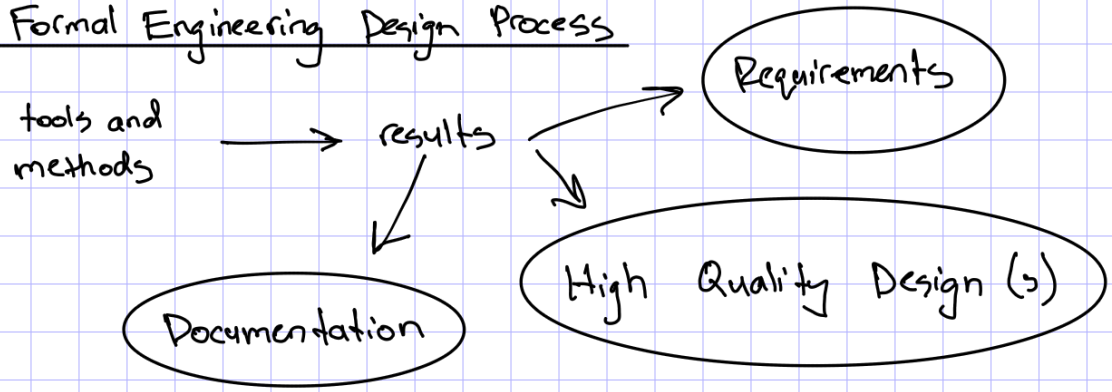
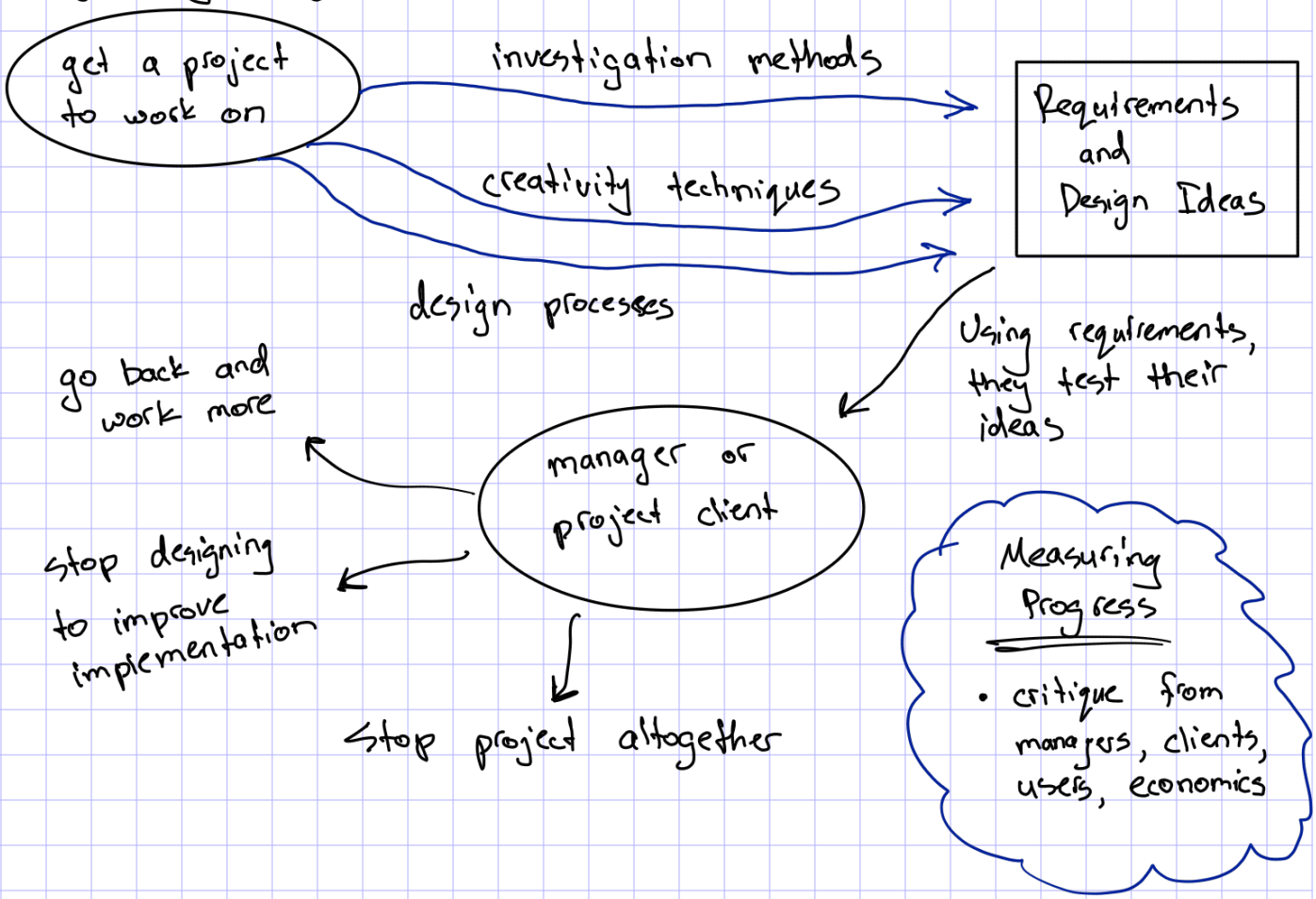
2. Design Process Overview (Pg. 5-9)

- design is iterative
  - ↳ to improve understanding, proposed design, and more quality information

Formal Engineering Design Process



Engineering Design Team



3. Project Phases (Pg. 10-13)

phases of engineering design project → primary purpose of each phase and role in overal development

how each phase feeds to the next

The Phases of A Project

Project Requirements

involves lots of info gathering and analysis

open-ended problems → research and documentation to guide decisions (and constrain)

results in

at same time

The most completed description of the problem the design team can formulate

Problem Statement

- define problem
- guide process
- design team returns to requirements development process to...
  - ↳ add to definition of problem
  - ↳ reminder for project goals

Conceptual Design Alternatives

- what team comes up with after problem is defined
- requires creativity, engineering work
- can be practiced to get better

need to evaluate ideas to decide what to pursue

Decision-making Tools

- comparing proposed solution to design criteria documented in project requirements
- get input from variety of ppl.
- engineering tools and models to evaluate the solutions

many iterations needed to refine design solutions

Reality Checks

- concepts actually feasible?
- proj. req. and definition of goals and design prob. can change

Detailed Design Phase

- design may continue to evolve
- if successful, product will be launched and ready for operation.

Operation & Decommision

- engineers keep working after product's launch

Summary

project requirements (1) → problem statement (2) → solution generation (3) → evaluation and testing (4)

5. What Engineers Design

→ different thing engineers design
→ how diff. disciplines contribute to a design

Engineering Disciplines

- similar across disciplines, but most important diff. is what the engineers design.
- almost always multidisciplinary

Civil Engineering

Design and construction of...

- water treatment / waste facilities
- power plants
- buildings
- transportation systems

Chemical and Material

- products like pharma, food, fertilizer
- design of processes (chemical refining)

Industrial Engr.

- processes like manufacturing processes, IT systems like financial, database, and online shopping systems

Mechanical, Electrical, Computer

- product or system design

Computer / Software Engr.

- software or algorithms

Plant

small production facility → huge offshore oil platform

Engineers Design Technology

- tech: anything real or virtual that doesn't occur naturally.

paper → quantum encryption

What Engineers Design

Systems

- set of organized components or elements that operate together as a unit.
- natural systems ~ solar system
- engineered systems ~ subway system, communication network
- arranged to perform set of functions

Plants

- structure + internal equipment designed to produce a product.
- product production plants, power plants, waste water plants

Products

- physical or virtual thing that is the result of a design process.
- consumer products (iphone), commercial products, energy products
- agricultural products

Materials

- a substance that has been designed
- gasses, liquids, alloys, ceramics, polymers, composites
- cloned animals, artificial diamonds

Processes

- sequence of operations needed to tranform material, energy, or info. from one form to another.
- ore → metal, crude oil → gasoline, search engines

Structures

- engineered product or system designed to support a load
- virtual structures ~ network system (virtual load: network traffic)

	Designing Large Water Treatment Plant	Designing A New Product
Project Requirements	Long Time	Short time
Problem Statement	Long Time	Short time
Solution Generation	Short Time	Long Time
Evaluation and Testing	About Same	About Same

7. Navigating The Engineering Design Process (27-31)

→ list essential process stages in engineering design
→ describe each stage briefly
→ identify where to find more info on each part

Design Process Skills and Tools

- iterative and nonsequencial
- start with requirements ... end at post-conceptual design
- can revisit and iterate through steps as needed

The Design Space

- design process is about defining and reshaping the design space.

Design Space

- abstract concept of a space encompassing all design solution ideas that are being considered at any time during project.

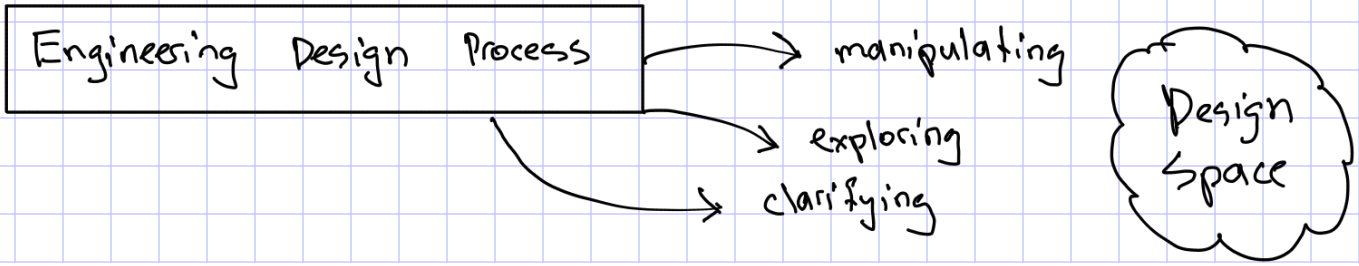
→ Developping Requirements ~ defines boundaries of design space

→ Generating New Solution Ideas ~ populates (expands) the space

→ Discarding Ideas ~ shrinks the design space

→ Building & Testing Prototypes ~ explores (investigates) the design space

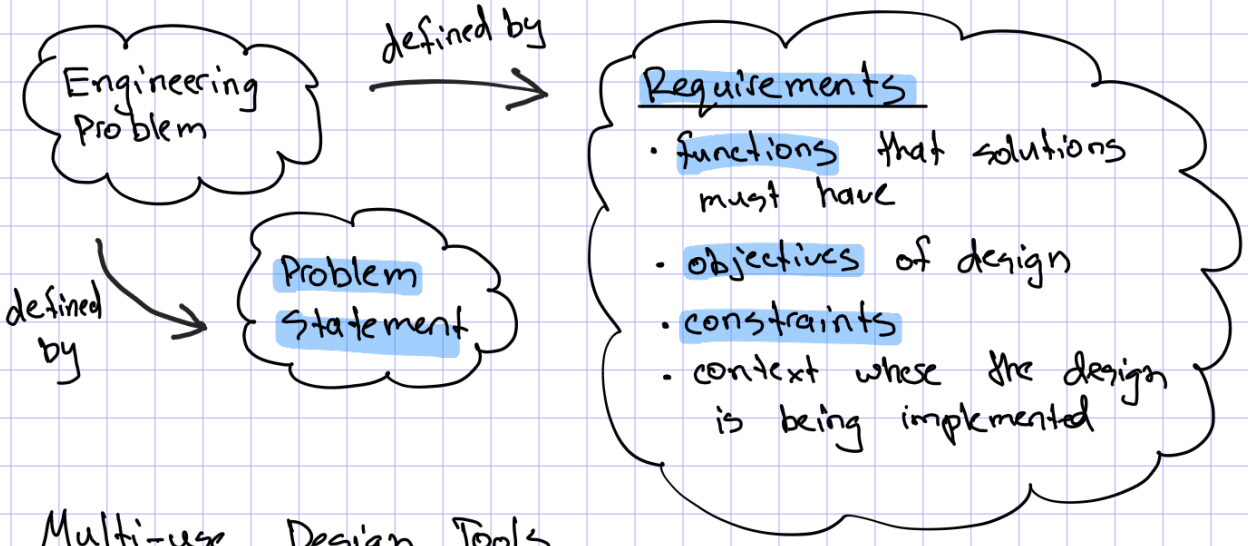
→ Creating Detailed Design ~ focuses design space



Clusters in Design Process Core

Requirements Generation : Defining Design Space

- begin with clear understanding of problem



Multi-use Design Tools

- used to generate requirements
- generate and evaluate solution ideas
- to characterize, define, describe, or detail the design space

Idea Generation Tools : Expanding Design Space

- used to create ideas ~ creativity method
- generate ideas for design solution, requirements, etc.

Decision Making : Reducing Design Space

- how to make decisions aligned with project goals & requirements
- which ideas to discard and which to develop further?

Iterating

generate → select → reflect

better design outcome

ideal solution V.S. optimal solution

Investigating Ideas: Exploring Design Space

Tools
- developping metrics
- modeling
- prototyping

used to →

Test and Evaluate design solutions.

Post - Conceptual Design: Leaving Design Space

what to do to bring design to reality? →

- implement, install, or produce the tech that results from design process

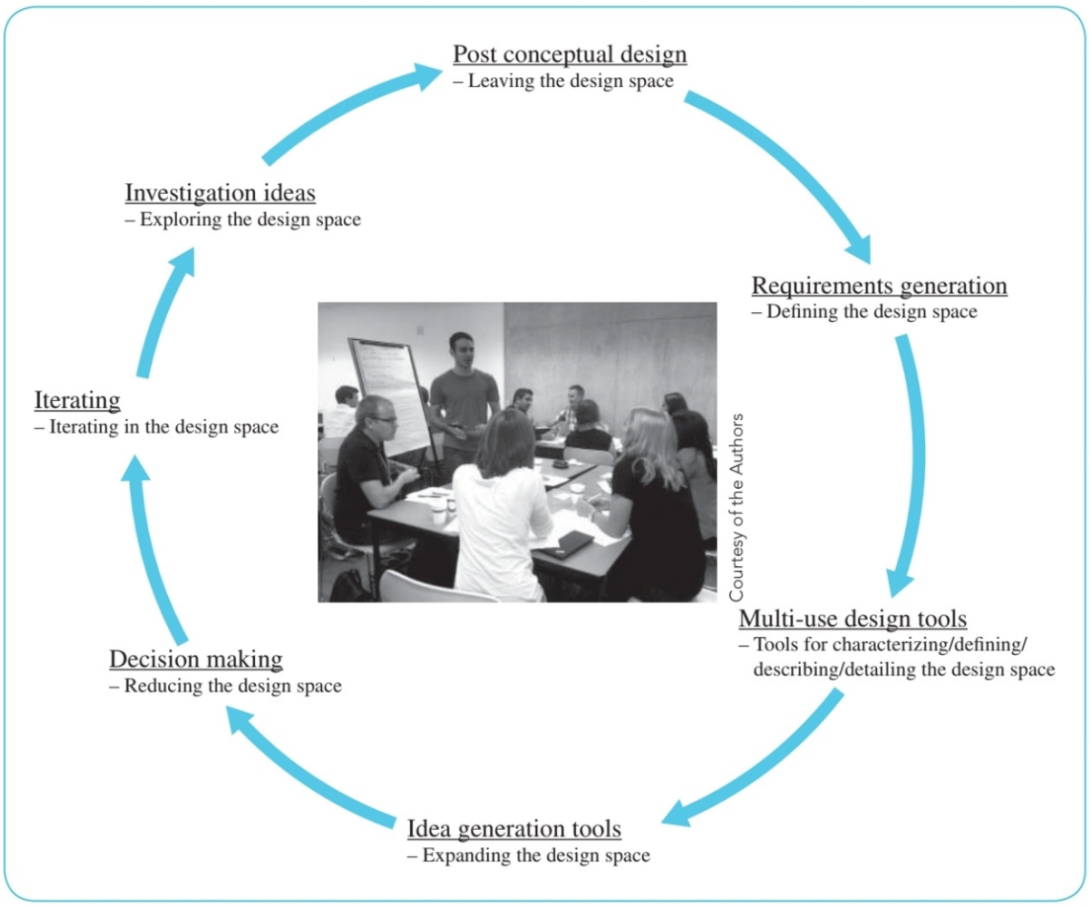
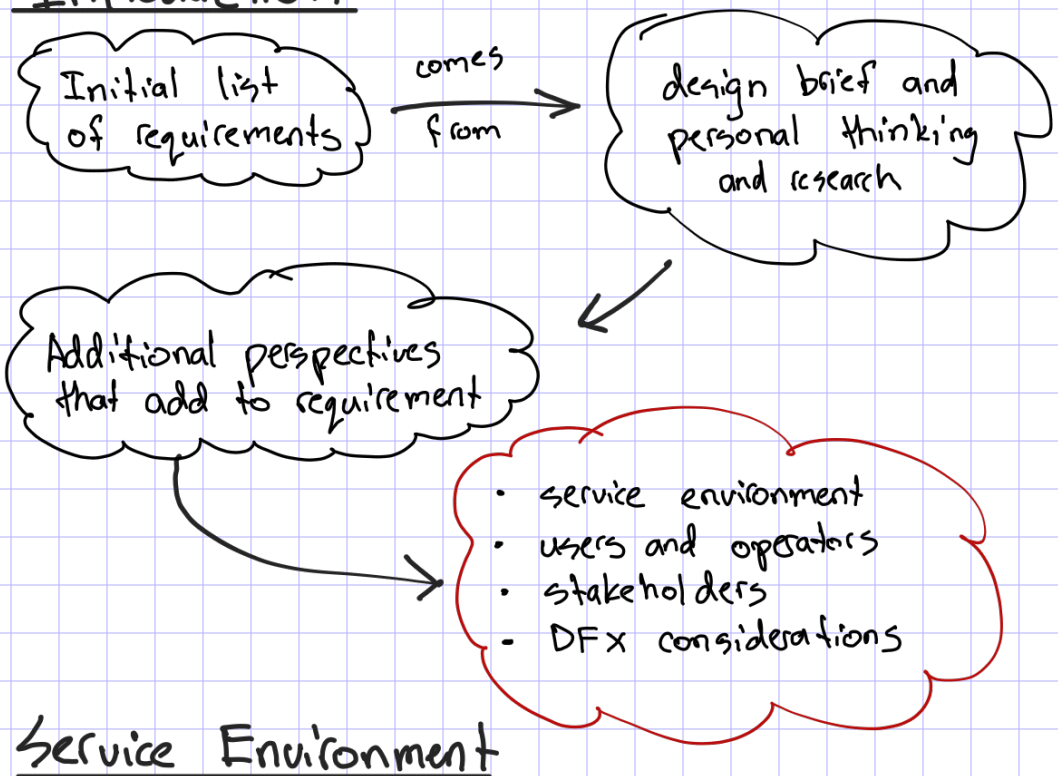


FIGURE 2 **The typical engineering design method revolves around a few essential core processes: requirements specification, idea generation (ideation), decision making, and detailed design work.** These processes are enabled and supported by using tools and strategies. The core process modules explain these activities.

5. Documenting The Context (pg. 61-68)

→ define and explain "service environment"
→ generate objectives and constraints from service environment description and use it to add depth to problem statement
→ describe service environment of existing tech

Introduction



Service Environment

- location where the design will operate

description of all elements present in that location

if tech is mobile, then describe range of environments

* description of environment is important when it can cause design to fail

Service Environment Documentation

- not how product will be designed to operate within service environment
- rather, a description of what the environmental conditions are

Example

Not: " the design must be waterproof "

Rather: " the design will be used outdoors in Toronto, CA, and temp is ~ rainfall is ~ wind is ~ etc. "

Identifying and Describing Service Environment

1. Physical Environment

- temp, pressure, wind, rain, snow, ice, sun, humidity
- extremes of physical environment
- work over time : corrosion and fatigue
- other things, like machinery, appliances, services, computer specs and software requirements

2. Living Things

- people : users and operators
  - eg: vacuum cleaner at home ~ kids, but V.C. at industry, no kids
- animals : pets, livestock, wild animals, microbes
- malevolent being : bugs or microbes, vandalizers, hackers for virtual technologies

3. Virtual Environment

- wireless networks, satellite coverage (GPS), or cell phone signals
- can leave section out if unsure whether virtual environment is important to design ~ can come back later to it.

Further Considerations

→ something doesn't fit into above categories?

eg: standard electric service in N.A. (110V)

↳ is it physical or virtual?

- put it in "other" cat. ~ it doesn't matter as long as you include it in your service environment doc.

eg: designing shampoo bottle → don't write about electricity service since it won't use it

eg: installing water pump in remote location → Yes, say you assume electricity service since you need it.

How to Use Service Environment Info?

- use the info to revise/guide functions, objectives, and constraints

eg: no electricity → new constraint: "design must operate without power from the grid"

eg: design requires energy input → functions list: "design will use available energy resources as necessary to provide functionality"

eg: vandals → new objective: "make design hard to vandalize"

Conclusion

why all this info in service environment?

- making sure I'm making assumptions explicit
- fosters diligence, research, and the gathering of info
- Being intentional as a designer

Functions

- what the design must do.
- must be solution independent
- describes boundary of design space

Primary Function
↳ design must lock bike
↳ must lock
↳ must unlock

Generating Functions

- brainstorming
- 5 whys
- black box method

- means analysis
- use case
- task analysis

- means statement
↳ possible solution that does function

↳ Inputs
1) matter
2) energy
3) information

Outputs
1) matter
2) energy
3) information

Functional Basis Method

- Technology manipulates mass, energy, and information
flows or components

- 11 set of operations (functions) that tech. can do on components.
↳ goal: control (a function in and of itself)

1. sense
2. support
3. combine
4. separate
5. replicate
6. store
7. extract
8. tranform
9. generate (information)
10. transport
11. control → function of all tech.

Why use Functional Basis?
1) helps in identifying underlying functionality of design
2) can be used to compare other tech. that serves same functional basis ~ to take inspiration.

Objectives

- What design should be.
- Used to judge how well design solves the problem.
- Measure of effectiveness.