Product Design and Development, Generative Design

Module III: Industrial Design, Human Factors, and Serviceability

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Outline

Industrial Design (ID)

Human Factors Design

Design for Serviceability (DfS)

Conclusion

What is Industrial Design?

Definition

Industrial Design (ID) is the professional practice of designing products, devices, objects, and services used by millions of people around the world every day. It is the creative act of determining and defining a product's form and features.

Core Goals

- **Aesthetics:** How the product looks and feels. Creating visual appeal.
- **Usability:** How easy and satisfying the product is to use.
- **Manufacturability:** Ensuring the product can be produced efficiently and cost-effectively.

Figure: The intersection of core ID goals.

The Role of an Industrial Designer

Industrial designers are the bridge between the user, the technology, and the business.

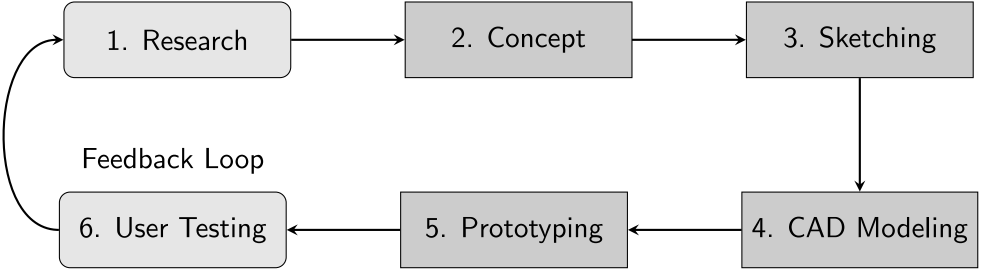
User Needs (Desirability)	**Technology** (Feasibility)	**Business Goals** (Viability)

Key Responsibilities

They are responsible for the visual appearance, functionality, and overall user experience of a product. This includes form, color, material selection, and ergonomics.

The Industrial Design Process

A structured approach is used to move from an idea to a finished product.



- The process is iterative, with feedback from testing often leading back to earlier stages.
- This ensures the final product is both desirable and viable.

Core Principles of Aesthetics

Good design often follows fundamental principles that create visual harmony and clarity.

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- **Contrast:** Using differences in color, size, or shape to create visual interest and highlight key features.

Industry Example: Dyson

Design Philosophy: "Form Follows Function"

- Dyson products transparently showcase their engineering. The cyclone technology is a key visual element, not hidden away.
- **Aesthetics:** The use of bright, contrasting colors on functional parts (like release buttons) serves both as a design accent and a guide for the user.
- **Materials:** Use of tough, lightweight polymers like ABS polycarbonate, chosen for durability and manufacturing precision.
- **Innovation:** The design is driven by solving a problem (loss of suction in vacuums), and the unique solution dictates the unique form.

Industry Example: Braun

Design Philosophy: "Less, but better"

- Championed by designer Dieter Rams, Braun's products are famous for their minimalist and functionalist approach.
- **Aesthetics:** Simple geometric forms, a muted color palette (white, gray, black), and an absence of unnecessary decoration.
- **Usability:** The focus is on clarity and ease of use. Controls are logical, intuitive, and clearly labeled.
- **Influence:** Braun's design language has been a major inspiration for many companies, including Apple.

1111.png

Figure: Braun's Product

Materials and Finishes in ID

The choice of material is crucial as it affects aesthetics, cost, performance, and user perception.

Table: Comparison of Common Materials in Product Design

Material	Key Characteristics	Typical Applications	Perception
Plastics (ABS, PP, PC)	Versatile, lightweight, low cost, easy to mold complex shapes	Consumer electronics, toys, automotive interiors	Modern, economical, sometimes "cheap"
Metals (Aluminum, Steel)	Strong, durable, premium feel, good thermal conductivity	Laptops, high-end appliances, tools, vehicles	Premium, durable, heavy, strong
Wood	Natural aesthetic, warm feel, sustainable (if sourced well)	Furniture, decorative trim, audio equipment	Natural, classic, warm, luxurious

The Impact of Good Industrial Design

Good ID is more than just making things look pretty; it's a strategic business tool.

- **Creates Brand Identity:** A consistent design language makes products instantly recognizable (e.g., the Apple iPhone silhouette).
- **Increases Market Success:** A well-designed product stands out from competitors and can command a premium price.
- **Enhances User Satisfaction:** An easy and enjoyable product to use leads to customer loyalty and positive reviews.
- **Drives Innovation:** The design process can uncover new ways of solving problems, leading to breakthroughs in functionality and form.
- **Communicates Quality:** The fit, finish, and feel of a product convey a sense of its underlying quality and durability.

What is Human Factors Design?

Definition

Human Factors (or **Ergonomics**) is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system. It applies theory, principles, data, and methods to design in order to optimize human well-being and overall system performance.

In Simple Terms...

It's about fitting the product to the person, not the other way around. The goal is to maximize safety, comfort, and efficiency.

If the user is having a problem, it's not their fault; it's the fault of the design.

The Three Domains of Human Factors

Human Factors is a broad field covering physical, cognitive, and organizational aspects.

Physical Ergonomics
Anthropometry, Biomechanics, Physiology

Cognitive Ergonomics
Perception, Memory, Decision Making, Mental Workload

Organizational Ergonomics
Teamwork, Communication, Work Design

- **Physical:** Deals with the body's responses to physical and physiological loads. (e.g., designing a chair to prevent back pain).
- **Cognitive:** Deals with mental processes. (e.g., designing an intuitive software interface).
- **Organizational:** Deals with optimizing socio-technical systems. (e.g., designing shift work schedules).

Physical Ergonomics: Anthropometry

Designing for Body Size and Shape

Anthropometry is the science of measuring the human body. In design, we use this data to create products that fit the target user population.

Key considerations:

- **Design for the average:** A risky approach, as very few people are "average" in all dimensions.
- **Design for the extremes:** Designing for the 5th percentile female to the 95th percentile male. This accommodates 90% of the population.
- **Design for adjustability:** The best approach. Allow the product to be adjusted to fit a wide range of users (e.g., adjustable office chairs, car seats).

Figure: Ergonomic chair design is based on key anthropometric measurements.

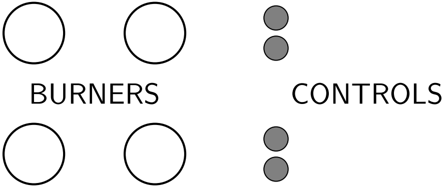
Cognitive Ergonomics: Mental Workload

Definition

Mental workload is the amount of cognitive "effort" required to perform a task.
Designs should aim to minimize unnecessary mental load.

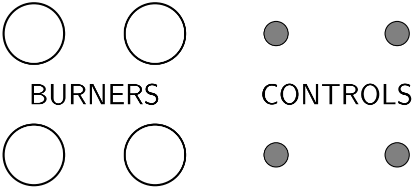
Example: Good vs. Bad Stove Top Controls

Bad Design (High Workload)



User has to think: "Which knob controls which burner?"

Good Design (Low Workload)



The spatial mapping is intuitive and requires no thought.

Industry Example: OXO Good Grips

A Case Study in Inclusive Design

- **The Problem:** The founder's wife had arthritis and struggled with traditional kitchen tools.
- **The Solution:** Design tools that are comfortable for the widest possible range of users, including those with limited hand strength.
- **Human Factors Principles:**
  - **Grip:** Large, soft, non-slip handles reduce the force required.
  - **Force:** Sharp blades and efficient mechanisms minimize user effort.
  - **Inclusive Design:** By designing for users with arthritis, they created a product that was better for everyone.

Industry Example: Automotive Cockpit

Optimizing the Driver's Environment

Car interiors are a complex human factors challenge, balancing information display, control access, comfort, and safety.

- **Accessibility:** Critical controls (steering, brakes) and frequently used controls (indicators, wipers) are placed for easy access without looking.
- **Visibility:** Instruments are designed to be legible at a glance. Heads-Up Displays (HUDs) project information onto the windscreen to keep the driver's eyes on the road.
- **Feedback:** Controls provide tactile (clicks) or auditory (beeps) feedback to confirm an action has been taken.

Usability Testing Methods

How do we know if a design is actually easy to use? We test it with real users.

Table: Common Usability Testing Techniques

Method	Description	What it Measures
Observation	Simply watching users as they attempt to perform tasks with the product.	User behaviour, frustration points, common errors.
Think-Aloud Protocol	Users are asked to verbalize their thoughts, feelings, and opinions while interacting with the product.	User's mental model, expectations, areas of confusion.
System Usability Scale (SUS)	A 10-item questionnaire with five response options for respondents.	A quantitative score of perceived usability. Quick and reliable.

The Cost of Poor Human Factors

Ignoring human factors is not just an inconvenience; it can have severe consequences.

Case Study: Three Mile Island Nuclear Accident (1979)

A major contributing factor was poor control room design.

- **Poor Feedback:** Over 100 alarms went off with no way to prioritize them. A critical indicator light was positioned behind a maintenance tag, obscuring it from view.
- **Lack of Standardization:** Controls for similar functions operated differently, leading to operator error under pressure.
- **Result:** A partial meltdown of the reactor core. While no immediate deaths occurred, it was a near-catastrophe that highlighted the critical need for human factors in complex systems.

What is Design for Serviceability?

Definition

Design for Serviceability (also **Design for Maintainability**) is the process of designing a product to be diagnosed, repaired, and maintained easily, quickly, and cost-effectively throughout its lifecycle.

Key Questions DfS Asks

- How easily can the product be taken apart?
- Can a faulty component be accessed without removing many other parts?
- Are standard tools sufficient for repair?
- Are replacement parts available and affordable?

Figure: A well-designed engine bay with clear access to service points (oil, coolant, washer fluid).

Why is DfS Important?

Designing for serviceability offers significant benefits for both the company and the customer.

Benefits for the Manufacturer

- Lower warranty costs
- Faster repair times for field technicians
- Improved brand reputation
- Enables profitable service contracts

Benefits for the Customer

- Lower total cost of ownership
- Reduced downtime
- Increased product lifespan
- Empowerment to perform simple repairs

DfS is a key component of a sustainable **Circular Economy** by promoting repair over replacement.

Core Principles of DfS

These four principles are the foundation of designing a serviceable product.

Accessibility

Easy physical access to components

Standardization

Use of common fasteners, tools, and parts

Modularity

Components are independent units that can be easily swapped

Diagnostics

Easy to identify and isolate faults

Principle in Action: Standardization

Using common parts and tools simplifies the entire service process.

Benefits of Standardization

- **Fewer Tools Required:** Technicians and users don't need specialized, proprietary tools. Using Phillips head or hex screws instead of pentalobe or tri-wing screws.
- **Simplified Inventory:** Fewer unique spare parts need to be stocked, reducing logistics complexity and cost.
- **Interchangeable Parts:** Components can be shared across different product lines, increasing availability.
- **Reduced Training:** Technicians familiar with standard components can work more efficiently.

Anti-Example: "Part Paring"

Some companies use software to lock serialized parts to a specific device. Even if you use a genuine replacement part, the device will reject it unless authorized by the manufacturer. This is a significant barrier to serviceability.

Industry Example: Fairphone

A Case Study in Modularity and Repair

Fairphone is a smartphone designed from the ground up for serviceability.

- **Modularity:** The phone is built from several distinct modules (camera, speaker, battery, USB-C port) that can be individually replaced.
- **Accessibility:** Modules can be replaced by the user with just a standard screwdriver.
- **Standardization:** Uses a common Phillips #00 screwdriver.
- **Availability:** Replacement modules are sold directly to consumers on their website.
- **Result:** This extends the usable life of the phone far beyond typical devices, reducing electronic waste.

Industry Example: Business vs. Consumer Laptops

Serviceability often varies based on the target market.

Business Laptops (e.g., Dell Latitude, Lenovo ThinkPad)

- **Good DfS**
- User-replaceable battery, RAM, SSD.
- Components are often accessible via a bottom panel held by standard screws.
- Detailed service manuals are publicly available.
- Designed for IT departments to service a large fleet of devices efficiently.

Modern Ultrabooks (e.g., MacBook Air, Dell XPS)

- **Poor DfS**
- Soldered RAM and SSD (not upgradeable).
- Glued-in batteries.
- Proprietary screws and complex internal layouts.
- Design prioritizes thinness and lightness over serviceability.

Quantifying Serviceability

Serviceability can be measured with metrics to guide design improvements.

Mean Time To Repair (MTTR)

A key metric representing the average time required to repair a failed component.

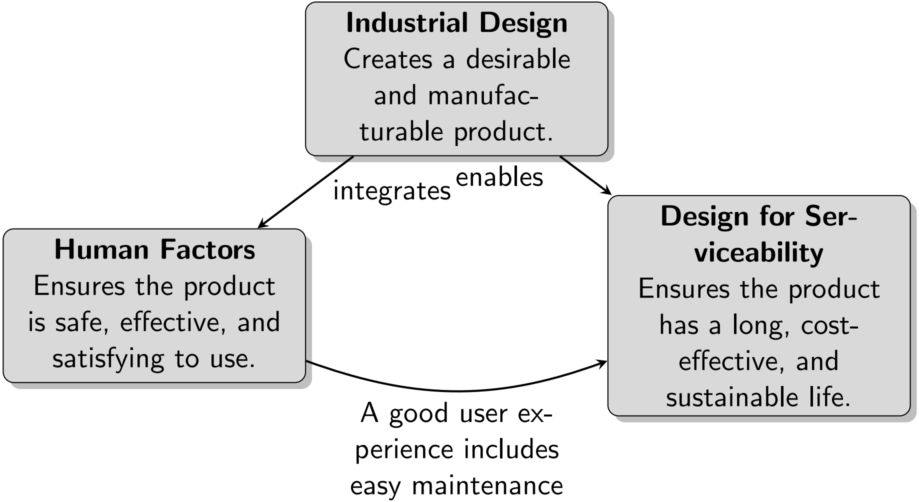
$$\text{MTTR} = \frac{\text{Total Downtime for Maintenance}}{\text{Total Number of Repairs}}$$

Table: How Design Choices Impact MTTR

Design Choice that DECREASES MTTR (Good)	Design Choice that INCREASES
Quick-release latches	Threaded fasteners
Standard fasteners (Phillips)	Proprietary fasteners (Pentalobe)
Modular components	Highly integrated components
Built-in diagnostics (e.g., error codes)	No fault indication
Accessible test points	Buried test points

Synthesis of Concepts

The three topics we discussed are deeply interconnected and essential for successful product development.



Thank You

Questions?