GENERAL SIR JOHN KOTELAWALA DEFENCE UNIVERSITY

Engineering Product Design

ET 3153

Outline

Design Thinking, Inclusive Design and Design for X.

General Introduction to Standards.

Design Practice.

Documentation.

Formulation of Product Marketing Strategy.

Design for X

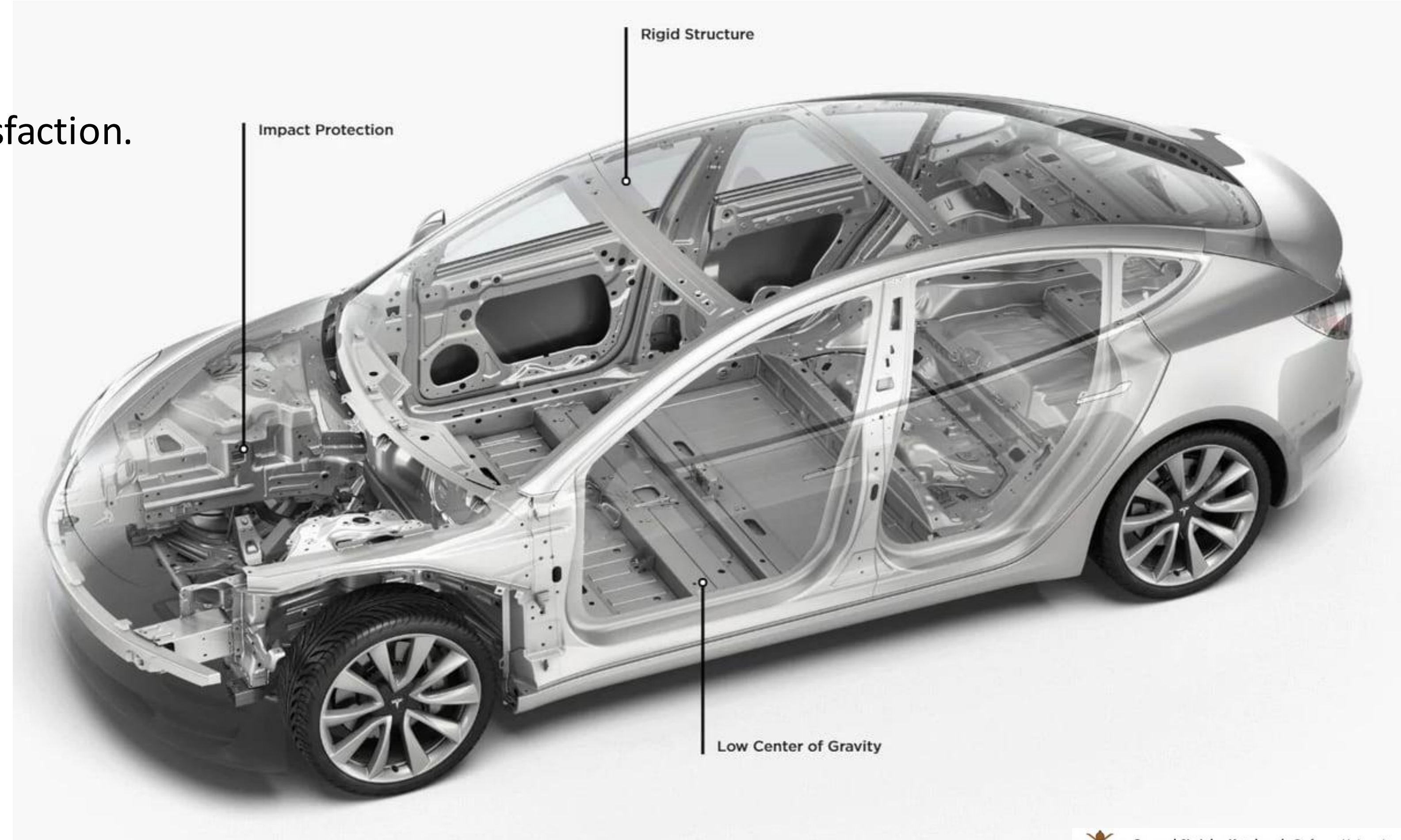
Design for X (DfX)

The term "design for X" first made an appearance at the Keys Conference in 1990 and in the AT&T Technological journal [14].

A key to competitive, profitable product realization is design for X (DFX); i.e., design for manufacturability, testability, installability, compliance, reliability, and other downstream considerations.

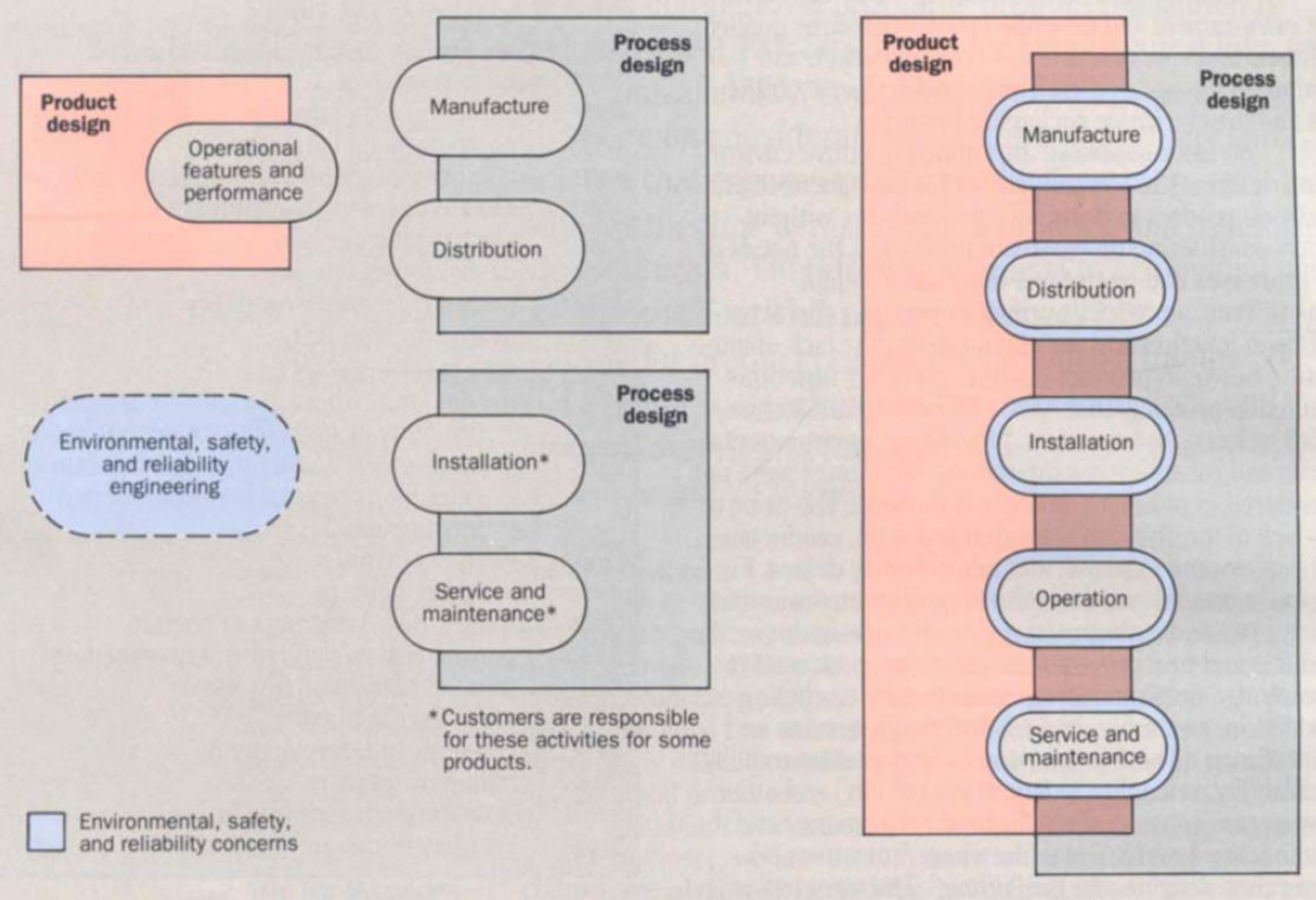
DFX is a philosophy and practice that ensures quality products and services, reduces the time to market for a product, and minimizes life-cycle costs.

Therefore, it is crucial to achieving customer satisfaction.



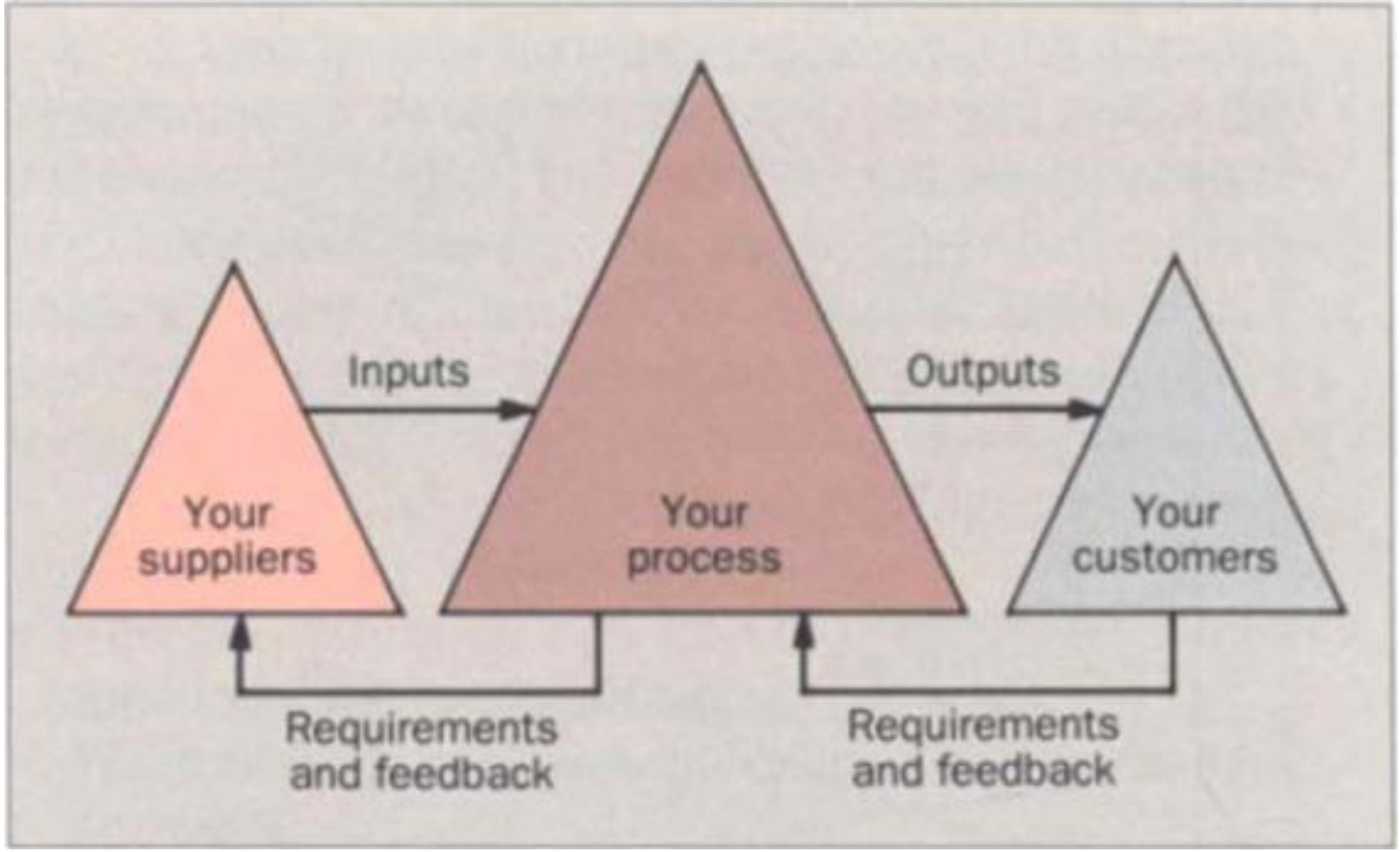
Design Environment

- Product and process design are integrated from end to end in the DFX environment.
- This integration across Product Realization Process (PRP) and business-operation functions permits the Design of products and processes for easier manufacture, distribution, installation, operation, service, and maintenance-while considering reliability, environment, and safety.
- The integrated DFX environment leads to higher quality, reduced time to market, and lower cost.



- The functions are linked through customer-supplier relationships and are driven by the customer's quality requirements, as well as by internal business objectives.
- DFX requirements and feedback are key elements in each of the customer-supplier relationships in the PRP.

Customer Supplier Model



- The customer requirements and feedback, as well as internal business obJectives drive the process as it converts supplier inputs into outputs delivered to customers.
- These customer-supplier relationships link all functions in the DFX environment.

Design for X

“Design for X (DfX) is

a set of technical guidelines

that may be applied during the design of a product

for the optimization of a specific aspect of the design.

DfX can control or even improve the product’s final characteristics” [12].

Design for X Process Trade Offs

- The team needs to understand how a design's attributes affect all the Xs, so that one DFX concern is not inadvertently optimized at the expense of another.
- For example, suppose a development team wants to combine or integrate parts to improve assembly operations and reliability. The team also needs to consider:
  - Manufacturability from a parts-fabrication viewpoint.
  - Repairability and serviceability.
  - Material-logistics overhead for introducing additional, unique parts. (Material logistics is the planning, managing, and movement of materials needed to manufacture a product and deliver it to customers.)
  - The effects on purchasing volumes of existing parts.

Design for X Process Trade Offs

- These parts-reduction DFX considerations are important for mechanical piece-parts and housings, as well as for silicon integrated circuits (ICs) and printed wiring boards (PWBs).
- Similarly, the team must consciously evaluate tradeoffs between DFX and performance or functionality considerations.
- For example, an assembly that has fewer parts is usually much easier to manufacture.
- However, one criterion for eliminating a partis that its elimination does not affect the assembly's function.
- Alternatively, the assembly's function could be reengineered, so that the part could be eliminated or combined with another part.
- Similarly, reducing the number of gates on an IC could lead to a lower cost chip. But maintaining the required functions, while reducing the gate count, can be a challenge.
- For example, when circuits that generate dual-tone, multifrequency signals for dialing were combined with those that produce the telephone's ring, a cost-effective, single-chip implementation of a telephone circuit was achieved. The gate count was halved, compared to separate dialing and ringing circuits.

Design for Manufacturing (DFM)

Designing or engineering a product in order to facilitate the manufacturing process:

- Reduce manufacturing cost
- 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

Design for M - 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.

BlueRobotics is raising funds for The T100: A Game-Changing Underwater Thruster on Kickstarter! An efficient, rugged, affordable underwater thruster to propel the future of marine robotics.

Design for M - Guidelines

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

Design for M - Guidelines

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

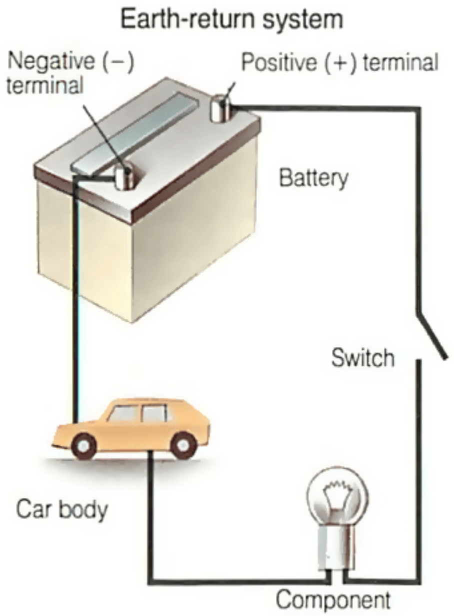
Design for M - Guidelines

3.Design parts to be multi-functional

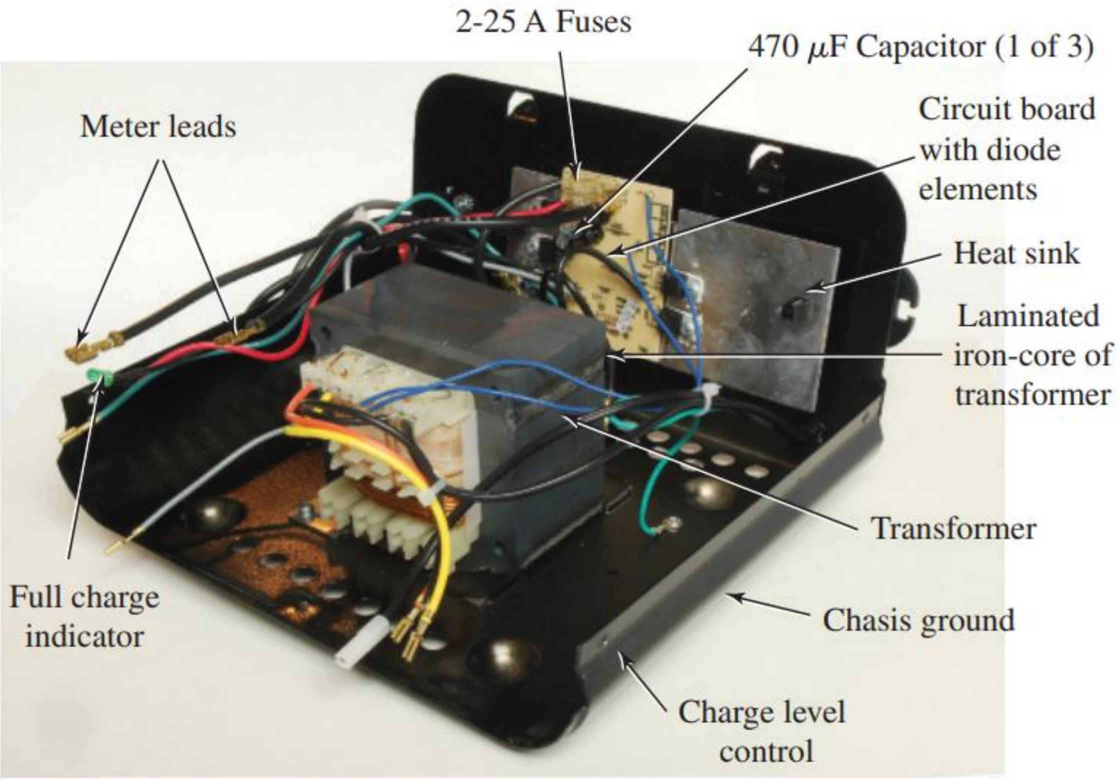
Multi-functional parts reduce the total number of parts in a design, thus, obtaining the benefits given in rule Automobile chassis

act as structural member as well as electricity earthing line

Bike engine casing act as heat dissipater



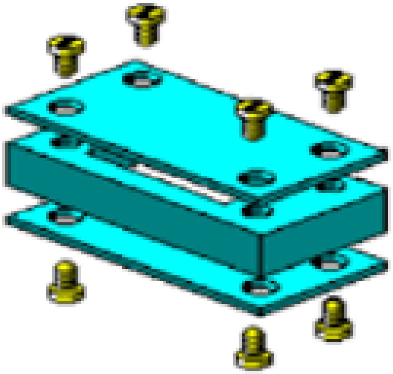
Inside of a battery charger the green wire grounds the chassis for safety.

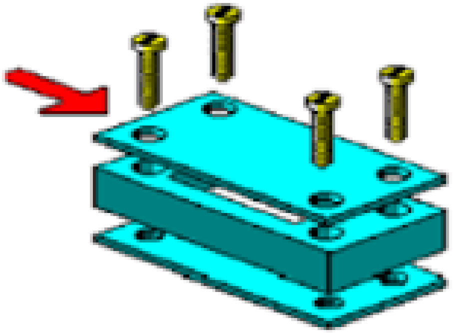


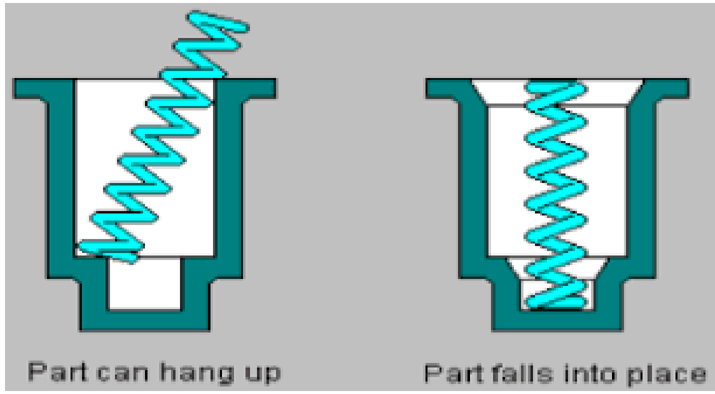
Design for M - Guidelines

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

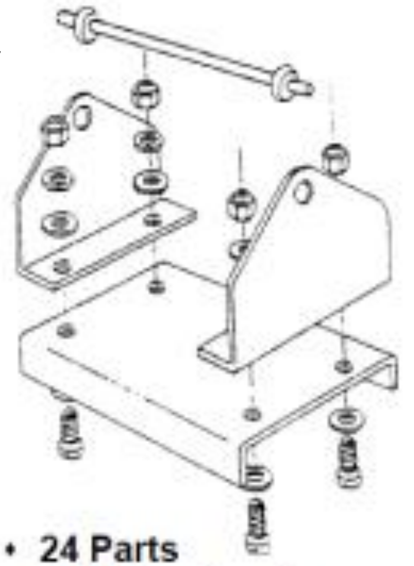
- Each manufacturing process has an inherent ability to maintain a certain range of tolerances, and to produce a certain surface roughness (finish).
- To achieve tolerances outside of the normal range requires special processing that typically results in an exponential increase in the manufacturing cost

Design for M – Design for Assembly

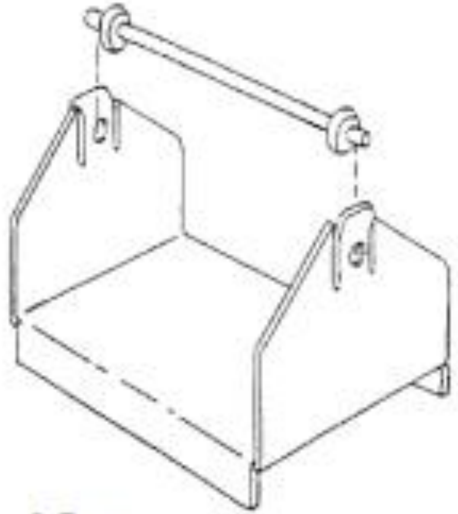
It is a subset of DFM which involves the minimization of cost of assembly

To maximize ease of assembly

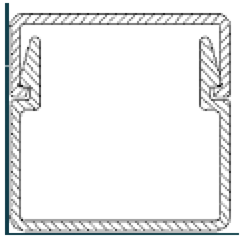
- Part is inserted from top
- Part is self aligned
- Part does not need to be oriented
- Part requires only one hand for assembly
- Part require no tool
- Part is assembled in single linear motion
- Part is secured immediately upon insertion

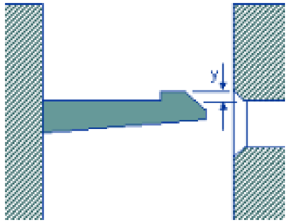


- 24 Parts
- 8 different parts
- multiple mfg. & assembly processes necessary

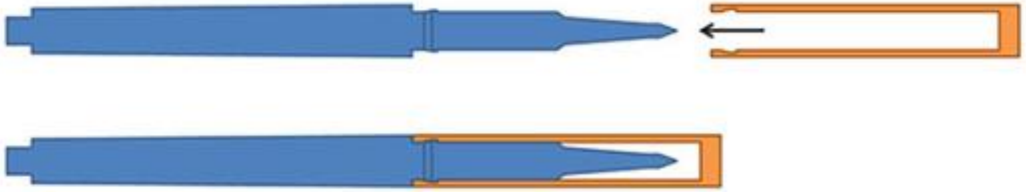


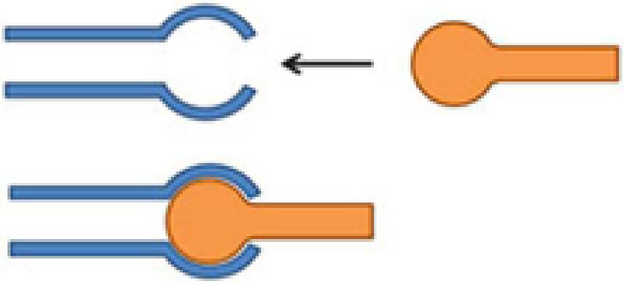
- 2 Parts
- 2 Manufacturing processes
- one assembly step



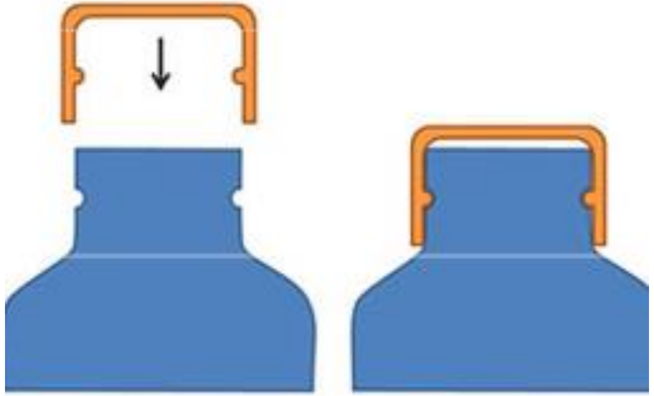


Design for M - Design for Assembly





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

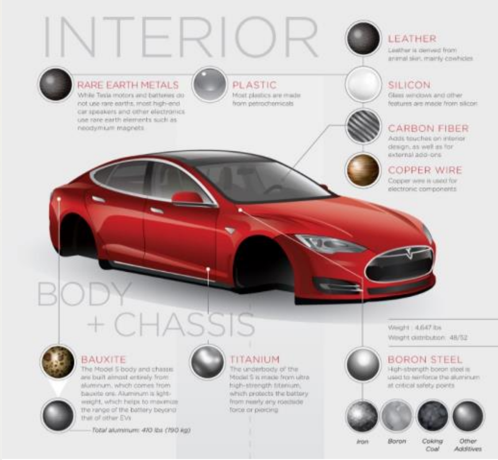


Bottle cap uses an annular snap fit

Design for R

- 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)

300 A 45 kV Type K Inverted mount Disconnecting Switch



Design for S

- Product safety is to be ensured in design.

- This covers the materials used, design aspects on safety in operation,

  fool proofing, warning systems etc.

- They prepare test plans and go accordingly.

The dummy's position in relation to the door frame, steering wheel, and instrument panel after the crash test indicates that the driver's overall survival space was maintained well, despite moderate intrusion of the lower part of the door hinge pillar and buckling of the door sill.

Design for S & R - A Case Study

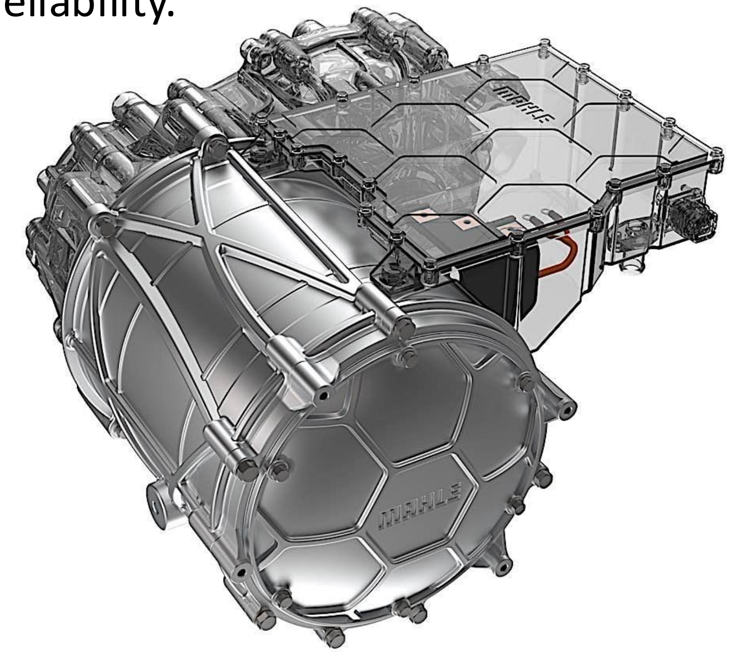
This product led to a recall because 137 laceration injuries to the hands and fingers were recorded. It looks like a very big oversight in the design of the product is at the root cause of this hazard.

Poor safety, in such an example, usually comes from:

- Poor understanding of users (i.e. how will they use it?)
- Poor definition of requirements (e.g. 'nothing that can cut a finger/hand can be detached unintentionally', which would be translated into technical requirements for the type of materials, for the tolerances, and for the attachment mechanisms), which of course relate closely to CPSC regulations
- Poor testing of the requirements (e.g. after opening & closing 1,000 times, all the dangerous components still stay well in place, and they haven't got to the point where the blades are dull and the user has to make moves that are not desired)
- Poor testing of assumptions (e.g. is it true that typical users will never be tempted to put their fingers in the "danger area"?)
- Poor manufacturing of components and/or poor assembly
- In case there is a residual amount of risk, poor education of the user in the form of warning stickers, user manual, etc.

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:
  - The downtime for maintenance,
  - User and technician maintenance time,
  - Personnel injury resulting from maintenance tasks,
  - Cost resulting from maintainability features, and
  - Logistics requirements for replacement parts, backup units, and personnel



magnet-free and maintenance free electric motor, new engine could reduce internal friction and can therefore dramatically increase the life of the motor. Dispensing with magnets and therefore the use of rare earth elements offers great potential not only from a geopolitical perspective but also with regard to the responsible use of nature and resources. *The entire motor is also free of rare-earth elements such as neodymium-boron-iron, samarium-cobalt, and more that are often found at the very heart of EV motors. [13].*

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.

Achille Castiglioni's tool-less method of replacing a watchband on the AL6021 watch.

Design for Environment

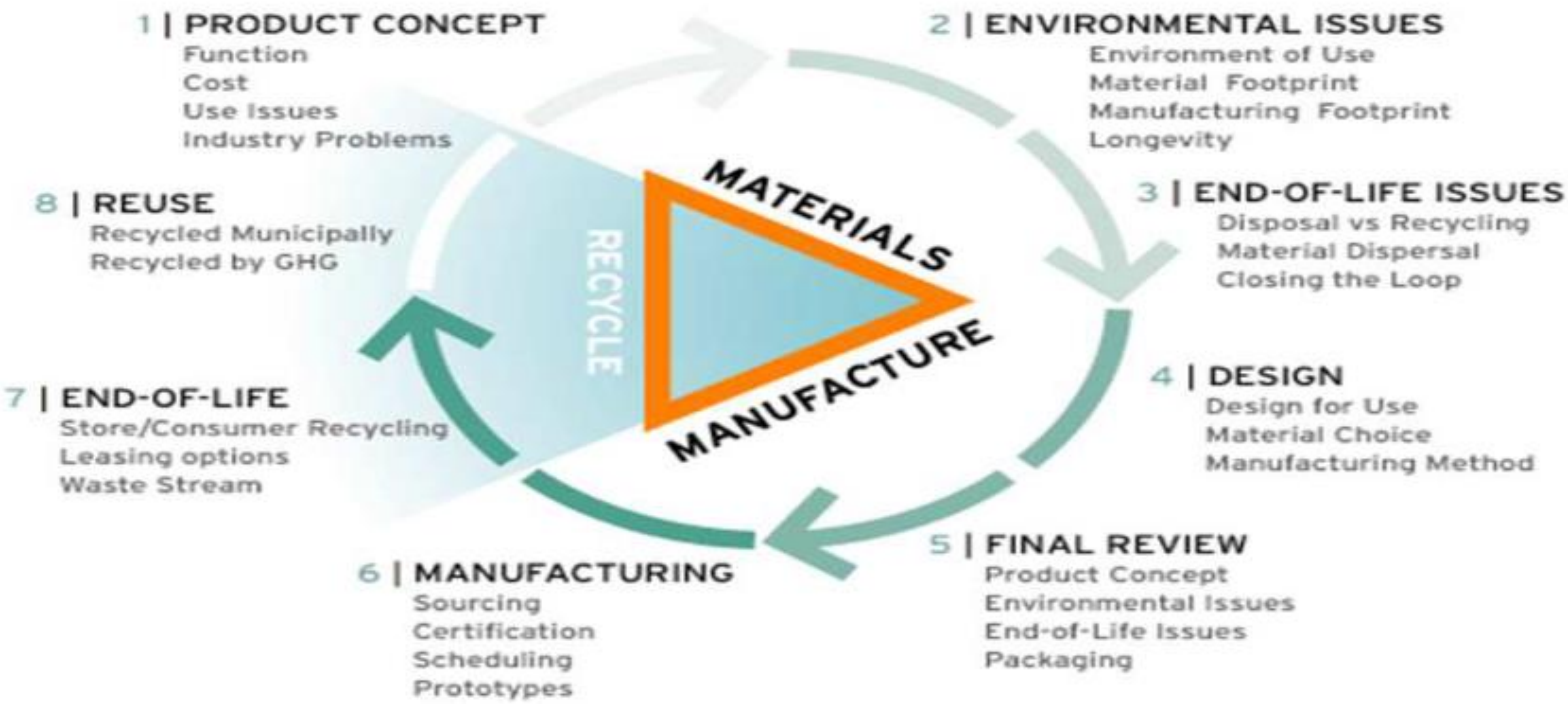
- Design for environmental processing and manufacturing
- Design for environmental packaging

- Design for disposal or reuse
- Design for energy efficiency
- 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 Logistics

- Design for packaging, handling, transportation and storage.
- Design for seamless transportation.
- Optimal packaging to save space and damage.
- Provision for product handling with safety.

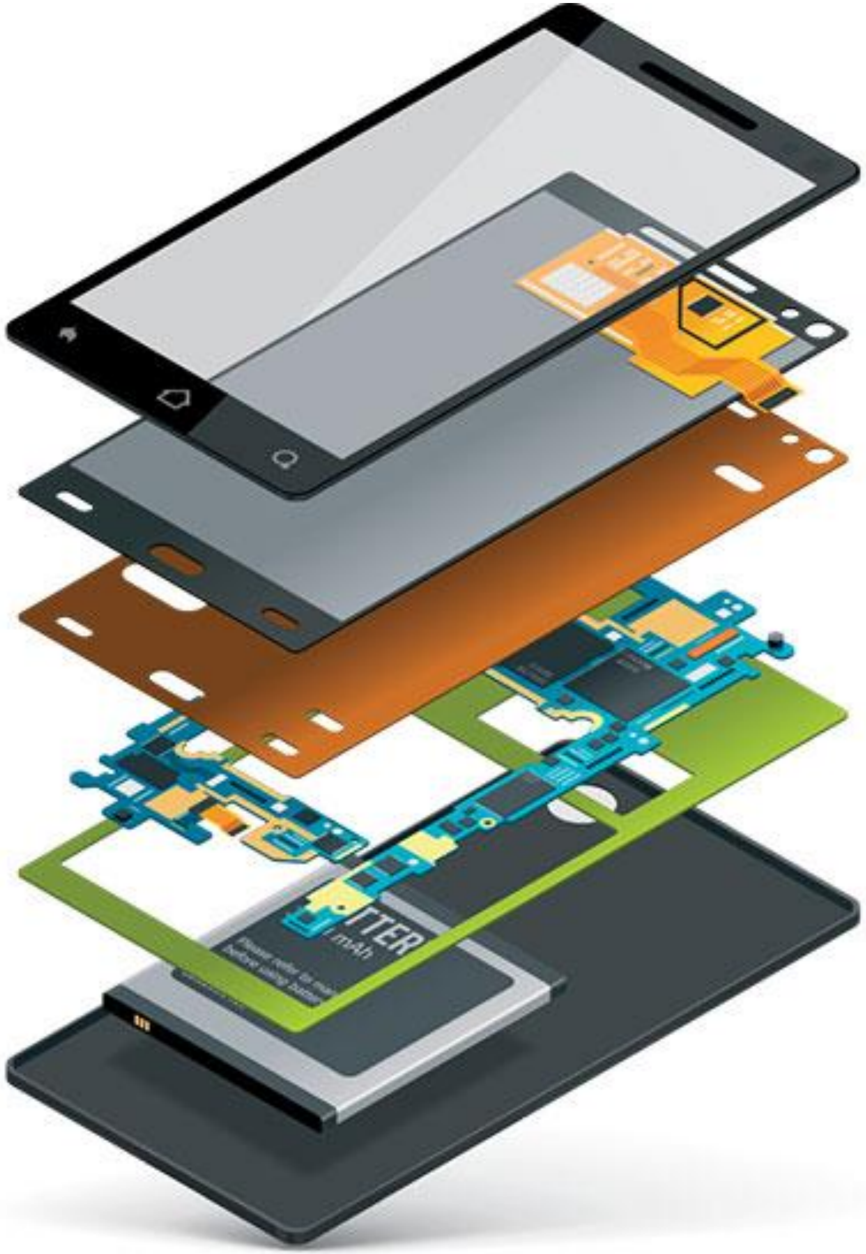
Design for Life Cycle Cost



Design for Disassembly & Recycling

- Design for disassembly is the strategy that considering the future need of a product that to be disassembled for repair, refurbish or recycle.
- The challenge in DfD is as much about product de-creation as it is about product creation and the strategies are to be applied throughout the whole design process.
- DfD reduces labour costs as products that disassemble easily often assemble easily. This too is the case with products that require repair, maintenance or refurbishment. The saving in time and effort means a saving all round and leads to a more satisfied customer.
- The strategy's solutions emphasise simplicity. Designers are able to find components that can be combined or dropped altogether, saving material and production costs and being less impactful on the environment.
- Because of the disassembly aspect of the DfD strategy there is less reliance on adhesives and harmful substances in the production process. The aim is environmentally conscious. Recyclability driven solutions are being found to eliminate or to limit the use of toxic substances as these substances and their safe disposal is a cost to be carried by the manufacturer.

Design for Disassembly & Recycling

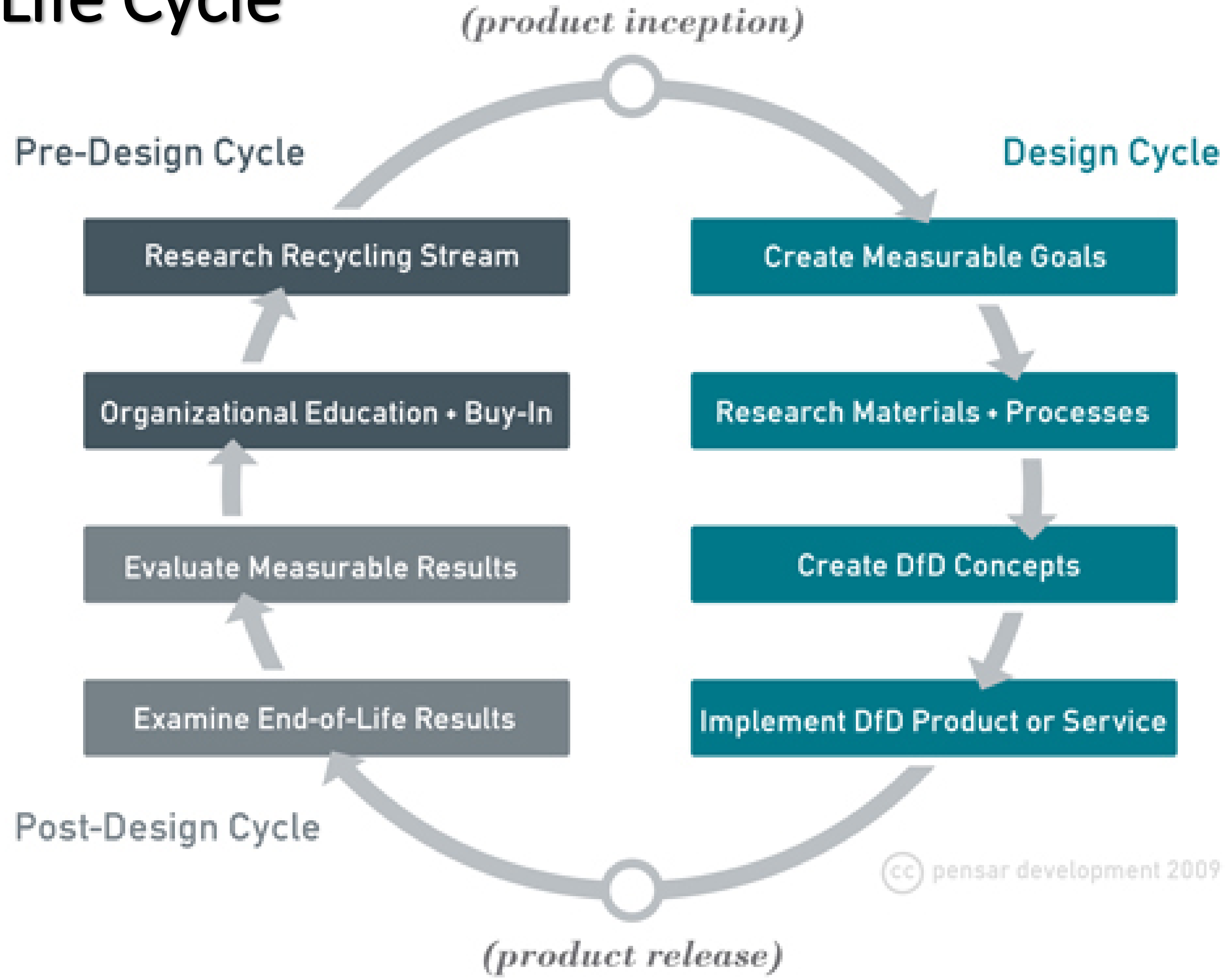


Design for Reassembly

Ten seconds to full disassembly.

The floss container below embodies the essence of DfD- both easy to assemble and disassemble. It's easy to open- free of glues, screws, or heat stakes. The main component's material is clearly labeled, and parts are quickly separated.

Product Life Cycle



Design for X

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Exercise Four


SOLVING
STORIES OF WHAT WORKS
HEATHER M.A.
RISE
of the
DEO
LEADERSHIP BY
THE
RISE
OF THE
RICHARD
HOW DESIGN THINKING TRANSFORMS ORGANIZATIONS AND INSPIRES INNOVATION
CREATIVE CONFIDENCE
UNLEASHING THE CREATIVE POTENTIAL WITHIN US ALL
by TOM KELLEY
& DAVID KELLEY
DESIGN
WORKS
HOW TO TACKLE YOUR TOUGHEST INNOVATION CHALLENGES THROUGH
BUSINESS DESIGN
NATIONAL BESTSELLER
CREATING
INNOVATORS
The Making of Young People Who Will Change the World
THE TEN FACES OF INNOVATION
IDEO'S STRATEGIES FOR BEATING THE DEVIL'S ADVOCATE & DRIVING CREATIVITY THROUGHOUT YOUR ORGANIZATION
TOM KELLEY
WITH JONATHAN LITTMAN
AUTHOR OF THE ART OF INNOVATION