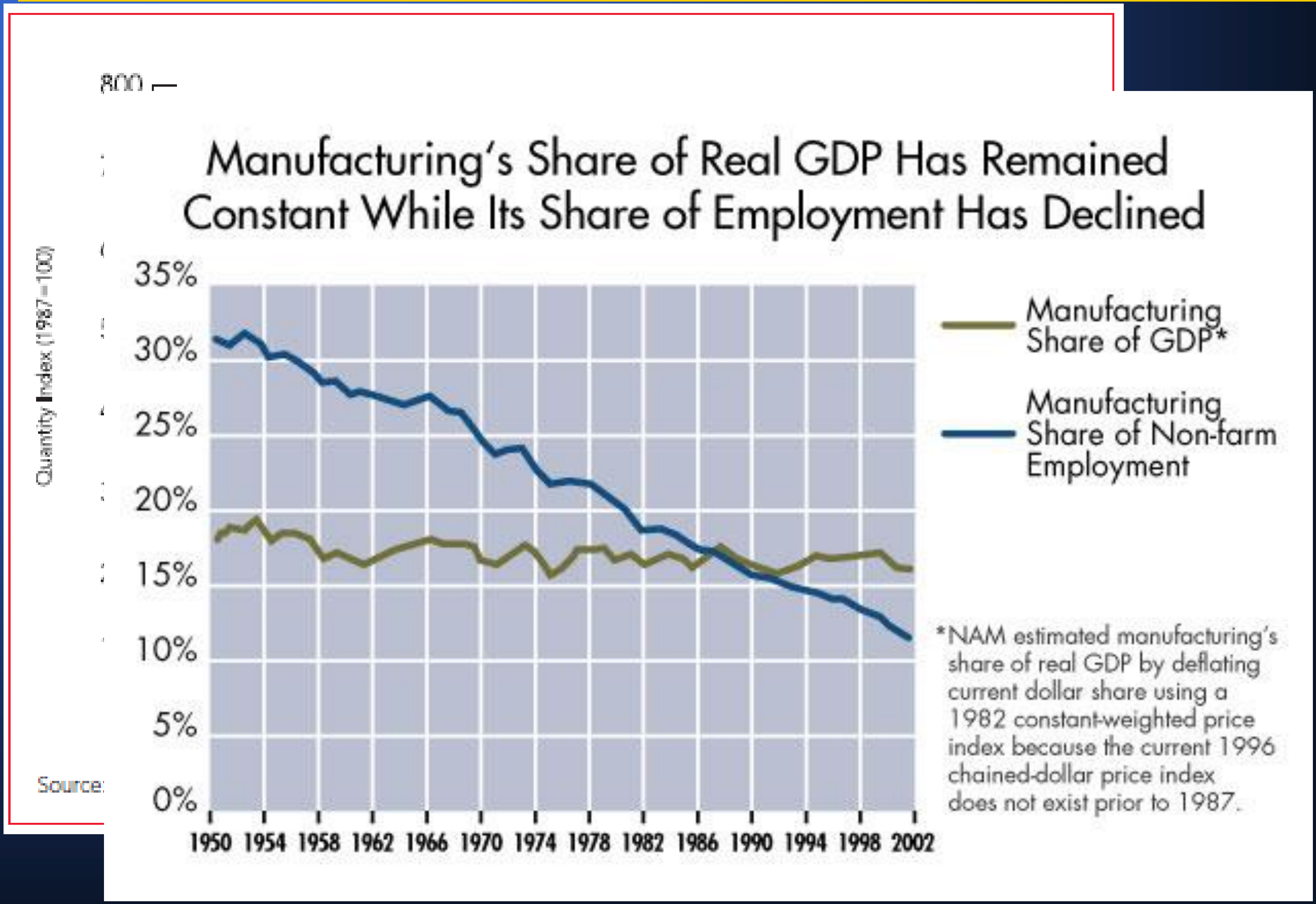
Here in the US, not so much…

MANUFACTURING IS NOT DEAD!



Source: Bureau of Economic Analysis of the U.S. Department of Commerce.

MANUFACTURING IS NOT DEAD!



Manufacturing workplace

http://en.wikipedia.org

http://www.digital-daily.com/editorial/intel_ireland/in

Manufacturing changes: 1899 – 2009

- Automation
- Six sigma
- Lean

- Sensing/communication technology
- Factory information systems
- Standards
- Heterogeneous systen integration

- Aging workforce
- Declining academic standards
- Off shore competition
- Global products
- Global value chains

Manufacturing changes: 1899 – 2009

- Automation
- Six sigma
- Lean
- Sensing/communication
- …andards

It's not so clear that our graduates are as well prepared as they need to be to add value in solving today's manufacturing problems.

Manufacturing changes: 1899 – 2009

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- Six ...sing/communicati...

...ndards

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Low hanging fruit all picked or easily picked by "day labor"?

Not in the IE "kit bag"?

Not simple Taylor Process or Taylor Process Network?

Our future

The "status quo" fork

- We are a high-priced resource, competing with a commodity resource—not a good competitive position
- The manufacturing experience is a leading indicator of the future of IE in other domains—e.g., all of services
- Down this fork lies a dim future—more and more IE departments absorbed into ME or closed altogether; loss of ABET status; IIE absorbed into one of the "supply chain" practice associations

http://pupillageandhowtogetit.files.wordpress.com/2009/04/homer_the_scream.jpg

The "potpourri " fork

- Requires individual department responsiveness to market
- Necessarily dilutes the "core IE content" of the curriculum
- Always one generation from oblivion

http://www.agingresearch.org/content/article/detail/892

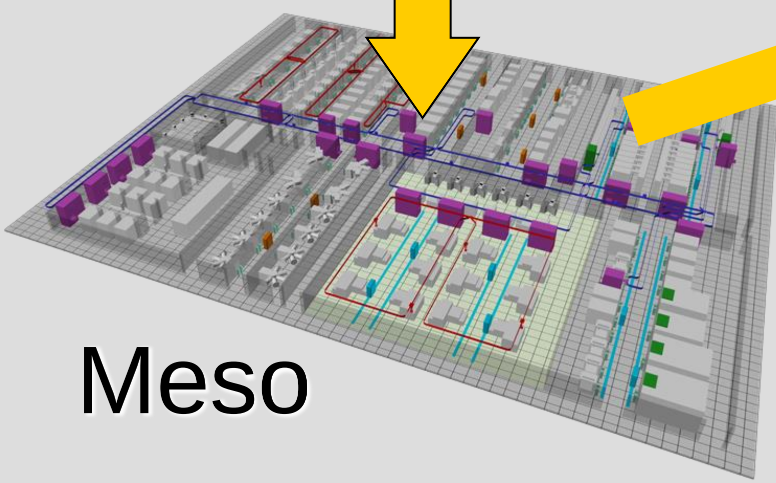
A third fork: beyond simple Taylor process networks

- Complex, non-homogeneous networks
  - Multiple disciplines
  - Flows and activities
  - Large scale, unpredictable, persistent, dynamic

ISE in global value chains

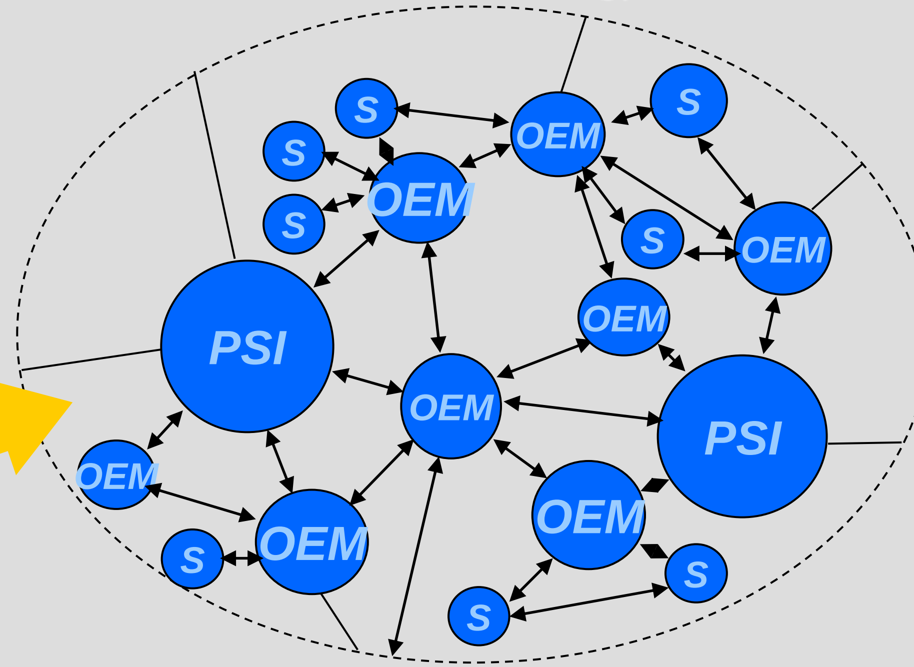
Micro

Meso



Macro

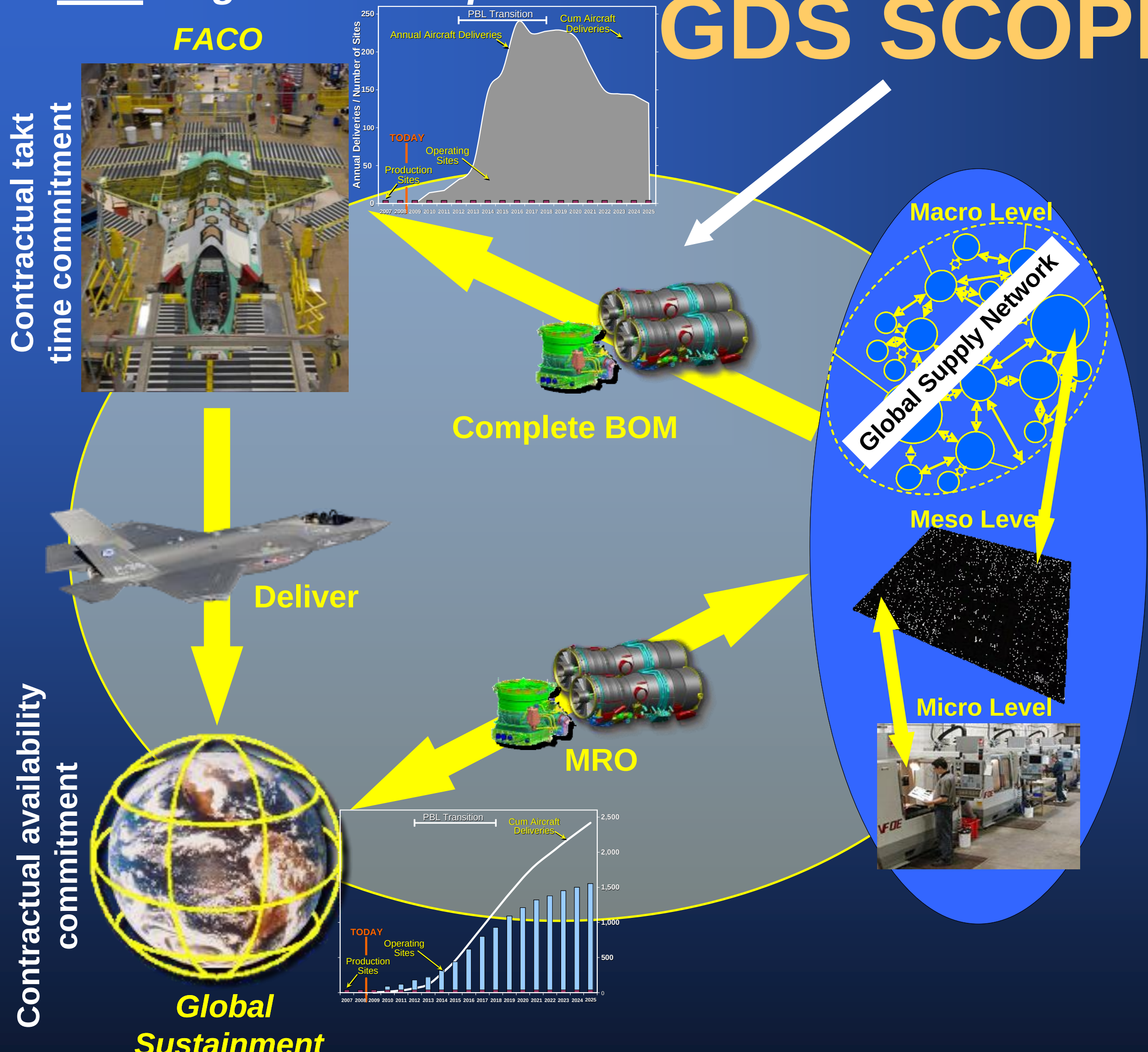
(Network Centric Manufacturing)



ISE in global manufacturing

***Risk**: significant ramp deltas*

GDS SCOPE & RISKS



***Risk**: significant MRO deltas*

Endogenous Risks:

- *Technical failure at micro level*
- *Cycle time or capacity failure at meso level*
- *Response time failure at meso level*
- *Network failure at macro level (e.g., synchronization failure)*
- *Network Complexity & Relationships*

Exogenous Risks:

- *Politics, Policies*
- *Economics, Money*
- *Culture*
- *Demand*
- *Acts of Nature*

GDS Inertia Risks

- *"Readiness"*
- *Change Management*
- *Organization Design*
- *Governance/Control*

Scenario-Based Risks

- *Combinations*
- *Black Swan & Stress Test*

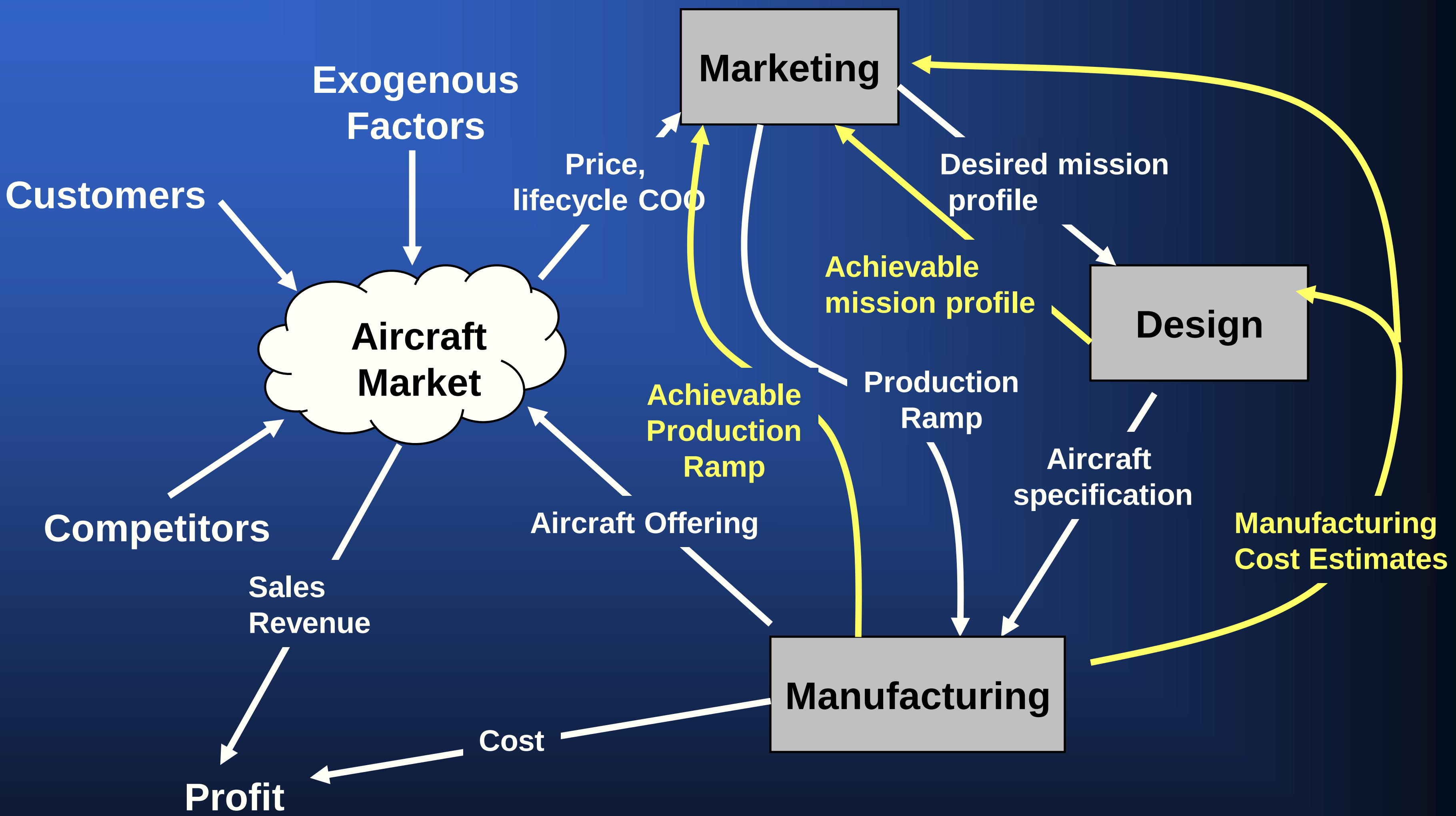
Global manufacturing value chains are socio-technical enterprise systems.

IE graduates may need new tools and new learned abstractions to contribute in this domain.

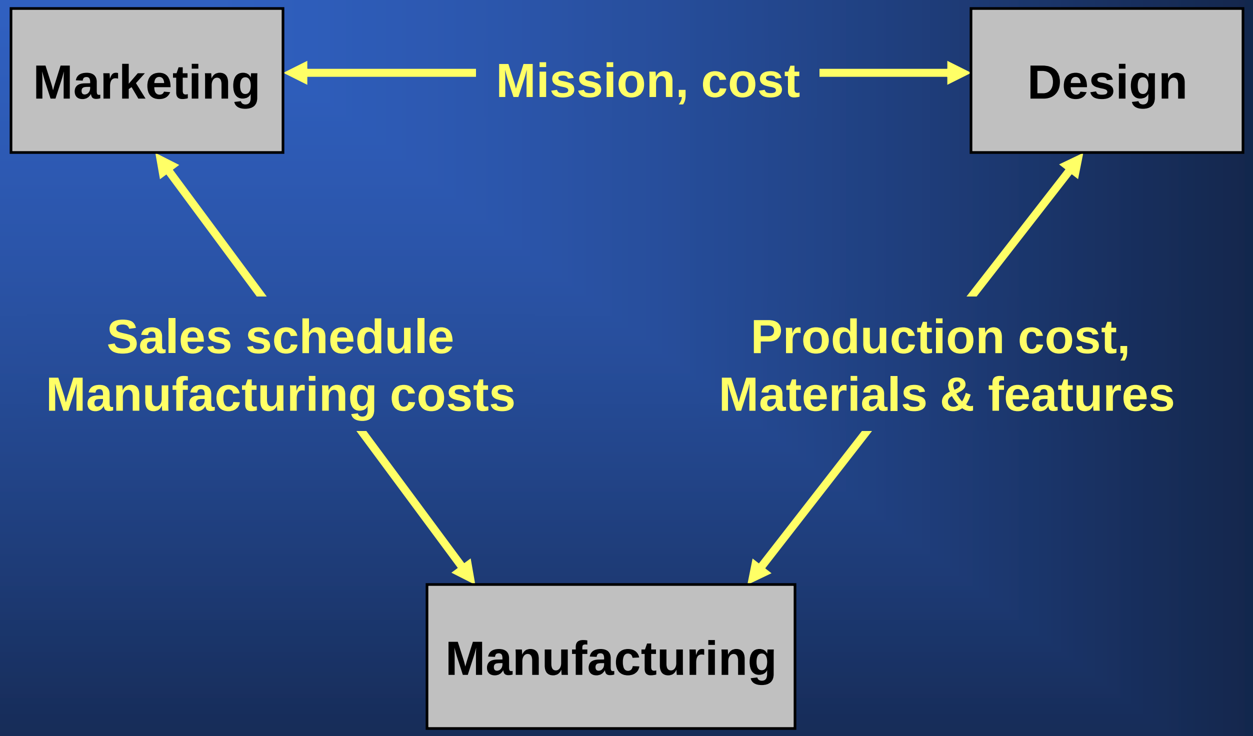
A third fork: beyond simple Taylor process networks

- Complex, non-homogeneous networks
  - Multiple disciplines
  - Flows and activities
  - Large scale, unpredictable, persistent, dynamic
- More than analysis—systems design and engineering

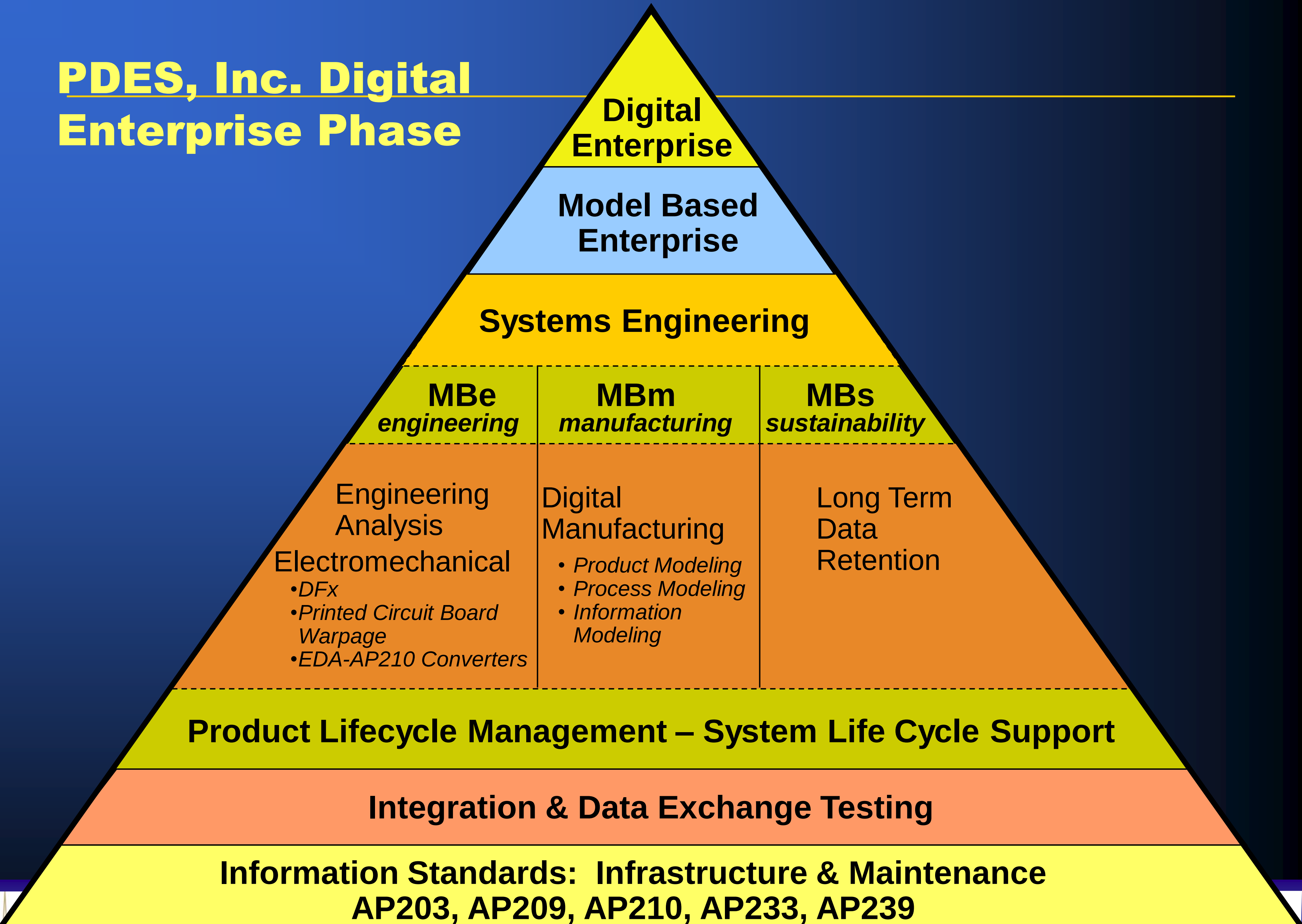
New aircraft design



Required Functional Agreement



PDES, Inc. Digital Enterprise Phase



Fundamental challenges

- Formal language for systems description
- Model based systems engineering
- Standards and open models/software
- False idol of mathematical rigor


THANK YOU