
Design For Manufacturability (DFM)

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September 15, 2004

Agenda

Introduction What is DFM? Why use DFM?	
DFM Process DFM Approach, DFM Tools and Methods	
Summary Overview and DFM comparison table	
Where can I get more information? Resources, DFM Pro's and Con's and Comparisons	

Introduction

- **What is DFM?**

- DFM is product design considering manufacturing requirements
- DFM is the first step in which a team approach is taken to develop the product
- DFM is an umbrella which covers a variety of tools and techniques to accomplish a manufacturable product

- **Why DFM?**

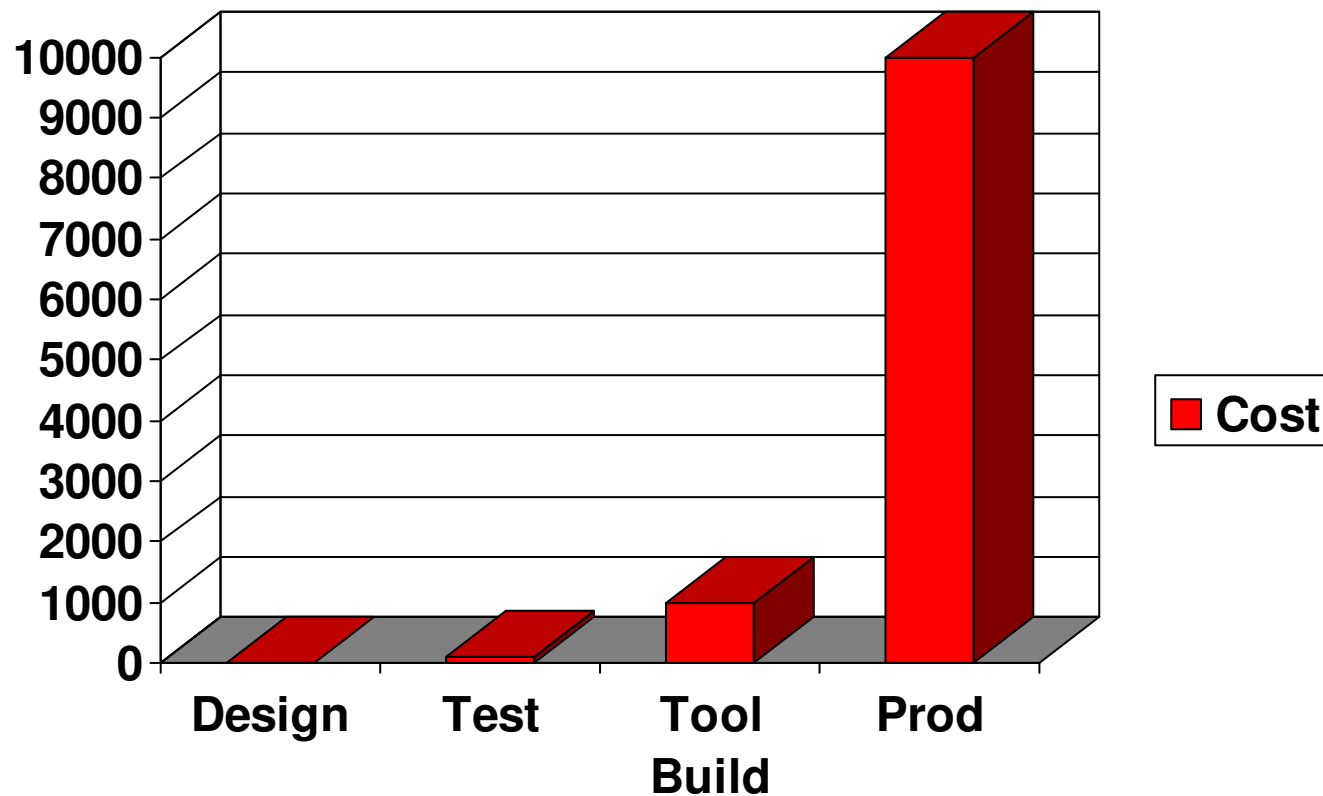
- Lower development cost
- Shorter development time
- Faster manufacturing start of build
- Lower assembly and test costs
- Higher quality

Introduction

- **How do all the pieces fit together?**
 - The objective of DFM is to identify product concepts that are easy to manufacture
 - Focus on component design for ease of manufacture and assembly
 - Integrate manufacturing to ensure the best match of needs and requirements.
 - DFM in industry is typically divided into 2 main activities:
 - A team which will be responsible for the product development and delivery. (cross functional team: ME, EE, MFG., CE, PE, Quality)
 - The tools and methods to enable DFM that ensure the design meets the objectives.

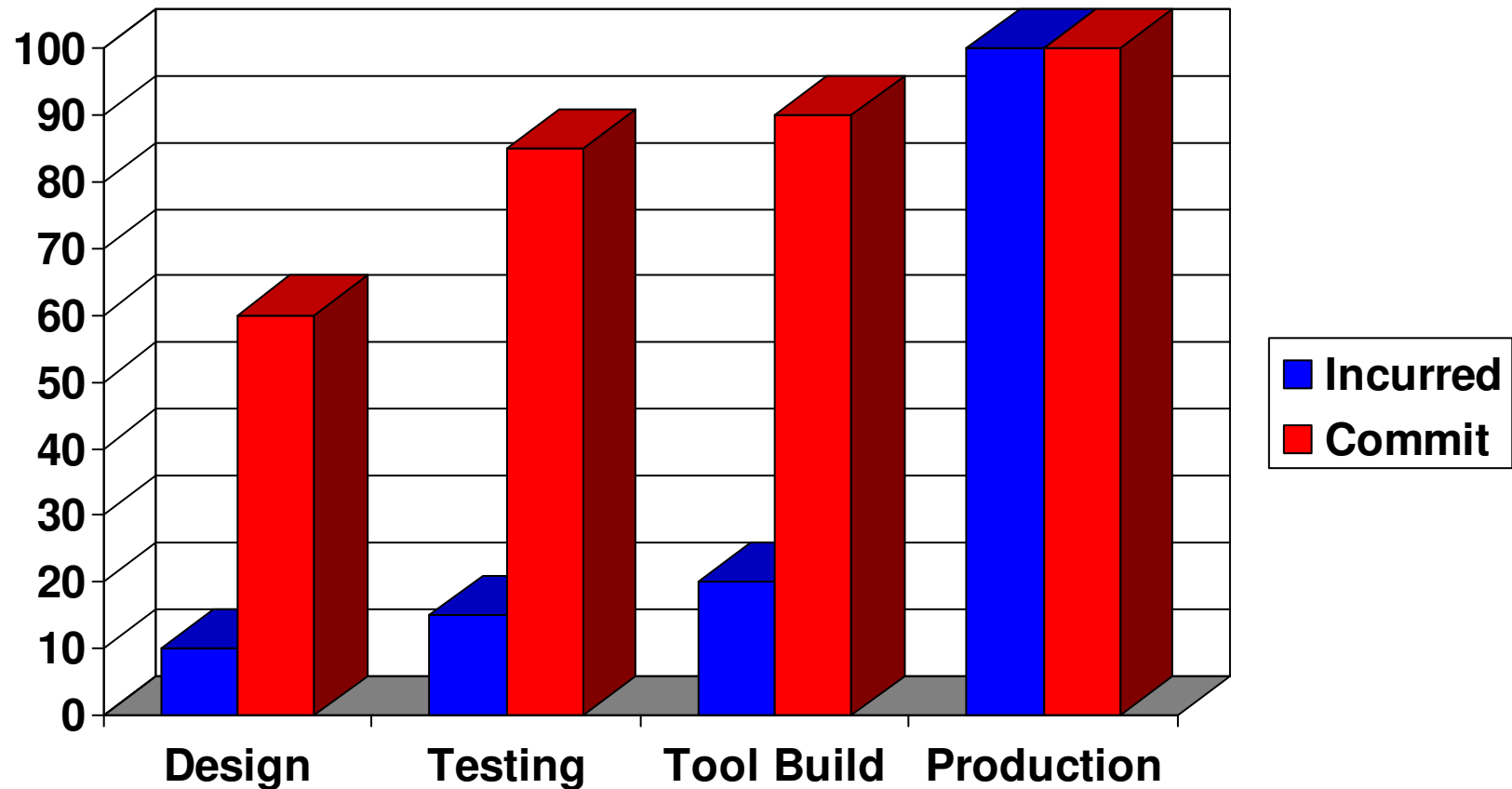
Introduction

How much do engineering changes cost after the design has been launched?



Introduction

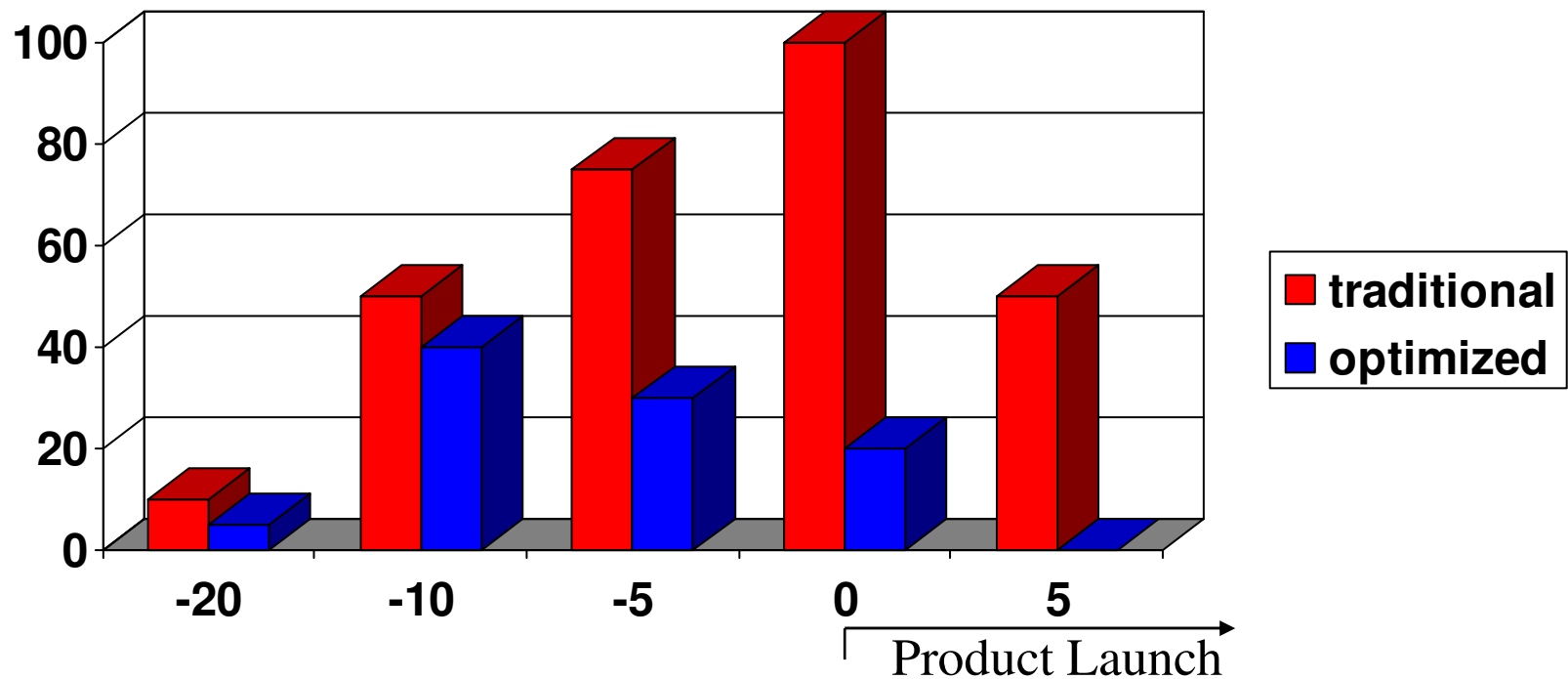
When has the total cost be committed?



Introduction

Which is the better process?

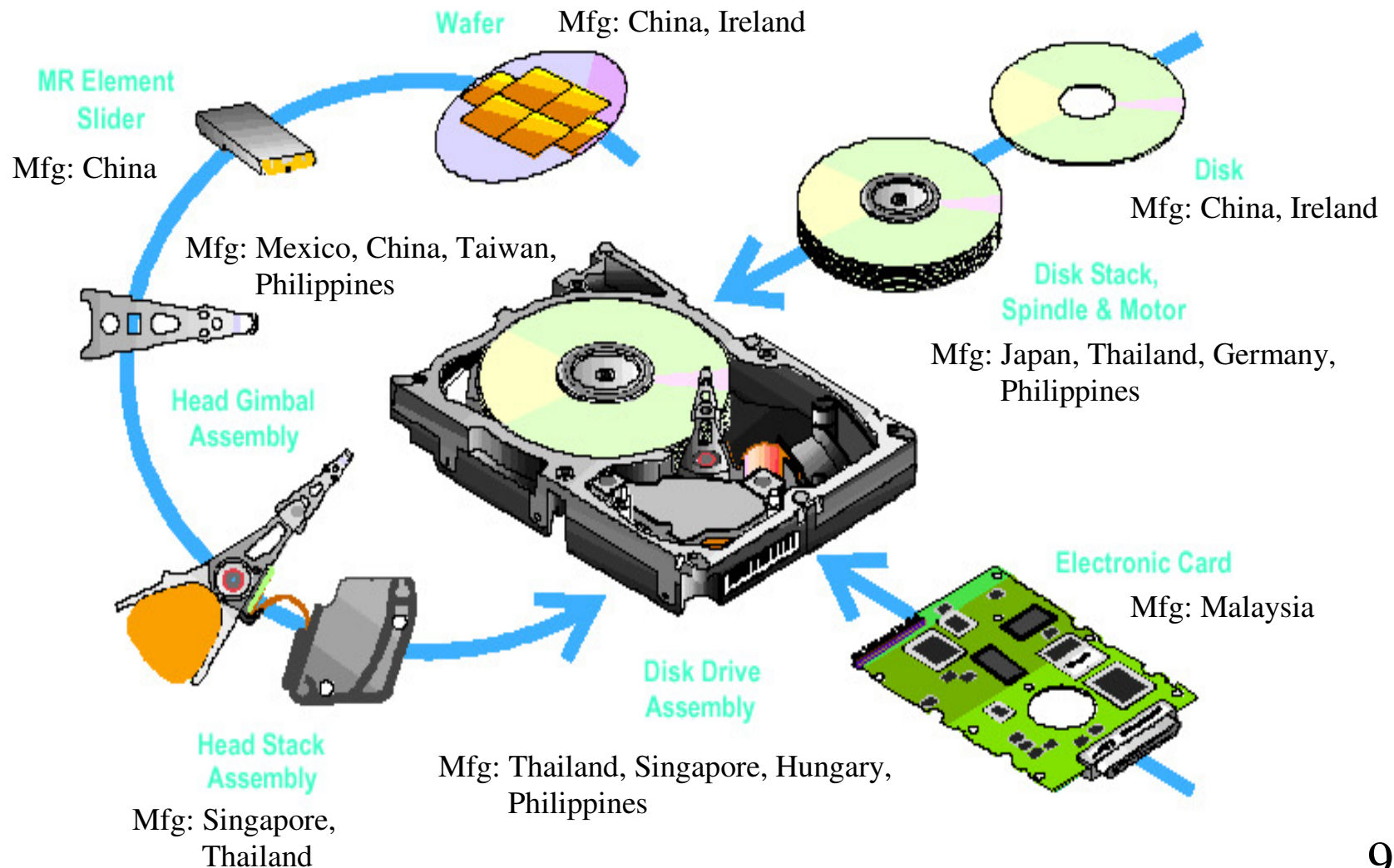
Number of Changes



Introduction

- **Manufacturing Today**
 - Global Competition
 - Trade barriers have been removed (NAFTA)
 - Must compete with the best from all over the world
 - Japan, Europe, India, Mexico, etc
 - Infrastructure's forming off shore
 - Quality Requirements
 - ISO 9000
 - Six Sigma (Motorola Inc)
 - Product Cycles
 - Every generation is faster
 - Rate of change is increasing
 - Cost
 - Costs decrease every year (customers expect costs to go down)
 - Performance increasing every year

Introduction: Global Manufacturing



Introduction: Product Design

- **Product Design Today**

- Development Cycle
 - Endless engineering changes
 - Non standard parts have long lead times
- Quality
 - “Designed and thrown over the wall”
 - Lower due to more parts, manual processes, and untested parts
 - Customer configuration management
- Cost
 - Higher due to unique designs and specialized parts
- Equipment and Tooling
 - Reliability and quality problems



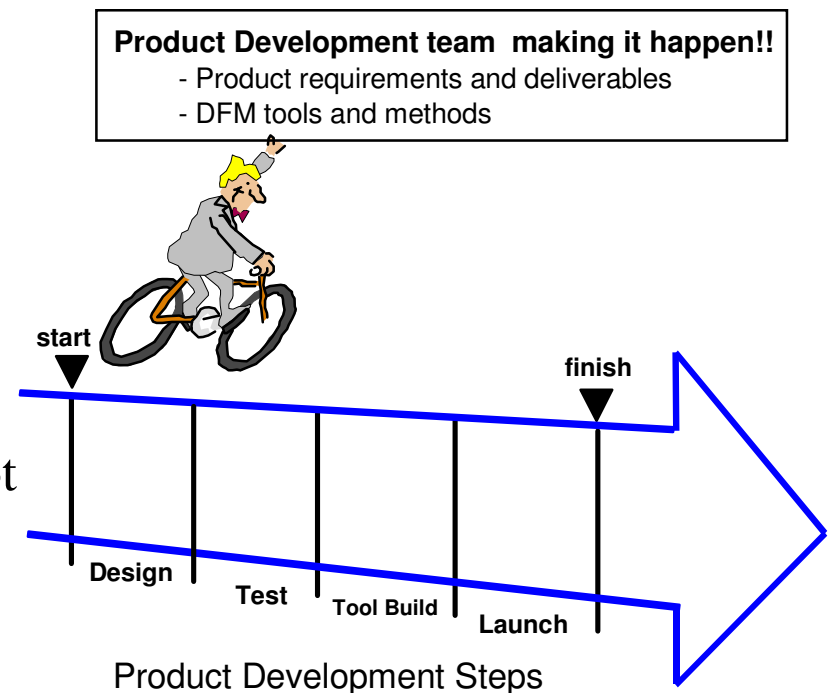
DFM Typical Approach

■ Product Development Process

- Conceptual **DESIGN** and development
- Product optimization, **TEST**
- **TOOL BUILD** (ease of assembly)
- **LAUNCH**, ramp, ship, and deliver

■ Product Team

- Product requirements and deliverables
- Collaborative cross functional team (ME, EE, MFG, Test, Quality, etc.). Not “designed in a vacuum”
- Uses **DFM tools and methods**



DFM Product Considerations

■ Product Considerations

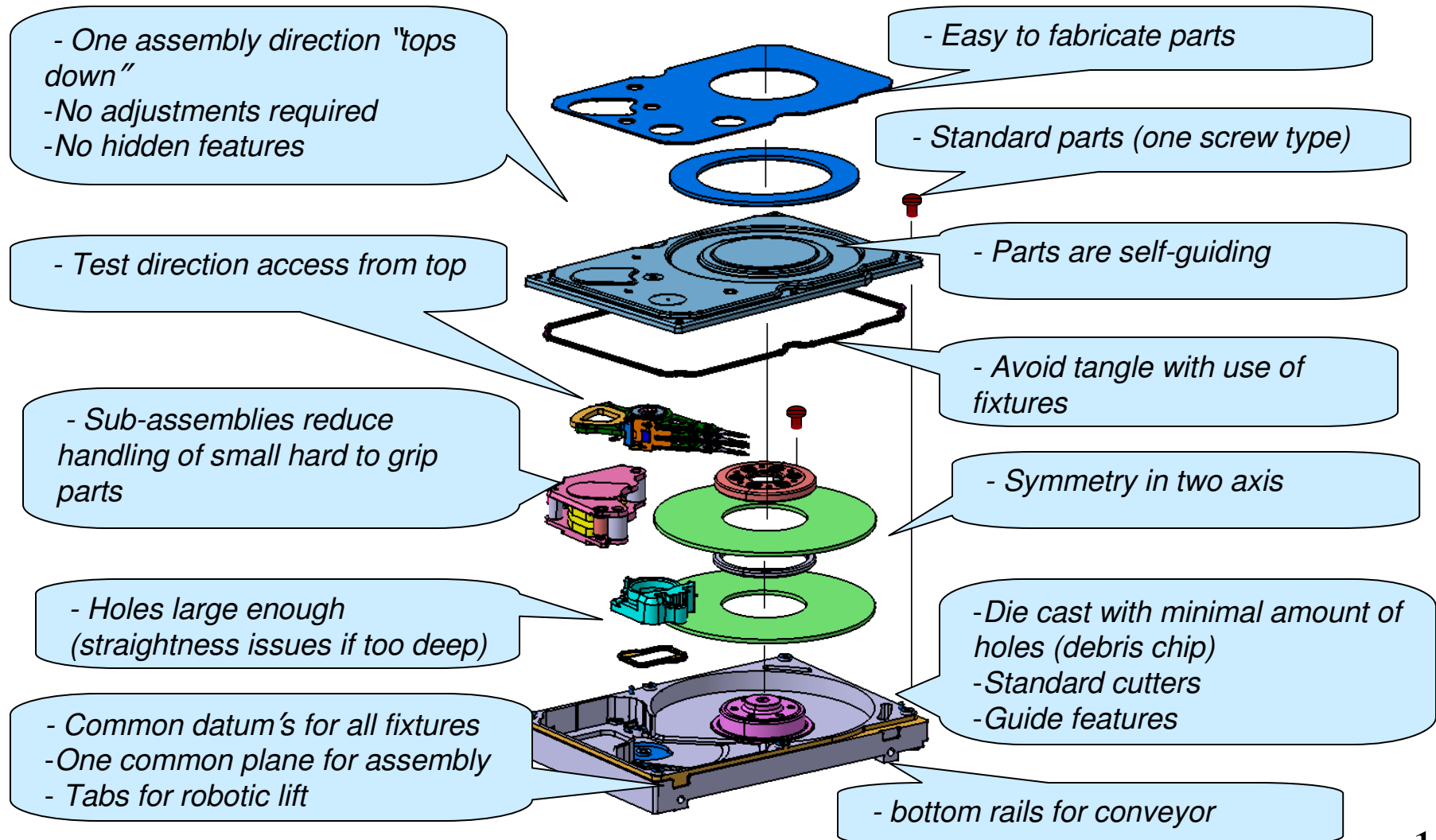
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|---|--|--|
| <ul style="list-style-type: none">■ Environmental<ul style="list-style-type: none">■ Ergonomics■ Safety■ Pollution■ Recycling■ Shock/vibration■ Temperature | <ul style="list-style-type: none">■ Customer<ul style="list-style-type: none">■ Depth of product line■ Customization■ Test requirements | <ul style="list-style-type: none">■ Process and Tooling<ul style="list-style-type: none">■ Cycle time■ Quality■ Ease of Assembly■ Ease of Testing■ Rework■ Shipping and Handling■ Tooling Costs |
| <ul style="list-style-type: none">■ Suppliers<ul style="list-style-type: none">■ Partnerships■ Supplier tolerance capability■ Merging mechanical sub-assemblies■ Costs | | |

DFM Tools and Methodology

- **Tools and Methodologies**

- Design For Assembly (DFA), (*IBM experience*)
- Failure Mode and Effect Analysis (FMEA), (*Sun example*)
- Taguchi Method, (*Hitachi experience*)
- Value Analysis--"Value Engineering" (*HP example*)
- Quality Function Deployment (QFD), Going to the *Gemba* (*Hitachi*)
- Group Technology, (*IBM example*)
- Cost management and optimization, SPC, Six-Sigma (*Motorola*), TQC, etc

DFM Tools: DFA Guidelines



DFM Tools: DFA Guidelines

- **Summary of DFA Guidelines**

1. Minimize the number of parts
2. Standardize and use as many common parts as possible
3. Design parts for ease of fabrication (use castings without machining and stampings without bend)
4. Minimize the number of assembly planes (Z-axis)
5. Use standard cutters, drills, tools
6. Avoid small holes (chips, straightness, debris)
7. Use common datum's for tooling fixtures
8. Minimize assembly directions
9. Maximize compliance; design for assembly
10. Minimize handling
11. Eliminate adjustments
12. Use repeatable, well understood processes
13. Design parts for efficient testing
14. Avoid hidden features
15. Use Guide features
16. Incorporate symmetry in both axis
17. Avoid designs that will tangle.
18. Design parts that orient themselves

DFM Tools and Methodology

- **FMEA (Failure Mode and Effects Analysis)**
 - Method for analyzing the causes and effects of failures.
 - Highlights designs and assemblies most likely to cause failures.
 - Helps identify and prioritize corrective action
 - Indicates where the most improvement in terms of severity, frequency, and detectability can be made.
 - Widely used manufacturing technique (Mil standards, SAE, ANSI Specs)

DFM Tools and Methodology

- **FMEA Method**

- On the next page is a simple example of FMEA for a Disk Drive Actuator assembly
- Here's the method I used:
 - Adopt a correlation scoring system between parts and failure modes. A system commonly used is:
 - 9 for a "A"- indicates a strong correlation.
 - 3 for a "B"- indicates some correlation.
 - 1 for a "C"- indicates possible correlation
 - Apply a weighting to the parts. For example, 1, 4, 9, 16, where 16 is more important than 1.
 - Sum these horizontally to give a gross weight for each part.
 - Calculate the percentages in the right-hand column.
 - The percentages prioritize the areas to which attention should be given.

DFM Tools and Methodology

■ FMEA for a Disk Drive Actuator Assembly

Assembly components	Parts Weight	Flux clean	Bent HGA	Touch up	Failure modes		Gross Weight	Percent
					Flash			
Cable align	16	A/144		C/48	A/144		336	42
Heat sink	16	A/144	A/144				288	36
Solder	4	C/12	C/12	A/36	A/36		96	12
Holder	9		A/81				81	10
totals							801	100

Weight according to importance

Assembly components

Failure modes

should be given highest priority

Most correlations, but not the highest priority

Summary

- **What is DFM?**
 - Design considering manufacturing
- **Why DFM?**
 - Shorter Development Cycle
 - Lower costs and higher quality
 - Fewer Engineering Changes
- **DFM Approach**
 - “Integrated” in product design process.
 - Not “designed in a vacuum”
- **Tools and Methods**
 - Design is the first manufacturing step.
 - The essence is use a combination of tools and methods which are appropriate for your application

DFM Tools Pro's and Con's

■ DFM Tools Pro's and Con's

Technique	Advantage	Disadvantage
Guidelines	• Cost and Effort • Management Team Approach	• Exceptions to list
Taguchi	• Systematic • Narrows possibilities	• Management • “Buy-in” • Designer Effort
FMEA	• Systematic • Prioritize corrective action • Provides guidance	• Management • Rates only ease of assembly

DFM Tools: Comparisons

■ DFM Tools Comparison Table

DFM TOOLS	DFM ACTIVITY			
	PRODUCT CONCEPT	SIMPLIFY CONCEPT	PROCESS NEEDS	FUNCTIONAL NEEDS
DESIGN GUIDELINES	X	X		
DESIGN FOR ASSEMBLY		X		
TAGUCHI	X			X
CUMPUTER AIDED DFM	X	X	X	X
GROUP TECHNOLOGY	X			X
FMEA	X			X
VALUE ANALYSIS				X



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I Want to Learn More!

- **Where else?**
 - SCPD.stanford.edu, ME396 (DFM Forum)
 - CACT Center, De Anza College, DFM Seminar
 - University of Rhode Island, DFA

