Sustainable Products & Infrastructure Design

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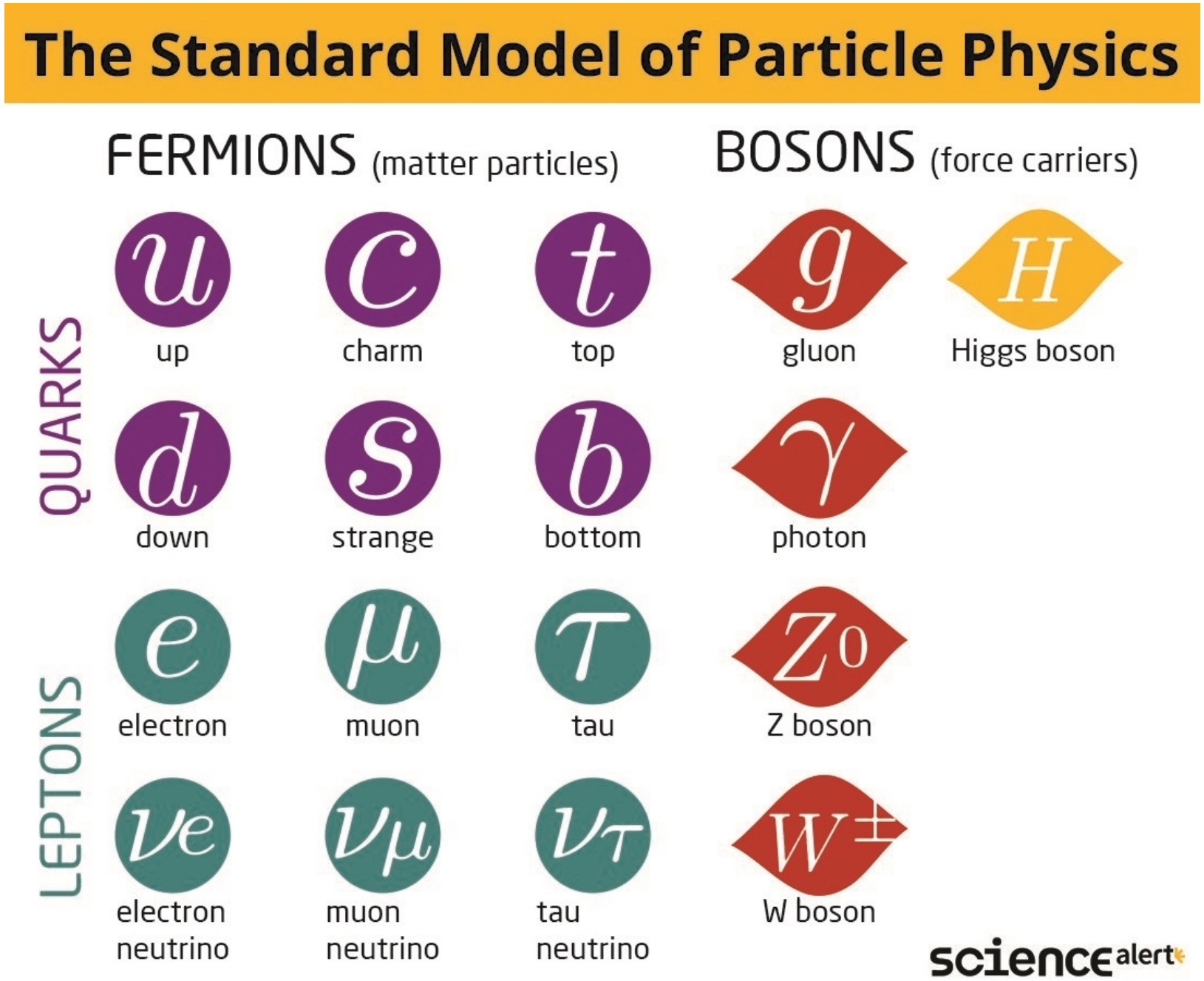
Aside


The Standard Model of Particle Physics
FERMIONS (matter particles)
BOSONS (force carriers)
QUARKS
LEPTONS
u
up
c
charm
t
top
g
gluon
H
Higgs boson
d
down
s
strange
b
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γ
photon
e
electron
μ
muon
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tau
Z0
Z boson
νe
electron neutrino
νμ
muon neutrino
ντ
tau neutrino
W±
W boson
sciencealert

CARIBBEAN EXAMINATIONS COUNCIL

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SYLLABUS

GREEN ENGINEERING

CXC A36/U2/16

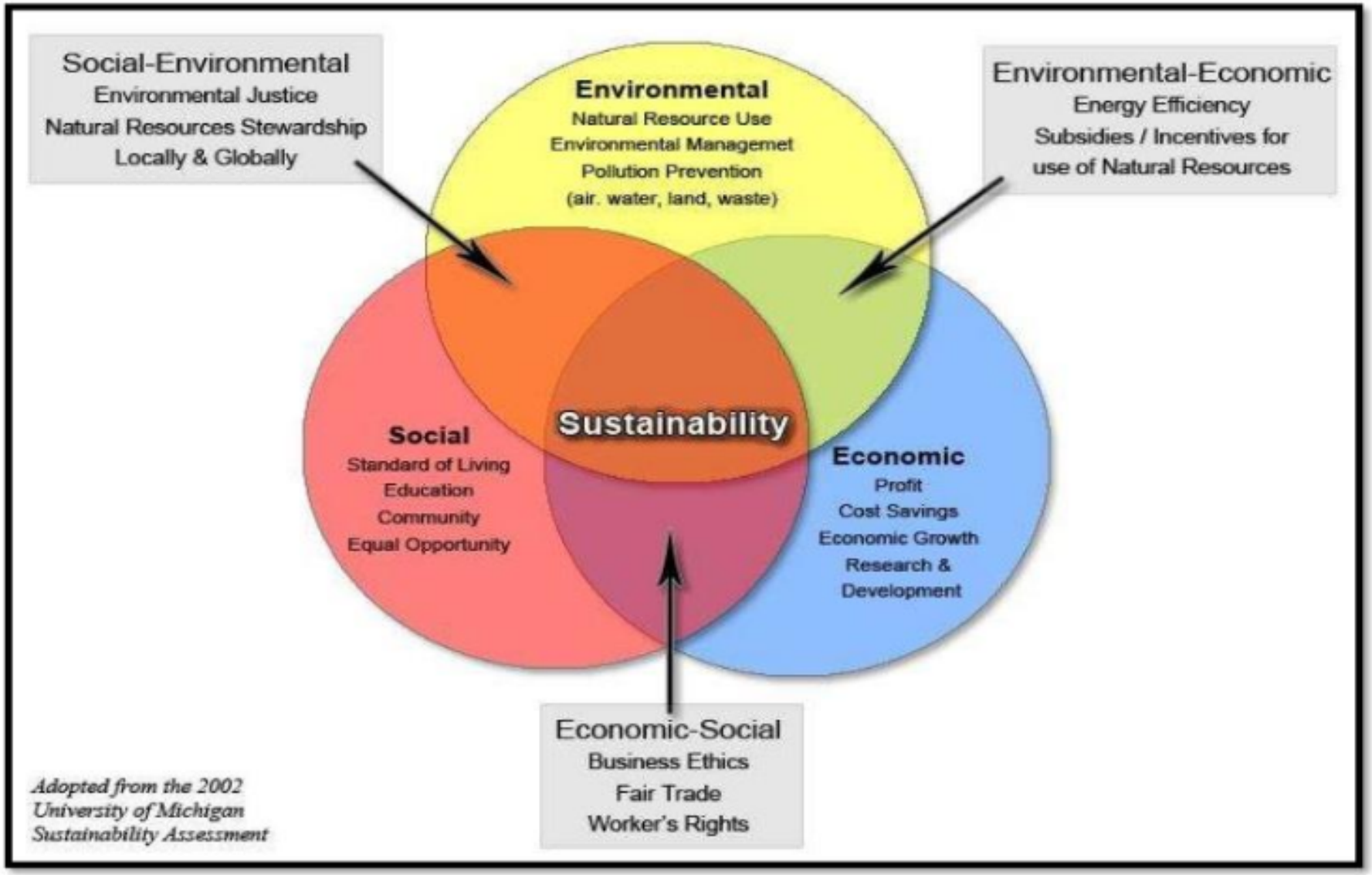
UNIT 2: APPLICATION OF GREEN ENGINEERING PRINCIPLES

MODULE 2: SUSTAINABLE DESIGNS

Principles Related to Designing Products and Infrastructure → with Examples

Stages of Product Design → Two case studies

Fundamental Components for Sustainability



7 Principles Designing Products and Infrastructure

(a) Equitable in use.

(b) Flexibility in use.

(c) Simple and intuitive.

(d) Perceptible information.

(e) Tolerance for error.

(f) Low physical effort.

(g) Size and space for approach and use.

PRINCIPLE ONE: Equitable Use

The design is useful and marketable to people with diverse abilities.

- It provides the same means of use for all users: identical whenever possible; equivalent when not.
- It avoids segregating or stigmatizing any users.
- Provisions for privacy, security, and safety are equally available to all users.
- The design is appealing to all users.

Principle 1: Equitable Use

The design is useful and marketable to people with diverse abilities.

PRINCIPLE TWO: Flexibility in Use

The design accommodates a wide range of individual preferences and abilities.

- It provides choice in methods of use.
- It accommodates right or left handed access and use.
- It facilitates the user's accuracy and precision.
- It provides adaptability to the user's pace.

Principle 2: Flexibility in Use

The design accommodates a wide range of individual preferences and abilities.

can be easily adjusted to suit different user needs.

Right & left-handed scissors

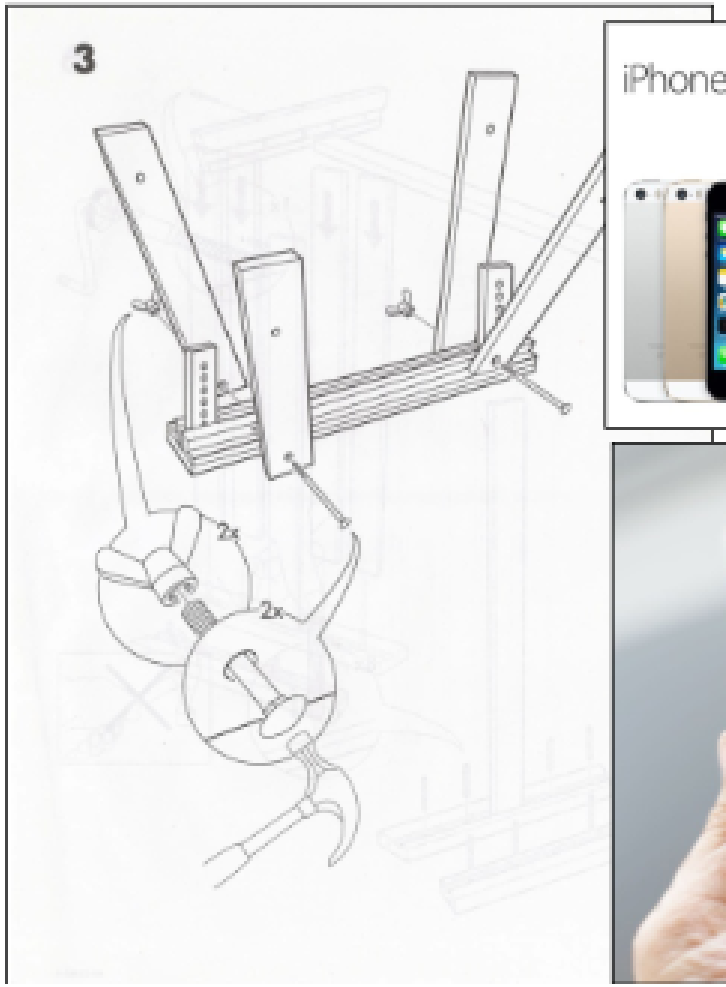
PRINCIPLE THREE: Simple and Intuitive Use

Use of the design is easy to understand, regardless of the user's experience, knowledge, language skills, or current concentration level.

- It eliminates unnecessary complexity.
- It is consistent with user expectations and intuition.
- It accommodates a wide range of literacy and language skills.
- It arranges information consistent with its importance.
- It provides effective prompting and feedback during and after task completion.

Principle 3: Simple and Intuitive Use

Use of the design is easy to understand, regardless of the user's experience, knowledge, language skills, or current concentration level.



PRINCIPLE FOUR: Perceptible Information

The design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities.

- It uses different modes (pictorial, verbal, tactile) for redundant presentation of essential information.
- It provides adequate contrast between essential information and its surroundings.
- It maximizes "legibility" of essential information.
- It differentiates elements in ways that can be described (i.e., make it easy to give instructions or directions).
- It provides compatibility with a variety of techniques or devices used by people with sensory limitations.

Principle 4: Perceptible Information

The design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities.

Nanakuma Line, Japan.
Each station is color coded and is identified in English, Japanese, and by its accompanying unique symbol. Symbols generally relate to the station's surroundings.

Looking down the length of the symmetrical platform, lighting accentuates train doorways and the adjoining gates that prevent riders from falling onto the tracks.
Nanakuma Line, Japan

PRINCIPLE FIVE: Tolerance for Error

The design minimizes hazards and the adverse consequences of accidental or unintended actions.

- It arranges elements to minimize hazards and errors: most used elements, most accessible; hazardous elements eliminated, isolated, or shielded.
- It provides warnings of hazards and errors.
- It provides fail safe features.
- It discourages unconscious action in tasks that require vigilance.

Principle 5: Tolerance for Error

The design minimizes hazards and the adverse consequences of accidental or unintended actions.

PRINCIPLE SIX: Low Physical Effort

The design can be used efficiently and comfortably and with a minimum of fatigue.

- It allows user to maintain a neutral body position
- It uses reasonable operating forces.
- It minimizes repetitive actions.
- It minimizes sustained physical effort.

Principle 6: Low Physical Effort

The design can be used efficiently and comfortably and with a minimum of fatigue.

PRINCIPLE SEVEN: Size and Space for Approach and Use

Appropriate size and space is provided for approach, reach, manipulation, and use, regardless of user's body size, posture, or mobility.

- It provides a clear line of sight to important elements for any seated or standing user.
- It makes reaching to all components comfortable for any seated or standing user.
- It accommodates variations in hand and grip size.
- It provides adequate space for the use of assistive devices or personal assistance.

Principle 7: Size and Space for Approach and Use

Appropriate size and space is provided for approach, reach, manipulation, and use regardless of user's body size, posture, or mobility.

Fare gates accommodate a wide variety of users. Note that the gate assembly is long enough so that exiting passengers do not have to slow or stop walking in order for the gate to open. The gate has multiple smart card targets to speed fare collection. Nanakuma line, Japan

The interior of the 100% ultra low floor Alstom Citadis tram has both wide open areas as well as 2X2 seating. LUAS light rail, Dublin, Ireland

What is life cycle analysis?

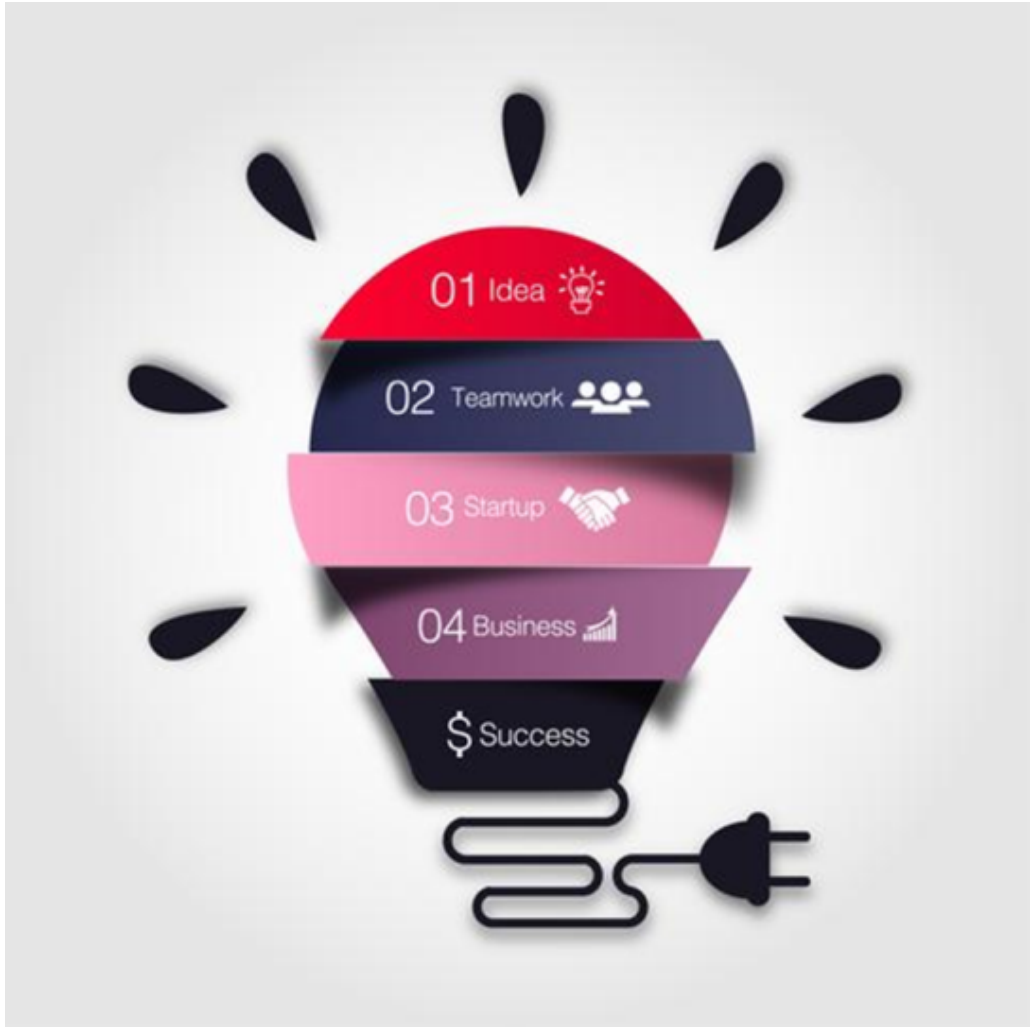
- Life Cycle Analysis is the technique which is used to analyse the environmental impacts which are an outcome of the processes involved in the life cycle of a particular product. As per ISO 14040:2006
- Also known as **"Cradle-to-grave"** or **"life cycle assessment"**

Stages of Life Cycle Analysis ⟹ Sustainability

The principal stages in the life cycle of any product include:

- Extraction of raw materials from nature
- Product design and Manufacture of the product using the raw materials
- Transportation or distribution of the product to various sites
- Use or consumption and maintenance of the product
- Waste management (recycling process and final disposal)

Stages in Product Design



(a) Concept development including Life Cycle Assessment (LCA).

(b) Product simulation.

(c) Prototype development/pilot testing.

(d) Product development (relate to LCA).

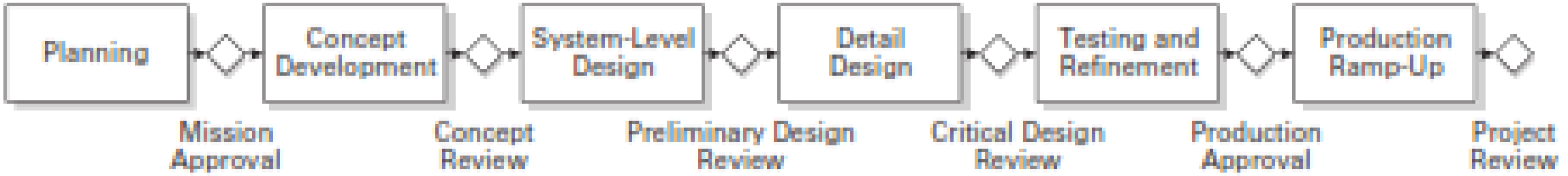
(e) Manufacturing process development.

(f) Product testing/evaluation.

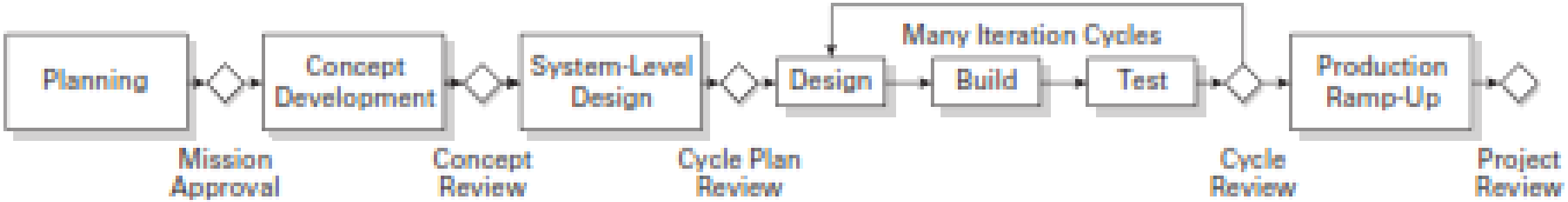
(g) Product commissioning.

(h) Product commercialisation.

Varying Details of the Design Process

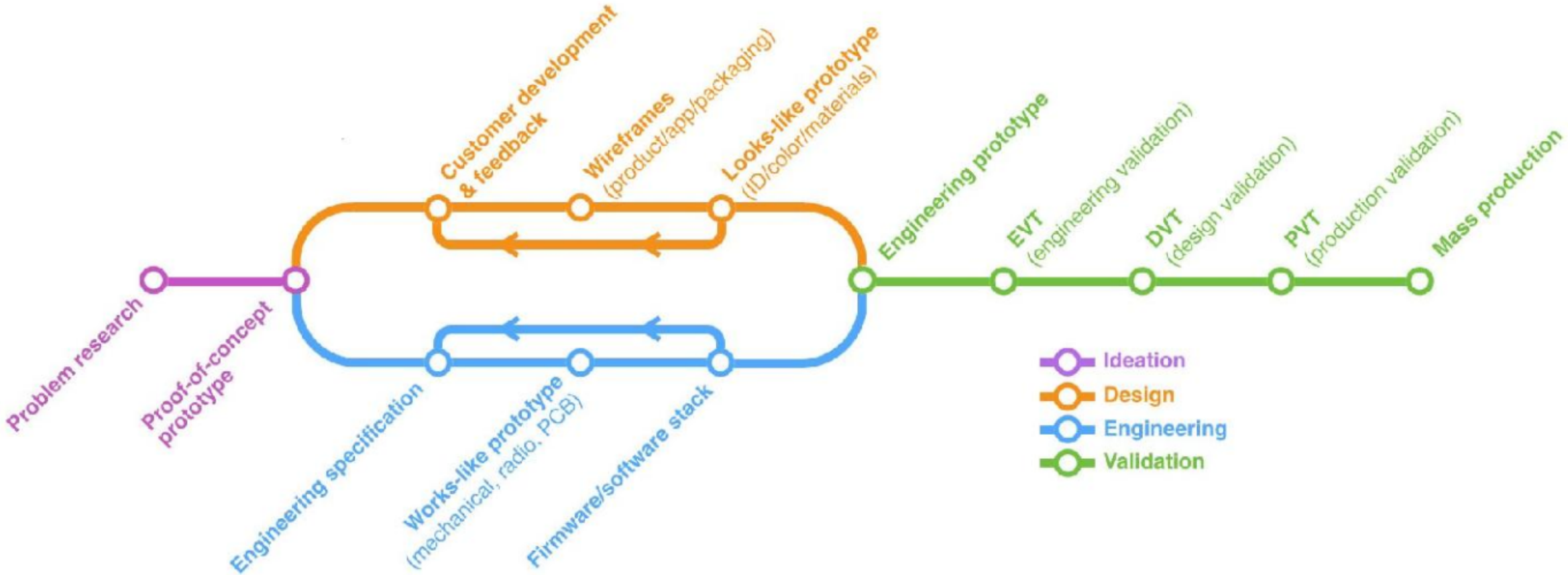


(a) **Generic Product Development Process**



(b) **Spiral Product Development Process**

Steps in Developing an Electronic Product



Stage 1. (Ideation)
Concept Development.

Identify risk, plan and develop concepts.

Key Activities:
- Key feature risk evaluation.
- Design plan and concept experimentation.
- Refine and test the look and function.
- Engineering architecture plans for ME, EE, SW.

Output:
- Product concept released to Detailed Engineering.

Stage 2. (Design)
Detailed Engineering.

Focus on delivering a 'ready for production' fully defined solution.

Key Activities:

- Develop the many engineering details.
- Create the 3D CAD assembly geometry.
- Bench model simulations and prototypes.
- Validate and refine primary design features.
- PCB layout and custom firmware coding.

Output:

- Full documentation for a pre-production prototype.

Stage 3. (Engineering)
Prototype and Test.

Build and test the production ready “alpha” prototype.

Key Activities:

- Validate product requirements.
- Confirm usability, look and feel of the design.
- Fine tune for production volume manufacturing.
- Engage reliable component and production suppliers.

Output:

Fully functioning pre-production prototype.

Stage 4. (Validation) Manufacturing Support.

Focus on transfer of knowledge to manufacturing teams.

Key Activities:

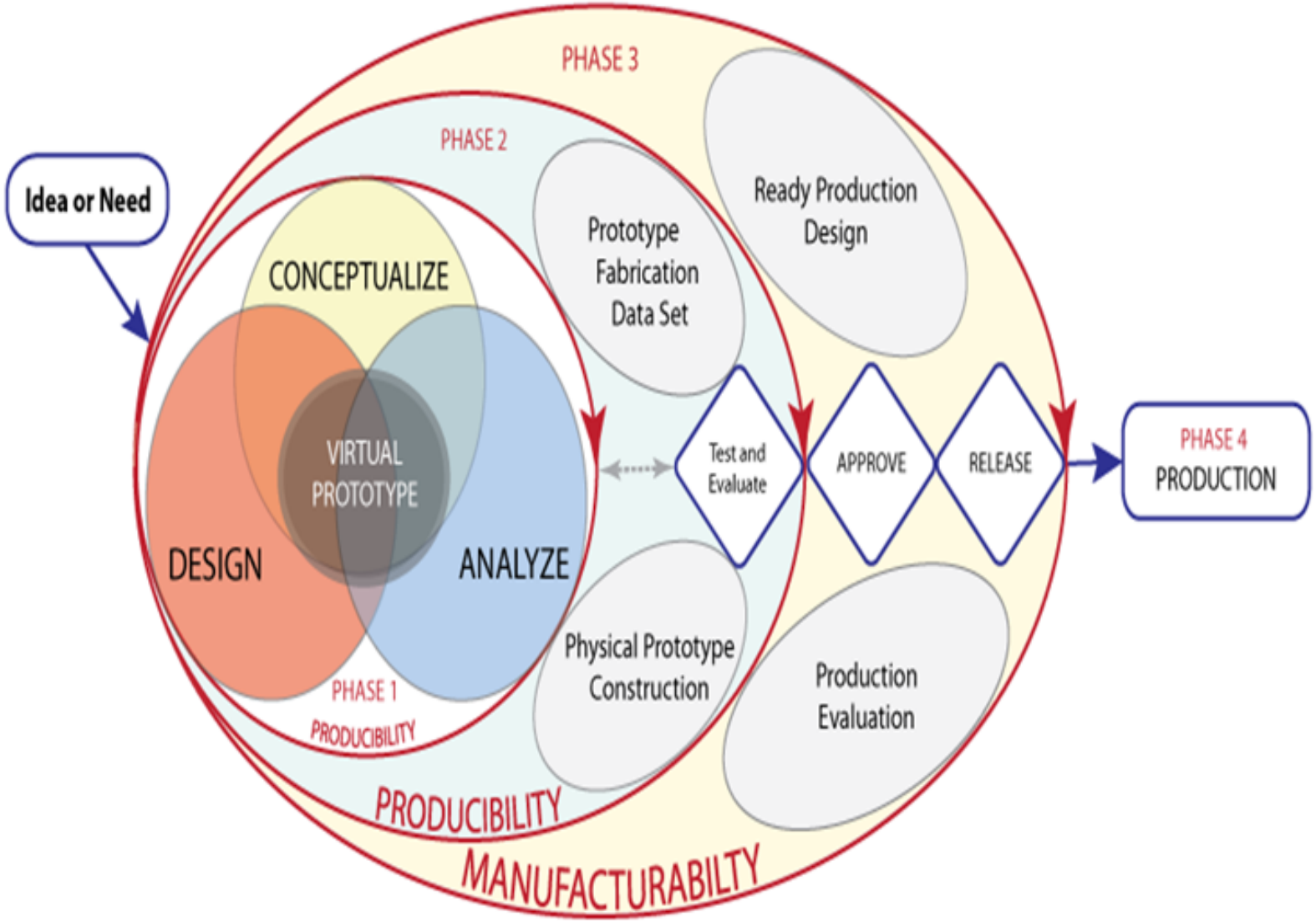
- Select high quality manufacturing partner.
- Implement appropriate quality control process.
- Product file coordination with document control.
- Pilot run approval support for volume manufacturing.

Output:

- **First production run and release of product**.

Product Design Methodology

METHOD

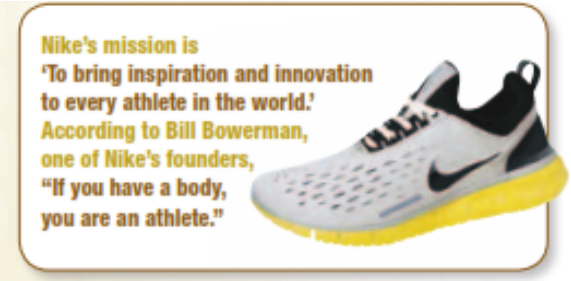


CASE STUDIES

1) Nike Free Shoe

2) Cardboard Box Re-design

The Nike Case Study (Nike Free)



Product development from concept to consumer;

"It's not the customer's job to know what they want" **Steve Jobs**

The Nike's **research and development (R&D)** centre's role is to identify the physiological needs of athletes

The Centre takes an idea, and researches and prepares a **design brief.** The brief is then passed over to the company's Innovation Kitchen – an incubator for new projects

The researchers then takes the idea to users, athletes and coaches, asking: What type of footwear are they looking for?

Track coach at Stanford University, who told them about his unusual training method – having athletes run on grass without shoes. The coach found the athletes were stronger, healthier and less injury-prone: no shoes …no way!

The idea led to an extensive biomechanical research project to see exactly what happens when we run barefoot.

The researchers brought in 10 men and 10 women to run barefoot on grass to see exactly how the body reacts without shoes on. They were videotaped with high-speed cameras to capture their movements.

At the end of the experiment, Nike had the most comprehensive picture of the biomechanics of barefoot running ever developed.

"Nike Free" was born,

A shoe that simulates the feeling of bare-feet but aids in the training **of the athlete**.

The goal is to use Nike Free to help strengthen the feet in addition to using more traditional, supportive running and training shoes.

Testing the prototypes

In a six-month trial, 110 every-day runners used the shoe.

participants were tested at the start of the six-month period on their abilities in a number of physical areas – shuttle runs, lateral running short sprints, and leg strength – and were tested again at the end of the six months. These

The test results from the group wearing the Nike Free shoes showed improvement in all the parameters measured, and improvements in speed, lateral movement, and coordination were significant :in the 10 to 20 percent range.

In simple terms, Nike Free was acting not only as a running shoe, but as a training technique! Athletes in the test group using Nike Free were found to be stronger and more flexible. One of the researchers put it this way: "Nike Free is a gym for your feet."

Reaching the consumer

Using television and cinema

Websites

Direct Sales to Athletes and Coaches

Nike Free was developed after extensive research and product testing. With a strategic promotion campaign, Nike hopes to deliver the message that Nike Free is not designed to replace athletic performance footwear but to be an important part of training, thus improving performance.

Case Study 2

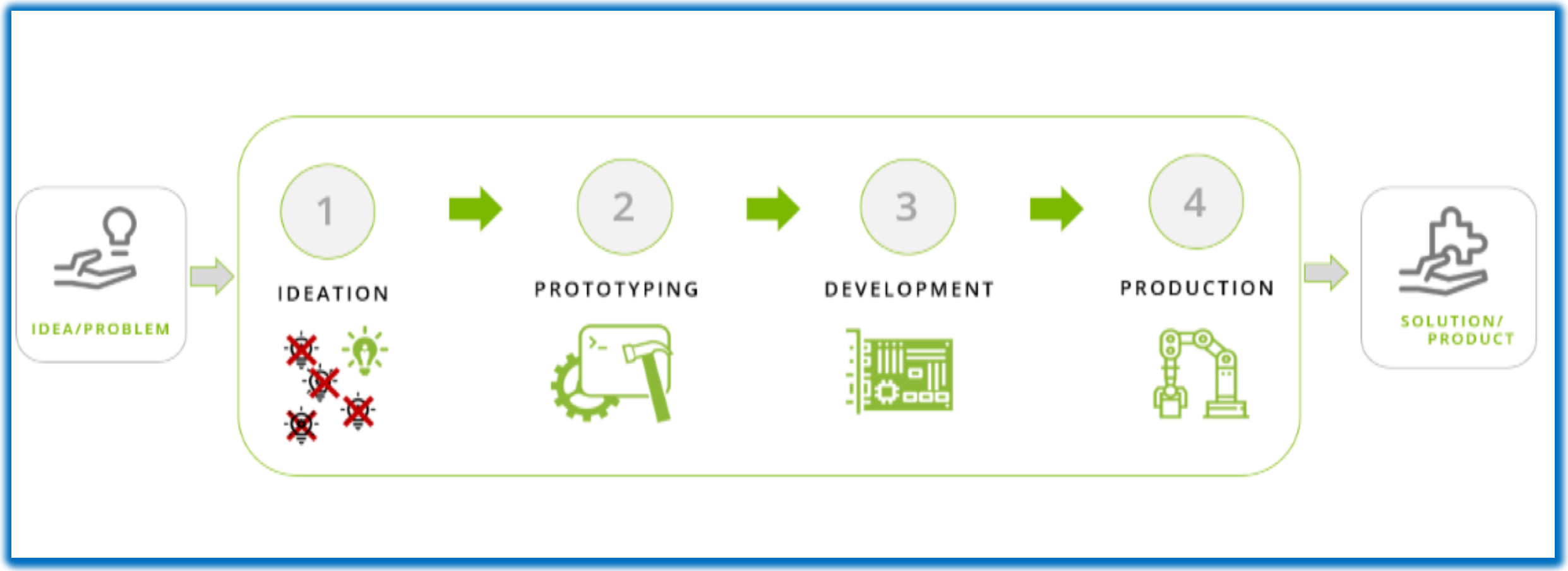
PRODUCT REDESIGN

Cardboard Flower Box

Motivation for D4S

Design has not changed in 20yrs. Light weight engineering could improve aspects: reducing the material input for the sake of environ-mental considerations and reducing costs due to expensive air transportation. It consisted of two pieces of cardboard which required a separate production process for each. The traditional boxes were formed by using metal staples or tape.

How would you handle this? : Discuss


IDEA/PROBLEM
1
IDEATION
2
PROTOTYPING
3
DEVELOPMENT
4
PRODUCTION
SOLUTION/
PRODUCT

Concept Development

Initial ideas were generated (during a workshop with researchers and different customers [flower producers, fruit and vegetable exporters etc]) such as reducing the thickness of the corrugated cardboard from 5 layers to 3 layers and strengthening the boxes with stiff edges and stiffeners at the same time. Furthermore, the idea of integrating the lid into the box design, which could help reduce the total mass of the box, was found.

Detailed Engineering AND Prototype Testing

Reducing the thickness of the corrugated cardboard from 5 layers to 3 layers and strengthening the boxes with stiff edges and stiffeners at the same time. Furthermore, the idea of integrating the lid into the box design, which could help reduce the total mass of the box.

Incorporate the comments of the customers and then redesigned the boxes, reduced costs and the environmental impacts at the same time.

Manufacture

Since the company was already in this sector, this was just the insertion of a redesign into a set manufacturing line.

Results and benefits

The redesigned box for flower export has the fol-lowingadvantages:

Resource efficiency : reduction in weight equal to 12% of the original design.

Improved production process: The production of the box involves one production step less since the bottom is 3 ply instead of 5.The box is self-locking and does not require any tape or staples.

Cost reduction: The box is sold at a cheaper price to the customer, air cargo charges are less since it is lighter.

Functionality and customer Satisfaction : This design offers better ventilation for the flowers, so the product can be better protected and the flowers are in better shape and consequently have higher value.

Thank You

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