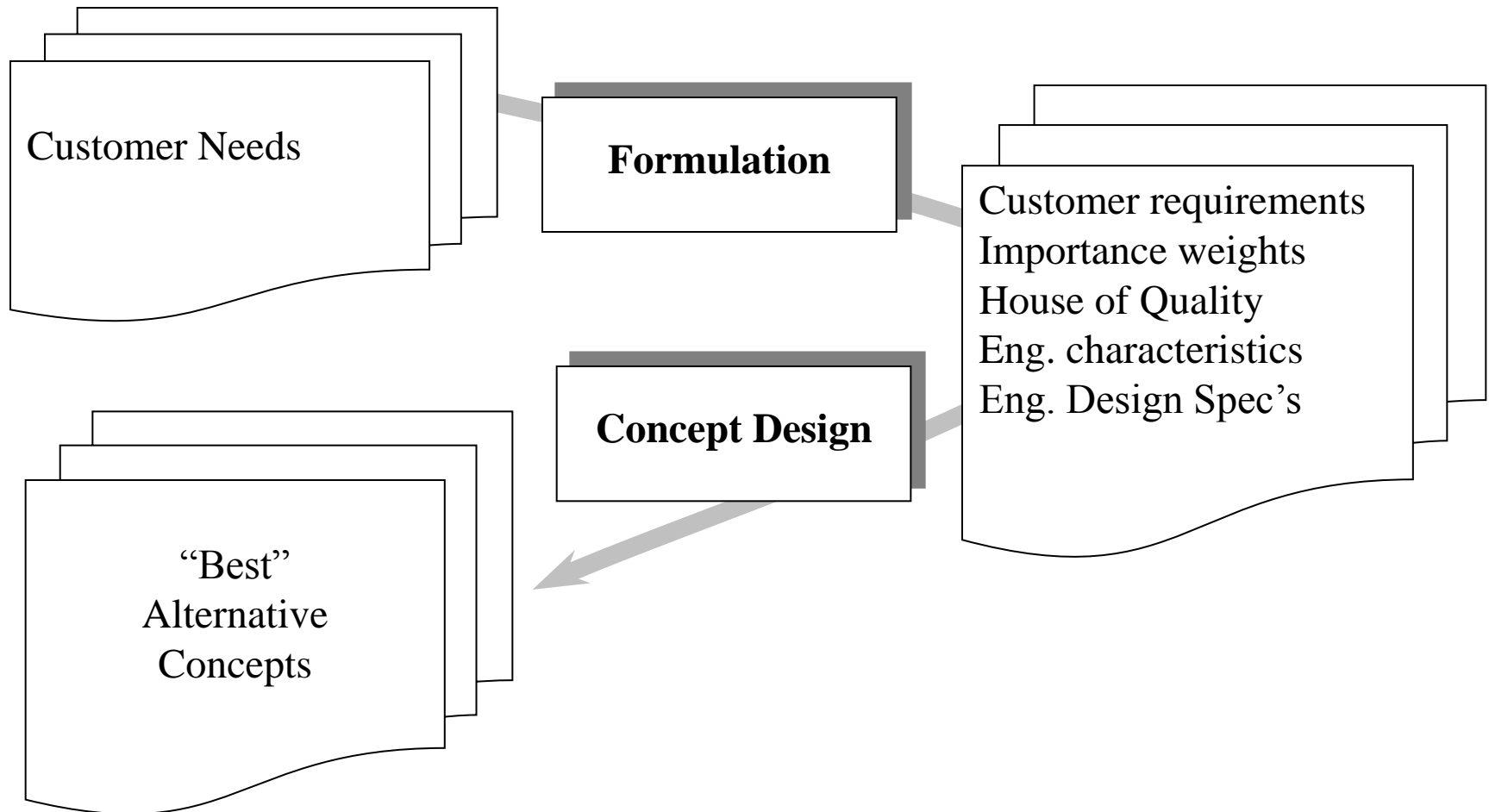




Concept design

- What is a design concept?
- Clarifying functional requirements
- Generating design concepts
- Analyzing alternative designs
- Developing “product” alternatives
- Evaluating product alternatives
- Concept Design Review
- Information flow & storage
- Intellectual property protection

Info flow during formulation and concept design phases





What is an alternative concept design?

For slowing and stopping a spinning shaft?

<u>Alternative</u>	<u>Physical principle</u>	<u>Abstract Embodiment</u>
1	fluid friction	fan blade on shaft
2	magnetic field	re-generative brake
3	surface friction	disk and caliper brake

For fastening sheets of paper?

<u>Alternative</u>	<u>Physical principle</u>	<u>Abstract Embodiment</u>
1	spring force	paperclip
2	bent clamp	staple
3	bendable clamp	cotter pin
4	adhesion	glue



Physical principle

Def. - the means by which some *effect* is *caused*

Conservation of energy

Conservation of mass

Conservation of momentum

Newton's laws of motion

Newton's law of gravitation

Coriolis effect

Coulomb friction

Euler's buckling law

Hooke's law

Poisson effect/ratio

Archimedes' principle

Bernoulli's law

Boyle's law

Diffusion law

Doppler effect

Joule-Thompson effect

Pascal's principle

Siphon effect

Thermal expansion effect

Newton's law of viscosity

Newton's law of cooling

Heat conduction

Heat convection

Heat radiation

Ohm's law

Ampere's law

Coulomb's laws of electricity

Gauss' law

Hall effect

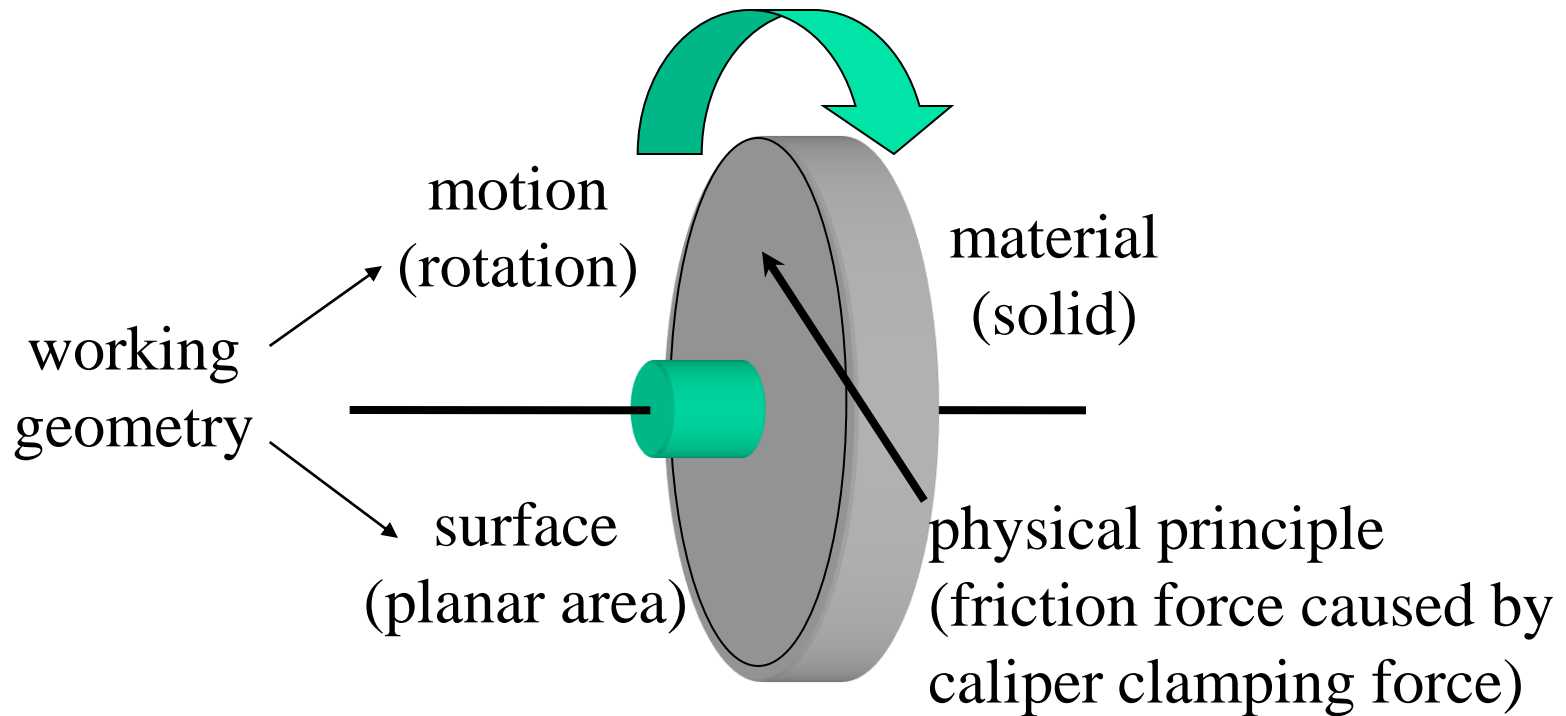
Photoelectric effect

Photovoltaic effect

Piezoelectric effect

"Working principle" of a disc brake

(Pahl & Beitz, European community)



Note: no sizes, only vague shape



Design concept

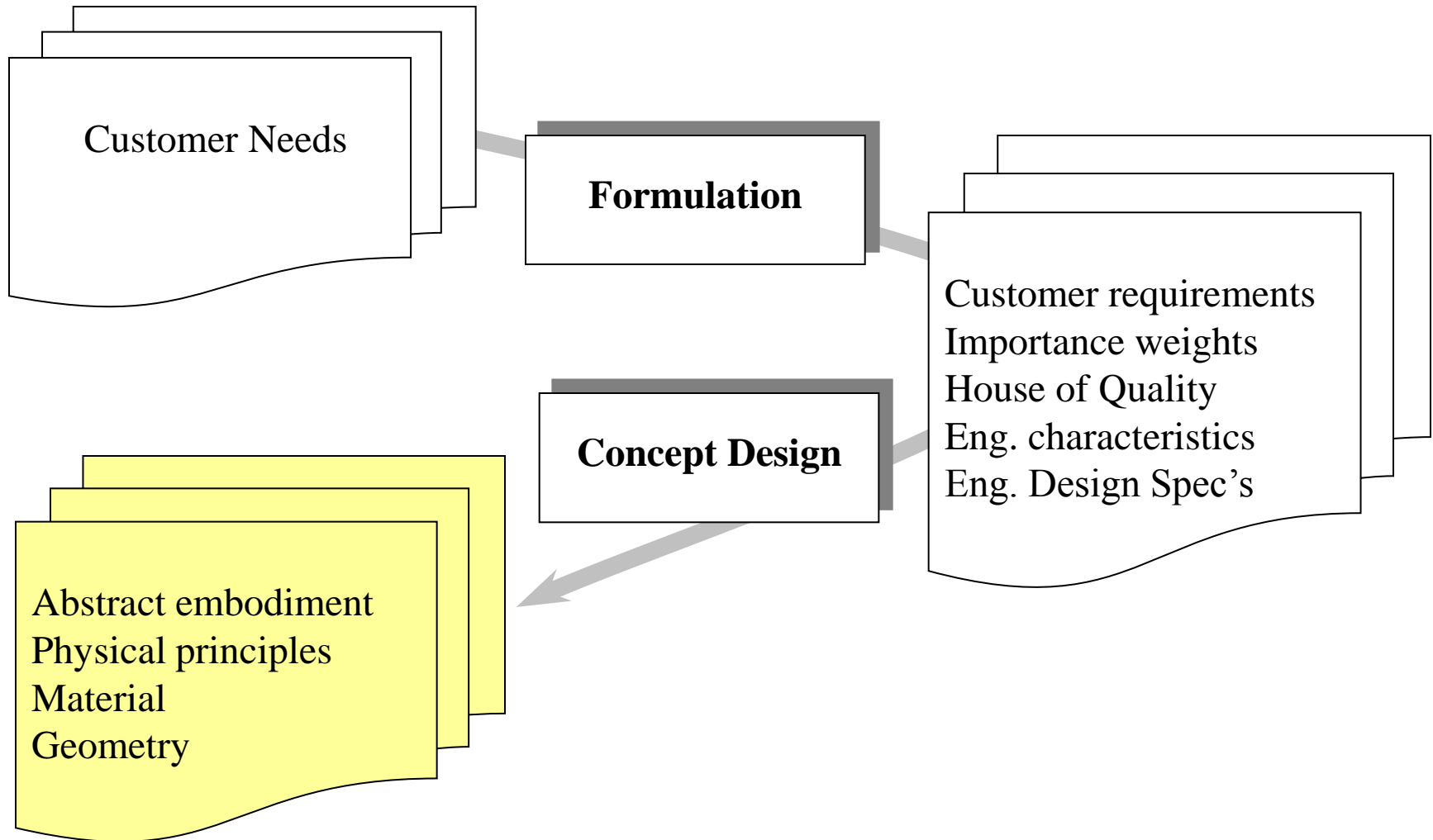
Definition:

abstract embodiment of:
physical principle,
material, and
geometry.

Purposefully vague

Surfaces, motion

Inputs & outputs to decision making

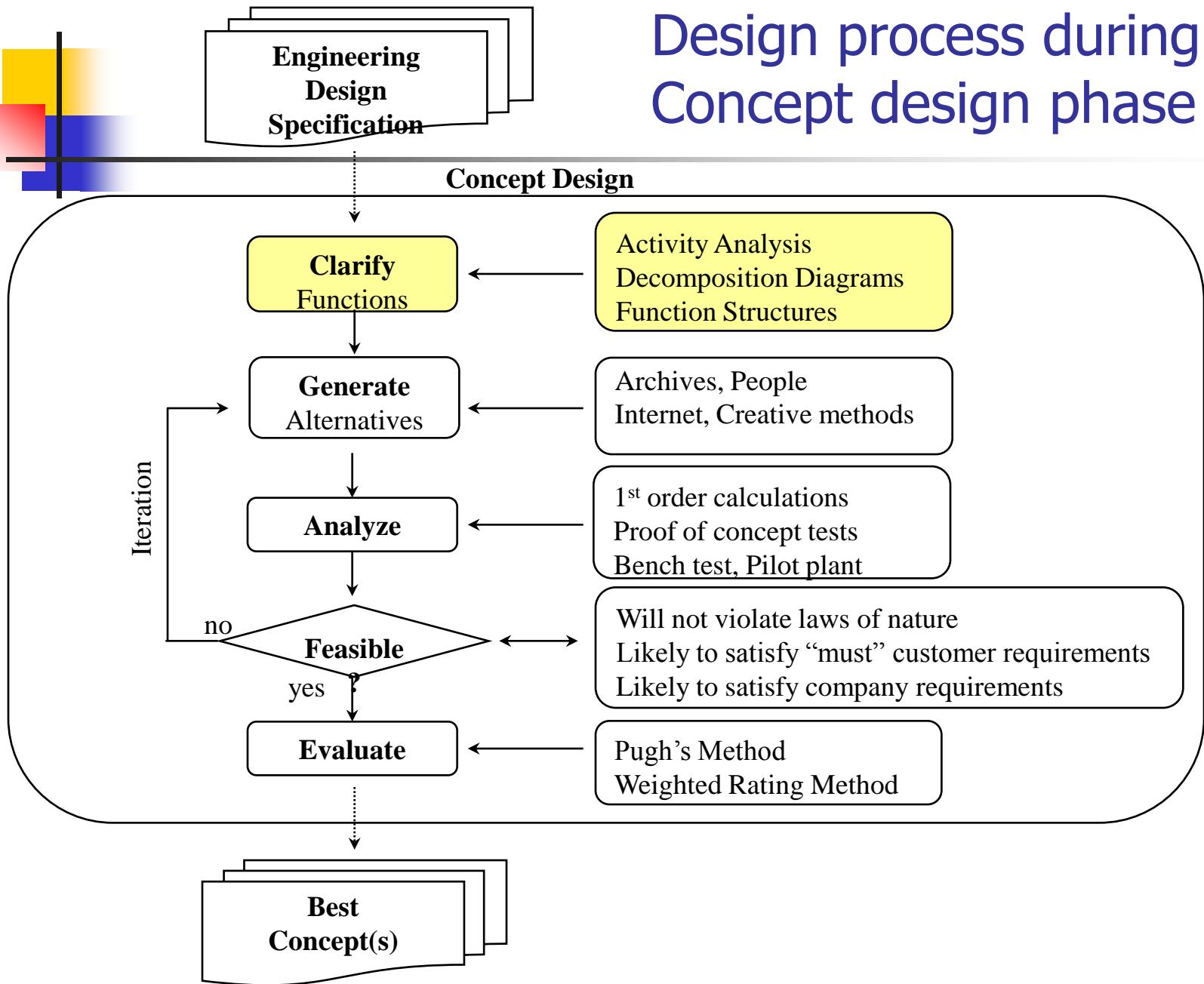




How do we proceed?

- Need lots of feasible design concepts (i.e. alternatives)
- Need to select the “best” one or two concepts
- Is there a process that we can follow?
- Can we use the overall design process to guide us through the concept design phase?

Design process during Concept design phase





Customer activities

Examine interaction between
customer and product

Use

set up
operate
maintain
repair

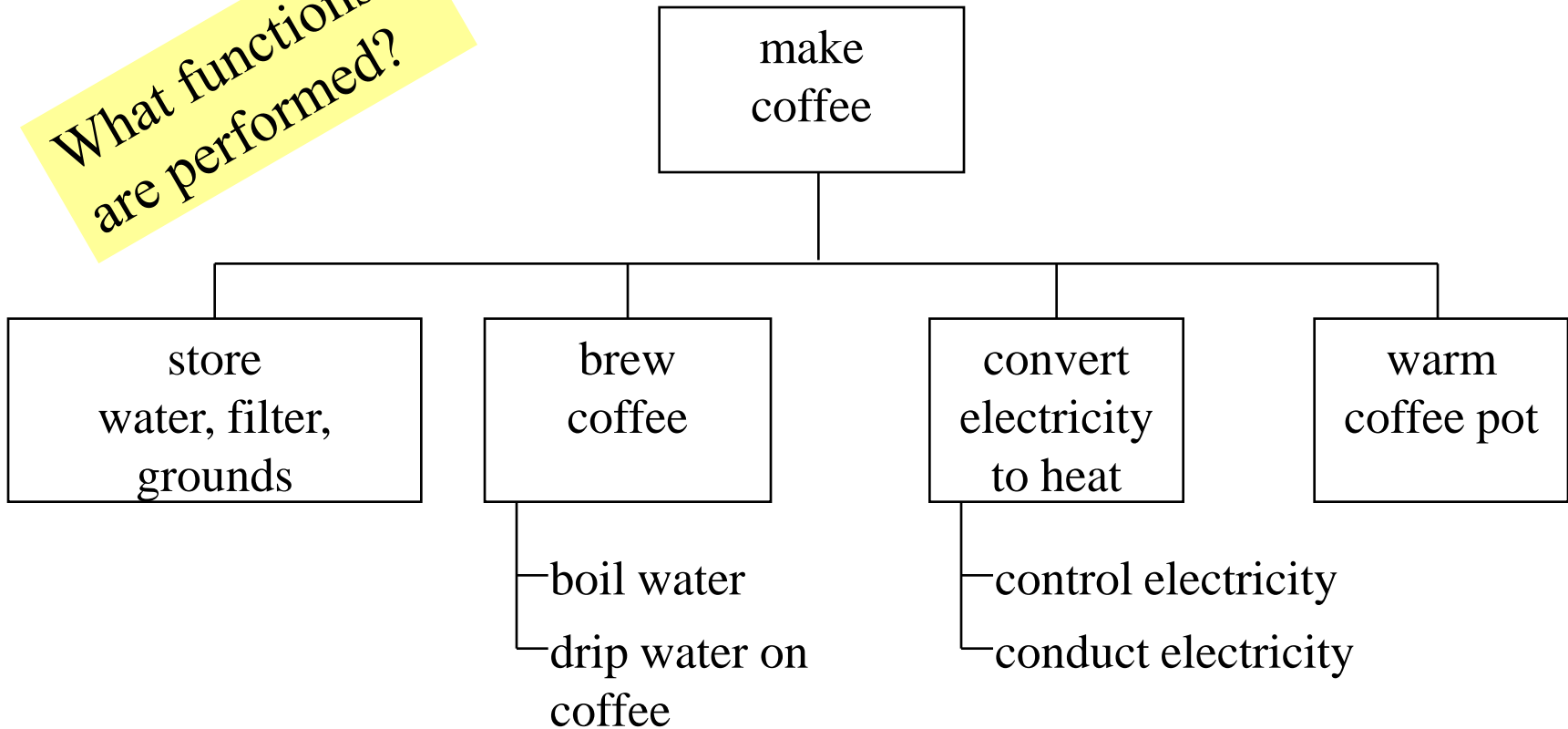
Retire

take down
disassemble
recycle
dispose

Clarifying functional requirements

Function decomposition diagram method

What functions are performed?



Remove? Combine? Reorganize?



Some functions that products/parts perform

amplify

change

channel

collect

conduct

control

convert

cool

decrease

dissipate

fasten

heat

hold

increase

join

lift

lower

move

protect

release

rotate

separate

store

supply

support

transform

translate



Why prepare function decomposition diagrams?

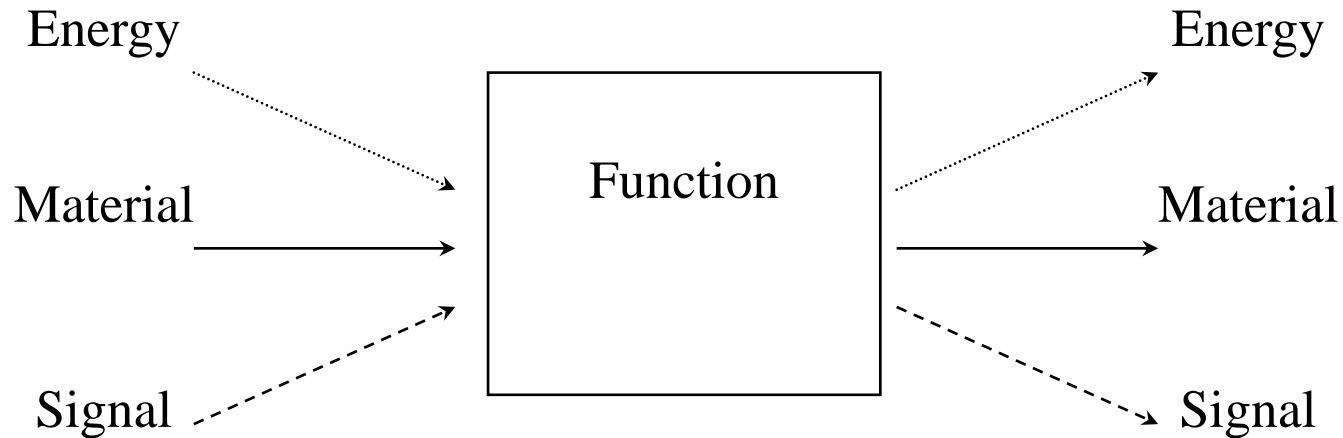
- To breakdown big functions into smaller basic subfunctions to improve our ability to “match” existing concepts to basic functions
- Fully understand customer requirements (use & retire)
- Disconnect function from form
- Identify system boundaries
- Increase the potential for new combinations



Function structure diagrams show all inputs and outputs

State 1

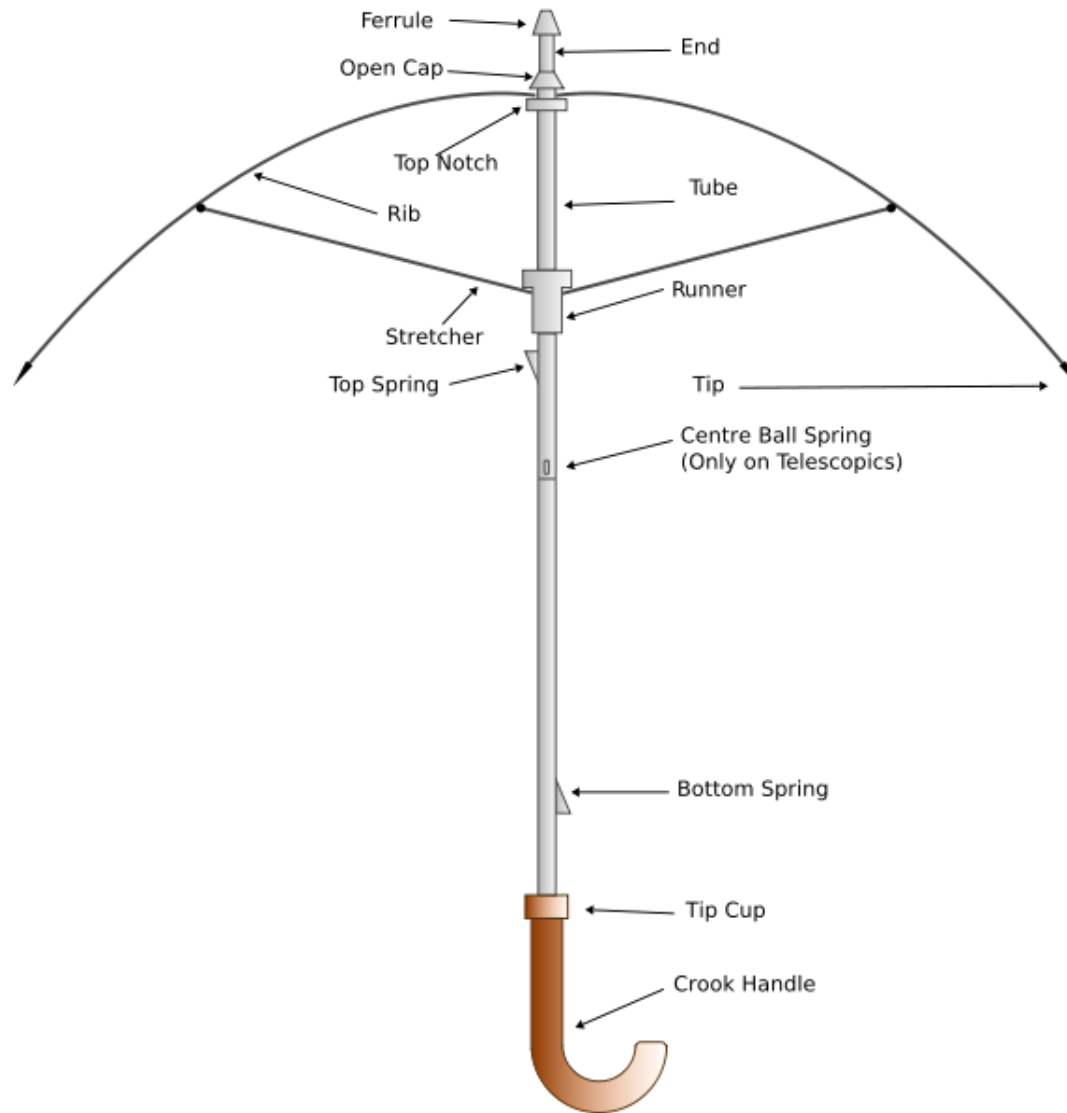
State 2



Example



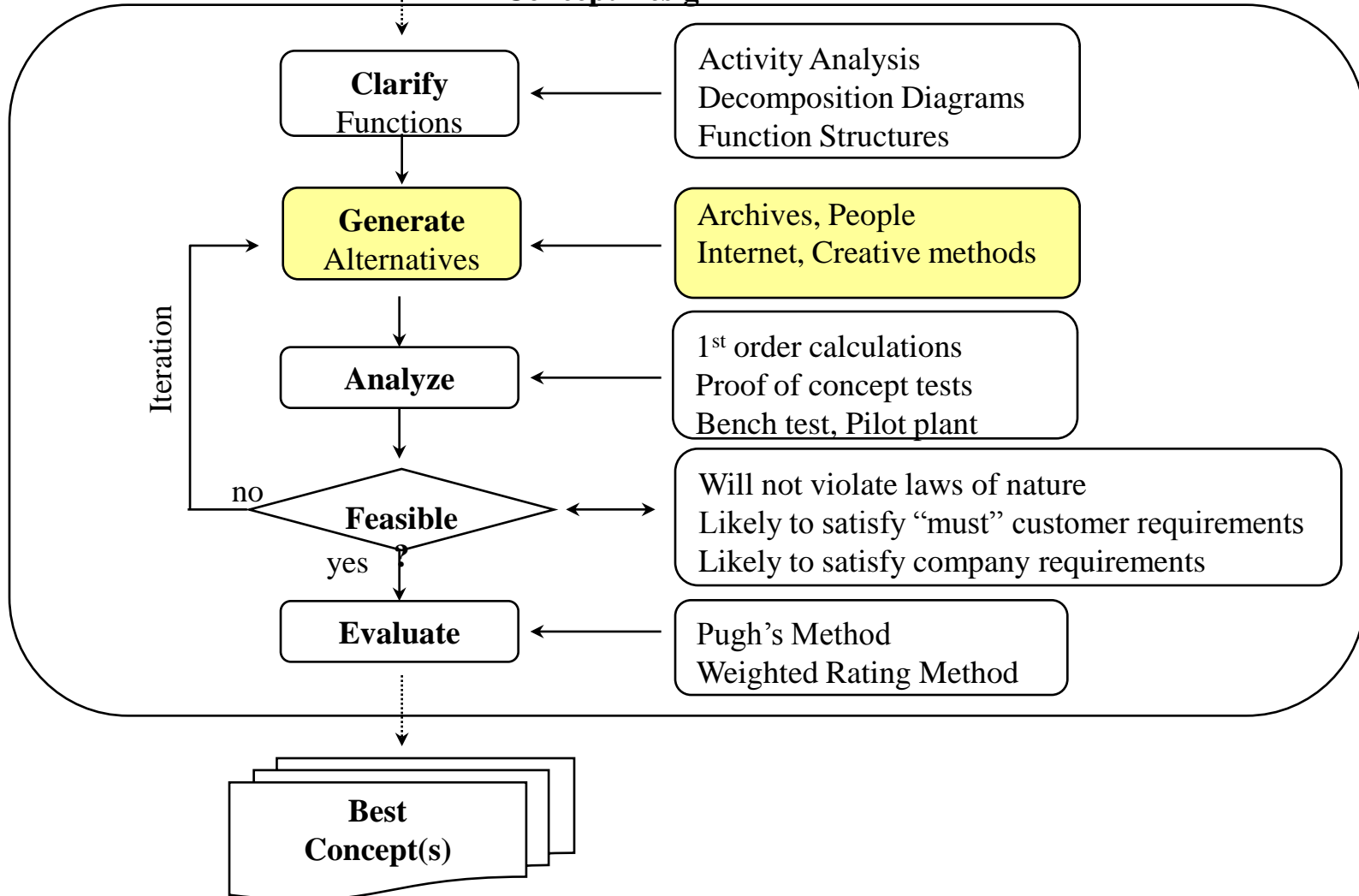
Example





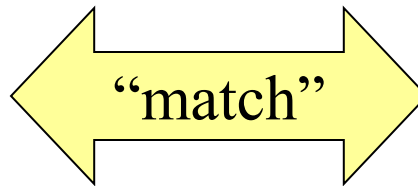
How do we do generate alternative concept designs?

Concept Design



Generating alternative concepts

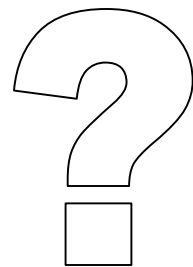
e.g. fasten papers



- a) flexible clamp, paperclip
- b) bent clamp, staple
- c) adhesion, glue

(Sub)Functional requirements

SF₁
SF₂



Concept

{C₁₁, C₁₂}
{C₂₁, C₂₂, C₂₃}

Generating = finding or creating “matches”



Finding or creating matches

Archives

libraries (university, public, corporate)

literature (handbooks, monographs, trade mag.s, journals, encyclop.)

People

coworkers, faculty, vendors, consultants

Internet

US Patent office, vendors, professional societies, etc

Existing products – similar or competitive products

dissection, reverse engineering

Creative methods

Brainstorming

Method 635

Synectics (analogies, fantasy, empathy, inversion)

Checklists (Osborn: substitute, combine, adapt, magnify, put to other use, eliminate, rearrange, and reverse).



“Developing” generated concepts

E.g. mini bike

		Alternative Concepts		
		1	2	3
Sub functions	Transmit	Chain	Belt	Gearbox
	Brake	Disc	Drum	
	Steer	Handlebar	Control stick	Fly-by- wire

Morphological matrices

Developing combinations of concepts into alternative product concept designs

		Alternative Concepts					
		1	2	3	...		n
Subfunctions	SF ₁	C ₁₁	C ₁₂	C ₁₃			C _{1n}
	SF ₂	C ₂₁	C ₂₂	C ₂₃			C _{2n}
	SF ₃	C ₃₁	C ₃₂	C ₃₃			C _{3n}
	...						
	SF _m	C _{m1}	C _{m2}	C _{m3}			C _{mn}

Alternative

Concept design

1

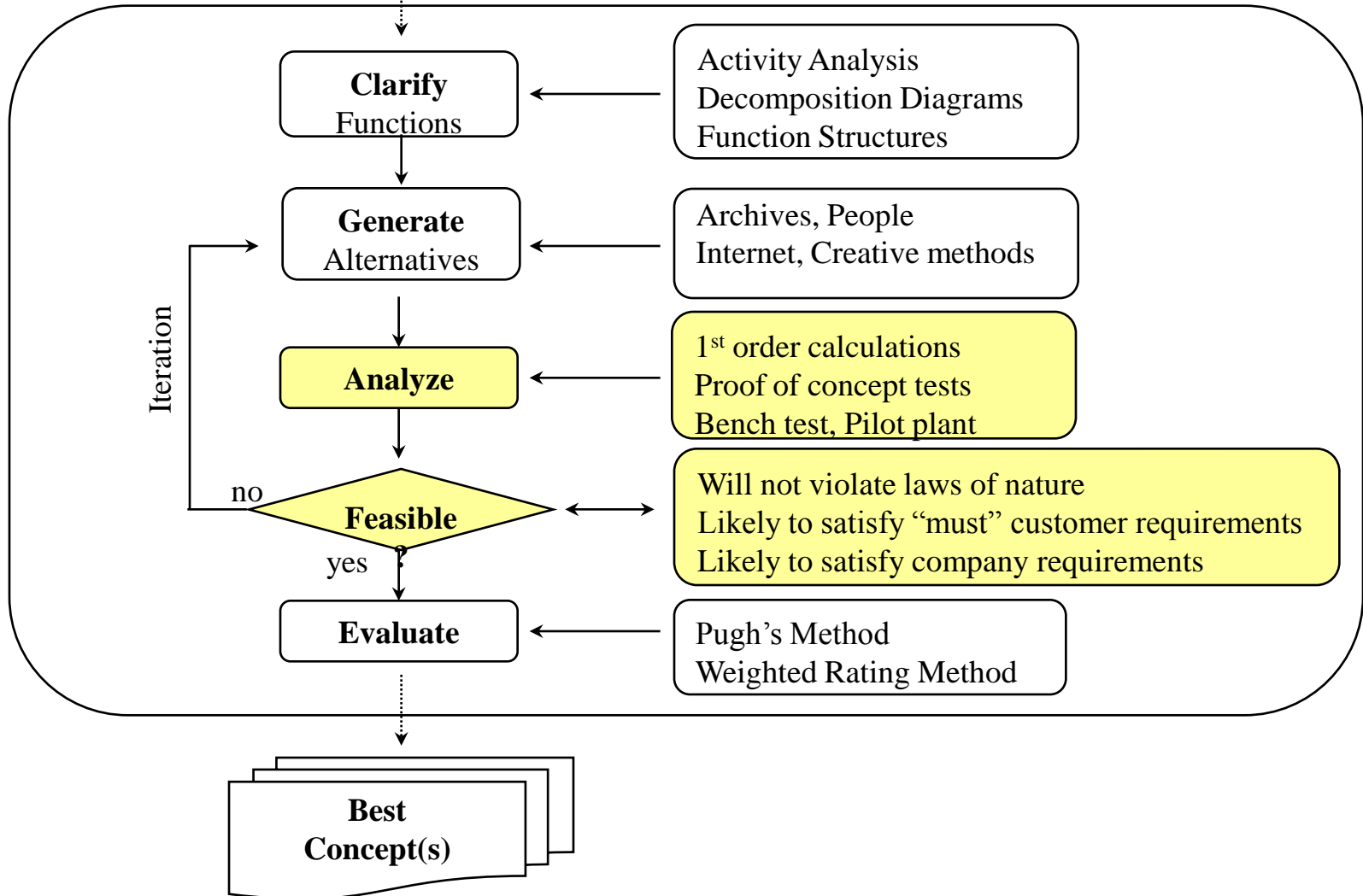
{C₁₁, C₂₂, C₃₁...C_{m2}}

2

{C₁₂, C₂₃, C₃₃ ...C_{m3}}

How do we do we "analyze" concepts?

Concept Design





Analyzing = “predicting” and “screening”)

(Roughly) *predict* / estimate each alternative’s performance

- 1st order calcs. (back of the envelope)
- Proof of concepts (physical principle “tests”)
- Bench top/pilot plant (subassembly/system tests)

Next step?



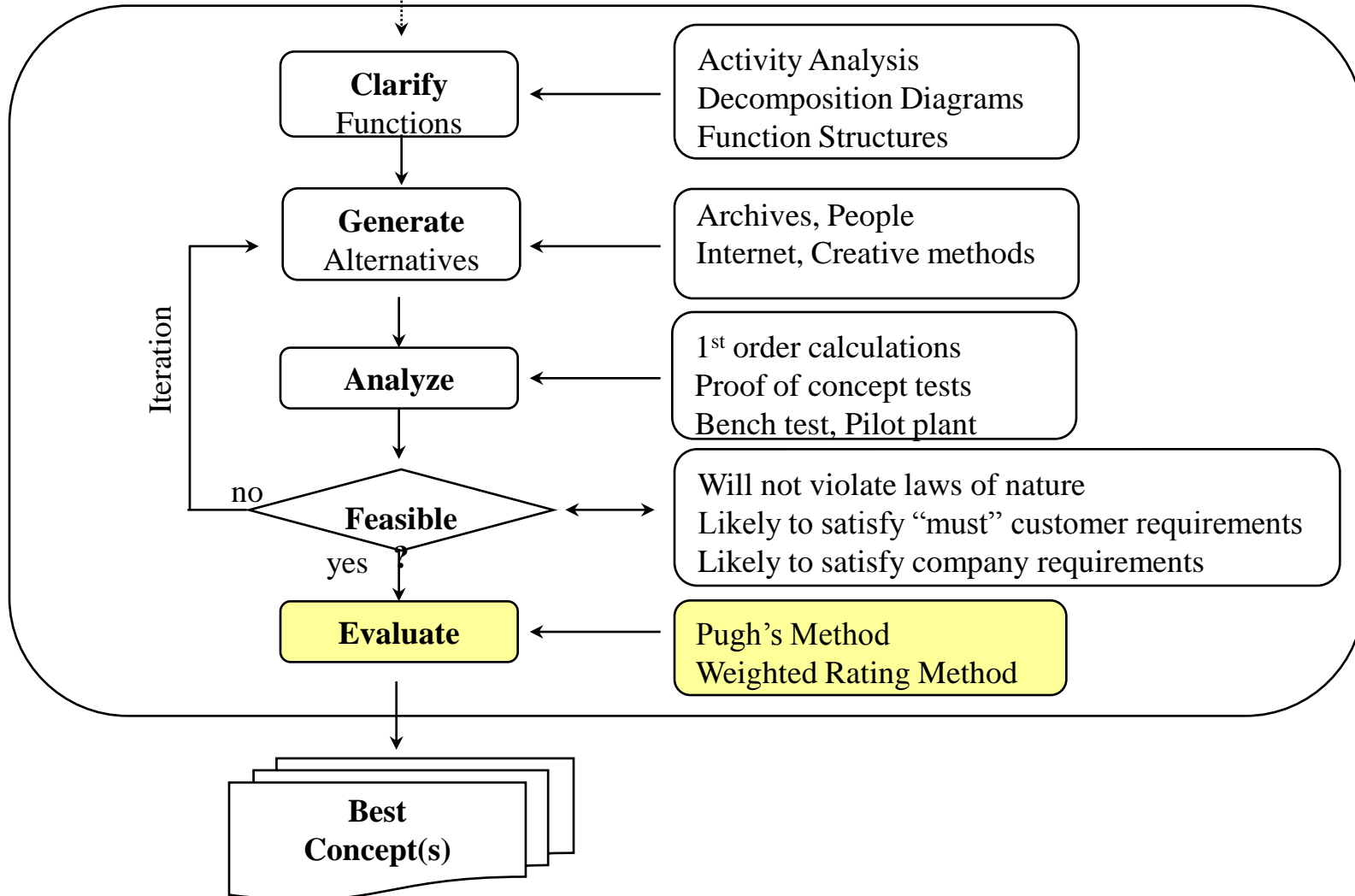
Screen alternatives for feasibility

- likely function (i.e. not violate laws of nature)?
- likely satisfy customer requirements?
- likely satisfy company requirements?

Evaluating

Engineering
Design
Specification

Concept Design



What does it mean to “evaluate” feasible concept designs?

feasible concept designs



However: e-“valu”-ate = values? whose?

Pugh's evaluation method

1. Select criteria,
2. Establish datum column,
3. Rate alternatives (+, -, S) against datum
4. Select best, or better alternatives

	Concept Alternatives		
Criteria	Gears	V-belts	Chain
high efficiency	+	D	+
high reliability	+	A	+
low maintenance	+	T	S
low cost	-	U	-
light weight	-	M	-
$\Sigma +$	3	NA	2
$\Sigma -$	2	NA	2
ΣS	0	NA	1

group discussion and decision

Modified Pugh's method

Add new column

Criteria	Importance Wt. (%)	Concept Alternatives		
		Gears	V-belts	Chain
high efficiency	30	+	D	+
high reliability	25	+	A	+
low maintenance	20	+	T	S
low cost	15	-	U	-
light weight	10	-	M	-
	100			
Σ_+		75	NA	55
Σ_-		25	NA	25
ΣS		0	NA	20

Weighted Rating evaluation method

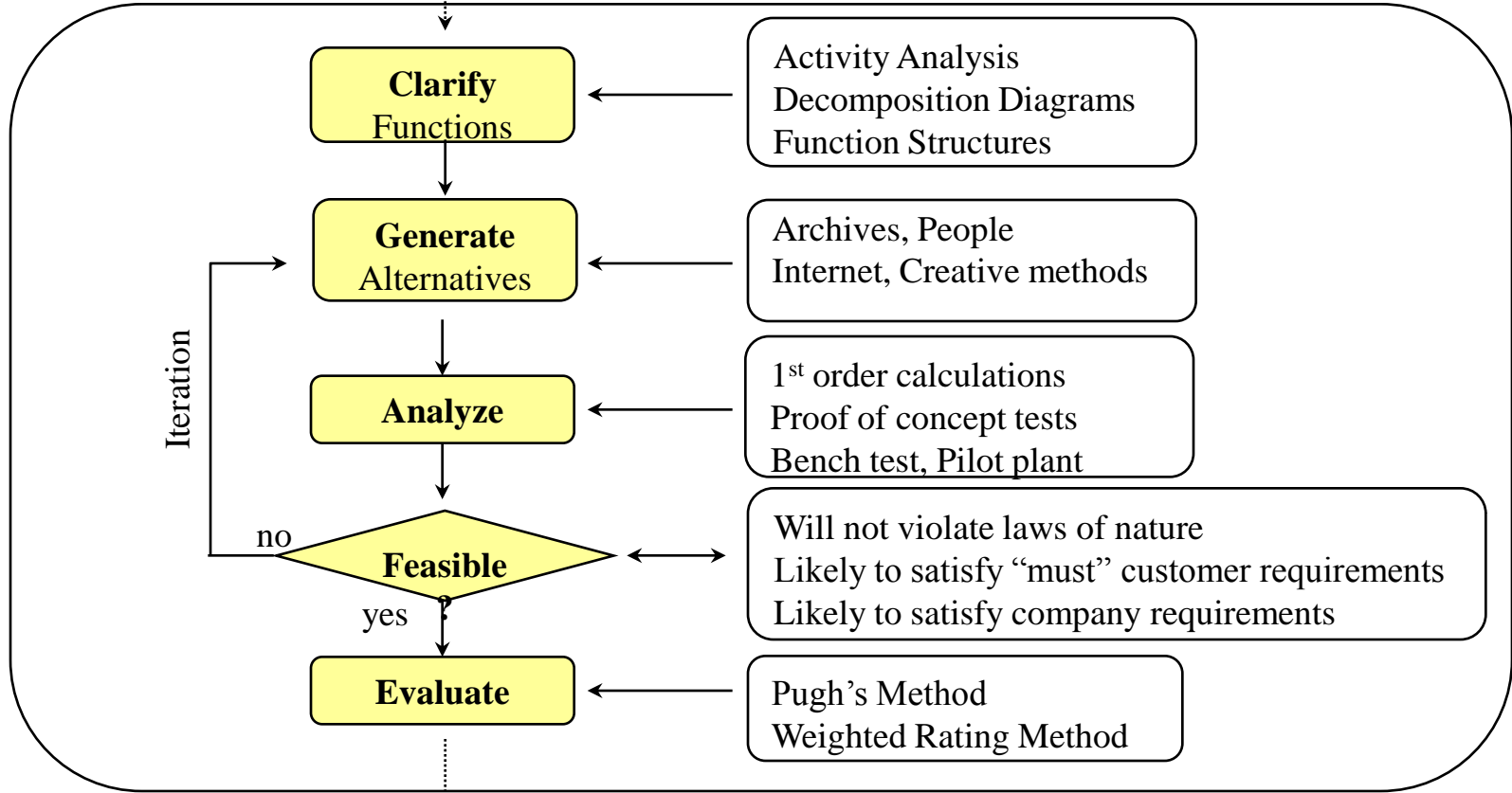
		Concept Alternatives					
		gears		v-belts		chain	
Criteria	Importance Weight (%)	Rating	Weighted Rating	Rating	Weighted Rating	Rating	Weighted Rating
high efficiency	30	4	1.20	2	0.60	3	0.90
high reliability	25	4	1.00	3	0.75	3	0.75
low maintenance	20	4	0.80	3	0.60	2	0.40
low cost	15	2	0.30	4	0.60	3	0.45
light weight	10	2	0.20	4	0.40	3	0.30
	100	NA	3.50	NA			

Rating	Value
Unsatisfactory	0
Just tolerable	1
Adequate	2
Good	3
Very Good	4



**Engineering
Design
Specification**

Concept Design

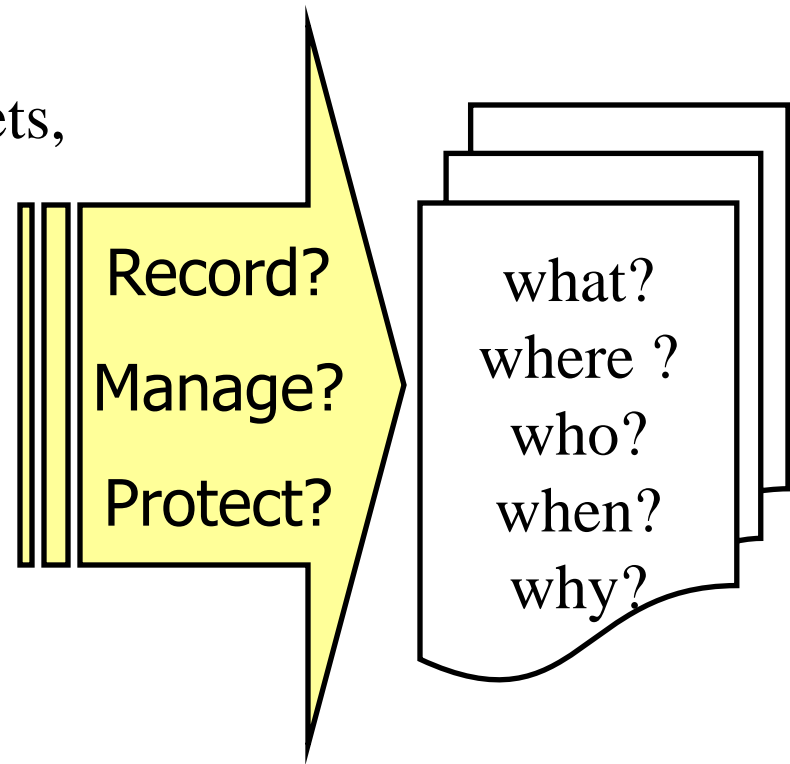


**Best
Concept(s)**



Information flow & storage

- photocopies of archival matter,
- printouts from the Internet,
- vendor catalogs and data sheets,
- preliminary test results,
- first-order calculations,
- patent abstracts,
- minutes of meetings,
- concept sketches,
- concept screening sheets
- concept evaluation matrices
- expert interview notes





Design information protection?

Is design “information” property?

Whose property is it?

Can it be protected?



Types of Property

Real property – land, buildings

Personal property

Tangible – trucks, machines, office equip.

Intangible -

contracts

copyrights

trademarks

patents

trade secrets

Can we protect each?