Elec 4309 Senior Design

Wendell H Chun

Aug. 29, 2017

Purpose of Design

- Design is where customer requirements, business needs, and technical considerations all come together in the formulation of a product or system
- The design model provides detail about the data, structures, electronics, architecture, interfaces, and components
- The design model can be assessed for quality and be improved before electronics and/or software are built and tests are conducted:
  - Does the design contain errors, inconsistencies, or omissions?
  - Are there better design alternatives?
  - Can the design be implemented within the constraints, schedule, and cost that have been established?

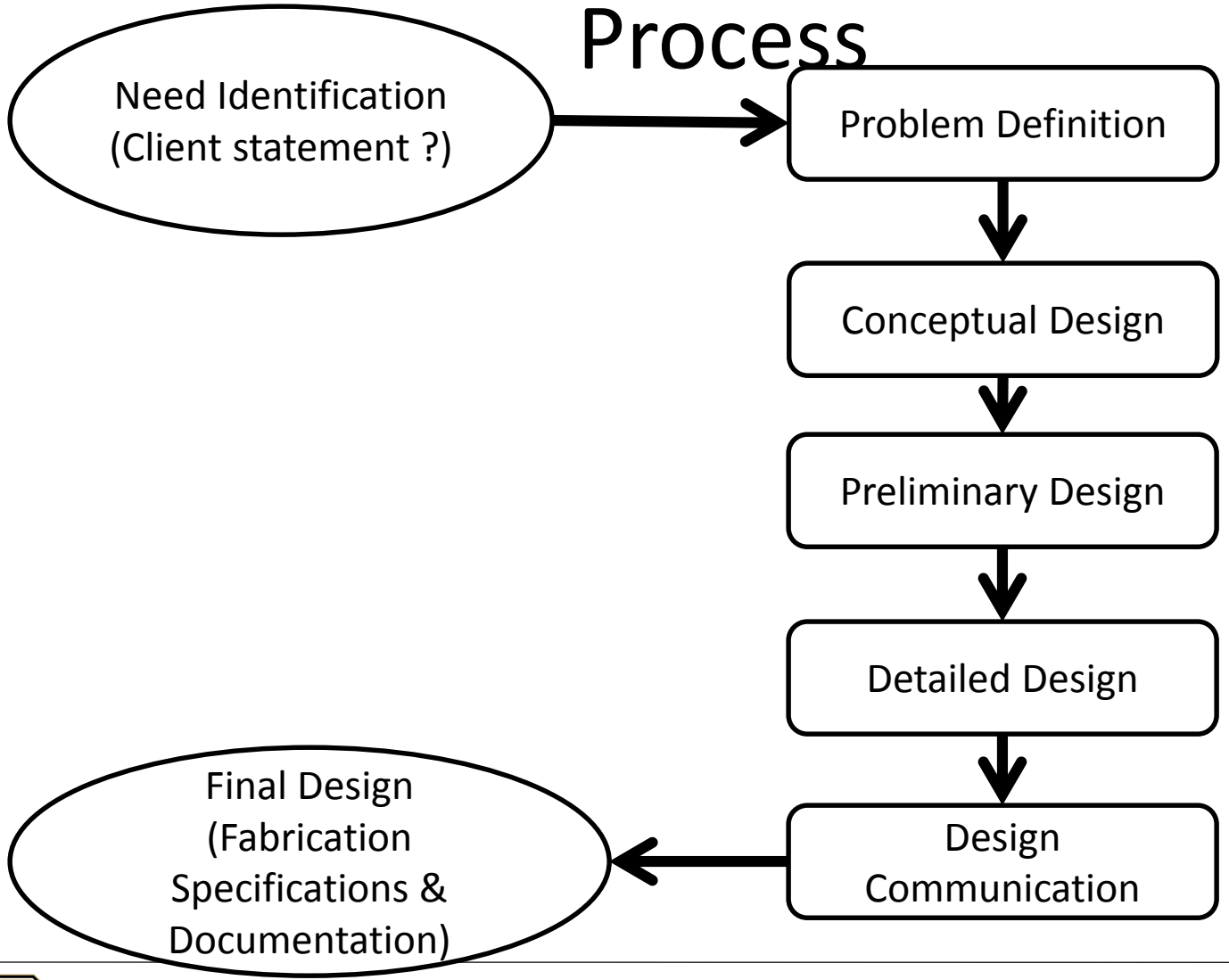
Purpose of Design

- A designer must practice diversification and convergence:
  - The designer selects from design components, component solutions, and knowledge available through catalogs, textbooks, and experience
  - The designer then chooses the elements from this collection that meet the requirements defined by requirements engineering and analysis modeling
  - Convergence occurs as alternatives are considered and rejected until one particular configuration of components is chosen
- Electrical design is an iterative process through which requirements are translated into a blueprint for constructing the hardware (same for software):
  - Design begins at a high level of abstraction that can be directly traced back to the data, functional, and behavioral requirements
  - As design iteration occurs, subsequent refinement leads to design representations at much lower levels of abstraction

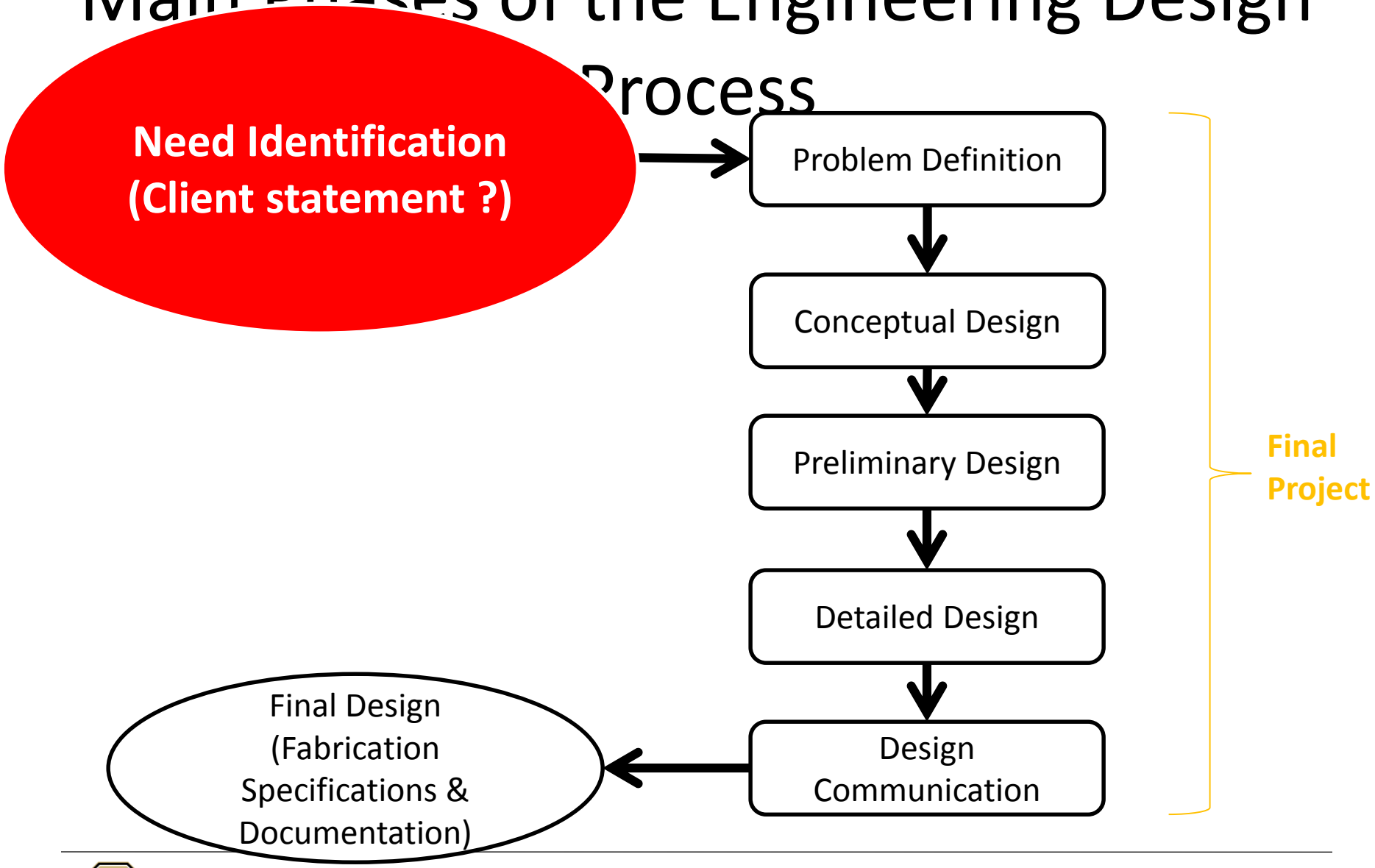
From Analysis Model to Design Model

- Each element of the analysis model provides information that is necessary to create the four design models
  - The data/class design transforms analysis classes into design classes along with the data structures required to implement the software
  - The architectural design defines the relationship between major structural elements of the software and hardware; architectural styles and design patterns help achieve the requirements defined for the system
  - The interface design describes how the software and hardware communicates with systems that interoperate with it and with humans that use it
  - The component-level design transforms low-level elements of the system architecture into detailed components

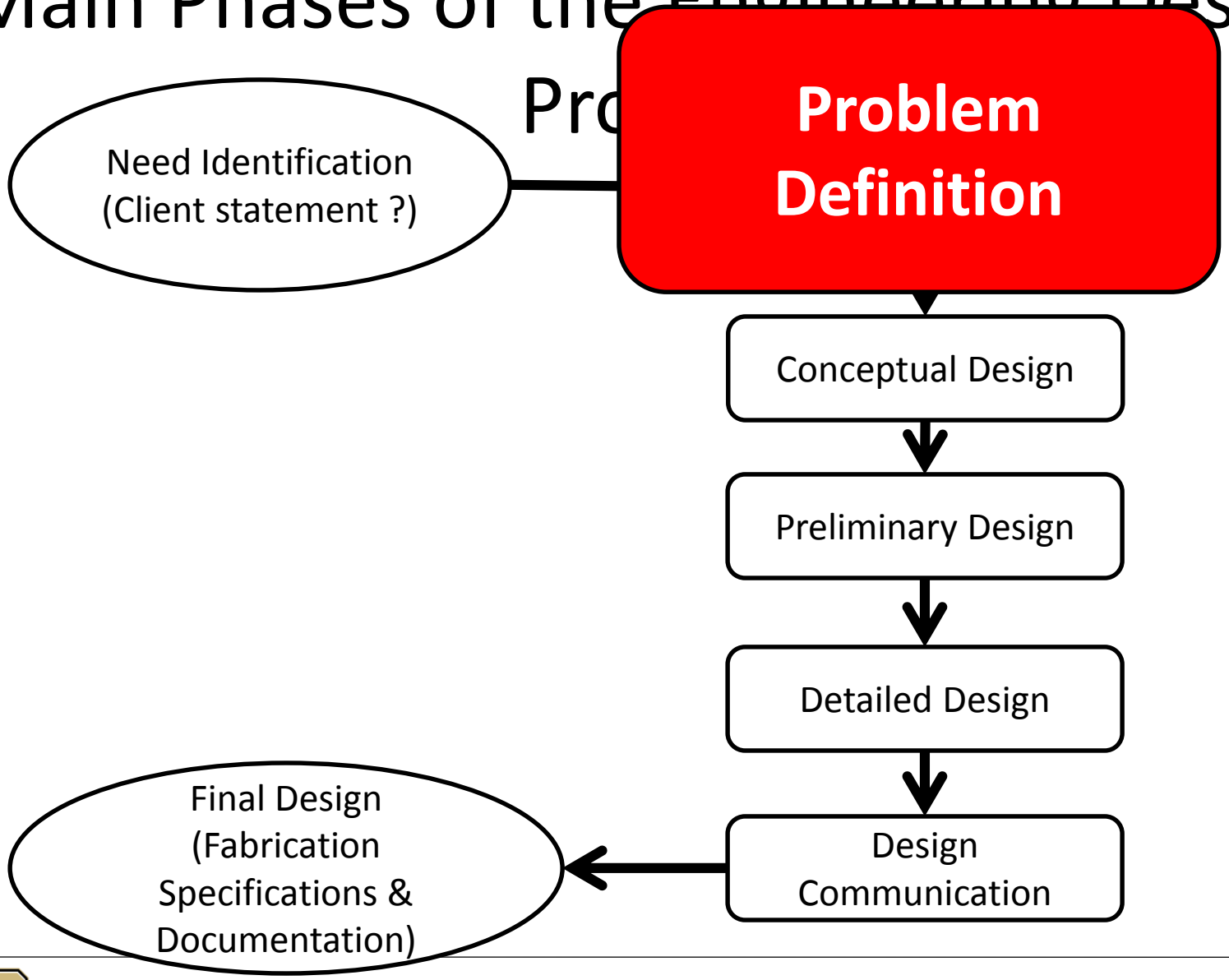
Main Phases of the Engineering Design Process



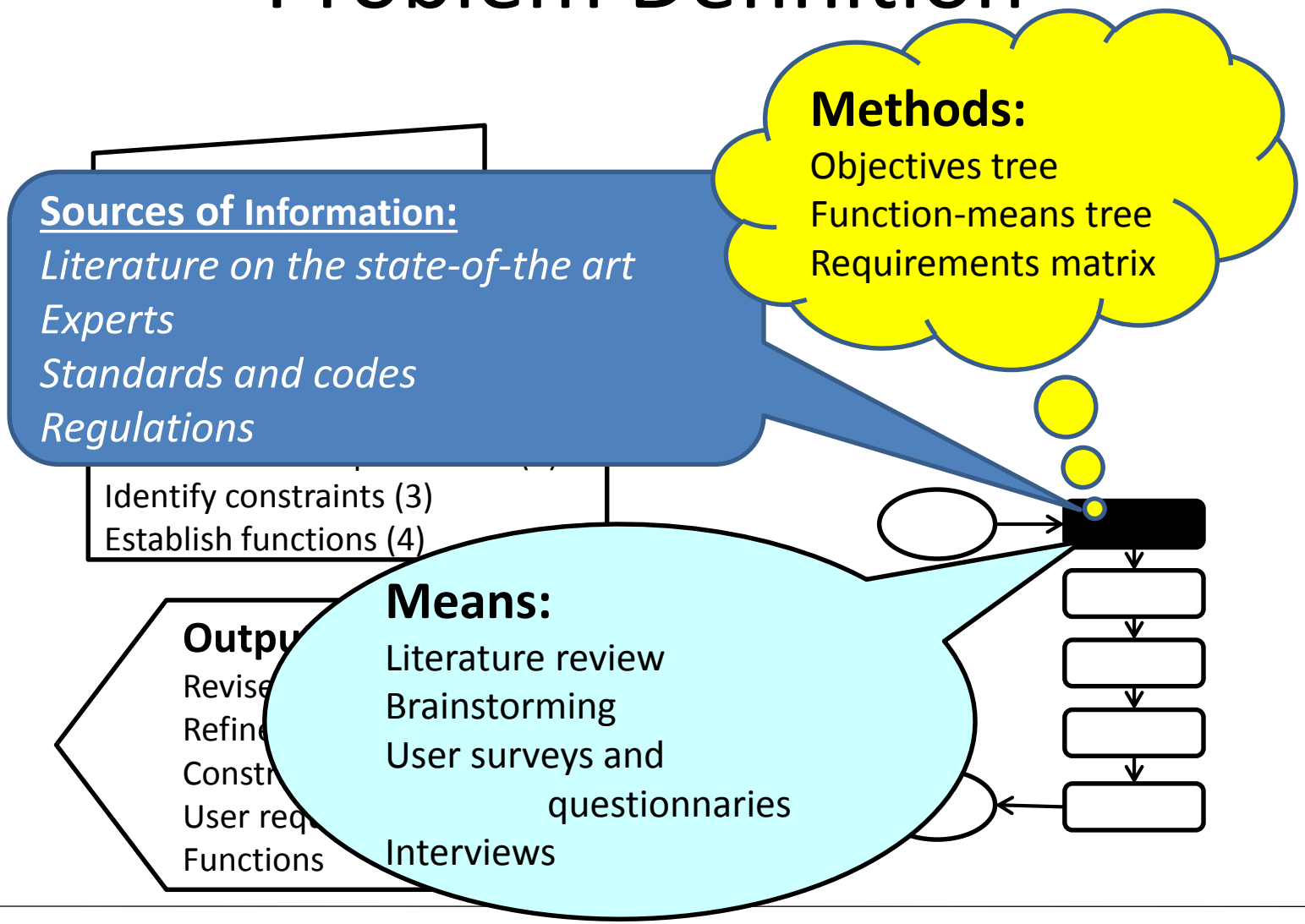
Main Phases of the Engineering Design Process



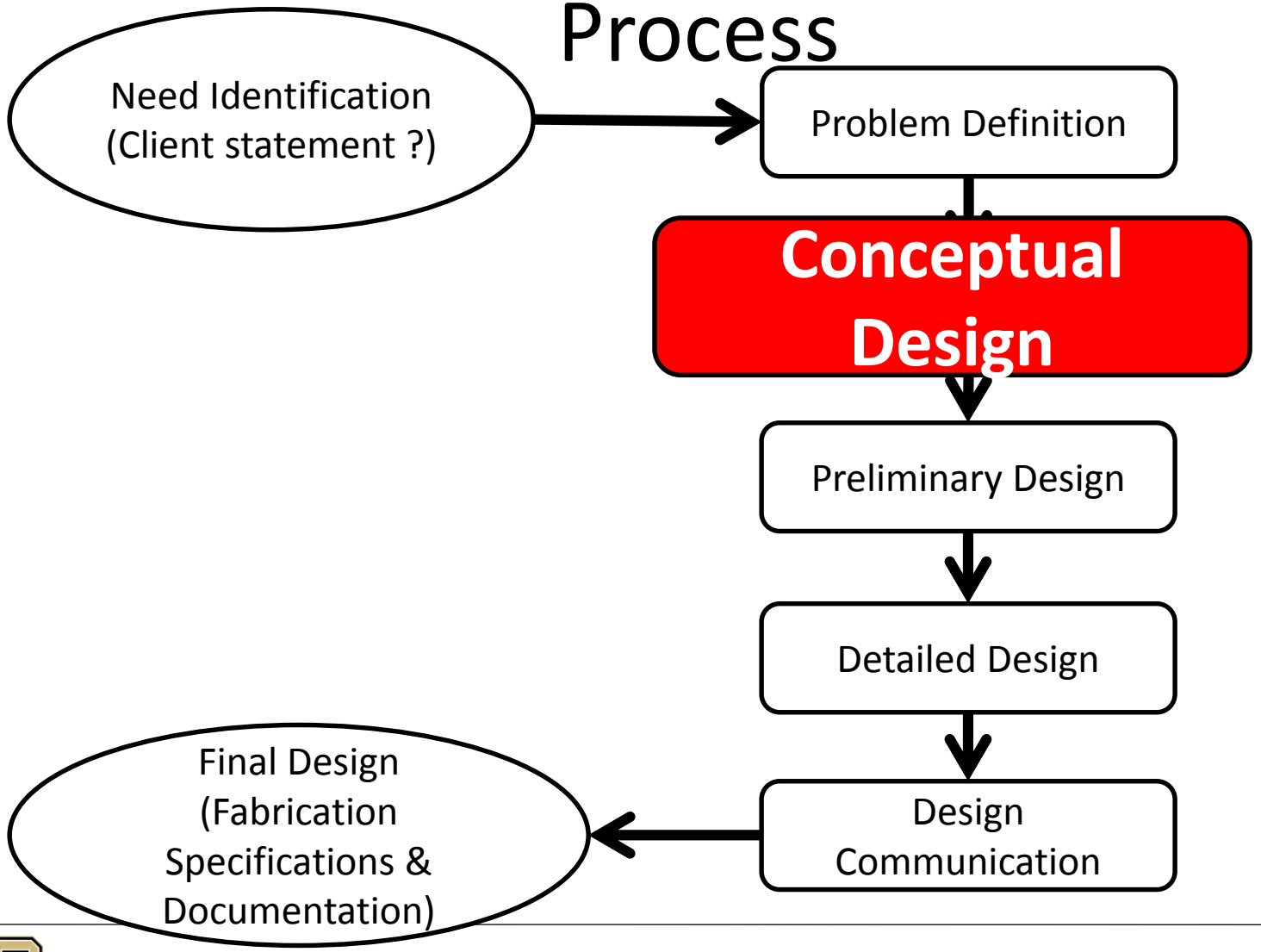
Main Phases of the Engineering Design Pro



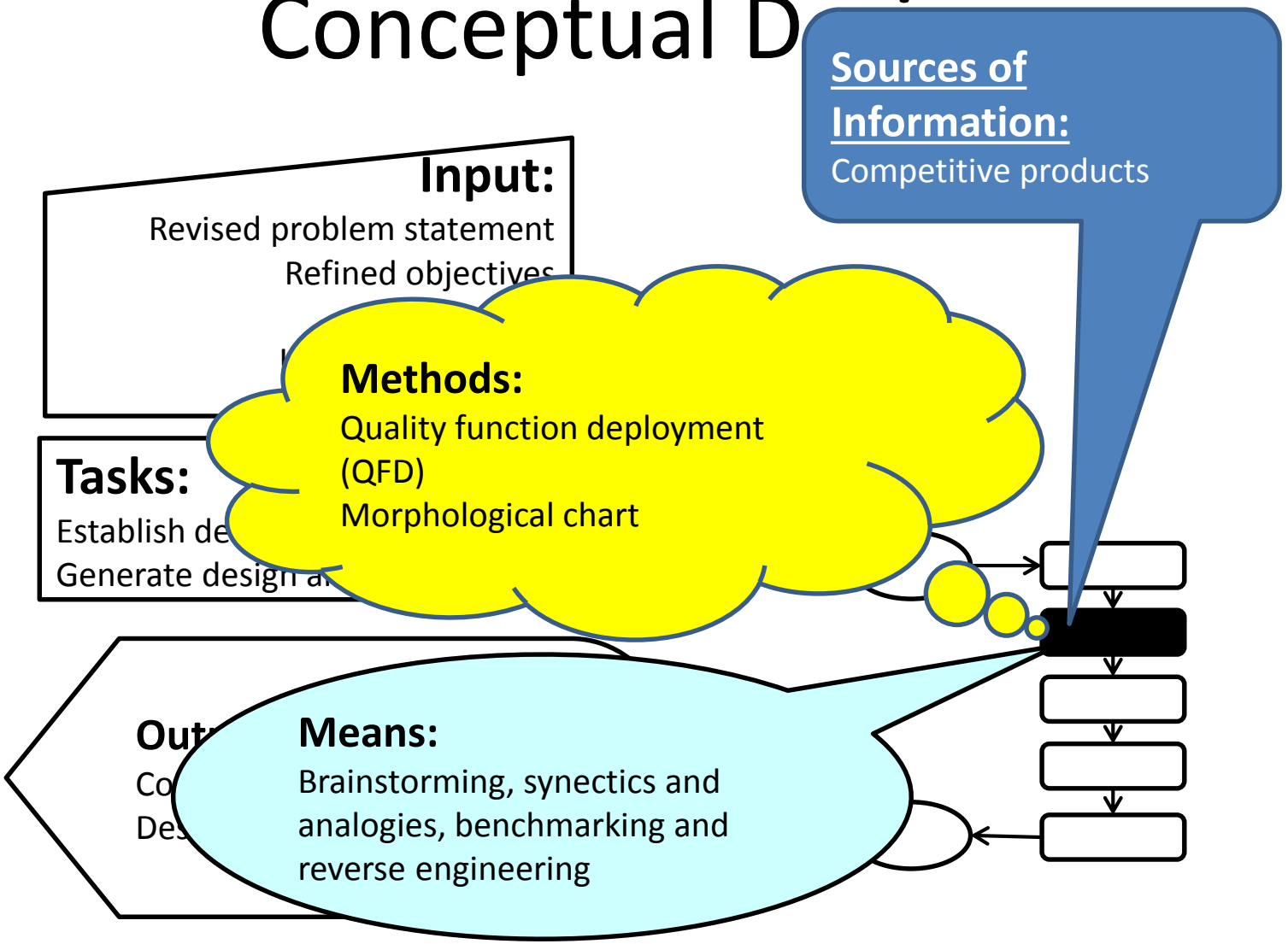
Problem Definition



Main Phases of the Engineering Design Process

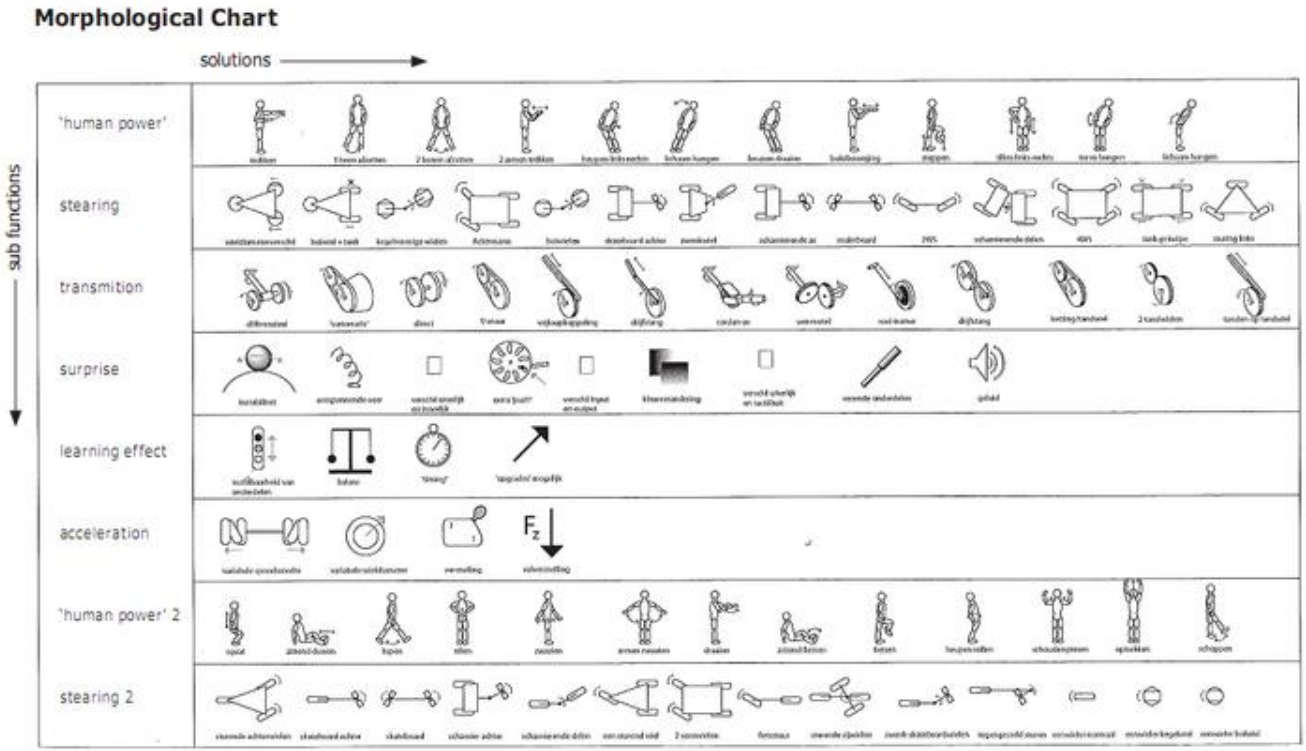


Conceptual D



Morphological Chart

- Morphological chart is the process of generating ideas in an analytical and systematic manner



Procedure

- List the features or functions that are essential to the product
- For each feature or function, list the means by which it might be achieved
  - derive these systematically
- Identify feasible combinations

Example: List the Features or Functions …

Engine
Shifting
Drive
Brakes
Steering
…

Example: List the Means by which …

Engine	Fully electric	Hybrid	Gasoline	Diesel
Shifting	Automatic	Semi-automatic	Manual	
Drive	Front-wheel	Rear-wheel	All-wheel	
Brakes	Standard	Anti-lock		
Steering	Regular	Power		
…	…	…	…	

Example: Identify Feasible Combinations

Engine	Fully electric	Hybrid	Gasoline	Diesel
Shifting	Automatic	Semi-automatic	Manual	
Drive	Front-wheel	Rear-wheel	All-wheel	
Brakes	Standard	Anti-lock		
Steering	Regular	Power		
…	…	…	…	

Typical Notation: Morphological Chart

Functions	Technological Options							
Capture/Collection	Wind	Solar	Micro-Hydro	River Energy (Underwater turbines)	Piezoelectric (Capture vibration energy)	Thermoelectric	Sound Energy	Algae
Storage	Kinetic Energy in a Flywheel	Compressed Air	Thermal (water or molten salts)	Lead-Acid battery	Nickel Metal Hydride Battery	Lithium Ion Battery	Ultra-capacitors	Hydrogen
Conversion	AC/DC Converter	Alternator	DC/DC	AC/AC	Fuel Cell			
Location/Transmission	Power Lines	Pick-up and carry	Water					
Consumption	AC Power	DC Power	Thermal					
Management/Control	Limit Switch	PLC Display	Constant Monitoring					

Criteria for Successful Use

- The various features or functions of the eventual design solution must be well understood
- The various features or functions of the eventual design solution must be relatively independent
- The various means per feature or function must not be infinite, and principally relate to one another so a systematic articulation can uncover all of them

Strengths and Weaknesses

Strengths

- Helps break down the design problem into features or functions
- Systematic manner of deriving possible means
- Avoids possible bias toward certain means
- Helps identify and consider novel/unusual combinations

Weaknesses

- Applicable only to design problems where the features or functions of the design solution are well understood
- Quickly leads to too many possible combinations
- No valuation attached to individual means

Focus on Essence

- Every design problem has an essence, the key – and often most difficult – part that must be understood and addressed ‘right’ for the design solution (plan for change in the world) to satisfy the stakeholders
- Postponing understanding and addressing the essence of a design problem incurs a significant risk of rework at a later time

Focus on the Unknown

- Every design problem involves knowledge deficiencies – gaps in the understanding of the design problem and its possible solutions – that must be addressed for the design solution (plan for change in the world) to satisfy the stakeholders
- Postponing understanding and addressing the knowledge deficiency incurs a significant risk of rework at a later time

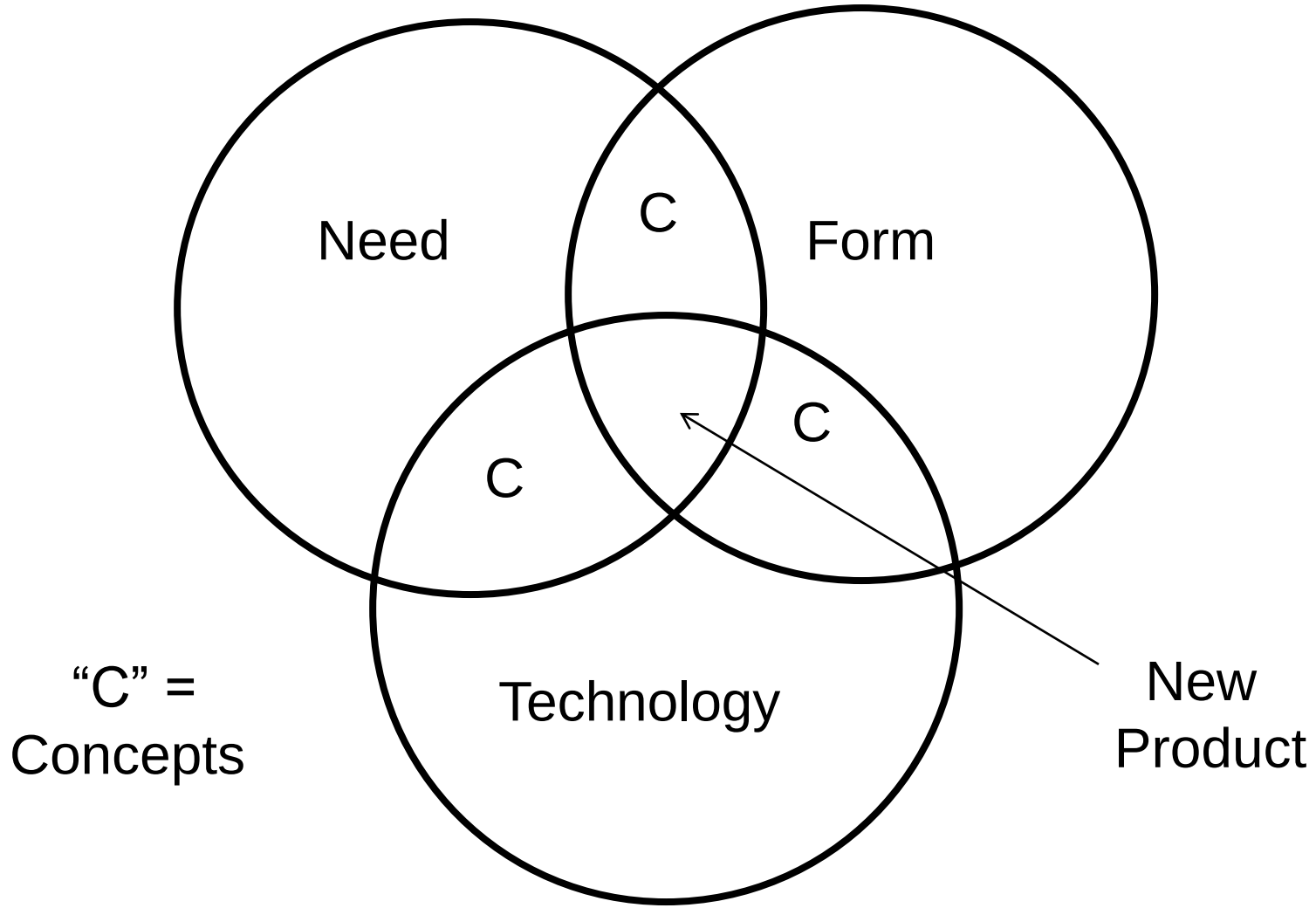
Focus on Making Progress

- Every design problem involves times during which the design project gets stuck; focusing effort elsewhere and continuing to make progress is often the right approach in response
- Continuing to focus on a stuck issue for extended periods of time tends to be effort that is wasted

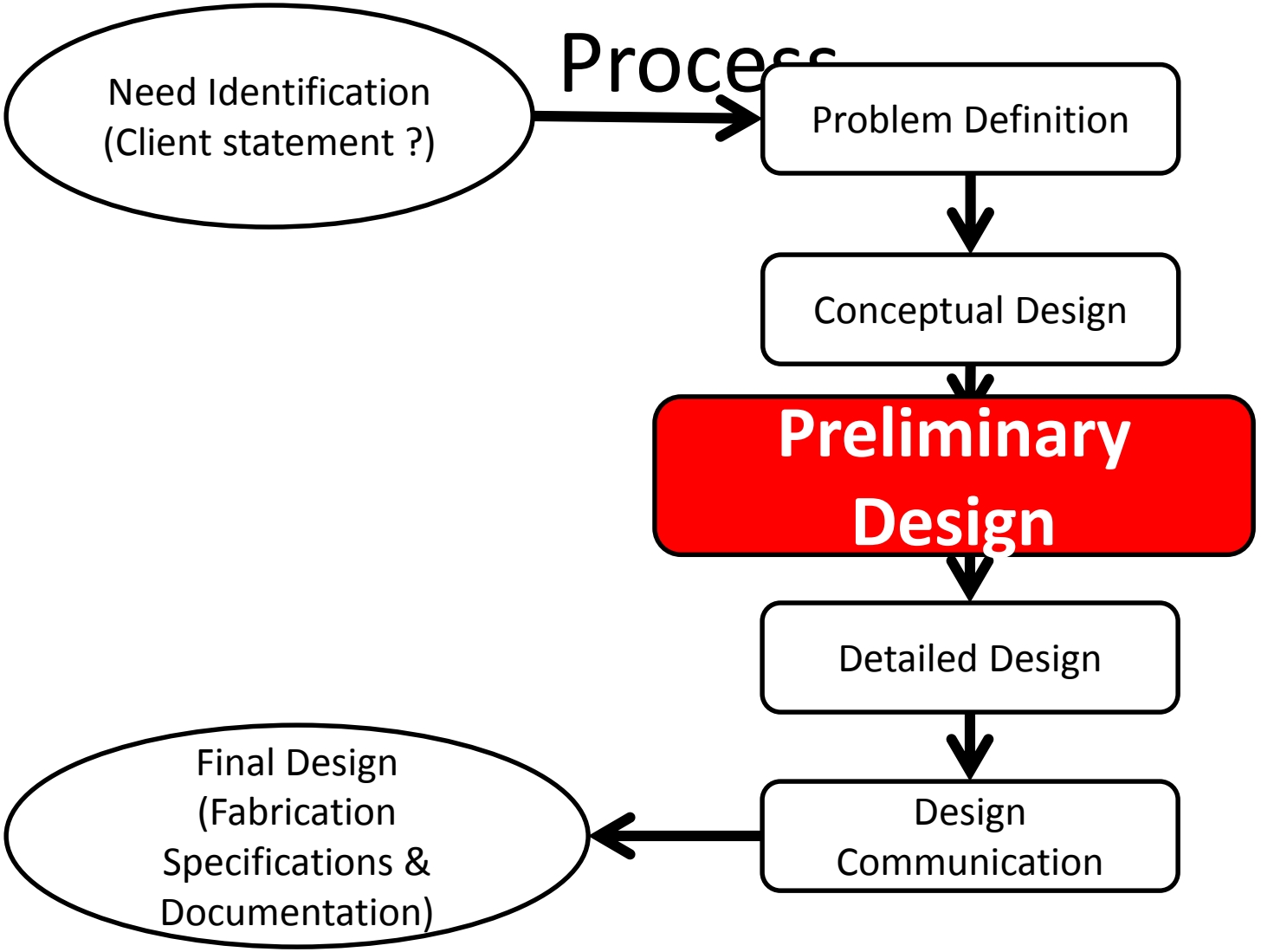
Why Do You Need a Concept and Not Just an Idea?

- Needed to judge whether it is worthy of development
- Potential customers do not have enough information to judge the worthiness of an idea: the product concept gives them the required information.
- Ex.: Would a taxi operator like cars with a 10 cents per mile operating cost? (need)
  - Not if it used Caterpillar tractor technology instead of wheels! (need plus technology)

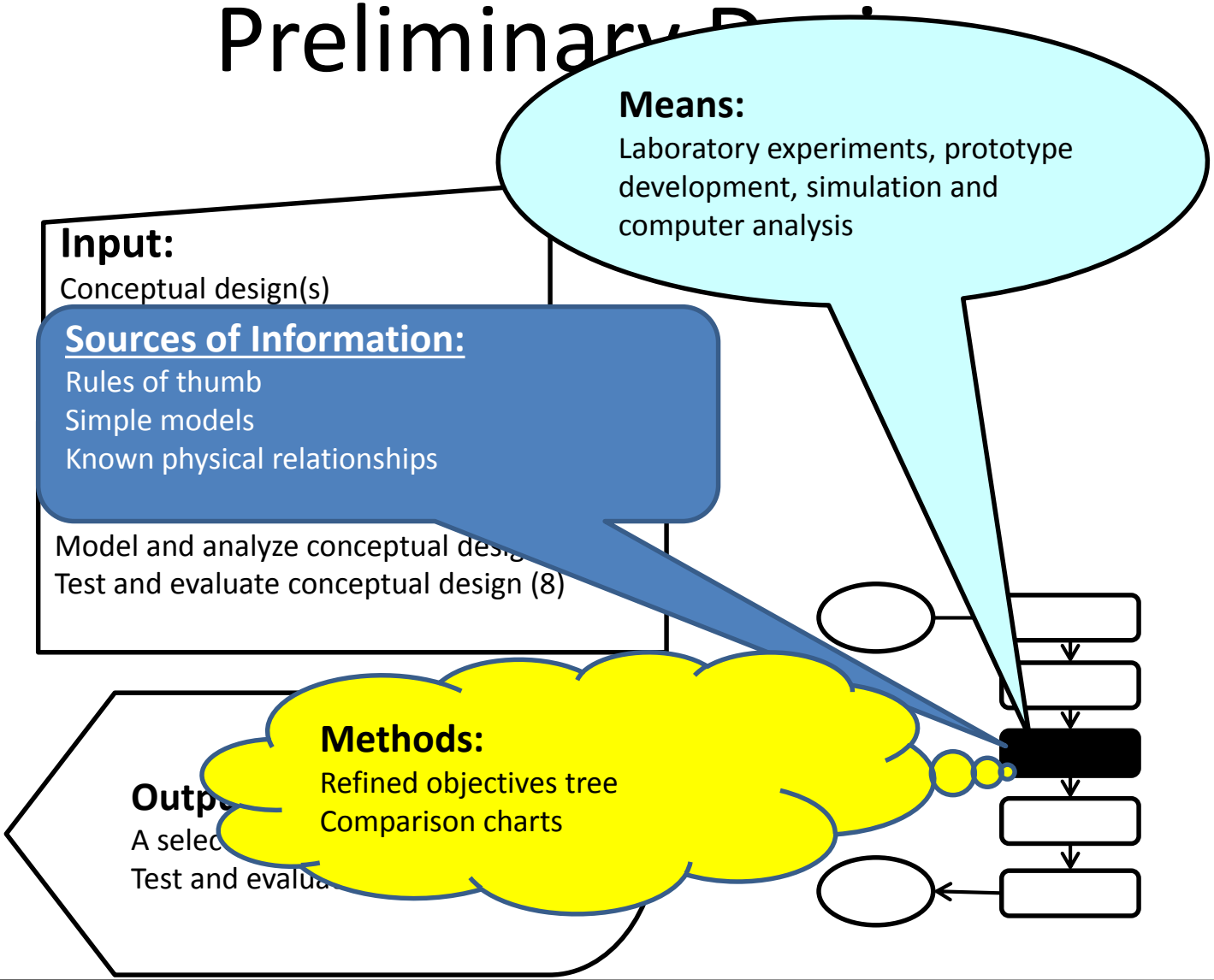
New Product Concept & the New Product



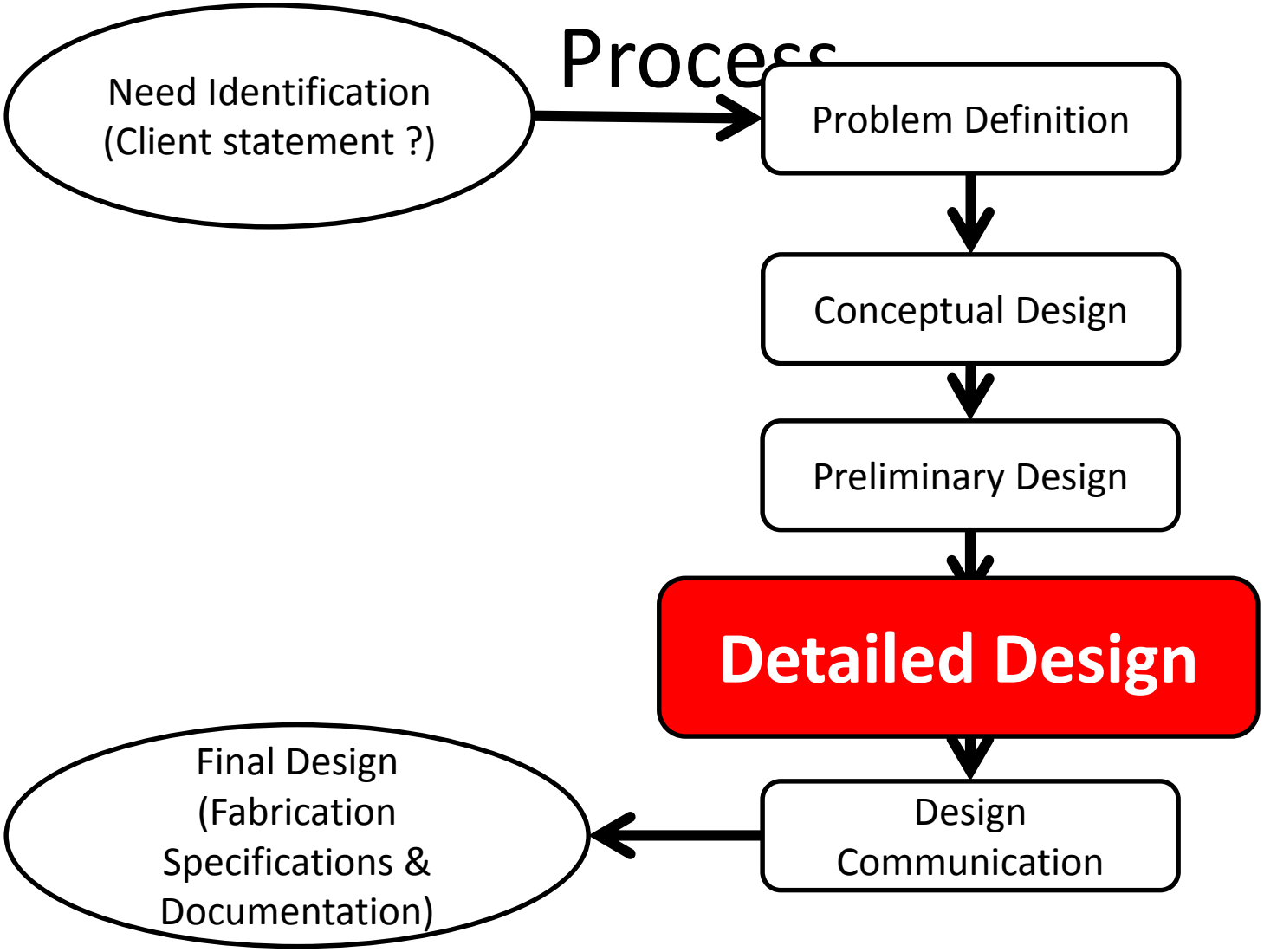
Main Phases of the Engineering Design Process



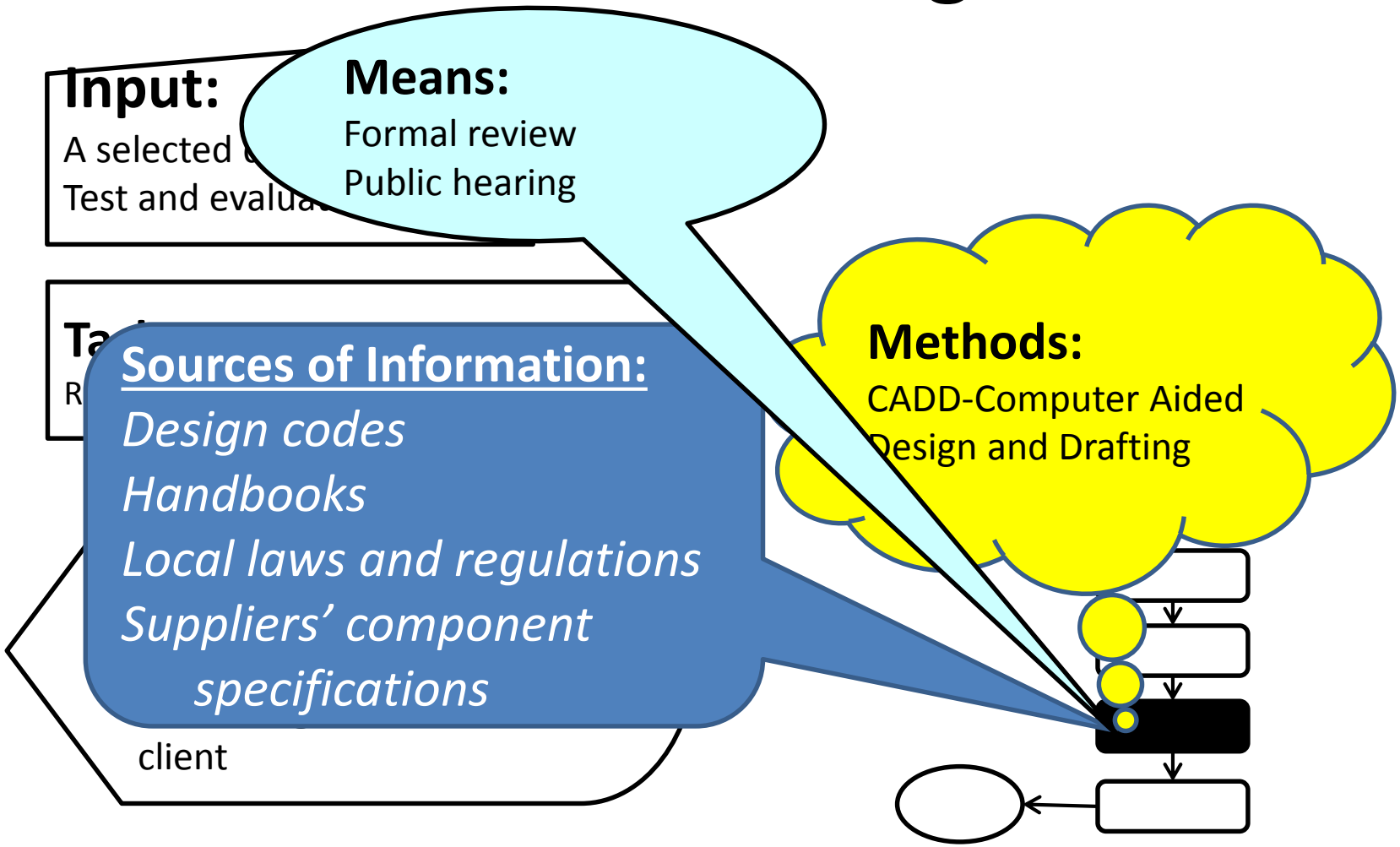
Preliminary D



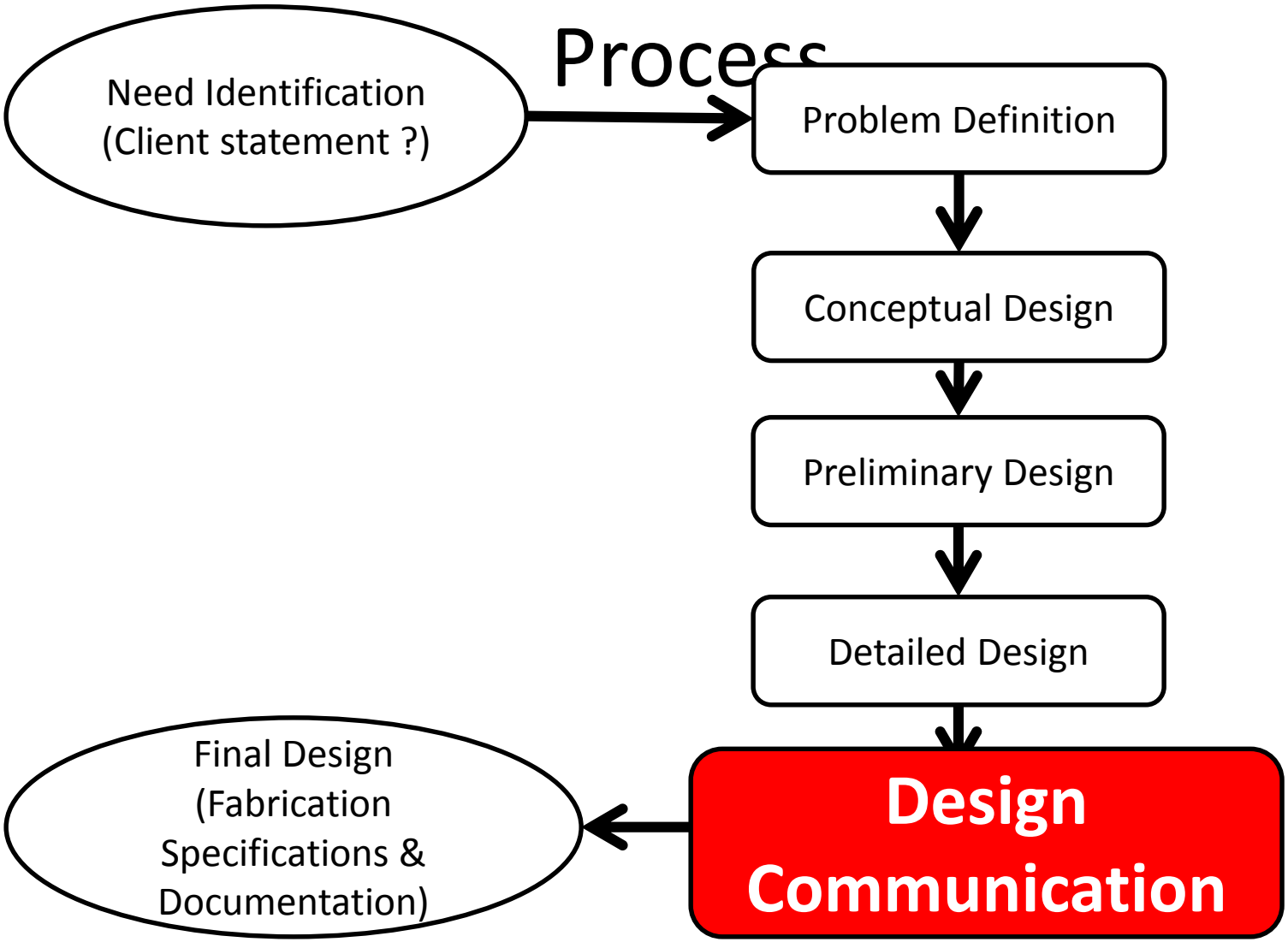
Main Phases of the Engineering Design Process



Detailed Design



Main Phases of the Engineering Design Process



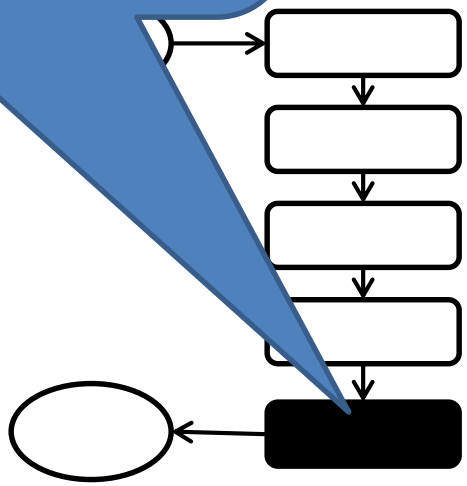
Design Communications

Input:
Manufacturing specific

Tasks:
Document the comple

Sources of Information:
Feedback from clients and users

Output:
Final report to client
containing manufacturing
specifications



Summary

- Design is a process
- Follow the structure!!!
- Start with the Problem or Need
- Do background investigation
- Conceptual Design is a skill that takes creativity and is essential to winning new projects
- Preliminary Design is the start of the engineering work, supported by trade studies and in-depth analysis. Often times include modeling.
- Detail Design is everything the project needs prior to manufacturing of the final product. Detail Design includes component specification and drawings (both electrical and mechanical).
- Communicate all results, often and continuously. The formal design process includes a few formal reviews (Requirements Review, PDR, CDR) to assess the maturity of the design.