



We put ideas in motion



DESIGN CONSIDERATIONS IN LOW VOLUME MOTOR (& GENERATOR) MANUFACTURING

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www.windings.com

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Background

- Windings, Inc
 - In business since 1965
 - Mfr of prototypes to 10,000 pcs/year
 - Primary business is stator mfg
 - Specialty motors is growing
- Presenters
 - Scott: Exec VP/CFO
 - Norm: Director, Motor Business

System Approach



Automation

- High volume is automated
- Automated processes are repeatable
- Direct labor is small portion
 - Machine operation, setup, maintenance
 - Light, repeatable assembly

Low Volume Mfg



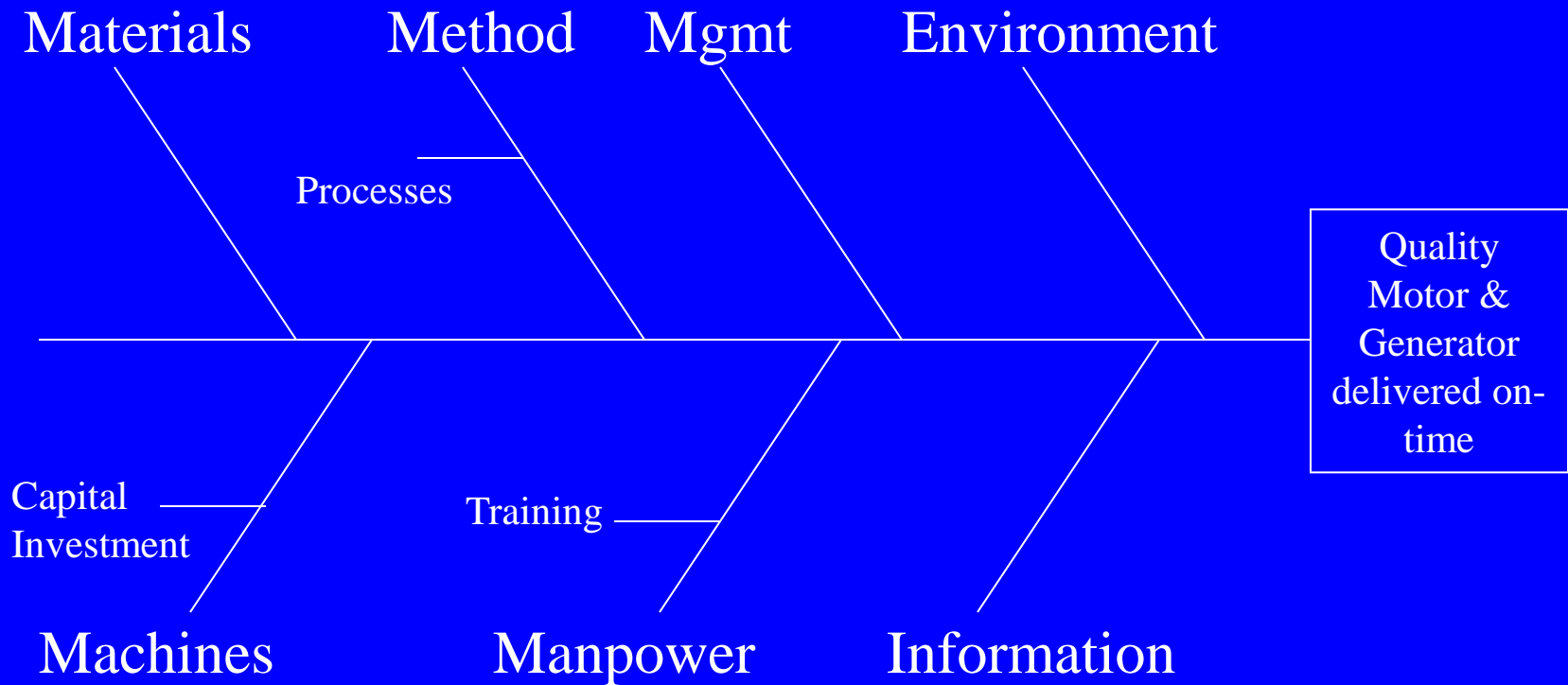
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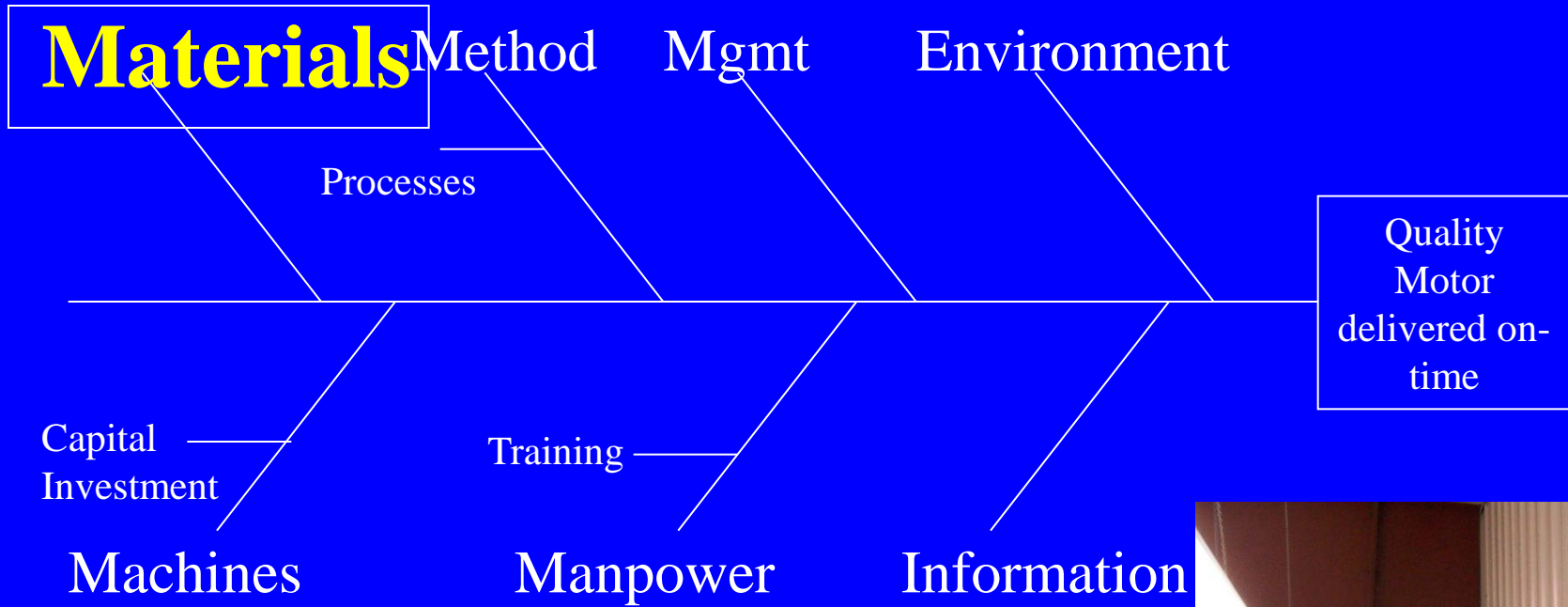
Design & Manufacturing

- DfX—tradeoffs and complexities
 - M—Manufacturability
 - A—Assembly
 - R—Reliability, Regulatory Requirements
 - P—Performance
 - C—Cost
 - T—Time to Market
 - F—Flexibility in configurations, market offerings



Framework for Low Volume



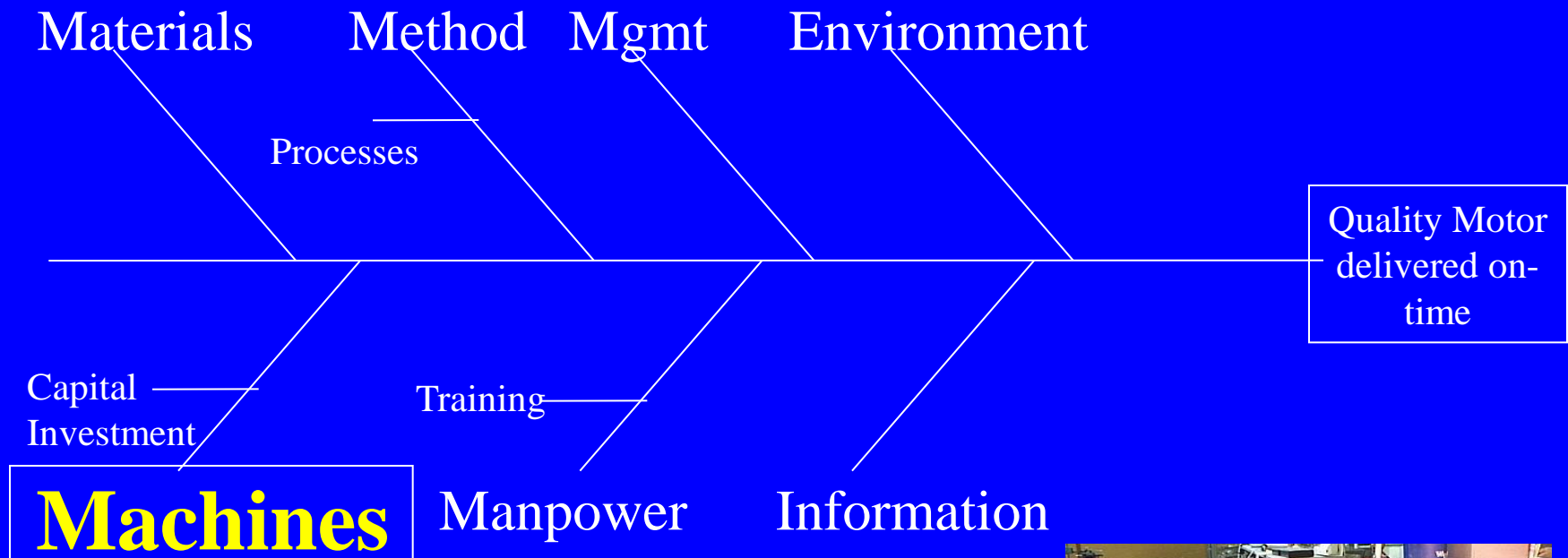


Total Cost

- Special materials or commonly used
 - Shelf life
 - Obsolescence
- Volume purchasing & price discounts
- Inventory growth & carrying costs:
 - material variety & minimum buys
- Source costs: import vs domestic

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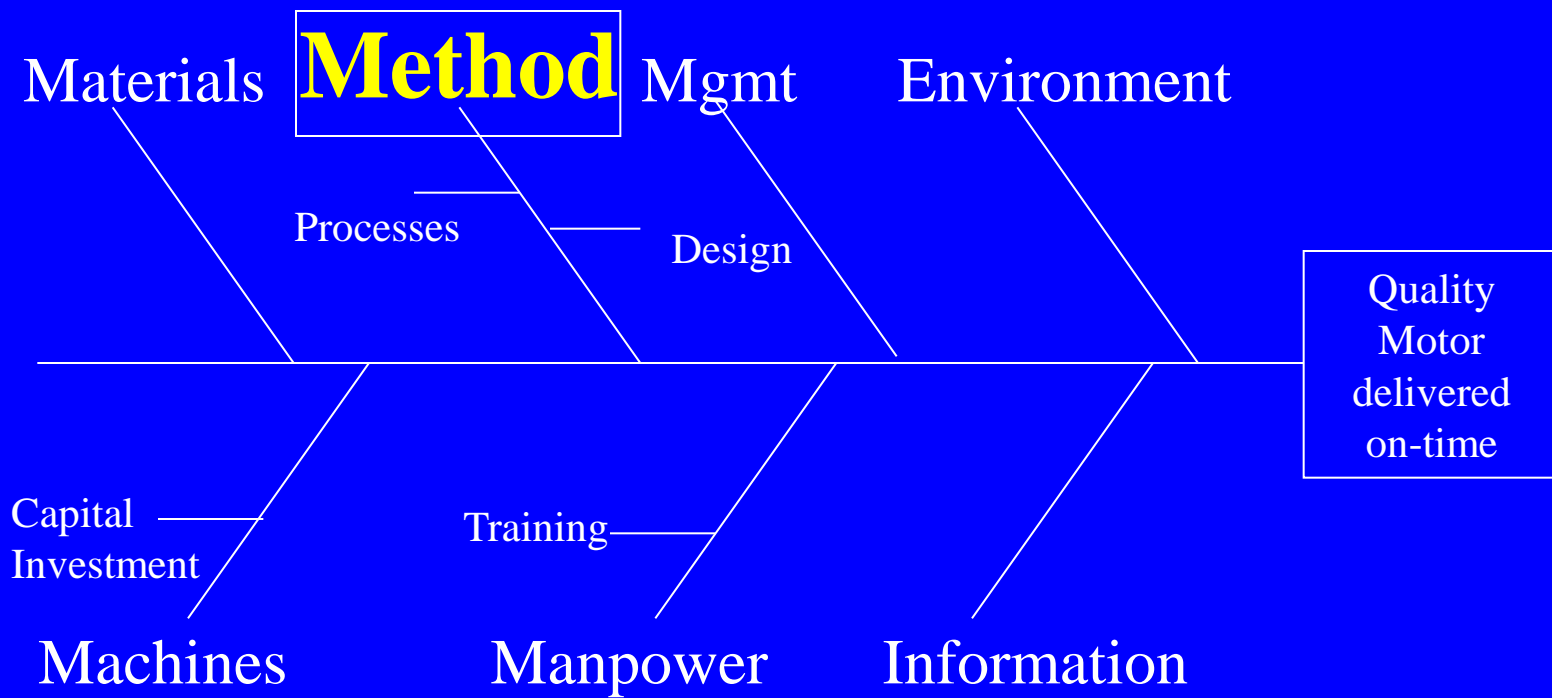


Capital Equipment Investment

- Unique configurations, Part-specific tooling
- “Utilization” of equipment for ROI
- Flexible, short changeovers to avoid over-production problems

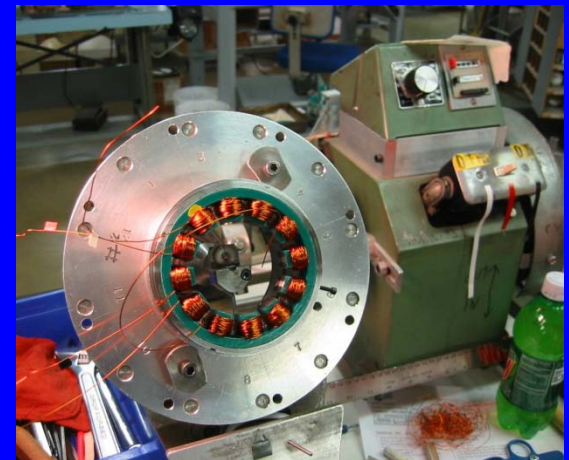
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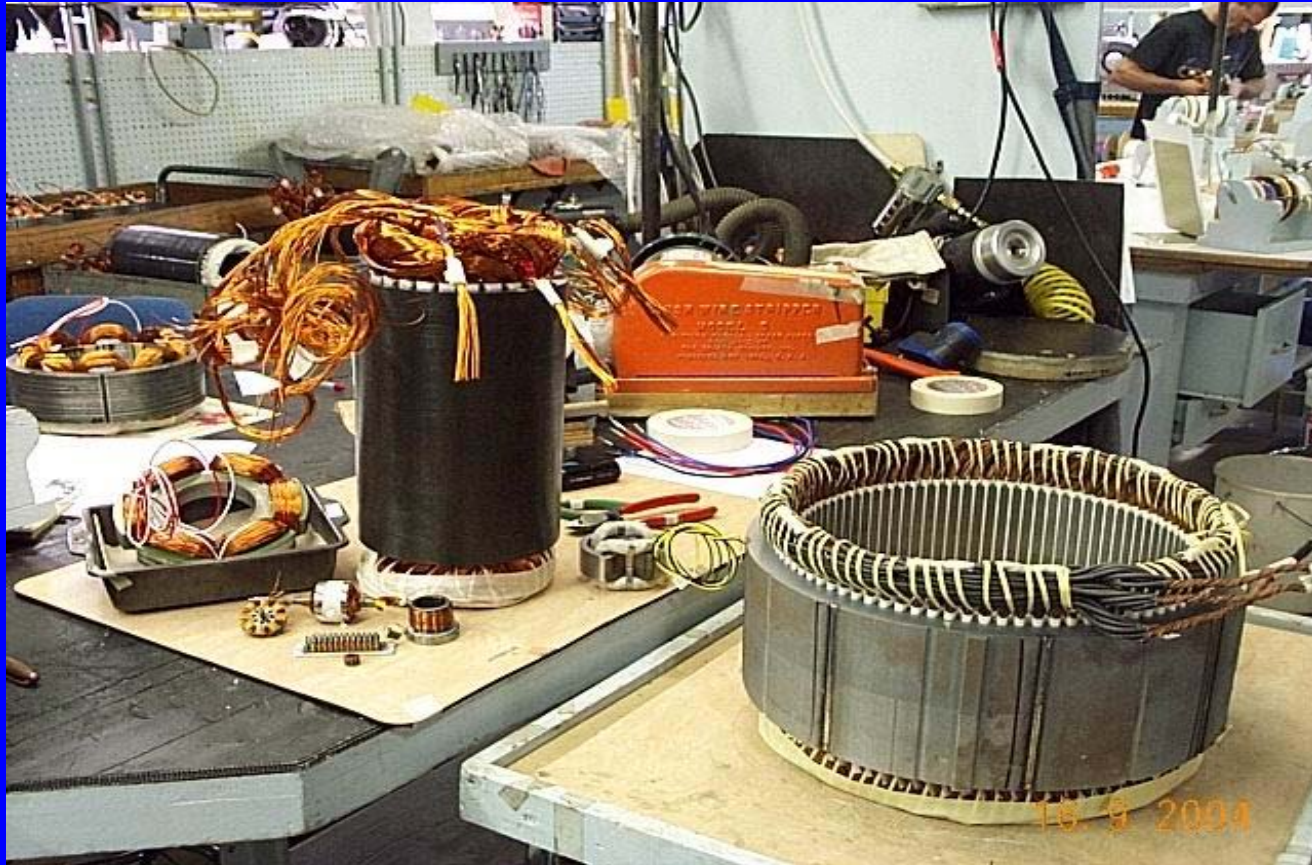


Process Control & Design

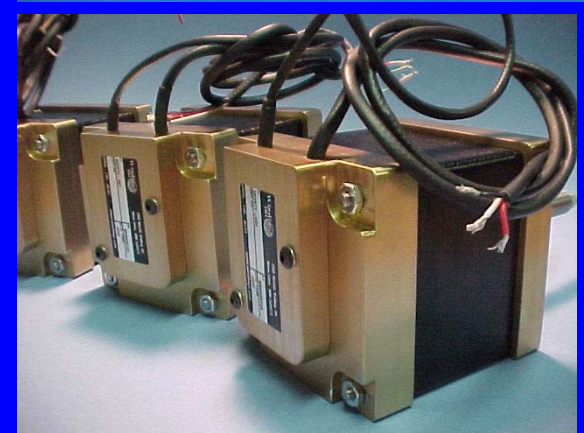
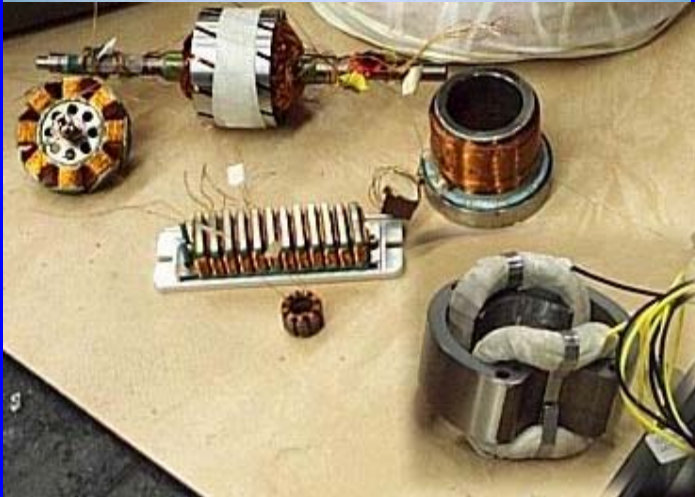
- Incorporate DFM expertise of manufacturer
- **Methods must be robust for piece-piece, lot-lot variability**

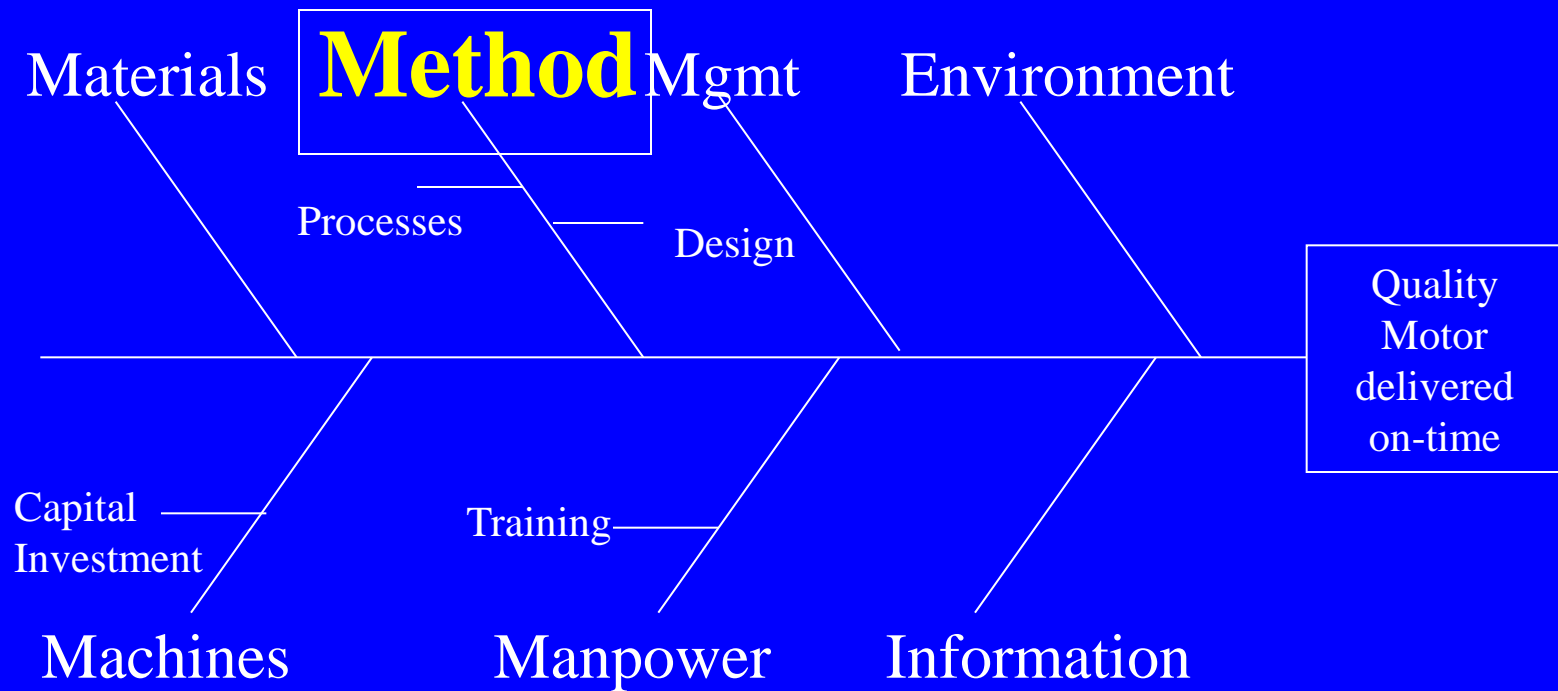


Methods to handle wide variety of part size / configuration or just one size?



Methods to handle wide variety of part size / configuration or just one size/type





- **Method will rely on operator interaction, so utilize things like:**
 - **Clear, concise instructions to reduce reading errors**
 - **Poka-yoke (mistake-proof) fixtures**
- **Special production methods?**

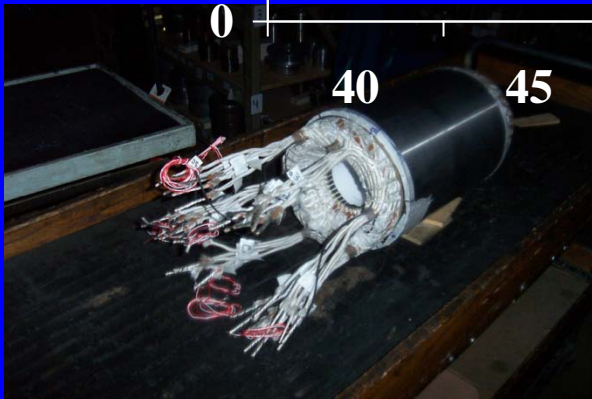
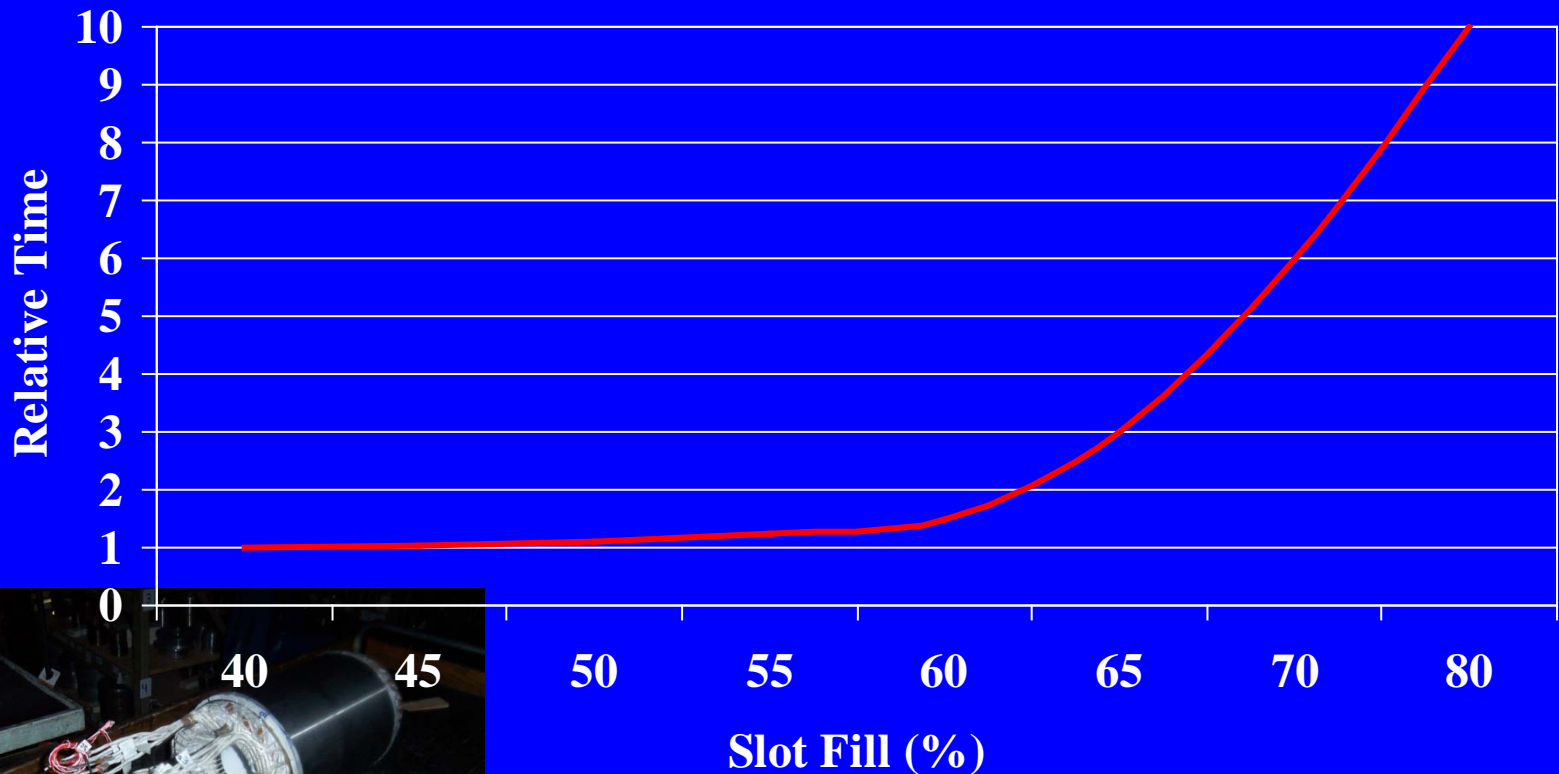


Mistake proof
fixtures for
easy, reliable
quality checks



Slot fill vs time

Slot fill vs cost (time~cost)



Materials Method Mgmt Environment

Processes

Quality
Motor
delivered
on-time

Capital
Investment

Training

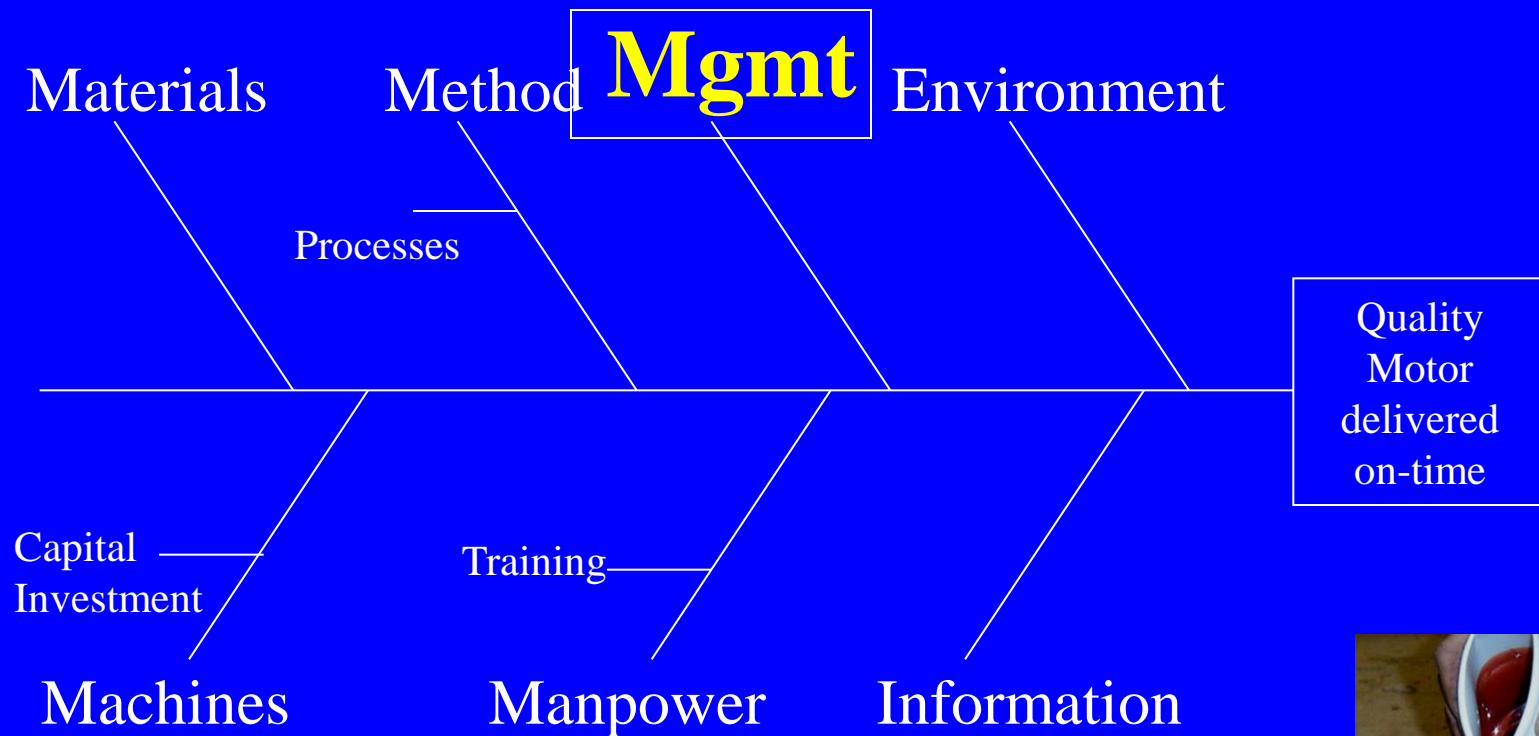
Machines

Manpower

Information



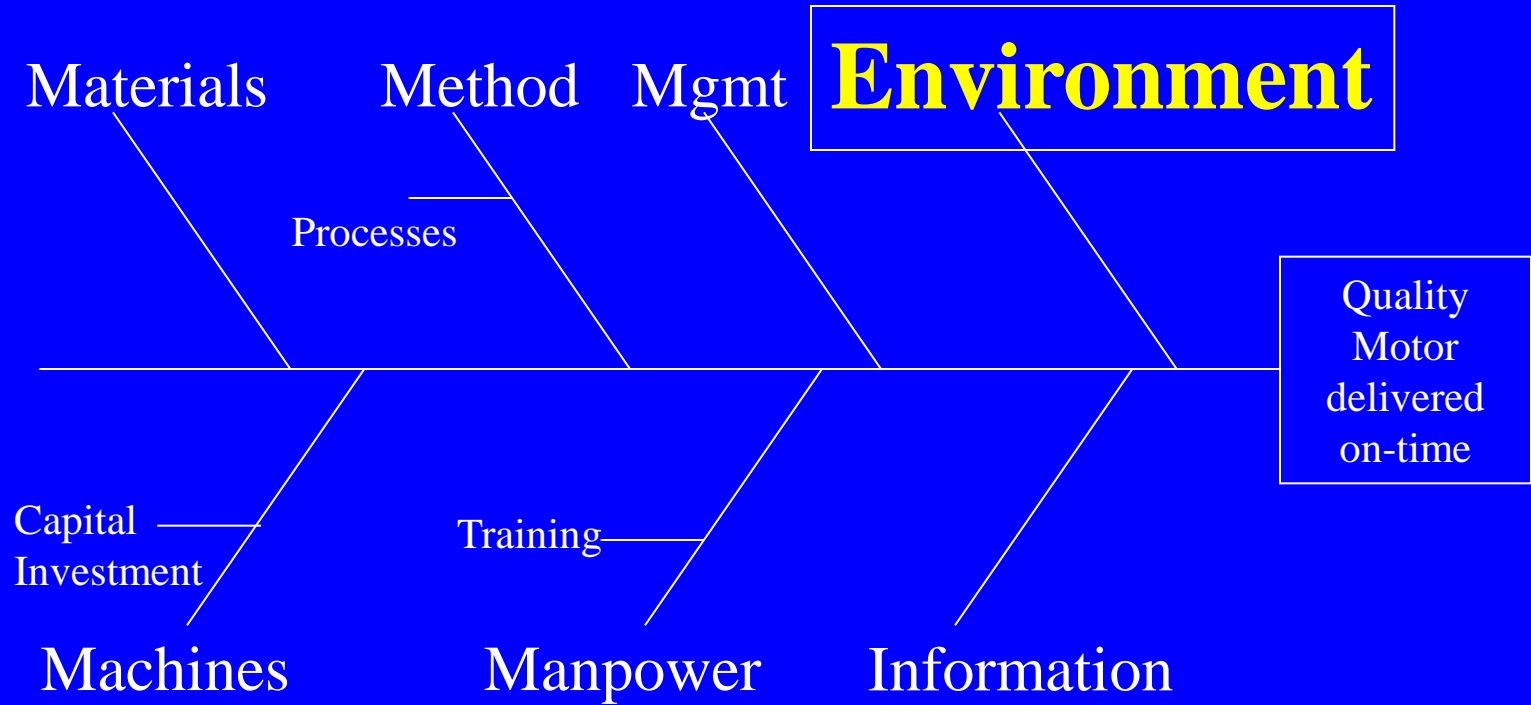
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- Schedule flexibility for customers
- Rapid decision-making structures
 - Self-managed production teams and engaged “coaches”
 - **Design & MRB decisions**
- **Prototypes built on production line or separate lab (“skunkworks”)**

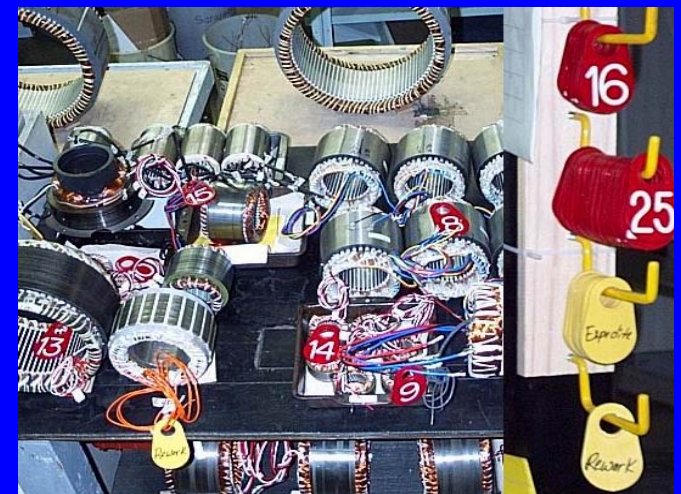
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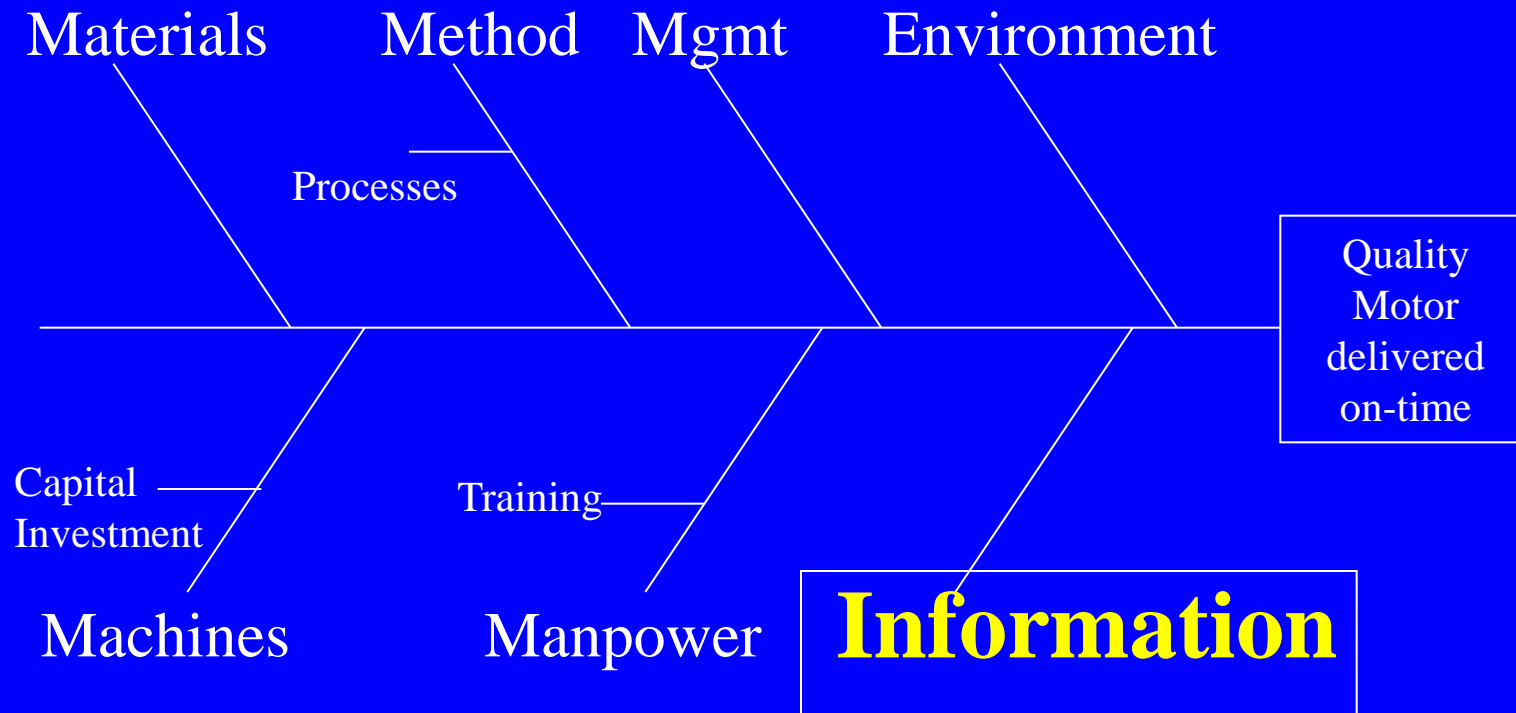




- Orderly material flow
- Visual systems for knowing the operational status of the parts, locating materials, tools quickly
- Safe, clean, comfortable, ergonomic, & well-lit

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- Clear customer expectations up front – Electrical, Mechanical, Performance
- Excellent BOM's, and routings
- Utilization of IT systems vs. travelers (or memory)
- Final inspection mutually approved

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Clear,
concise work
instructions
at point of
use and rapid
access to the
latest
information



Just-in-Time

- Right amount (not too much, nor too little)
- Right time (not too late, nor too early)
 - Materials
 - Information
 - Resources (staff, equipment)



System Approach

Concurrent Engineering

Critical Chain (multi-project resource scheduling)

DFx



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