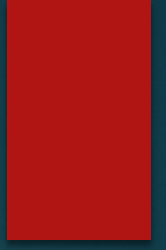
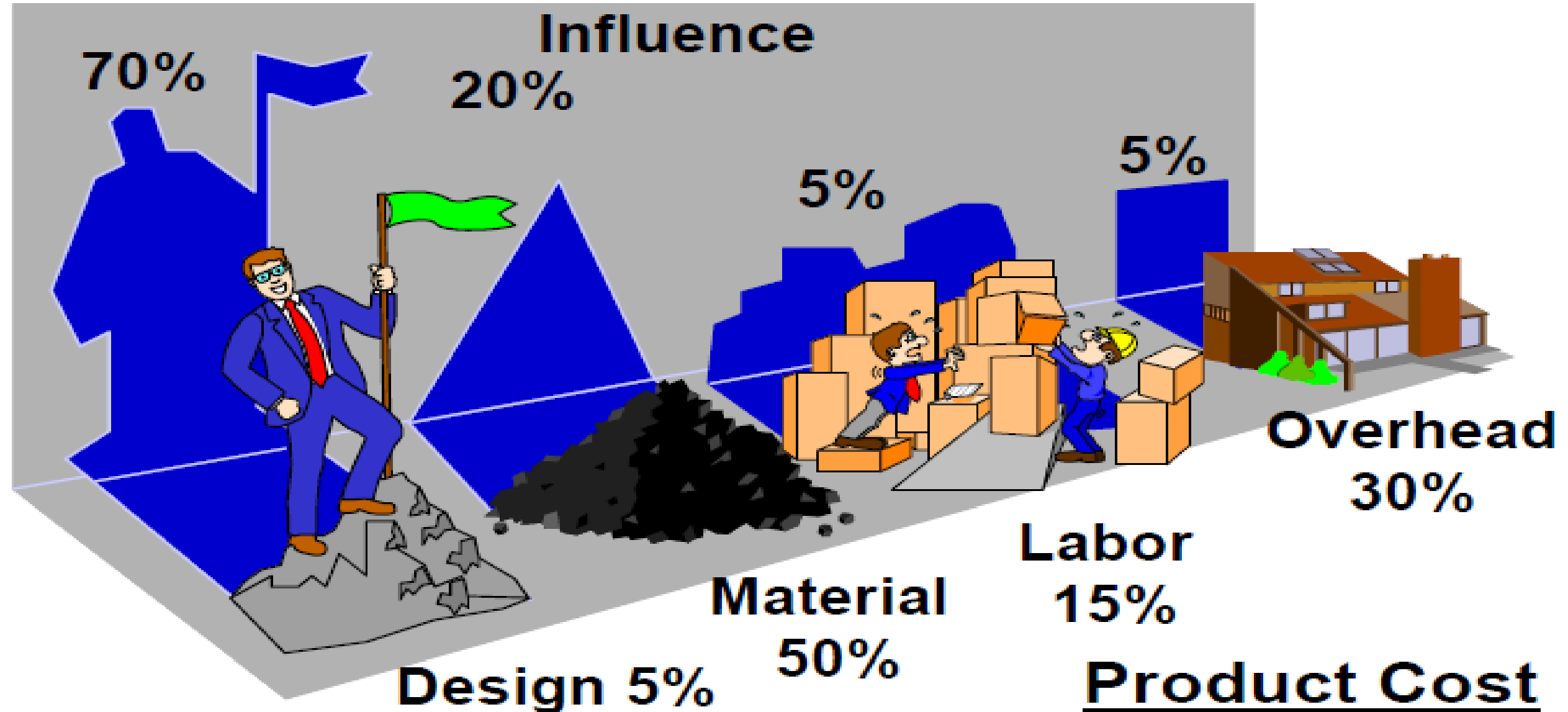


Design for **X**



Who Casts the biggest shadow ?



Design for X

X=MANUFACTURING

X=ASSEMBLY

X=RELIABILITY

X=MAINTAINABILITY

X=SERVICEABILITY

X=ENVIRONMENT

X=LIFE CYCLE COST



DFM

Design for manufacturability (DFM) is the general engineering art of designing products in such a way that they are easy to manufacture.

Design for Manufacturing (DFM)

- ▶ Designing or engineering a product in order to facilitate the manufacturing process
- ▶ Reduce manufacturing cost
- ▶ Engineer/Designer should consider the type of raw material and the form of the raw material
- ▶ Optimize all the manufacturing functions: fabrication, assembly, test, shipping, delivery, service, and repair
- ▶ Assure the best cost, quality, reliability, regulatory compliance, safety, time-to-market, and customer satisfaction.

DFM GUIDELINES

1. Simplify the design and reduce the number of parts

The reduction of the number of parts in a product is probably the best opportunity for reducing manufacturing costs. Less parts implies less purchases, inventory, handling, processing time, development time, equipment, engineering time, assembly difficulty, service inspection, testing, etc.

2. Develop a modular design

The use of modules in product design simplifies manufacturing activities such as inspection, testing, assembly, purchasing, redesign, maintenance, service, and so on.



3. Use of standard components

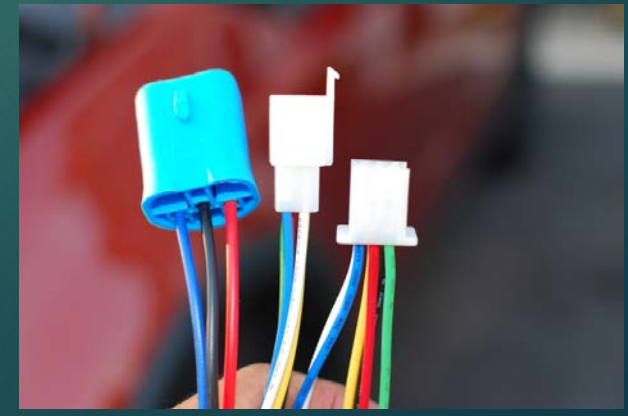
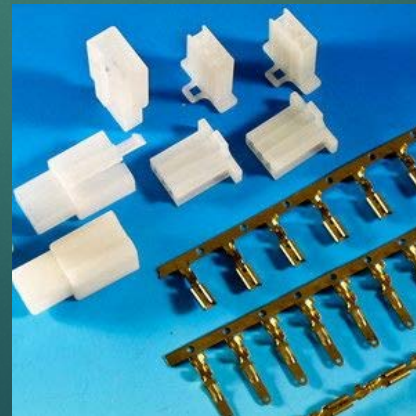
Standard components are less expensive than custom-made items. The high availability of these components reduces product lead times. Also, their reliability factors are well ascertained. Furthermore, the use of standard components refers to the production pressure to the supplier, relieving in part the manufacture's concern of meeting production schedules.



Standard Components



Non-standard components



3.Design parts to be multi-functional

Multi-functional parts reduce the total number of parts in a design, thus, obtaining the benefits given in rule



Automobile chassis act as structural member as well as electricity earthing line



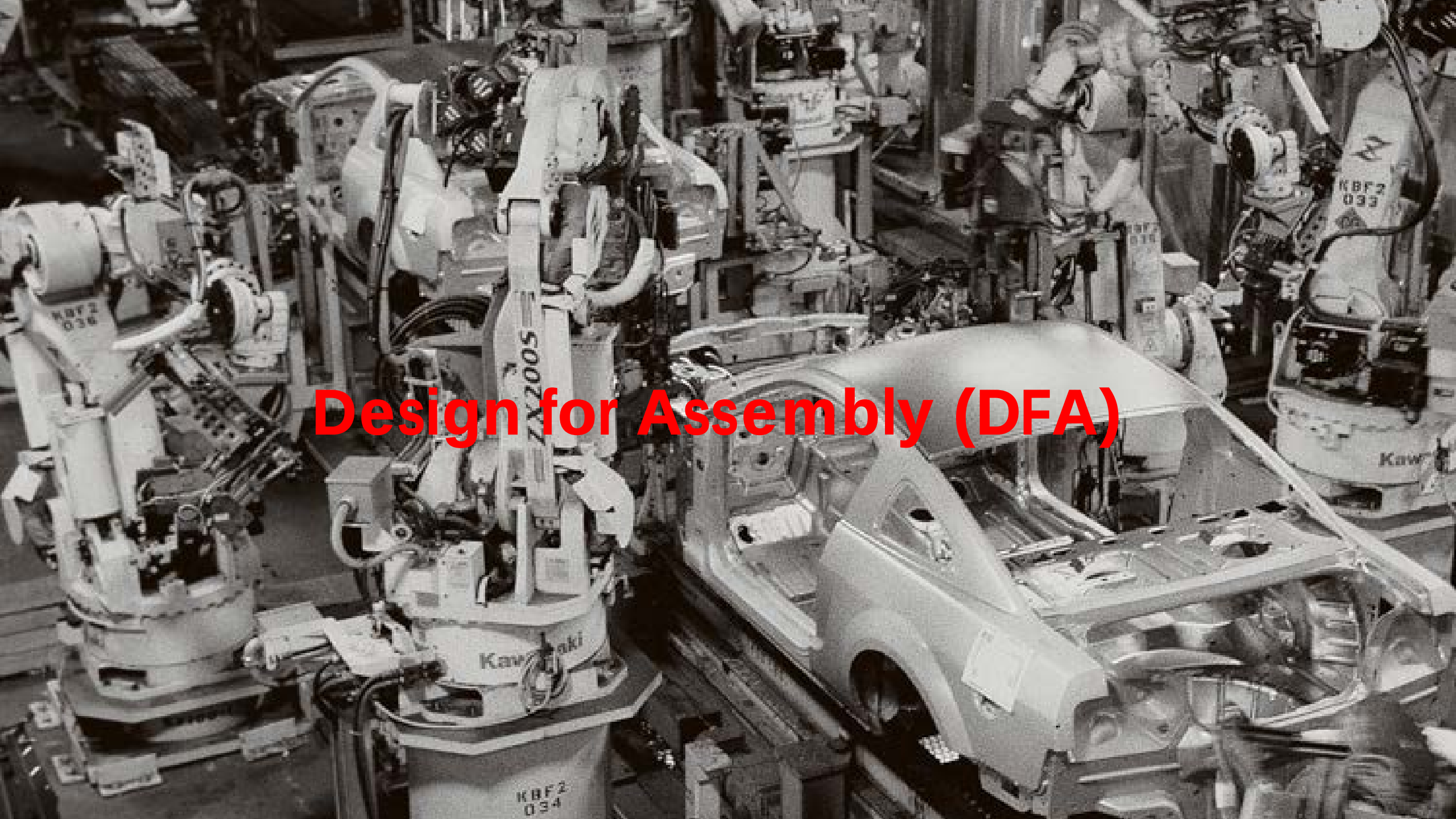
Bike engine casing act as heat dissipater

4. Design for ease of fabrication

Select the optimum combination between the material and fabrication process to minimize the overall manufacturing cost. In general, final operations such as painting, polishing, finish machining, etc. should be avoided. Excessive tolerance, surface-finish requirement, and so on are commonly found problems that result in higher than necessary production cost.

5. Provide Tolerance

Each manufacturing process has an inherent ability to maintain a certain range of tolerances, and to produce a certain surface roughness (finish). To achieve tolerances outside of the normal range requires special processing that typically results in an exponential increase in the manufacturing cost

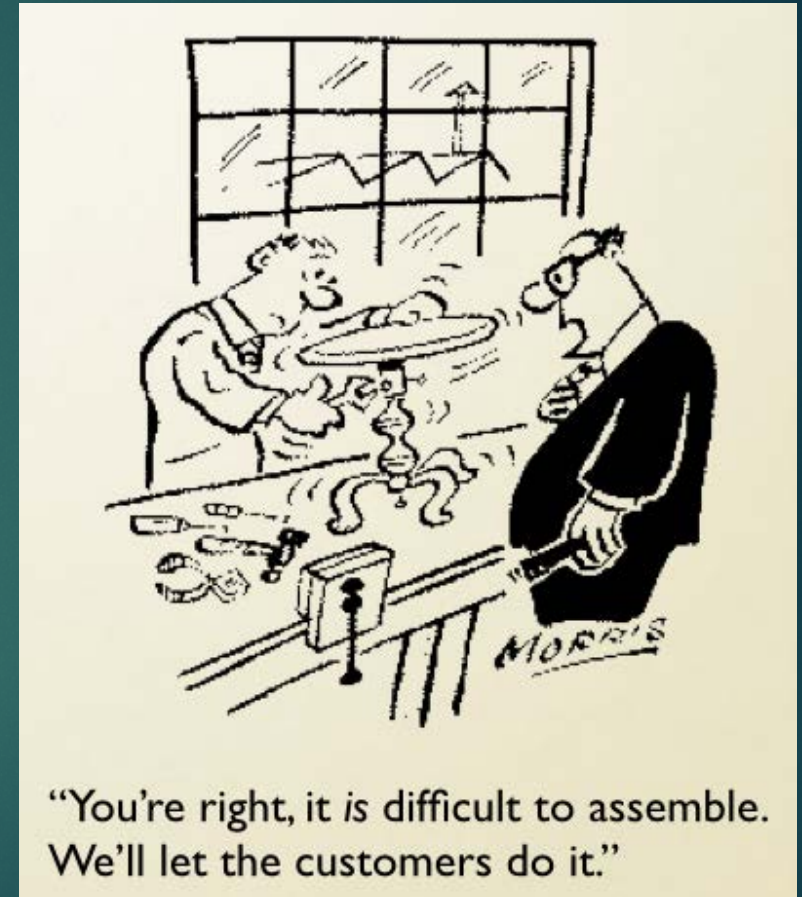


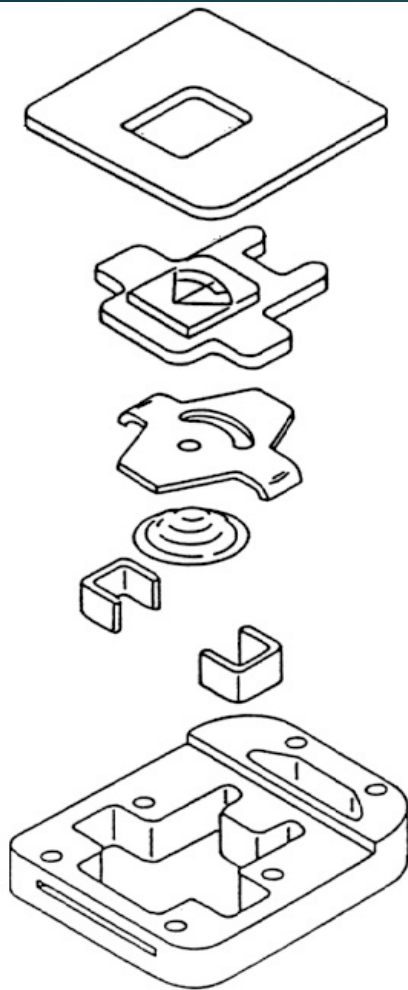
Design for Assembly (DFA)

It is a subset of DFM which involves the minimization of cost of assembly

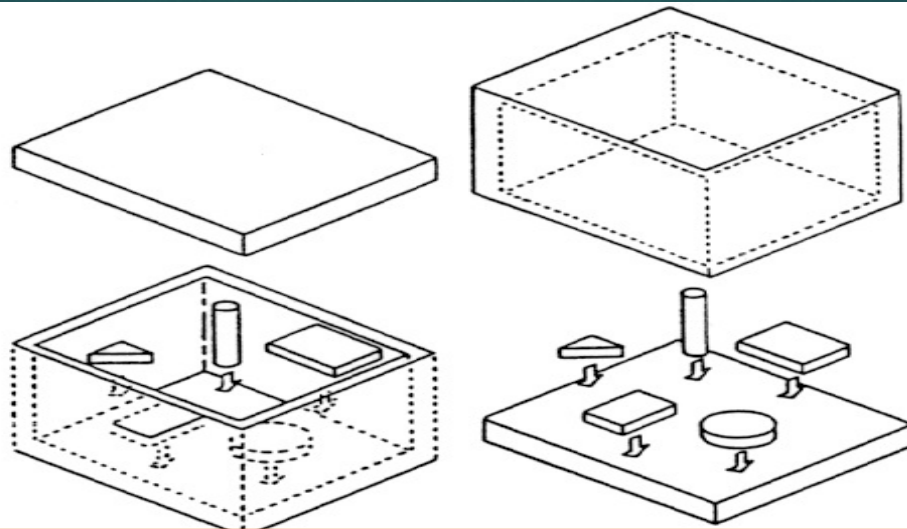
To maximize ease of assembly

- **Part is inserted from top**
- **Part is self aligned**
- **Part does not need to be oriented**
- **Part requires only one hand for assembly**
- **Part requires no tools**
- **Part is assembled in single linear motion**
- **Part is secured immediately upon insertion**

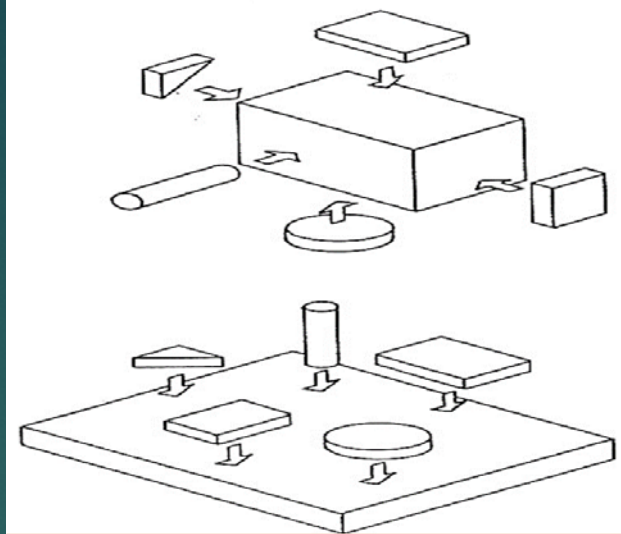




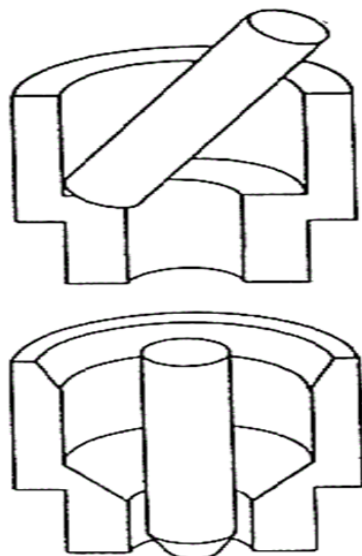
Design for uni-directional assembly preferably using gravity. Assembly to a stable base



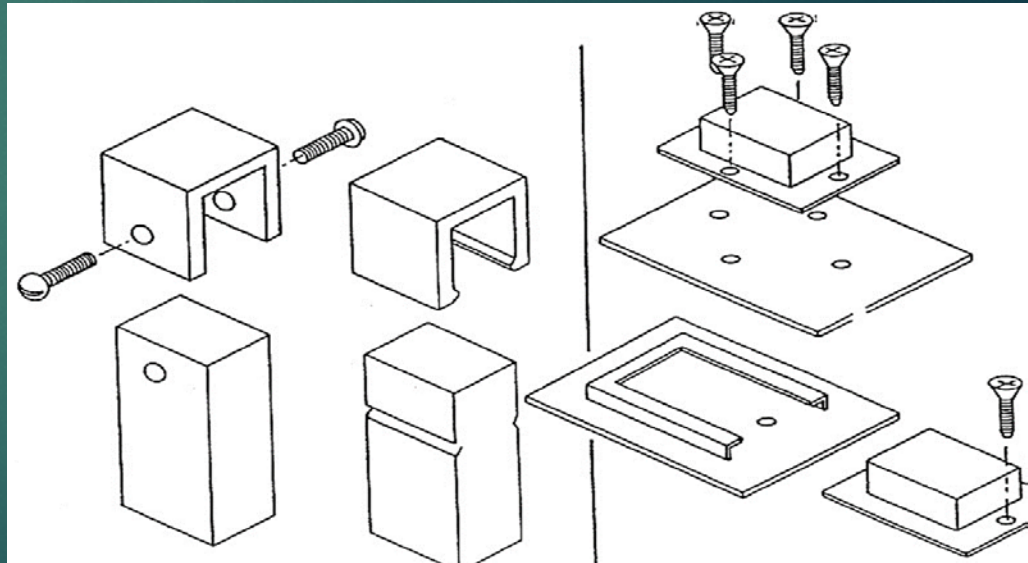
Design parts by considering access and visibility for ease of insertion



Uni-directional insertion



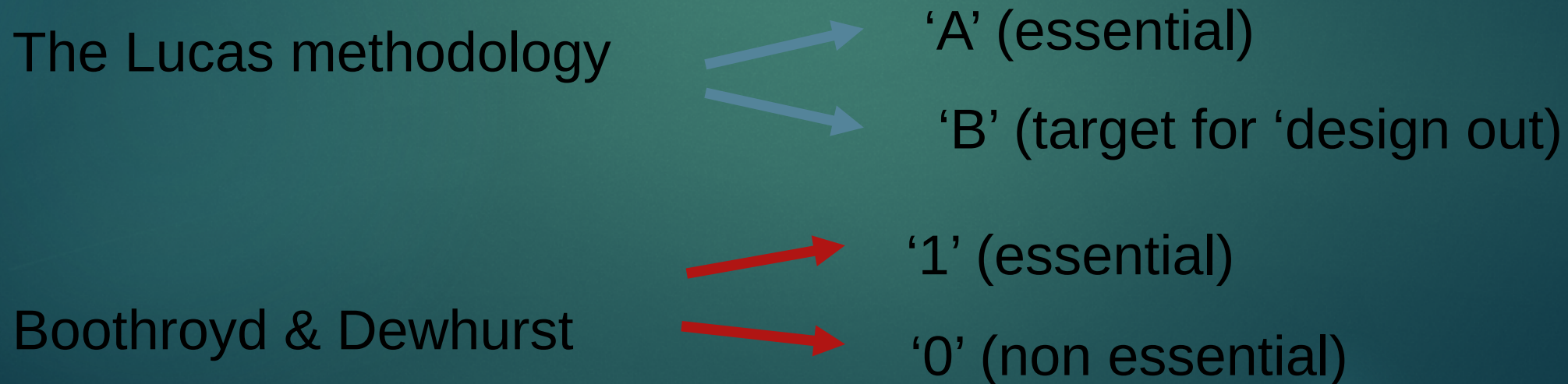
Self Aligned Parts



Avoid separate fasteners: design the fastening functions into the parts.

Which Parts are Essential?

- Both the Boothroyd & Dewhurst, and Lucas methodologies use the idea of fundamental or essential parts.
- All non-essential parts should be evaluated in case they can be designed out.



Design Efficiency

- Design Efficiency is the number of essential parts divided by the total number of parts, expressed as a percentage.

$$\frac{A}{A + B} \times 100\%$$

- Maybe use Design Efficiency in a decision gate, by specifying a target efficiency percentage.

START

Does this part move relative to all parts which have already been analysed?

Y

Is the movement essential for the product to function?

Y

Must the part be separate to provide the required movement?

Y

It's an "A" PART – essential

N

N

N

Is this part of a different material to all parts already analysed, with which there was no relative movement?

Y

Is a different material essential for the product to function?

Y

Must the part be separate to satisfy the different material requirement?

Y

N

N

N

Is the part separate to allow for its in-service adjustment or replacement?

Y

Is the adjustment or replacement essential?

Y

Must the part be separate to enable the adjustment or replacement?

Y

N

N

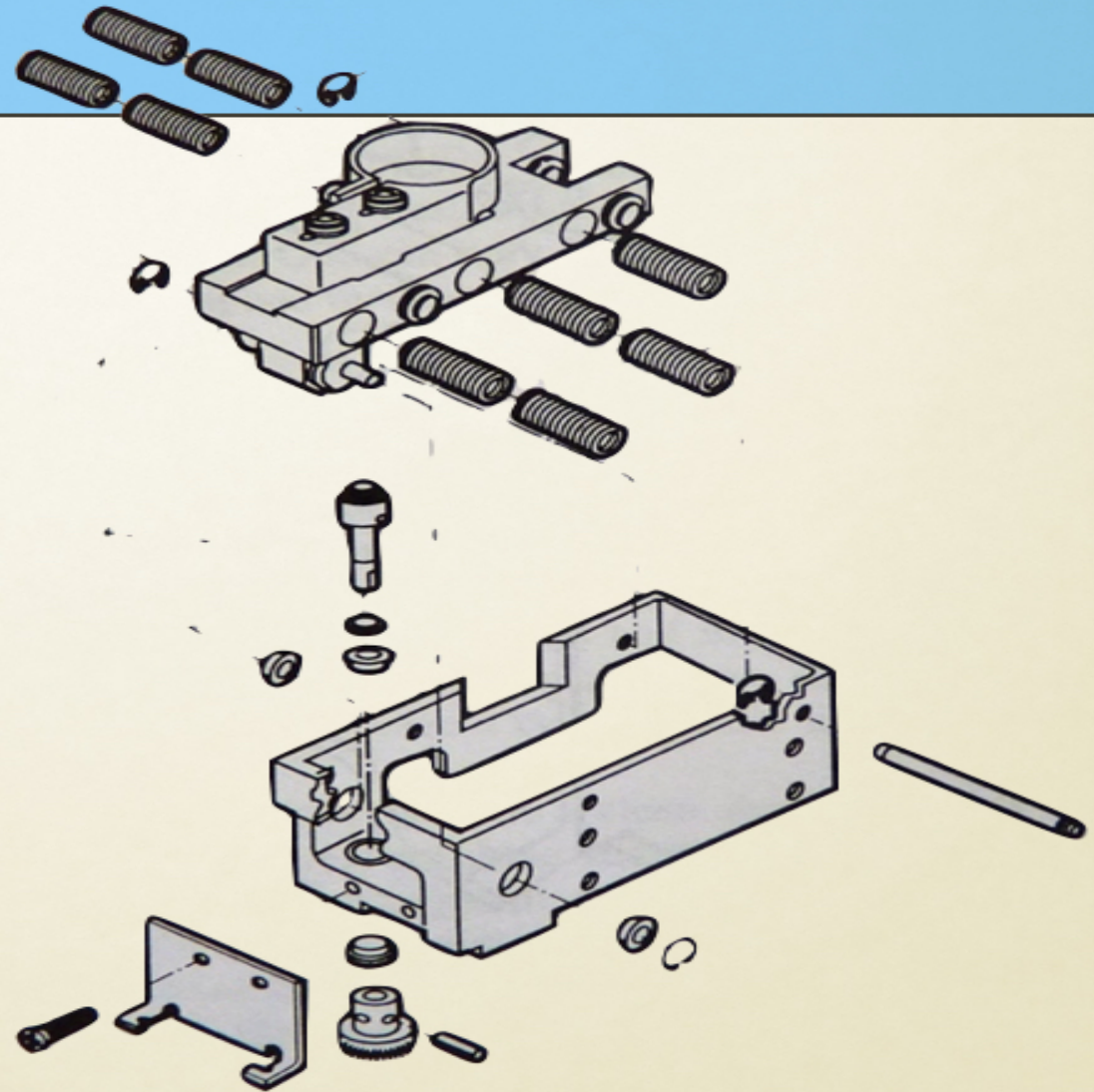
N

It's a "B" PART – non-essential

Example

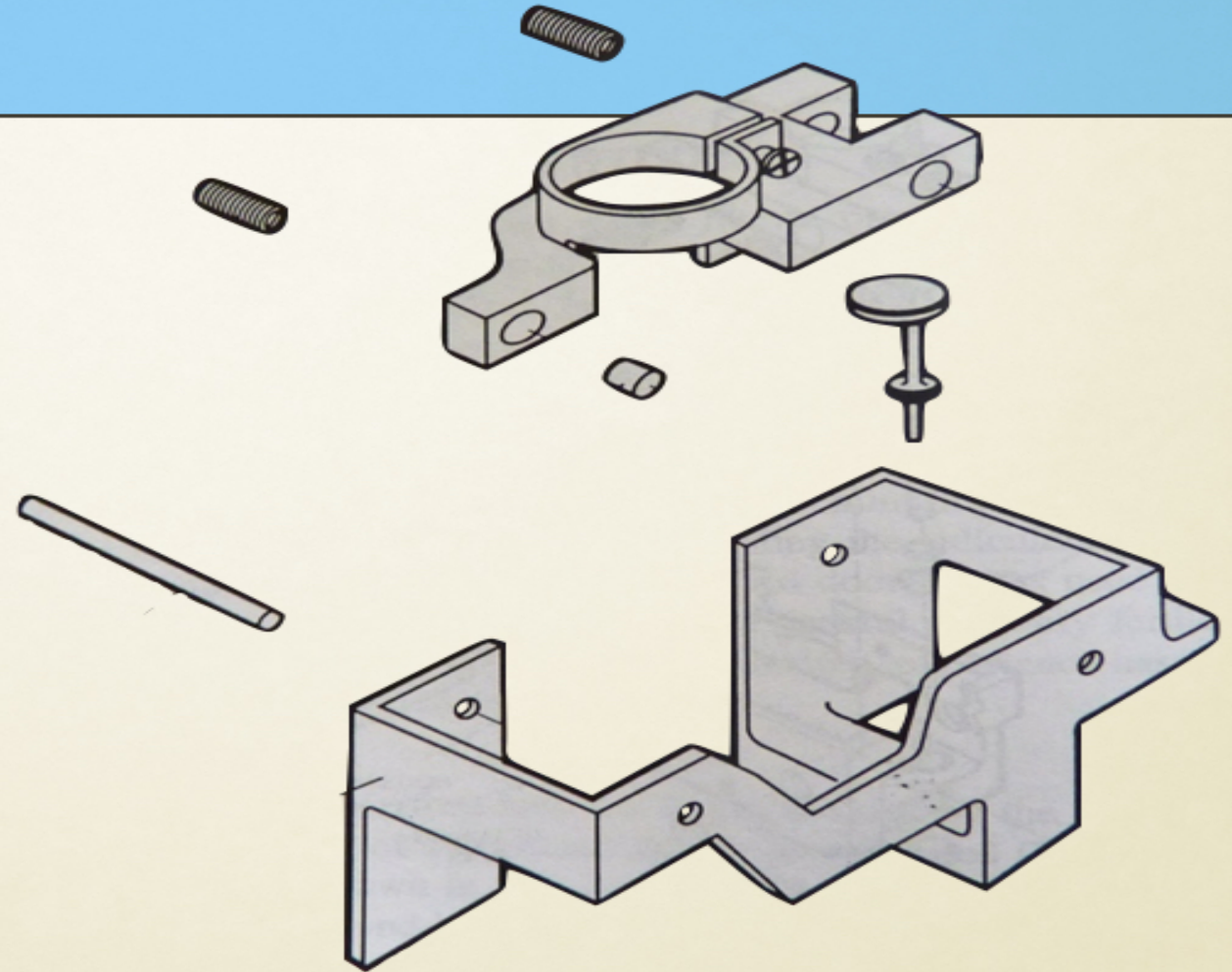
Original design for a thermal gunsight reticle in a US tank, made by Texas Instruments, Inc.

There are a large number of fasteners.



Example

Redesigned thermal
gunsight reticle:
simpler to assemble,
and less to go wrong!

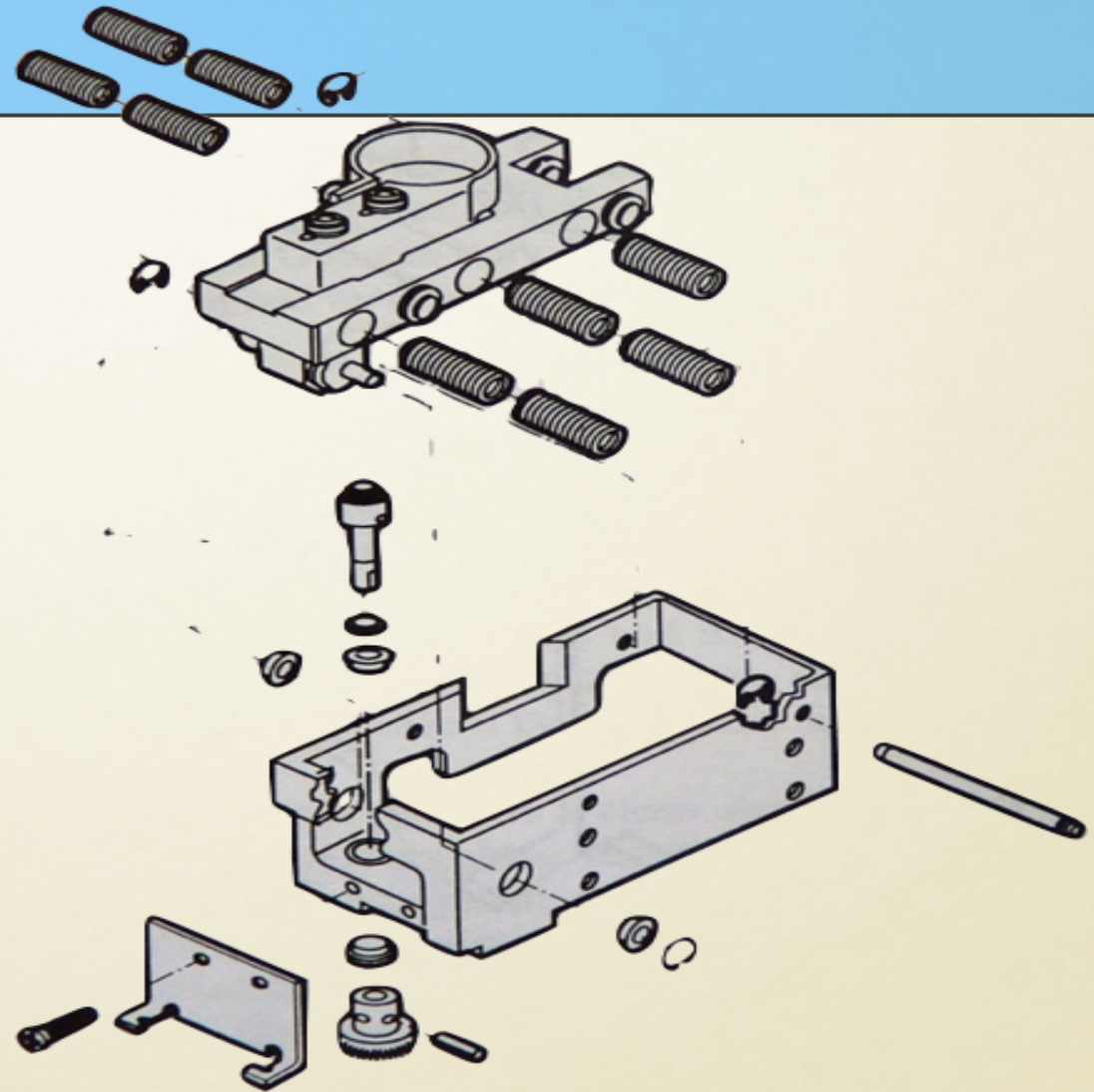


Source: Boothroyd, Dewhurst and Knight (1994)

Example

Original design for a thermal gunsight reticle in a US tank, made by Texas Instruments, Inc.

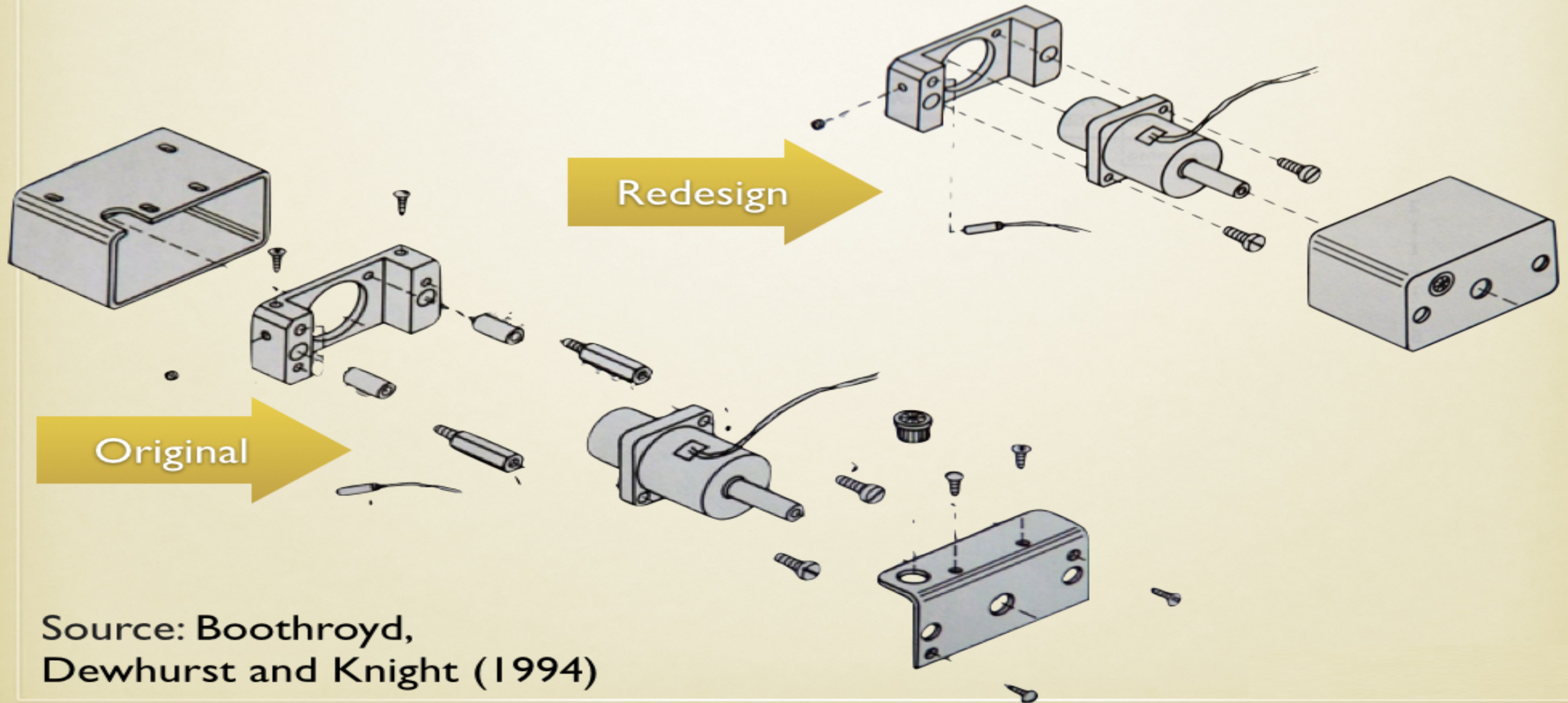
There are a large number of fasteners.



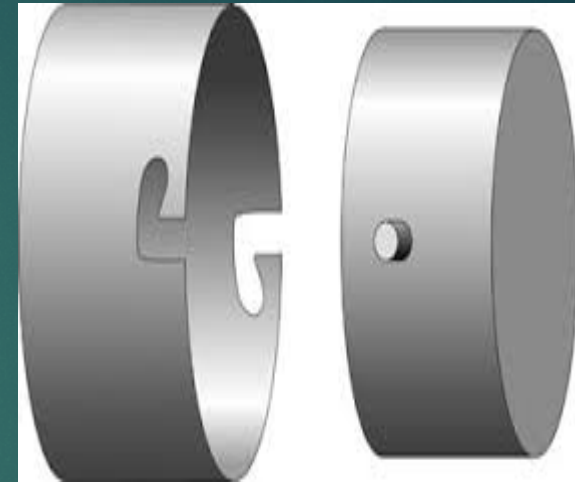
Measuring Improvement

	Original	Redesign	Improvement
Assembly time (h)	2.15	0.33	84.7%
Number of different parts	24	8	66.7%
Total number of parts	47	12	74.5%
Total number of operations	58	13	77.6%
Metal fabrication time (h)	12.63	3.65	71.1%
Weight (lb)	0.48	0.26	45.8%

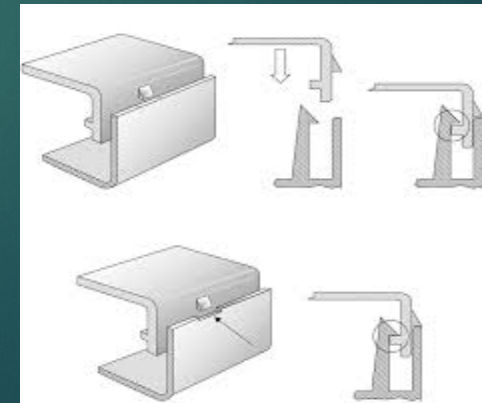
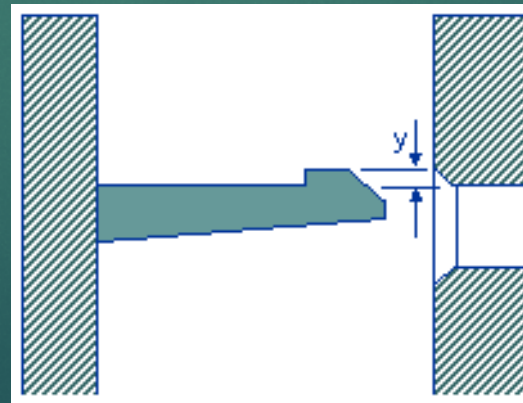
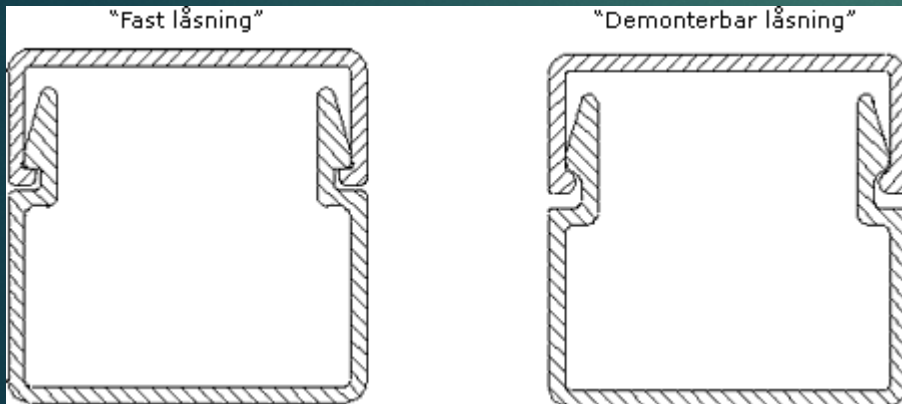
Another example



Use hassle free joining methods

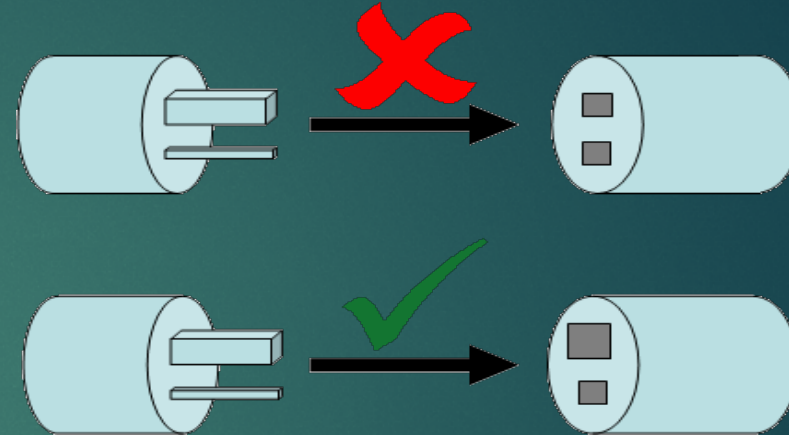


Snap Joints



MISTAKE PROOFING ISSUES (POKA-YOKE)

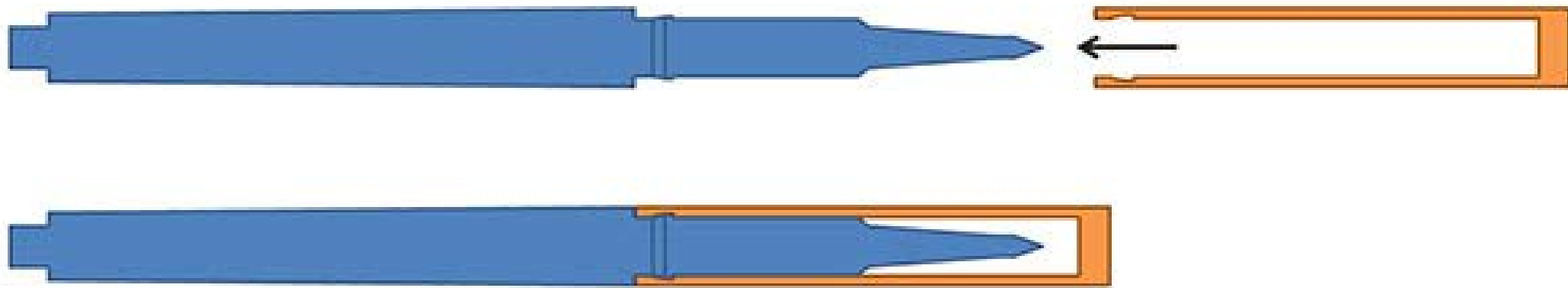
- Cannot assemble wrong part
- Cannot omit part
- Cannot assemble part wrong way around.



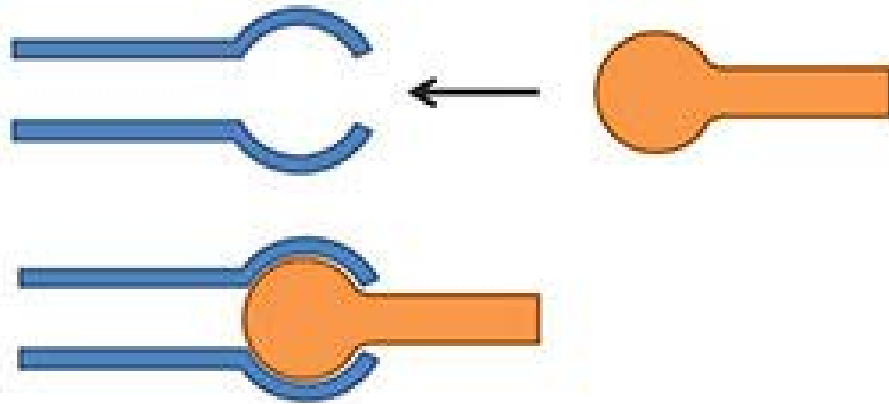
Poka-yoke example: Ethernet cable plug is designed to be plugged in only one orientation.



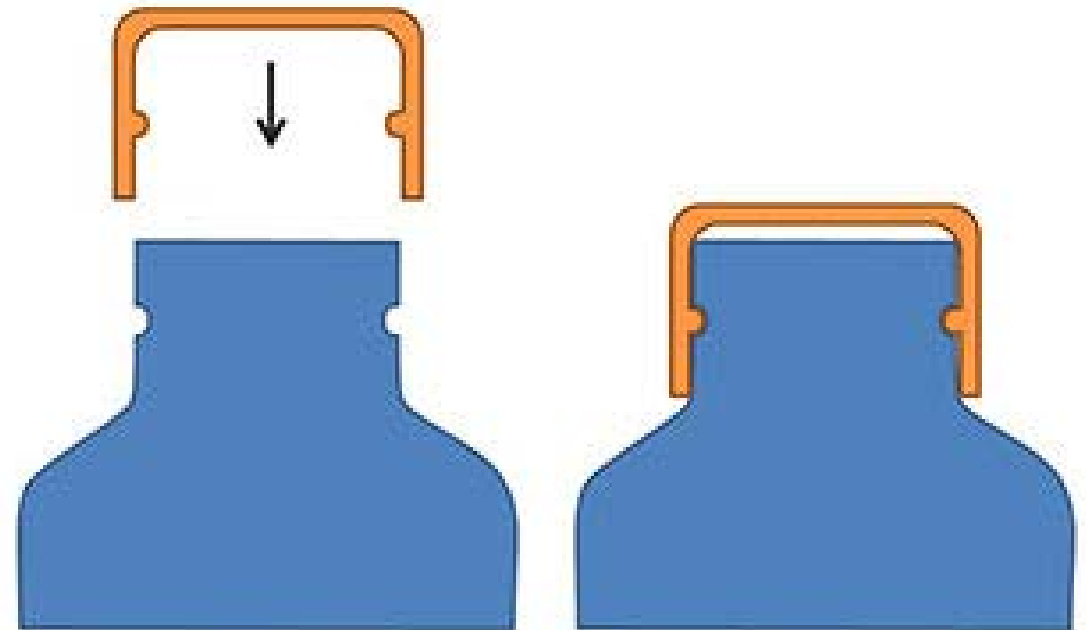
Annular Snap-Fits



A pen utilizes an annular snap fit to retain the cap

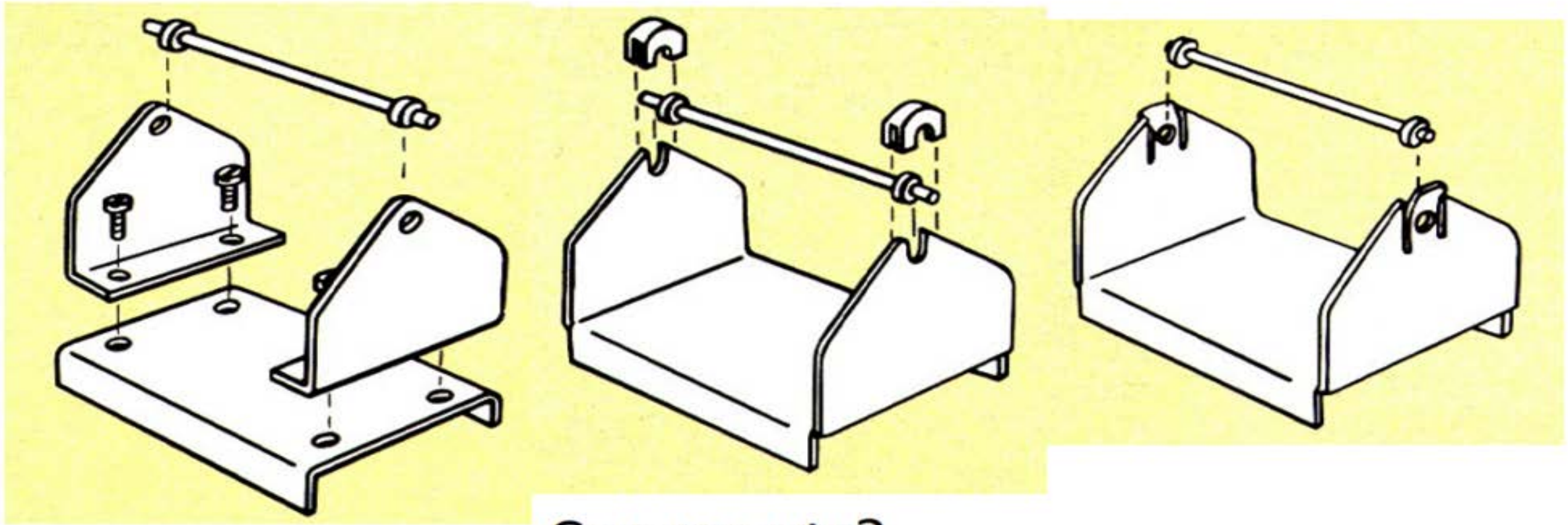


A ball and socket joint is a kind of annular snap fit



Bottle cap uses an annular snap fit

Three solutions to the same design issue.

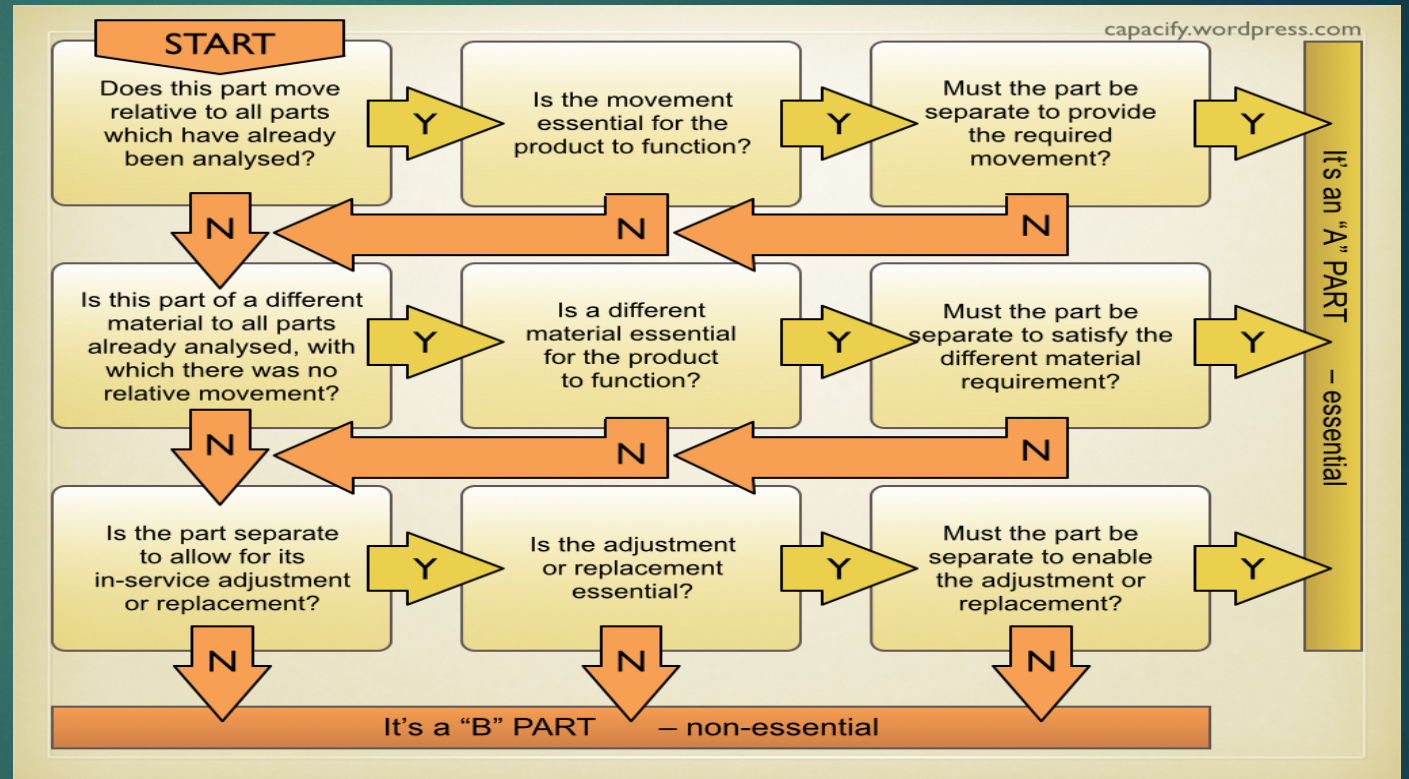


Comments?

Which do you prefer?

Why?

A Product Autopsy



Basic Principles

Some simple rules can save you some time when trying to identify fundamental parts...

- The first part analysed will always be 'essential' because there is nothing to compare it to (but try to choose something sensible...)
- Fasteners (nuts, bolts, screws, pins, rivets...) are never 'A' parts, and should *always* be considered as a target for designing out.

Product Autopsy

Any product that you no longer have a use for might be dismantled to see if it's as simple as it could possibly be.

- Learn by doing!
- Use the matrix of nine questions to see which parts are essential.
- Don't dismantle anything you might want to use again!



Fasteners...

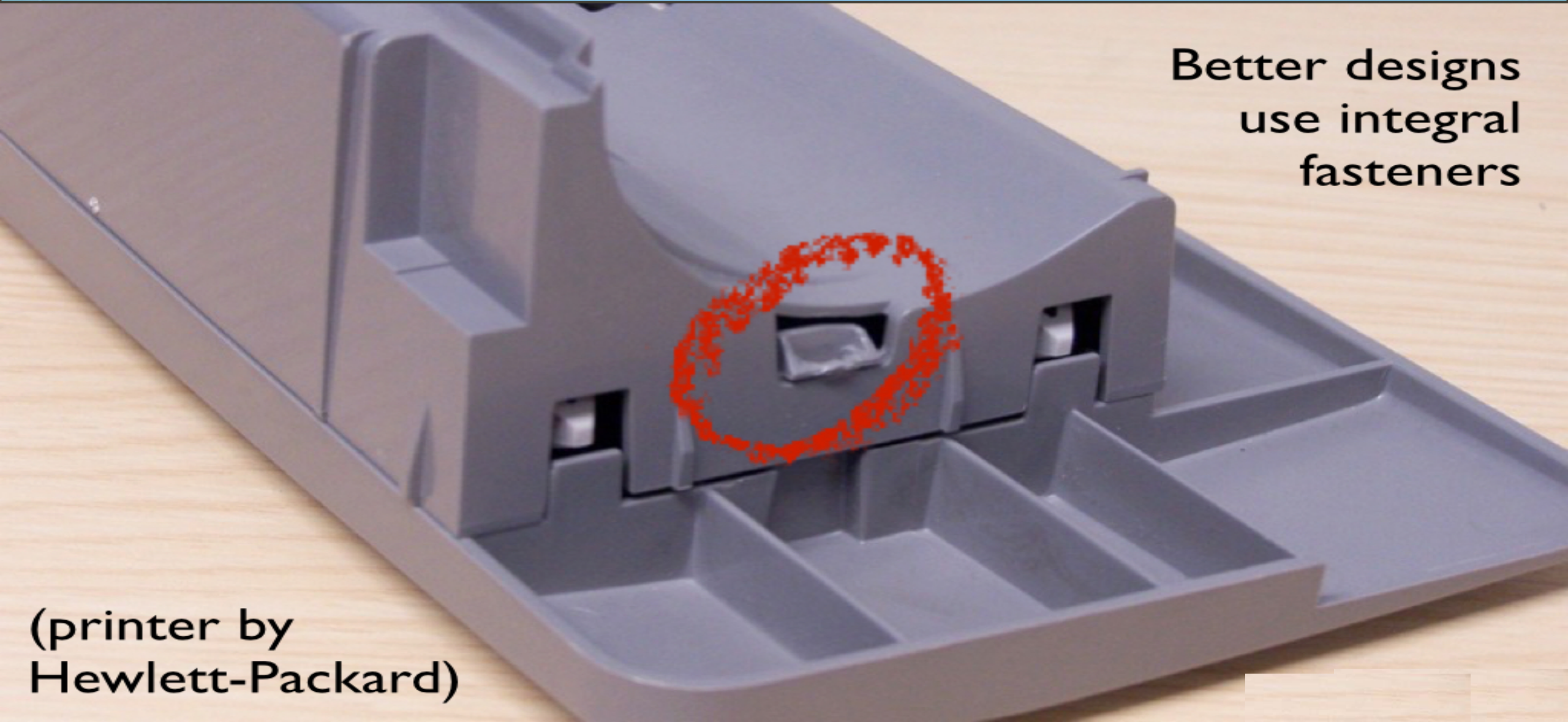
Five screws
hold two
halves of the
telephone
base
together



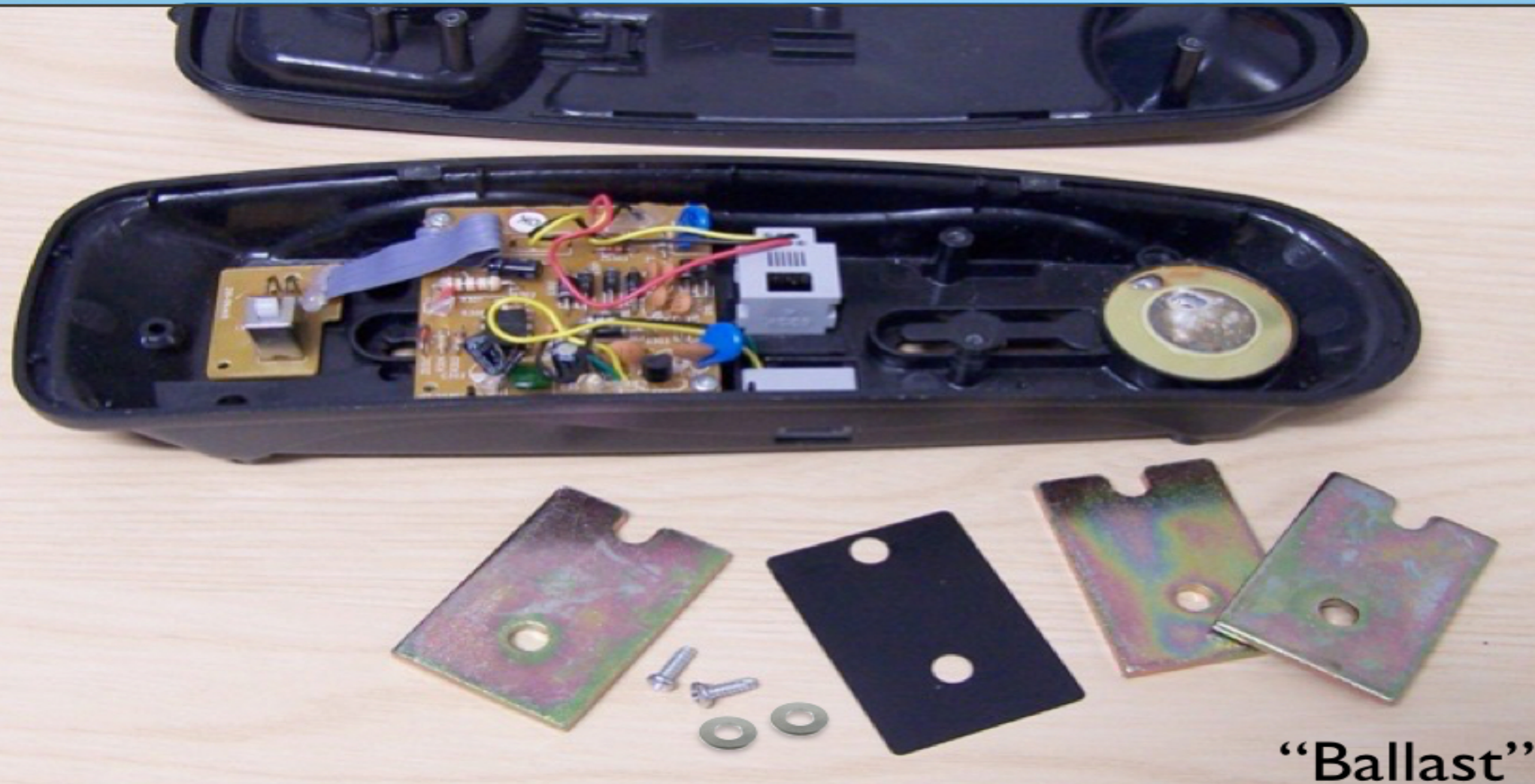
Fasteners...

Better designs
use integral
fasteners

(printer by
Hewlett-Packard)



More waste inside...



Discussion point #1

- What is the “ballast” for?

What is the “ballast” for?

Possible answers...

- Makes the phone base more likely to stay where it's put, perhaps?
- Makes it feel like a durable, 'quality' product because it's heavy?
- Other reasons?

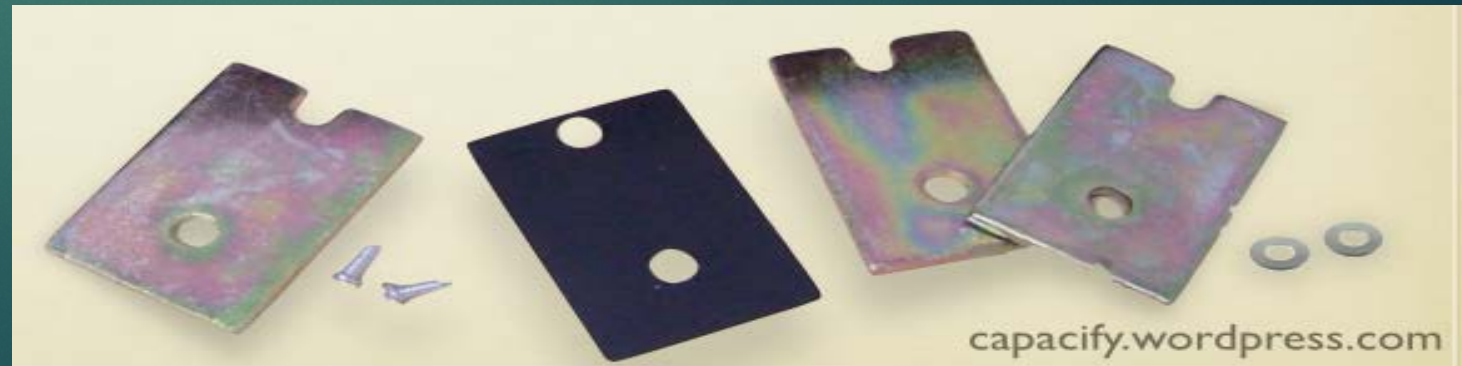
Discussion point #2

- Supposing the product needs to have a heavy base... is this the best way to achieve that design requirement?
- What's wrong with the approach taken?

What's wrong with the design?

Possible answers...

- Why are *three* pieces of sheet steel required?
- Why must they be held in place by two screws, and two washers?
- Is the plastic shim really necessary?
- Couldn't the phone base just have a single piece of steel, a big lump of putty, or a sandbag, or something?



DFA for electronics too...



Is all that interconnection necessary? Point-to-point wiring and a ribbon connector means more work.

Final verdict

- Too many components overall
- Too many fasteners (should be integral clips)
- Too much variety (different part types)
- Multiple parts to do a simple job (“ballast”)
- Too many assembly operations required
- Assembly operations that would be difficult to automate (including point-to-point wiring)
- Product was needlessly expensive to make
- Reliability was compromised by excessive interconnection via manual processes

Design for Reliability

Reliability is defined as the probability that a component, equipment or system will satisfactorily perform its intended function under given circumstances.

Improving Reliability

- Making failures less likely to happen in the first place
(e.g. By maintaining the equipment properly or fitting more reliable equipment)
- Making changes such that the overall system continues to function satisfactorily even when a failure occurs
(e.g. By fitting standby equipment)

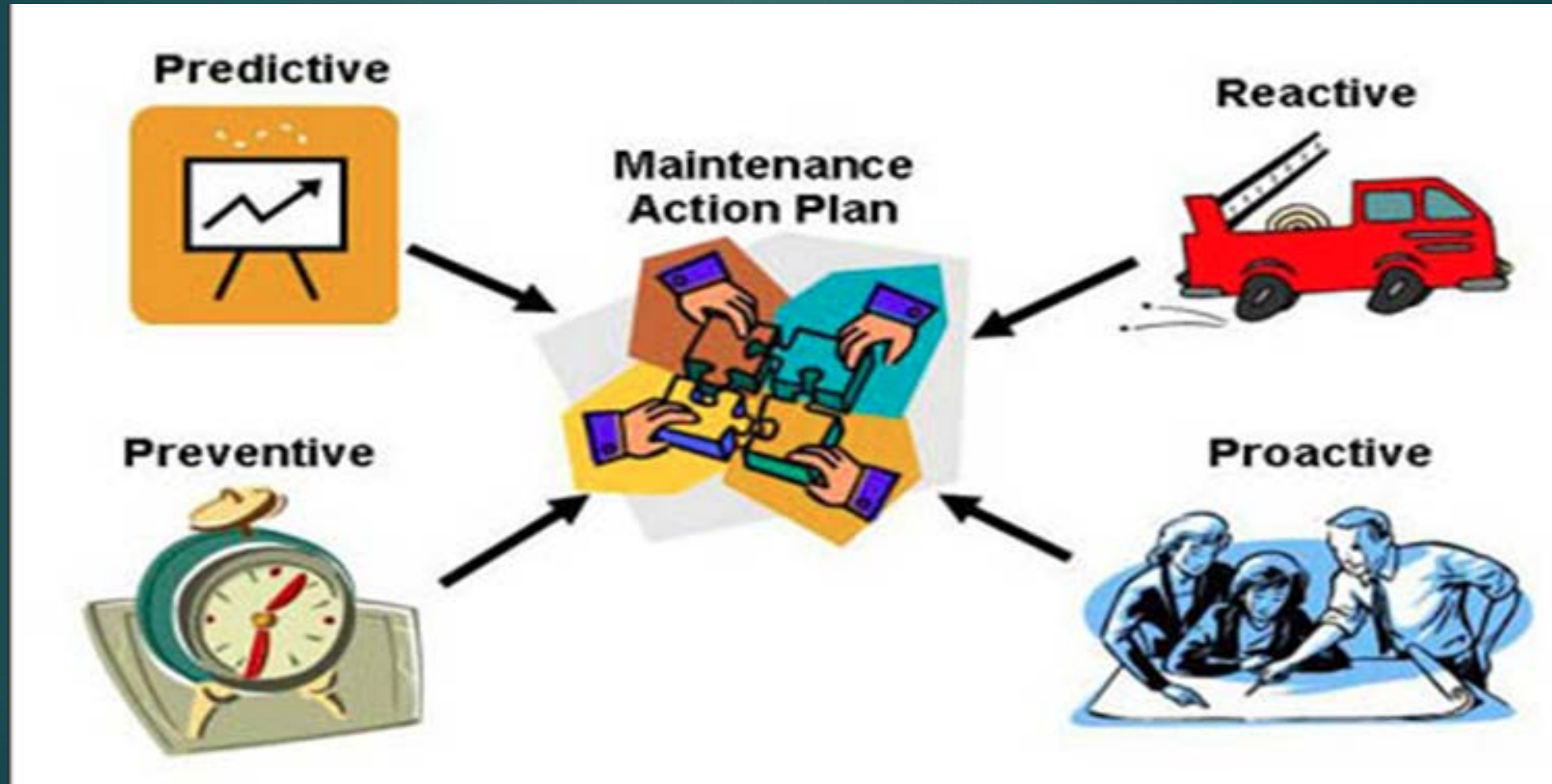
Design for Maintainability & Serviceability

The objective of Design for Maintainability is to assure that the design will perform satisfactorily throughout its intended life with a minimum expenditure of budget and effort. Design for maintainability (DFM), Design for Serviceability (DFS), and Design for Reliability (DFR) are related because minimizing maintenance and facilitating service can be achieved by improving reliability.

An effective DFM minimizes

1. The downtime for maintenance,
2. user and technician maintenance time,
3. personnel injury resulting from maintenance tasks,
4. cost resulting from maintainability features, and
5. logistics requirements for replacement parts, backup units, and personnel

Types of Maintenance



Improving Maintainability

- ▶ Minimize the number of serviceable design parameters (DPs) with simple procedures and skills.
- ▶ Provide easy access to the serviceable DPs by placing them in serviceable locations. This will also enhance the visual inspection process for failure identification.
- ▶ Use common fasteners and attachment methods.
- ▶ Design for minimum hand tools.
- ▶ Provide for safety devices (guards, covers, switches, etc.)
- ▶ Design for minimum adjustment and make adjustable DPs accessible.



Placing projector bulb at accessible location reduce maintenance



Use standard fasteners



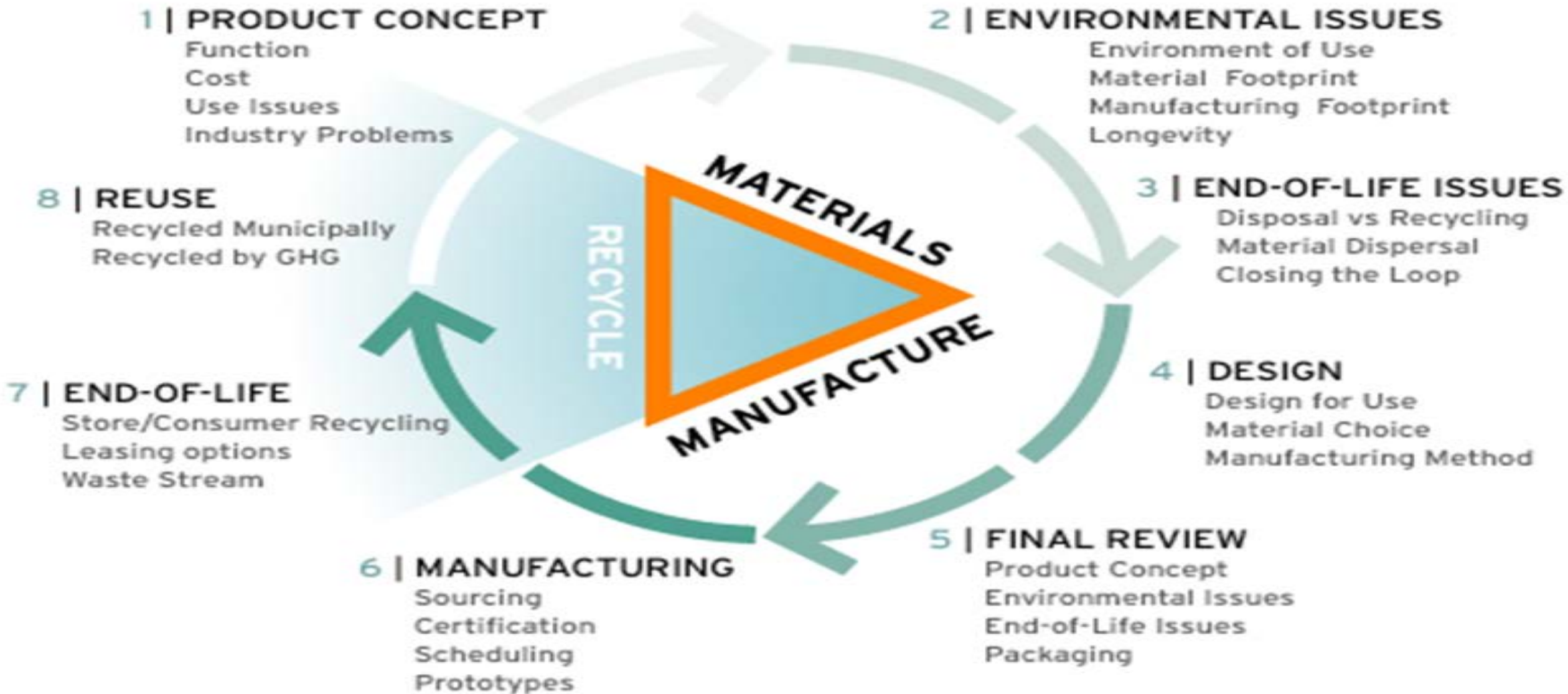
Providing protective casing is DSM

Design for Environment

Design for the Environment (DFE) is a design approach to reduce the overall human health and environmental impact of a product, process or service, where impacts are considered across its life cycle.

- ▶ Design for environmental processing and manufacturing
- ▶ Design for environmental packaging
- ▶ Design for disposal or reuse
- ▶ Design for energy efficiency

Design for Life cycle cost



Books/Sources

- *George E Dieter, Linda C. Schmidt-* Engineering Design
- *Dym, C. L., Little, P. and Orwin, E. J.,* Engineering Design - A Project based introduction-Wiley
- *Haik, Y. And Shahin, M. T.,* Engineering Design Process, Cengage Learning
- *Balmer, R. T., Keat, W. D., Wise, G., and Kosky, P.,* Exploring Engineering, Third Edition: An Introduction to Engineering and Design
- *V.B Bhandari-* Design of Machine Elements
- *Donald A Norman-* Living With Complexity
- *Jorma Tuomaala-* Creative Engineering Design
- *Don Norman-* Design of everyday things