
MISSION

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Misson & Technical Clarification of Task

DO Include all team members, discussion, note taking.

INSTRUCTIONS Create a sentence to define your project. It should focus your design efforts and define goals. Clarify with the mission statement template.

KEYPOINTS Think of the mission statement as a calling card and banner stating the design team's intentions. It is used to explain what you will be doing and what your end goal is.

OUTCOME Mission, Product Description, Key Business or Humanitarian Business Goals, Primary Market, Secondary Market, Assumptions, Stakeholders, Avenues for Creative Design, Scope Limitations.

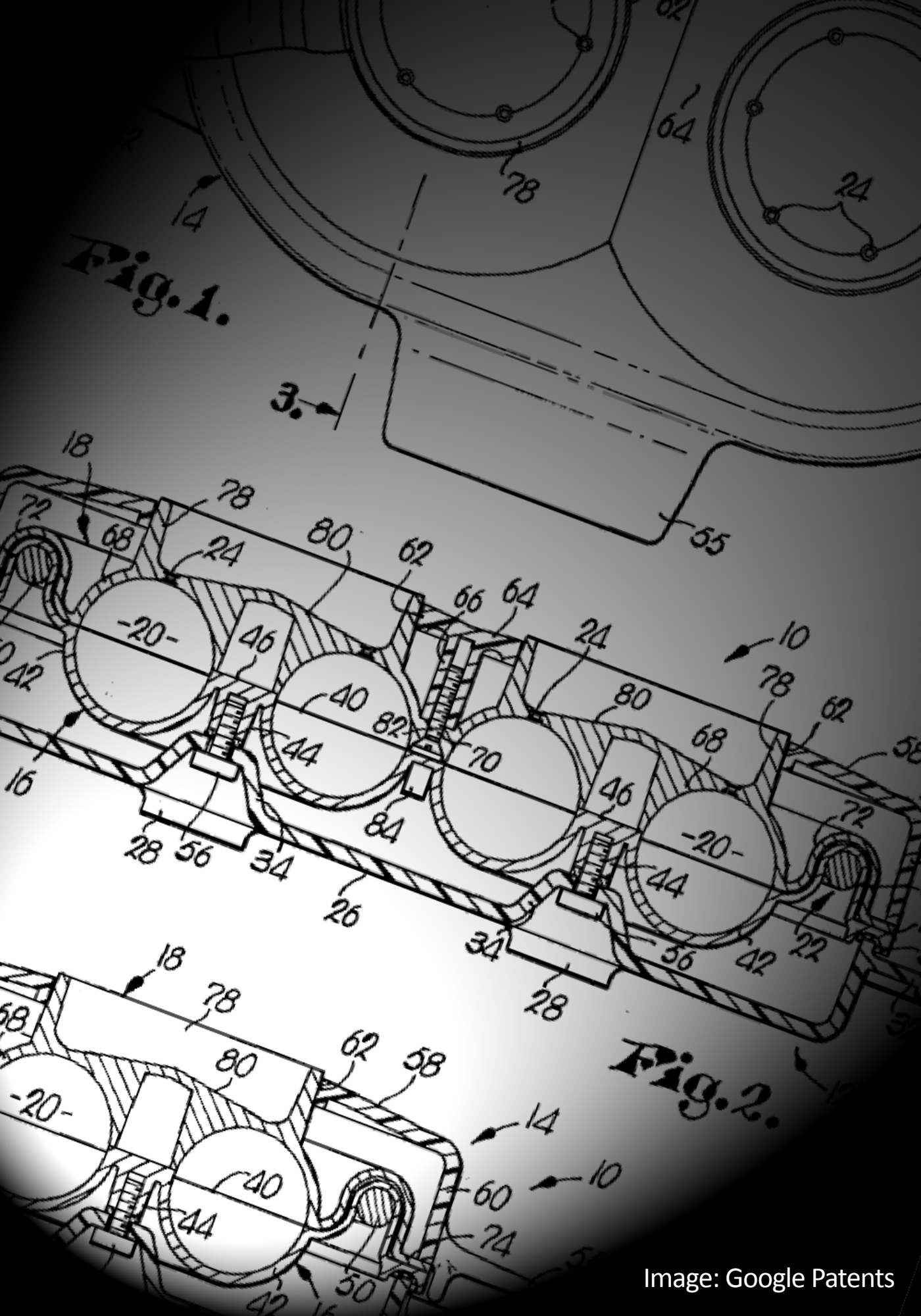

Image: Google Patents

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Background Research

DO Use multiple resources.

INSTRUCTIONS Search online for existing systems, patterns, and papers. Look at journals, periodicals, markets, etc. Also ask experts in the field about their knowledge.

SUGGESTIONS Document all your references, keep a list of things that may be important later.

OUTCOME Knowledge of the existing market in terms of patents, products, and companies.

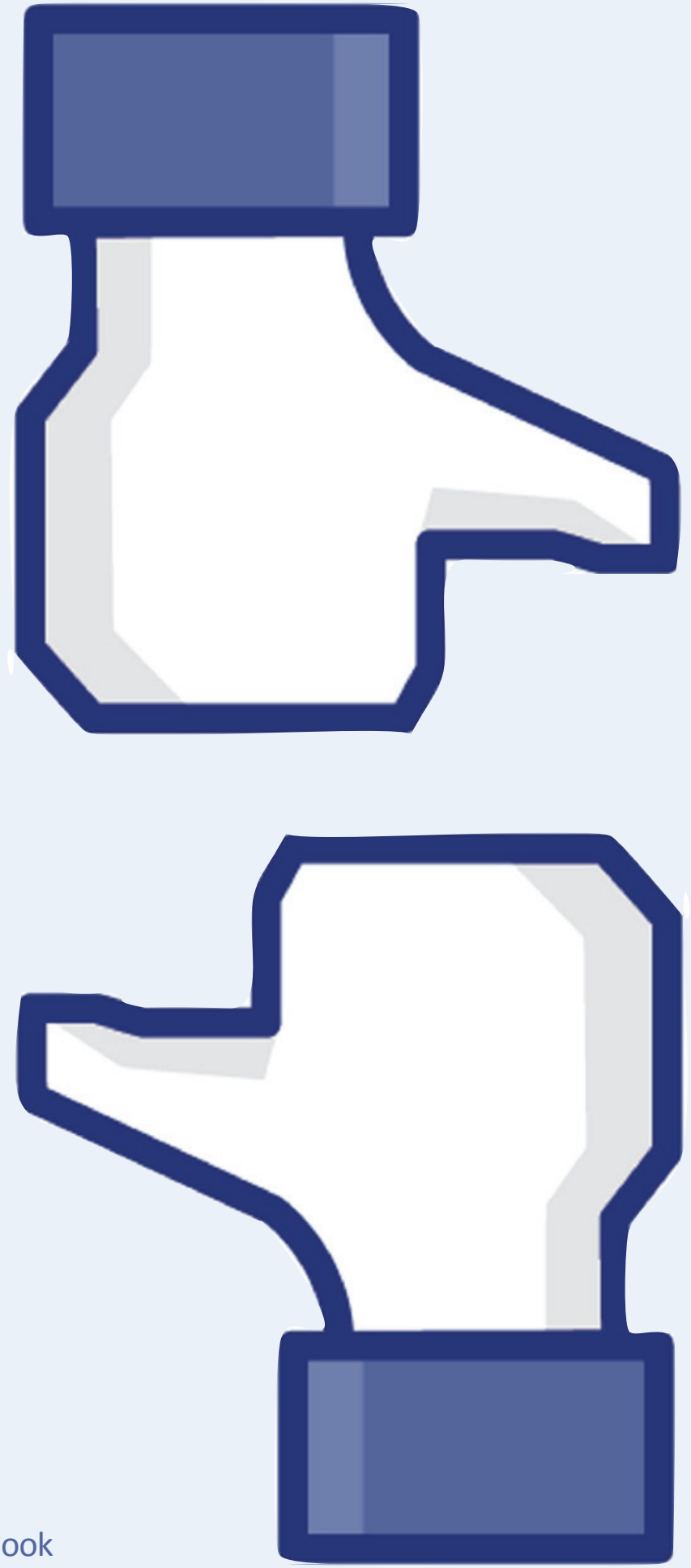

Image: Facebook

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Customer Needs Analysis (Like/Dislike)

DO Discuss with a single customer at a time, keep in the customer environment, and record with video or audio as appropriate.

COMPLEMENTS Questionnaires, Focus Groups, Contextual Needs Analysis, Empathic Lead User.

INSTRUCTIONS Interview customers by asking how they use the product. Ask what they like about a system and what they dislike. Also capture their typical uses. Be sure to follow with asking why to understand latent needs they may not express out loud.

SUGGESTIONS Go with the flow, use visual stimuli and props, suppress preconceived notions, have the customers demonstrate, be alert for surprises, watch for non verbal information. Select a sample that represents an unbiased group.

OUTCOME Chart of typical uses, likes, dislikes, and suggested improvement with columns of customer statement, interpreted need, and importance.

Mission Statement & Technical Clarification of Task

Contextual Method

What specific purpose will product be used for? How will the product b
How often will product be used? How long will product be used each ti
How much quantity of the product's performance is needed? How roug
produc e handl treated? How will product be transported & how m
Wh ype of surroundings will product be used? What is t
charac istics of the surroundings affect what the product must be like
What weather/climate will product be exposed to? Will product be expo
to any nusual sub ances or conditions? How much space is available f
using p uct? and where will product be stored? How much spac
available ng product? What do the product surroundings look li
How sho roduct interact w/ the surrounding aesthetics? How m
availab of ma enance & parts? What is the cost & availability of pos
energy sources (hu nan, battery, gas, electric, biomass)? How much nois
acceptab ere the product will be used? What are objects and substa
the pro ill in ract with? What are their characteristics? What phys
positic will e u be in (standing, sitting, hands occupied)? What qua
of perf mar e m t the product provide? How and where might the
product ? About how much time is the user willing to spend
setup this product? To operate this product? How valuable is saving tim
What is he most d ngerous product familiar to the user? Must this one
less da erous? W t product safety concerns does the user have?How
doe t the product to last? Who would purchase the proc
Where d how might they purchase it? How would the buying decisio
made (research, referral, impulse)? What specific features or qualities are
expecte cific purpose will product be used for? How will the
produc ow will you use the product? What is the primary rea
for usi this product? What are typical uses of the product? What types
foods w be sealed? How often will product be used?How long will pro
be use How much quantity of the product's performance is
needed How big is your pet that needs feeding? How many pets? How
area do you vacuum? How many and what size of rooms will be cleaned
How ro roduct be handled/treated? On a scale of 1-10, how
durabl o you n d this product to be? How will product be transporte
how m ch?What a objects and substances the product will interact w
What a their ch cteristics?What types of foods will be sealed? How t
a mixtur u stir? What floor types would you use it on? Would y
use it on we dry floors? What size pizza would you cook? What are
picking p with th hand vacuum? What will be cleaned?What physical
positic will the u be in (standing, sitting, hands occupied)? When us
the Du uster in v areas, what posture will you use? (bending over, a
squatti a chair) What quality of performance must the proc
provide? have two hands free? One hand? How would you rate
hand vac's ability to vacuum/pick up debris?How and where might the
product be cleaned? Are the pitches realistic? How would you clean the

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Customer Needs Analysis (Contextual)

DO Discuss with a single customer at a time, keep in the customer environment, record with video or audio as appropriate.

COMPLEMENTS Like/ Dislike Method, Focus Groups, Questionnaires, Empathic Lead User.

INSTRUCTIONS Use the Contextual Needs Analysis Questions while interviewing customers to understand needs more specific to their environment. Tailor contextual needs analysis questions to the problem.

SUGGESTIONS Ask questions neutrally/ don't bias questions, ask why and how along the way.

OUTCOME Create a list of key needs that were found in the interview.

Like/ Dislike Method

Empathic Method

A suit named AGNES, an acronym for the Age Gain Now Empathy System, is designed to help young engineers understand the physical limitations of older people.

EARPLUGS:
Reduce hearing.

NECK COLLAR:
Limits joint mobility and selection and extension of the spine.

WRIST GUARDS:
Reduce the flexion and extension of the wrists.

GLOVES:
A double layer of rubber gloves to reduce the tactile sensation through the fingers and restrict the movement of the hand.

BRACES:
Placed at the knees and elbows to compress the musculature, tighten the joint, restrict movement, and induce fatigue.

THE HELMET:
An anchor point for the bungee points that attach to the hip.

GOGGLES:
Mimic the natural yellowing of the eye lenses.

BUNGEE CORDS:
Run from helmet to hip, restricting movement. The tension they create makes spinal extension difficult, meant to mimic curvature of the spine. They also help to reduce the rotation of the spine.

BELT:
Used to anchor the bungee cords and elastic band from hip to wrist.

ELASTIC BAND:
Runs from hip to wrist to reduce shoulder mobility and cause fatigue.

SHOES:
These are civilian shoes for use in public, but in the lab, foam-padded shoes are used to throw off the subject's balance.

SOURCE: Rozanne Puleo, research fellow and suit creator, MIT AgeLab.

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Customer Needs Analysis (Empathic)

DO Discuss with a single customer at a time, keep in the customer environment, record with video or audio as appropriate.

COMPLIMENTS Like/ Dislike Method, Focus Groups, Contextual Needs Analysis, Questionnaire.

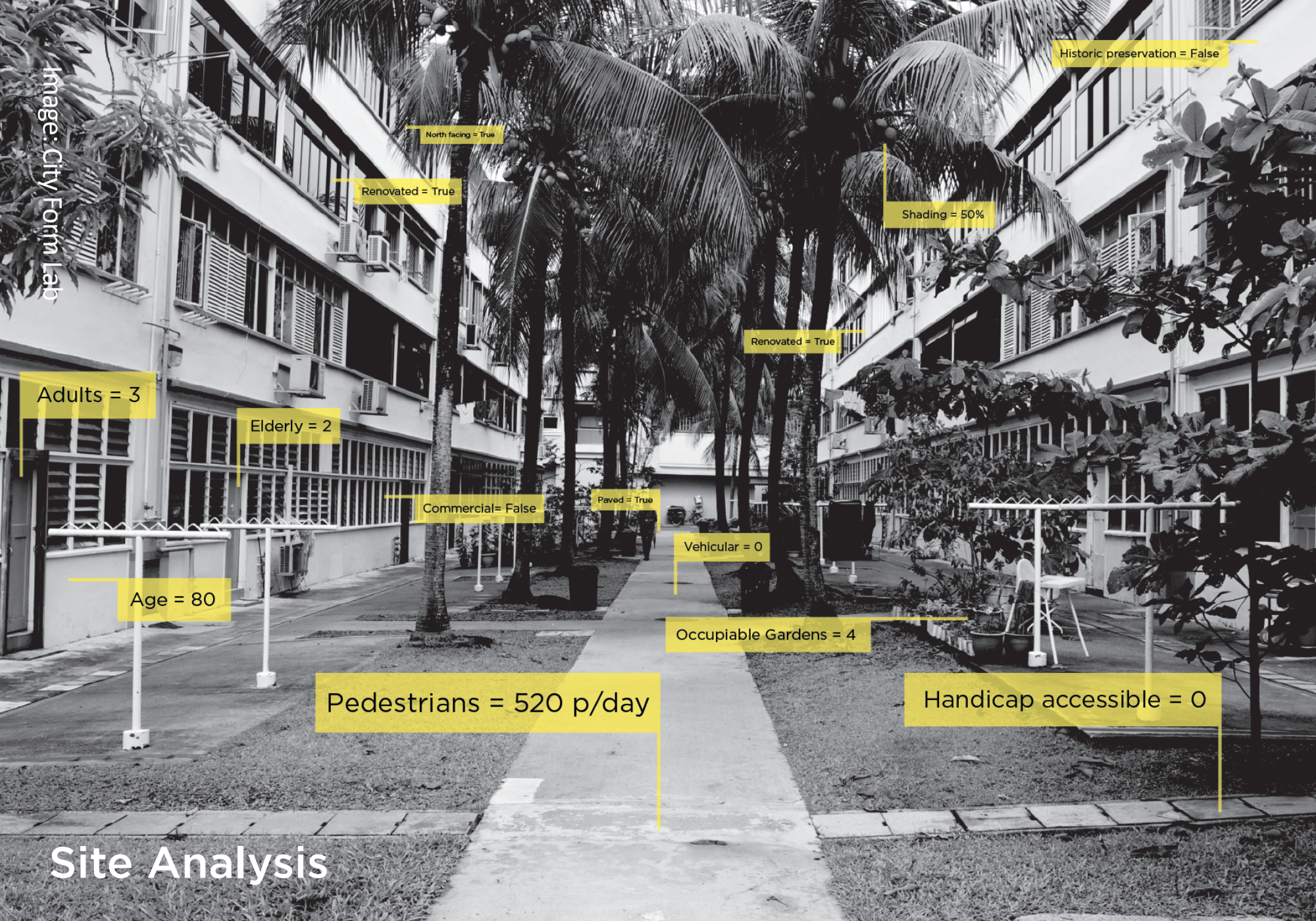
INSTRUCTIONS Create an environment or user experience that makes the system more difficult for the customer to use it and observe their actions and needs. Make their environment less kind to their sense of touch, vision, smell, etc. (i.e. Oven mitts on hands, Sunglasses indoors, very hot or cold, etc.).

SUGGESTIONS By having the customer work in a more extreme environment, issues with the system will stand out. Keep your customer in a reasonable environment, but think about things they may be dealing with. Select a sample that represents an unbiased group.

OUTCOME Create a list of key needs that were found in the observation.

Contextual Method

Site Analysis



Site Analysis

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Site Analysis

DO Collect existing plans and drawings, Observe, Sketch, Talk to stakeholders, Diagram, Photograph.

INSTRUCTIONS Site analysis allows a designer to detect important spatial, functional and cultural features of the site that will accommodate a proposed design project. Familiarize yourself with the site in person, sketch and draw it, observe how it is used and interview a representative sample of its users.

KEYPOINTS Keeping your project brief in mind, concentrate your site analysis into a few key drawings - a plan or section of its physical features; a diagram of key movement flows that explain its typical use patterns; and produce annotated diagrams of the sensual (e.g. Material) and cultural (e.g. Meaning) references of the site, as they relate to your task at hand.

OUTCOME Sketches, a site plan, a movement flow diagram, annotations of specific qualities and references that stand out to you.

Empathic Method

Affinity Diagram

Image: Wordpress

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Affinity Diagram

DO Cluster similar needs together to find categories.

INSTRUCTIONS To group the needs, each interpreted need, with associated customer identification, is copied onto a sticky note. The next customer need is compared with the first. If it is different, a new column is constructed on the board. If the statement is essentially the same need, the note is grouped with the similar statement.

SUGGESTIONS Interpret customer needs to your own language so they are easier to affinitize. More important categories will have more sticky notes.

OUTCOME Understand key customer desires, demands and their importance.


Excellent
Very good
Good
Average
Poor

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Customer Needs Analysis (Questionnaires)

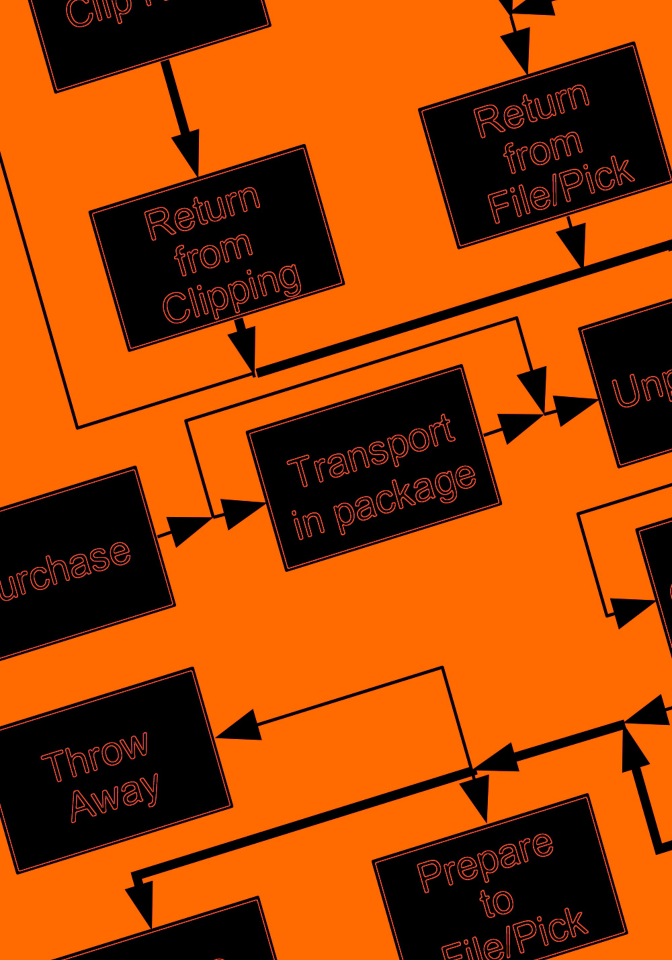
DO Discuss with a single customer at a time, keep in the customer environment, record with video or audio as appropriate.

COMPLEMENTS Like/ Dislike Method, Focus Groups, Contextual Needs Analysis, Empathic Lead User.

INSTRUCTIONS Have the team develop a list of criteria that is relevant to the customer's concerns. The questionnaire ranks the system on these criteria or forms a list of questions and then organizes the responses provided.

SUGGESTIONS Keep questionnaires short, unbiased towards certain outcomes, and easy for the customer to complete. Select a sample that represents an unbiased group.

OUTCOME Quantifiable and/or Qualifiable results.


Return from Clipping
Return from File/Pick
Transport in package
Throw Away
Prepare to File/Pick

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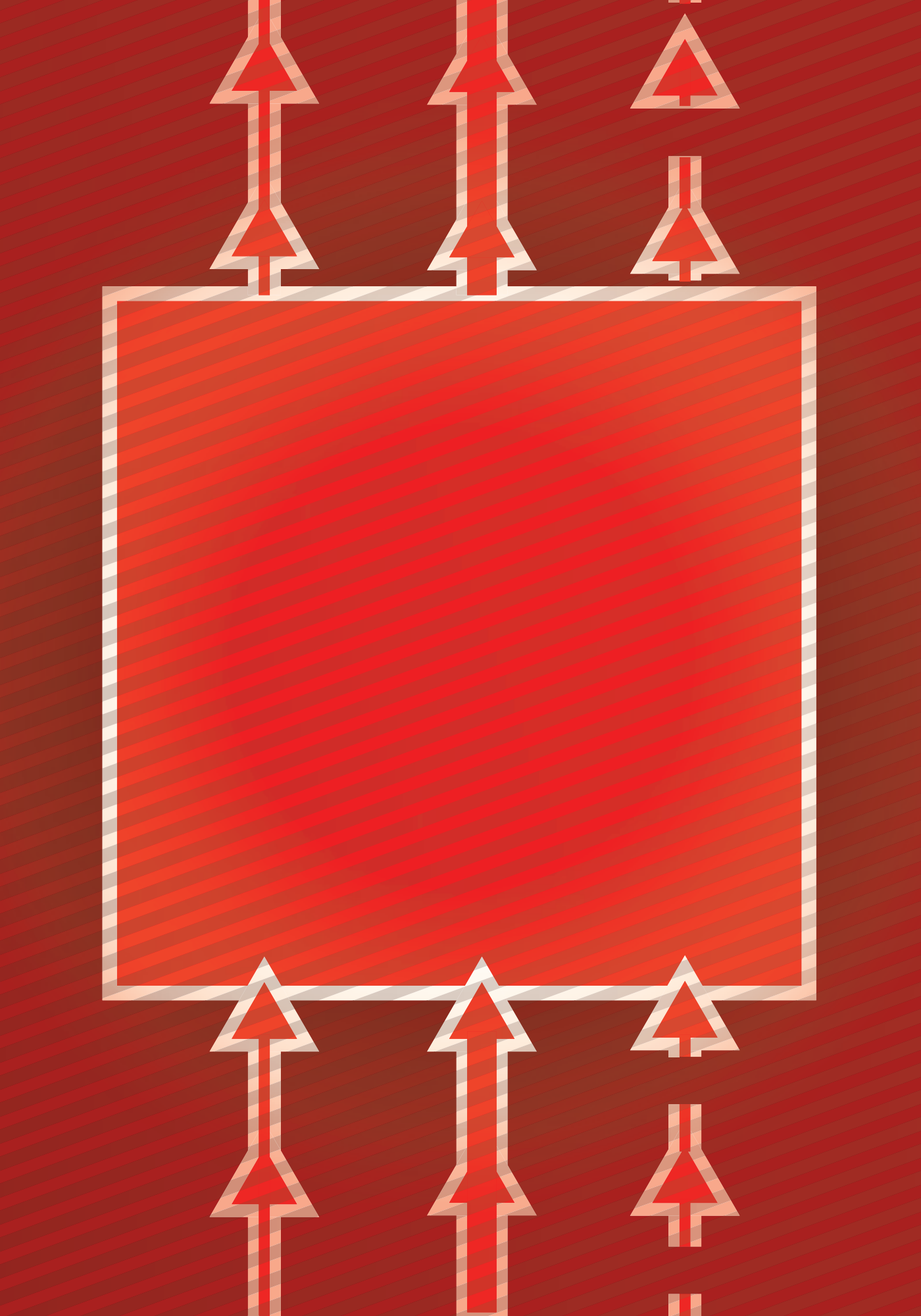
Activity Diagrams

DO Represent process(es) from a user function perspective.

INSTRUCTIONS Draw a box for each activity that a customer may engage, centered around using the system. Draw arrows to show direction of activities. Arrows may loop or cross to represent the use properly. It is important to capture parallel and sequential (causal) activities.

SUGGESTIONS The more details shown in the diagram, the more insight it can bring. Creating alternative activity diagrams for a system can lead to varied insights.

OUTCOME Helps us understand typical use of the system and can help us see areas to innovate. For example, adding, removing, targeting, moving, creating parallel structure, and developing ideas for activities.



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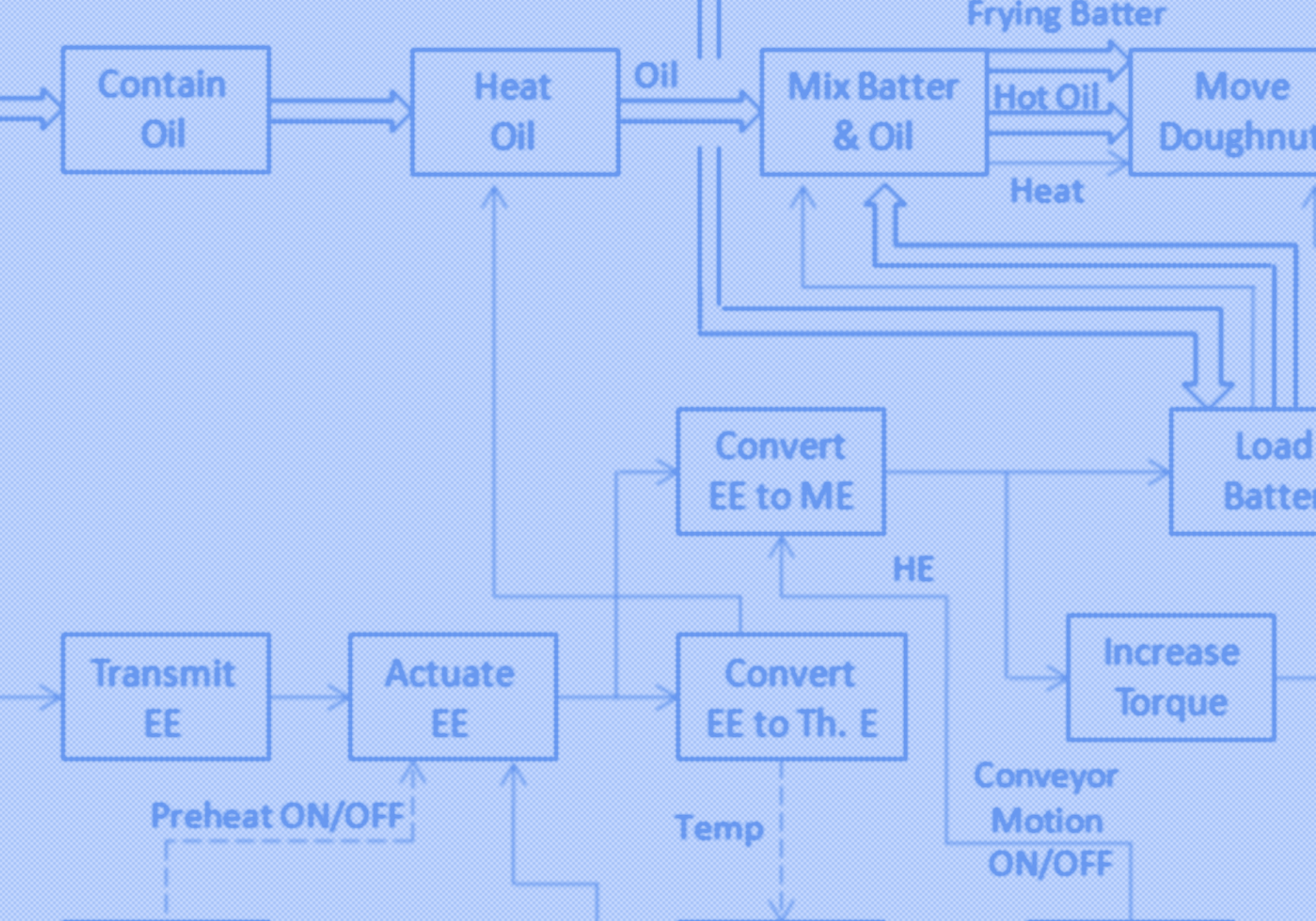
Black Box Modeling

DO Model your design as a system with inputs and outputs.

INSTRUCTIONS Draw a box with arrows entering and leaving it to represent the inputs and outputs of the functional system.

REMINDERS Use a thin line to represent energy, a thick line to represent materials, and a dotted line to represent information.

OUTCOME Initiates a technical understanding of a system based on its inputs and outputs, known as material, energy, and signal flows. Provides insights for innovations at the input/output level of the technical system.


Frying Batter
Contain Oil
Heat Oil
Oil
Mix Batter & Oil
Hot Oil
Move Doughnut
Heat
Convert EE to ME
Load Batter
HE
Transmit EE
Actuate EE
Convert EE to Th. E
Increase Torque
Conveyor Motion ON/OFF
Preheat ON/OFF
Temp

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Functional Analysis

DO Understand the technical aspects and innovation opportunities of your system.

INSTRUCTIONS All systems do something. Use action verbs that operate on energy, material, and information flows, to represent the atomic function flows of the system. Separate each input flow and follow the functional technical process with boxes and arrows to the outputs.

KEYPOINTS The more detailed the process is shown, the more insight it can bring. Use a thin line to represent energy, a thick line to represent materials, and a dotted line to represent information.

OUTCOME Helps us understand and brings insight to the basics of the system and can help us identify areas for innovation, such as focusing on the most critical functions, moving functions, removing functions, adding functions, and combining functions.

Black Box Modeling

QFD

Customer Requirement	Level of Importance	Gear Teeth	Torque Output from Gear Speed	Storage Volume	Number of Parts	Time Hopper Releases Dough	Consistency of Dough	Material of Parts	Hopper Volume	Oil Temperature	Color of Light Indicator	Motor Output	Color Scheme	Time to Reach Desired Oil Temp	Generic Fryer	Krispy Kreme	Dough-Nu-Matic
e works correctly	5	△				●	O			●					5	5	[illegible]
hine operates quickly	5	●	●			O						●		●	5	5	
ear instructions	1										△				5		
Machine operates safely	4		△							●		△			3		
Minimal vibration	3				△			O				●					
See doughnut-making process occu	3				△			●									
Produces more than just doughnuts	4					△	△										
Low overall cost of operation	3				●			●				●					
Large batter capacity	1			O					●								
Durable/High quality	4	O						●				●					
Low cleaning time	4					●	△		△								
assembled and stored	4			●	●			O	O								
	1																
								●									
								3	3								

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Quality Function Deployment

DO Develop metrics for customer needs.

INSTRUCTIONS The design team should understand their customer voice. Use this template to fill in customer and functional requirements to see how they relate to each other. Place customer requirements in the right column with their importance next to it. Customer targets and ratings are entered in the last column. Functional requirements are placed at the top of the matrix and targets are placed at the bottom. Relationships are shown in the large center matrix while correlations are shown in the top pyramid.

OUTCOME Understand which customer needs and dependencies are the important and tangible targets and where the challenges lie. Find weakly satisfied customer needs, their dependencies and relationships, and determine what product changes can effectively improve these weak points.

ME 366J Class Notes	Specification *for* Milling-Pin Fixture	Page: 1 of 3

Changes (Dates)	D W	Requirements	Resp.	Verification
		Function Requirements		
	D	Clamp Pin(s) for Milling		Test beta prototype with actual pins and UF 30 milling machine: load test set of 30 pins (normal dist.), measure slot, pin dims., and finish
	D	Mount Rigidly to Machine Table		
	D	Position Pin(s) Accurately		
	D	Resist Mechanical and Thermal Loads		
	W	Feed (Translate) Pin(s) into Cutter		
		1. Geometry		
	D	Pin dimensions (form and sizes): Refer to Figure 1		Given: NTR (no test required)
	D	Milling machine T-slots: Refer to UF 30 Mill Users Manual [ref.]		Given: NTR
	D	Table feed motions: 500 x 200 mm; spindle height: 300 mm		Measure usable range with ruler.
	D	Slotting cutter: width 6 mm, diameter 80-100 mm		Given: NTR
	D	Maximum fixture volume: 450 mm (feed length), 150 mm (axial width), 200 mm (height)		Calculate volume: bounding box.
	D	Minimize volume of device for storage.		Calculate volume by bounding box
	D	Align pin(s) within 0.05 mm axially and vertically. Feed alignment is not critical.		Measure with dial gauge on prototype
	W	Arrangement of workpieces: in-line or parallel within 150 mm cutter width adjustment		Calculate width: summation of components
		2. Kinematics		
	D	Vibration: approximately 600 N feed and 1000 N vertical load magnitudes; cutter teeth velocity at 500-1000 rpm; max. deflection: 0.05 mm		Lumped model: predict deflections
	D	Feed rate: 6-10 mm/s		Given: NTR
	W	No. of passes: 1		Mfg. process model or test case with load cells
		3. Forces		
	D	Pin mass: x [g] (TBD)		Given: NTR
	D	Milling forces (static): approximately 1000 N vertical, 600 N horizontal; resist loads in terms of strength (MPa) and deflections (0.05 mm).		Model with shear, isotropic assump.
	D W	Maximum Fixture weight: 90 N 40 N		Calc. lumped mass of comps. & sum
	D	Clamping force (two-side friction only): approx. 4000 N		Calculate mech. adv.; measure device w/load cells
	D	4. Energy		
	D	Mill power: 115 V @ 60 Hz		Given: NTR
		No external power source for fixturing		Given: NTR

• UNDERSTAND

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Specification Sheets

DO Understand customer and technical needs.

INSTRUCTIONS Define specifications for the system in terms of functional requirements, geometry, kinematics, forces, material, signals, safety, ergonomics, production control, quality, assembly, transport, operations, maintenance, cost, and schedules. Enter the create date for each specification. When specifications are changed the date is changed accordingly. Enter a demand or wish for the type of specification. Assign a responsibility for each specification. Provide a meaningful verification approach for each specification. An example verifications include checking drawings, performing calculations, running simulations, testing prototypes, or performing experimentation, or performing user studies.

SUGGESTIONS Support customer needs with engineering requirements.

OUTCOME Understand key system requirements to design within the phases that follow.

Quality Function Deployment

Brainstorming

Image: designshares.com

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Brainstorming

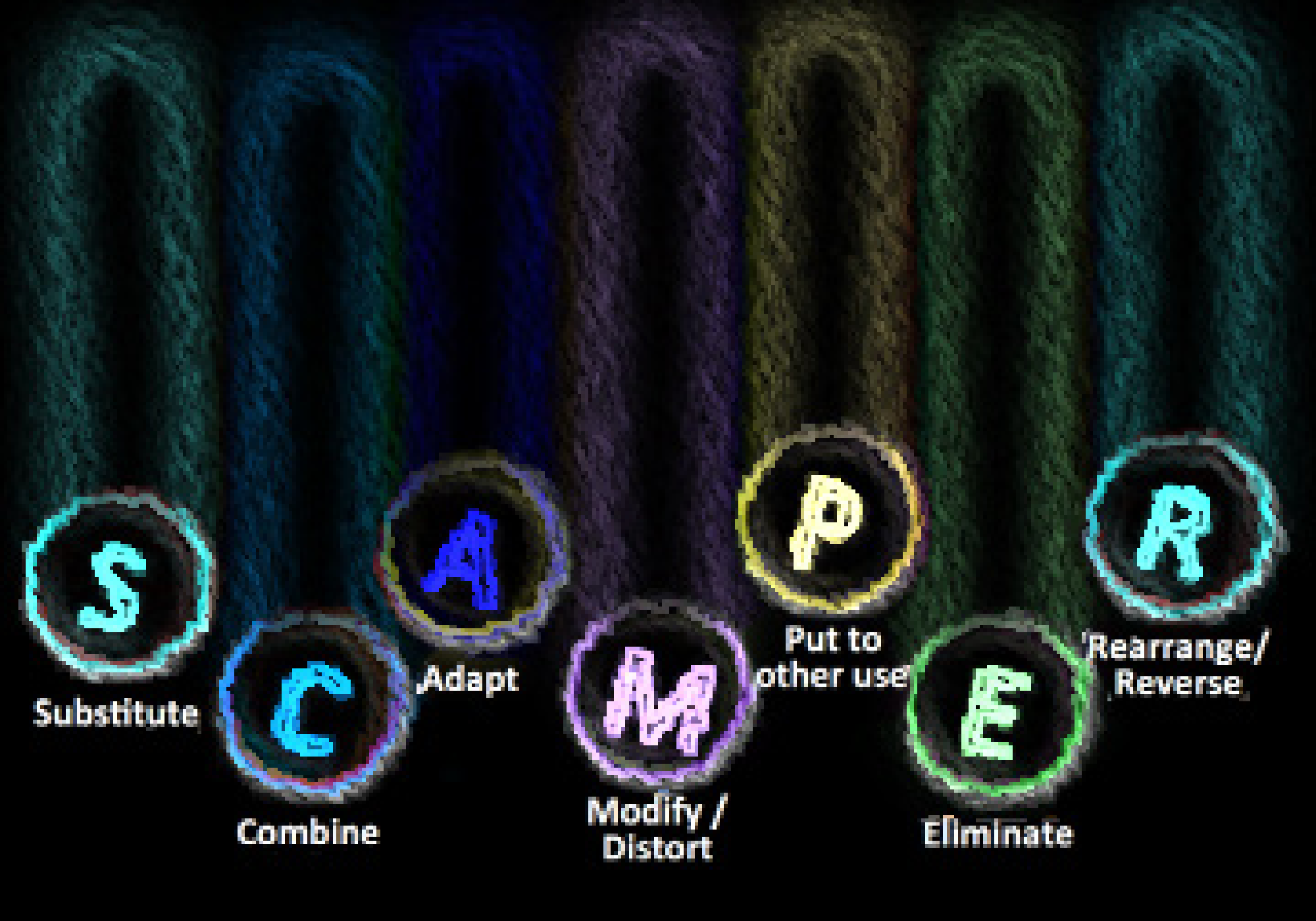
DO Keep an open mind and build upon others' ideas.

COMPLIMENTS Brainwriting, Lateral Thinking, Six Hats.

INSTRUCTIONS Verbally generate as many ideas as possible; Delay evaluation and judgement; Encourage crazy and unusual ideas; Pay close attention to others' ideas, combine and develop alternatives.

SUGGESTIONS Alternate individual and team brainstorming sessions.

OUTCOME 10's to 100's of ideas that span the design space. Document the process and keep record of lists of ideas and decisions made.


S
Substitute
C
Combine
A
Adapt
M
Modify / Distort
P
Put to other use
E
Eliminate
R
Rearrange/ Reverse

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SCAMPER

DO Use directed questions to come up with new ideas.

COMPLIMENTS Brainwriting, Lateral Thinking, Six Hats.

INSTRUCTIONS Ask yourself the SCAMPER questions. Example questions include:

Substitute: What materials or resources can you substitute or swap to improve the product?

Combine: What would happen if you combined this product with another, to create something new?

Adapt: How could you adapt or readjust this product to serve another purpose or use?

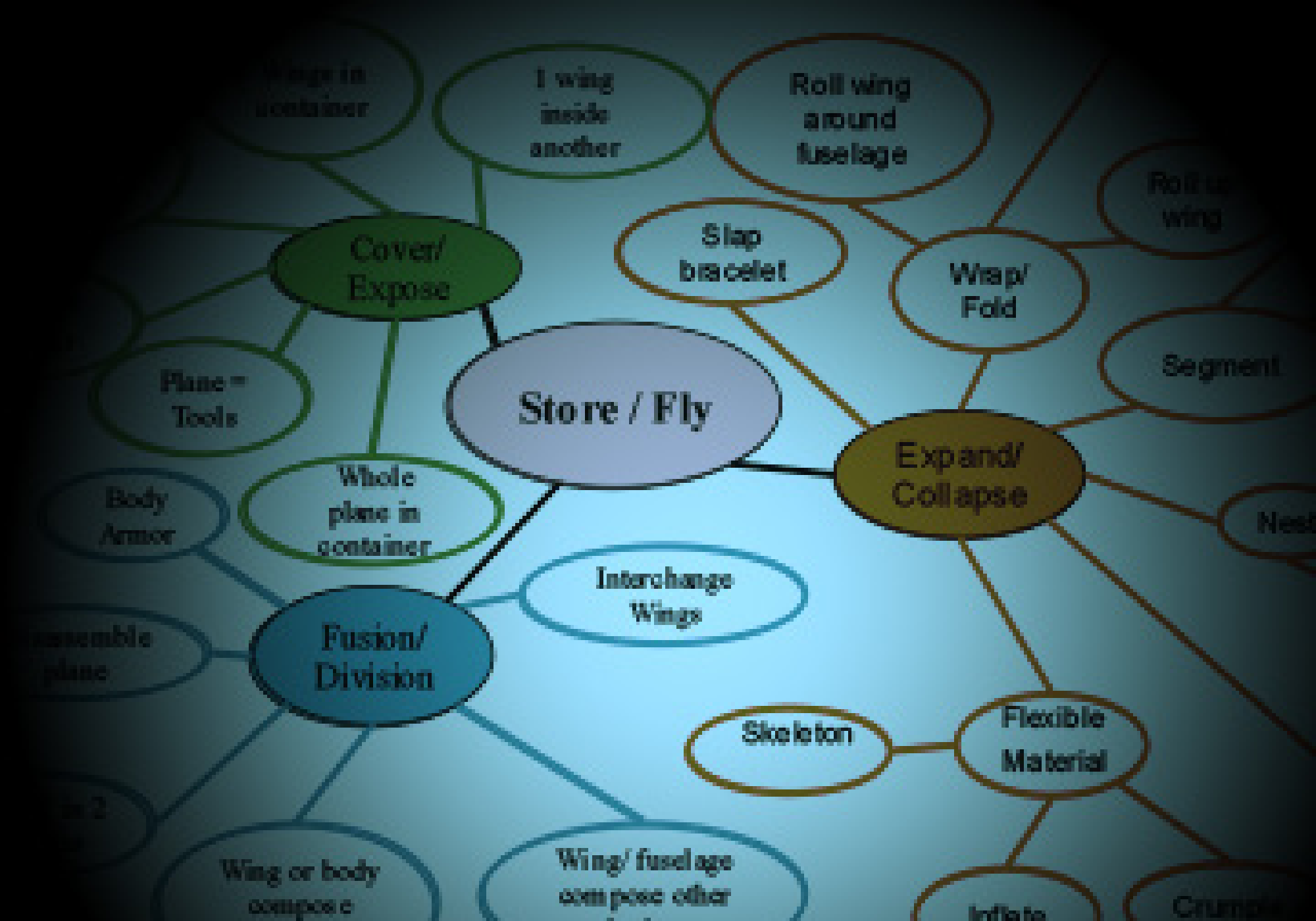
Modify: How could you change the shape, look, or feel of your product?

Put to Another Use: Can you use this product somewhere else, perhaps in another industry?

Eliminate: How could you streamline or simplify this product?

Reverse: What would happen if you reversed this process or sequenced things differently?

OUTCOME 10's to 100's of ideas that span the design space. Document the process and keep record of lists of ideas and decisions made.


I wing inside another
Roll wing around fuselage
Cover/ Expose
Slap bracelet
Wrap/ Fold
Plane = Tools
Store / Fly
Segment
Whole plane in container
Body Armor
Expand/ Collapse
Interchange Wings
Fusion/ Division
Skeleton
Flexible Material
Wing or body compose
Wing/ fuselage compose other

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Mind Mapping

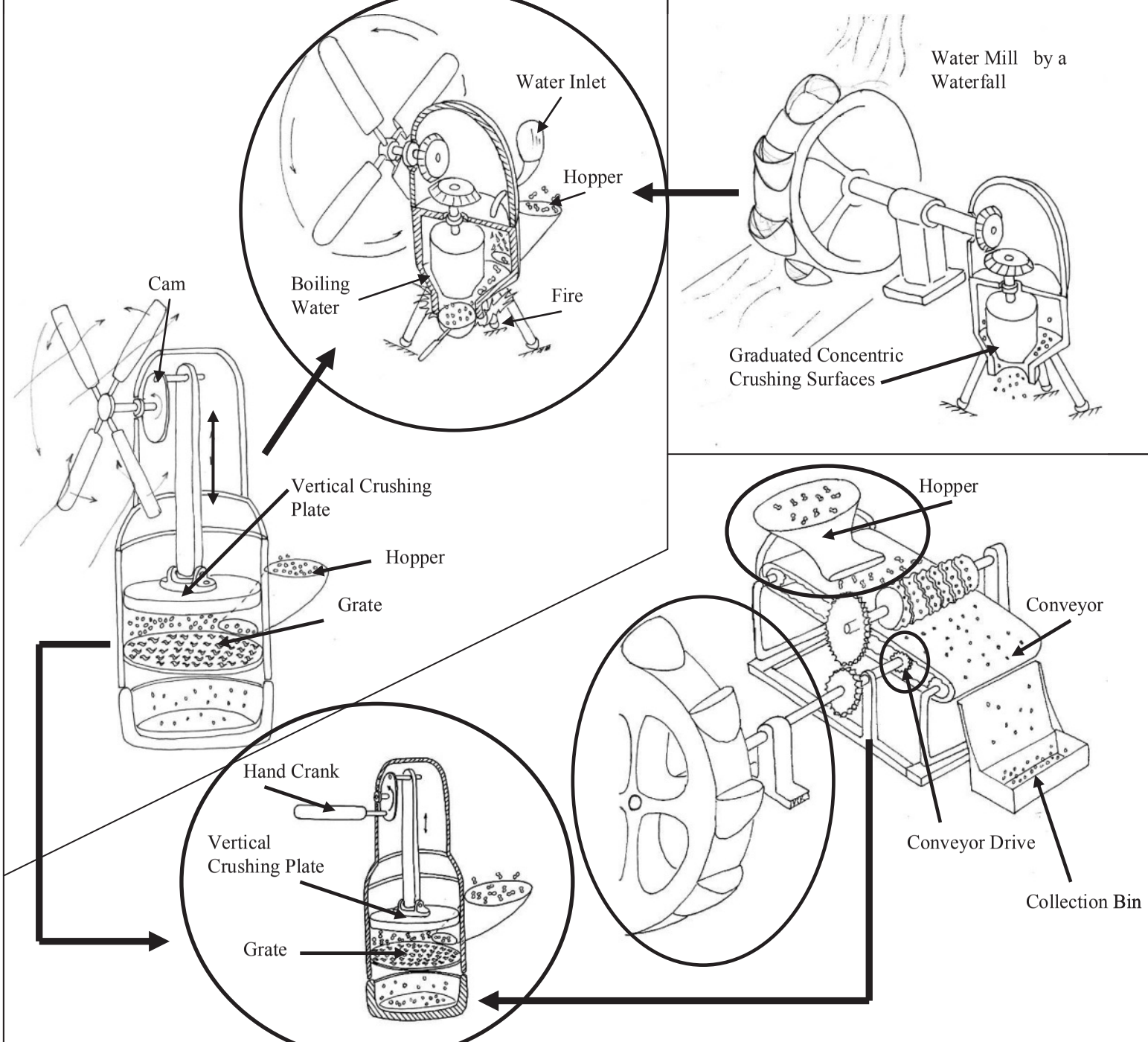
DO Come up with as many ideas as possible.

COMPLIMENTS Concept Diagram, Spider Graphs.

INSTRUCTIONS Register ideas and relationships between ideas in a spatial format using colours, labels, symbols and codes to visualise complex or rich information.

SUGGESTIONS Use radial or tree network formats, use a web-based app to share.

OUTCOME Generate 10's to 100's of ideas in classes or categories. It is useful to keep mind maps always visible so decisions can be made based on this information and ideas can be constantly added.


Water Inlet
Hopper
Boiling Water
Fire
Water Mill by a Waterfall
Graduated Concentric Crushing Surfaces
Cam
Vertical Crushing Plate
Hopper
Grate
Hopper
Conveyor
Conveyor Drive
Collection Bin
Hand Crank
Vertical Crushing Plate
Grate

• GENERATE

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6-3-5/ C-sketch

DO Use graphical media to generate concepts

SUGGESTIONS Trust your drawing abilities, it's ok if your pictures aren't perfect.

COMPLIMENTS Exquisite Corpse, World Café.

INSTRUCTIONS 6 teammates generate 3 ideas on their own piece of paper in 15 minutes. Every 5 to 10 minutes, the paper is passed to the next person. The process is iterated at least 5 times. In every cycle, participants sketch their ideas or modify ideas and pass their drawing sheet to the teammate next to him/her.

KEYPOINTS Only freehand speed sketching is allowed. No verbal communication. Use A3 sheets. No erasing.

OUTCOME Collaborative sketches are analysed by the team and displayed for reference.

Mind Mapping

Concept Development

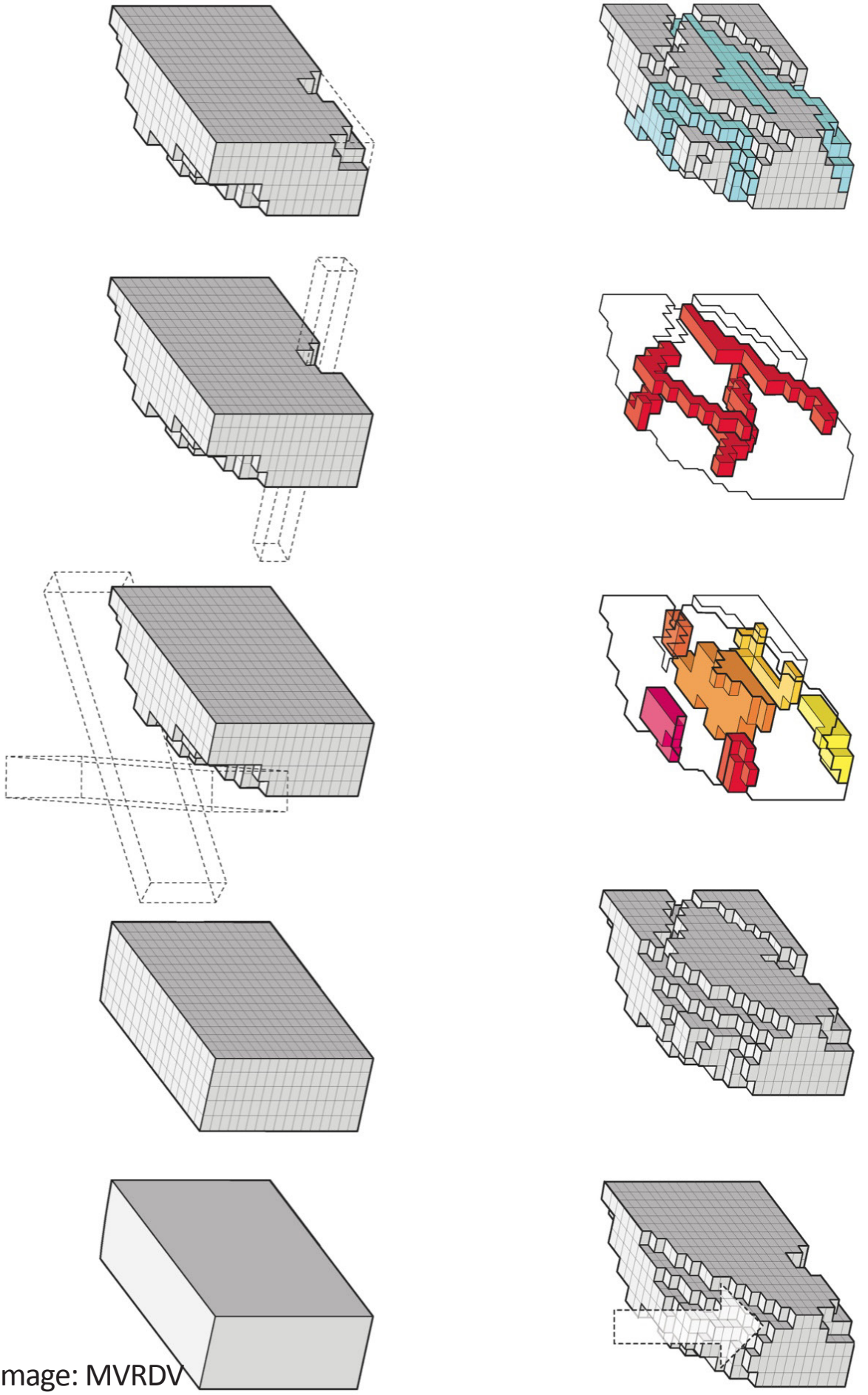

Image: MVRDV

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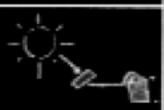
Concept Development

DO Sketch, Draw, Diagram, Model

INSTRUCTIONS In architectural design, a design concept is the design's guiding idea. A design concept includes a perspective on the design brief, as well as design principles and goals to guide the design process.

KEYPOINTS Keep it clear and abstract. A strong concept is general enough to be relevant for almost all aspects of the design, and definite enough to guide decision making.

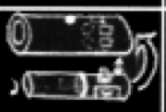
OUTCOME Sketches, conceptual models, diagrams and texts defining the design concept.

Functions / Solution Principles	Eccentric Moveable Weight	Direct Translation	Electrical
Transform Energy			

	Gripteeth	Friction Pad	Direct Attachment	Magnetic Field
Transmit to Untensil				

	Pre-position	Taper	Eccentric Weight	Track (Fixed)	Relative Rotation
Position Utensil					

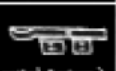
	Clamp	Friction	Magnets
Lock Position (Hard Locks)			

	Spokes	Rotational Metal	Electro-magnetic	Roller Pin	Screw
Reorient-ation (Soft Locks)					

	Track	User
Translate Food		

	Cylindrical	Toroidial	Prism	Outer Handle	Deformable
Accept User (shape)					

	Dycem	Ridges	Santoprene
(surface)			

	Clamping	Permanent Attach	Slot	Magnets
Accept Utensil				

	Eccentric Weight	Lever	Button	Squeeze Tube	Photocells
Accept Energy					

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Morph Matrix

DO List out all concept or solution principals for the key subfunctions of a system.

COMPLIMENTS Forced relationships.

INSTRUCTIONS Decompose a system into functions, list them in the first column. Fill at least five column cells for each row with alternative ways to satisfy each function. Find unconventional and insightful combinations of solutions across the matrix.

SUGGESTIONS Imagine every function independent from the current system. How is each function satisfied in other types of systems?

OUTCOME New combinations and synthesis of ideas are a springboard for innovative concept variants.

Image: mazur.net

Feature to Improve \ Undesired Result (Conflict)		1 Weight of moving object	2 Weight of non-moving object	3 Length of moving object	4 Length of non-moving object	5 Area of moving object	6 Area of non-moving object	7 Volume of moving object	8 Volume of non-moving object	9 Speed	10 Force	11 Tension, pressure	12 Shape
1	Weight of moving object			15,8, 29,34		29,17, 38,34		29,2, 40,28		2,8, 15,38	8,10, 18,37	10,36, 37,40	10,14, 35,40
2	Weight of non-moving object				10,1, 29,35		35,30, 13,2		5,35, 14,2		8,10, 19,35	13,29, 10,18	13,10, 29,14
3	Length of moving object	8,15, 29,34				15,17, 4		7,17, 4,35		13,4, 8	17,10, 4	1,8, 35	1,8, 10,29
4	Length of non-moving object		35,28, 40,29				17,7, 10,40		35,8, 2,14		28,10	1,14, 35	13,14, 15,7
5	Area of moving object	2,17, 29,4		14,15, 18,4				7,14, 17,4		29,30, 4,34	19,30, 35,2	10,15, 36,28	5,34, 29,4
6	Area of non-moving object		30,2, 14,18		26,7, 9,39						1,18, 35,36	10,15, 36,37	
7	Volume of moving object	2,26, 29,40		1,7, 4,35		1,7, 4,17				29,4, 38,34	15,35, 36,37	6,35, 36,37	1,15, 29,4
8	Volume of non-moving object		35,10, 19,14	19,14	35,8, 2,14						2,18, 37	24,35	7,2, 35
9	Speed	2,28, 13,38		13,14, 8		29,30, 34		7,29, 34			13,28, 15,19	6,18, 38,40	35,15, 18,34
10	Force	8,1, 37,18	18,13, 1,28	17,19, 9,36	28,10	19,10, 15	1,18, 36,37	15,9, 12,37	2,36, 18, 37	13,28, 15,12		18,21, 11	10,35, 40,34
11	Tension, pressure	10,36, 37,40	13,29, 10,18	35,10, 36	35,1, 14,16	10,15, 36,25	10,15, 35,37	6,35, 10	35,24	6,35, 36	36,35, 21		35,4, 15,10
12	Shape	8,10, 29,40	15,10, 26,3	29,34, 5,4	13,14, 10,7	5,34, 4,10		14,4, 15,22	7,2, 35	35,15, 34,18	35,10, 37,40	34,15, 10,14	
13	Stability of object	21,35, 2,39	26,39, 1,40	13,15, 1,28	37	2,11, 13	39	28,10, 19,39	34,28, 35,40	33,15, 28,18	10,35, 21,16	2,35, 40	22,1, 18,4
14	Strength	1,8, 40,15	40,26, 27,1	1,15, 8,35	15,14, 28,26	3,34, 40,29	9,40, 28	10,15, 14,7	9,14, 17,15	8,13, 26,14	10,18, 3,14	10,3, 18,40	10,30, 35,40
15	Durability of moving object	19,5, 34,31		2, 19, 9		3,17, 19		10,2, 19,30		3, 35, 5	19,2, 16	19,3, 27	14,26, 28,25
16	Durability of non-moving object		6,27, 19,16		1,10, 35				35,34, 38				
17	Temperature	36,22, 6,38	22,35, 32	15,19, 9	15,19, 9	3,35, 39,18	35,38	34,39, 40,18	35,6, 4	2,28, 36,30	35,10, 3,21	35,39, 19,2	14,22, 19,32
18	Brightness	19,1 32	2,35, 32	19,32, 16		19,32, 26		2,13, 10		10,13, 19	26,19, 6		32,30
19	Energy spent by moving object	12,18, 28,31		12,28		15,19, 25		35,13, 18		8,15, 35	16,26, 21,2	23,14, 25	12,2, 29
20	Energy spent by non-moving object		19,9, 6,27								36,37		

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TIPS/TRIZ

DO Use Theory of Inventive Problem Solving (TIPS or TRIZ) and this to generate inventive solutions to technical problems and conflicts.

COMPLEMENTS Morph Matrix.

INSTRUCTIONS Determine the conflicts in the design problem. Formulate as conflicts in the generalized engineering problems table. Determine the intersections in the TRIZ relationship matrix. Read the principles that apply to help and solve the problem.

SUGGESTIONS Have a copy of the generalized engineering problems table, TRIZ relationship matrix, and TIPS table of design principles.-

OUTCOME Strategies to address contradictions between features.

Image: Wikimedia

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Design by Analogy

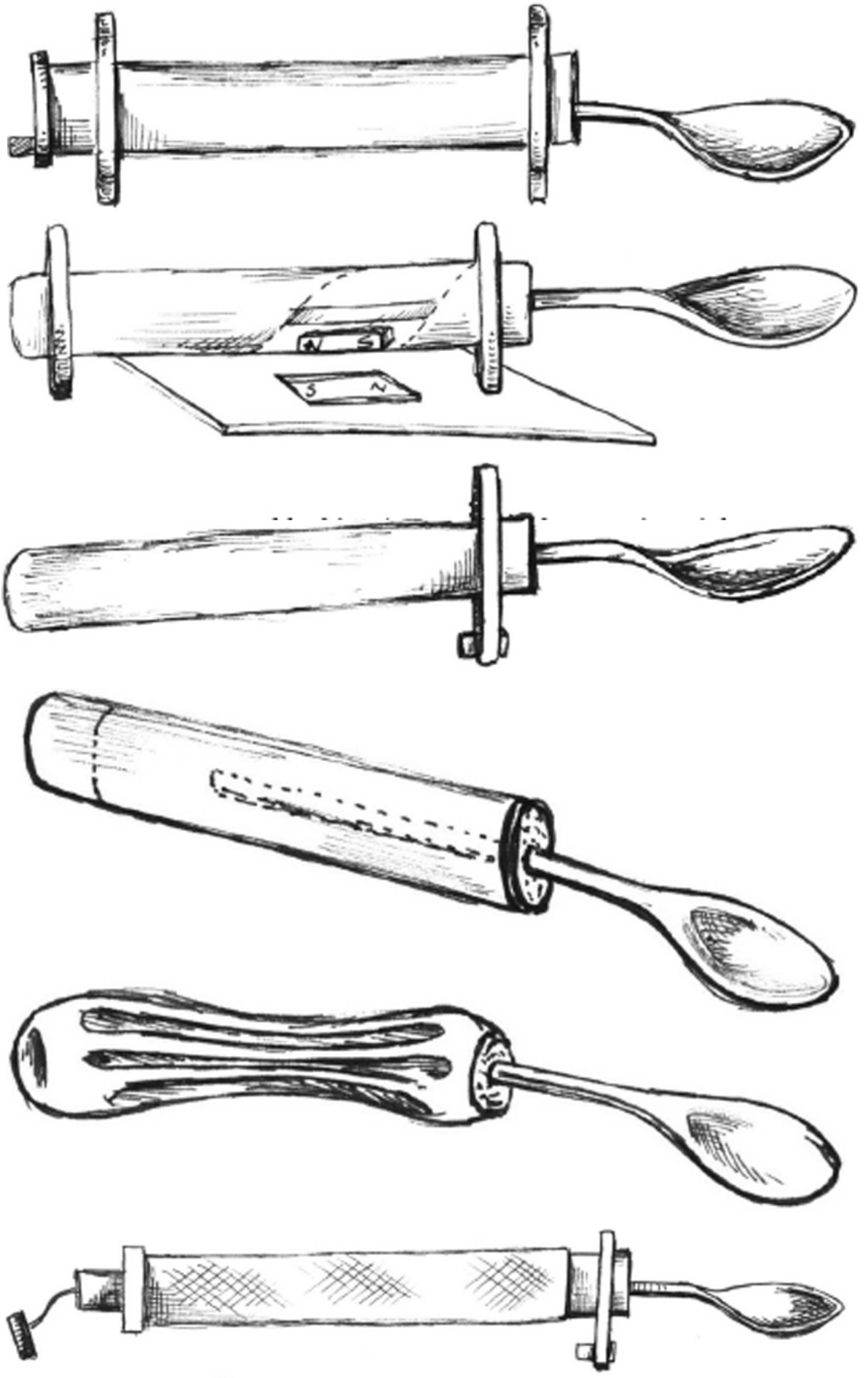
DO Use to develop concepts by similarities from other domains or ones experience.

COMPLIMENTS Ask Nature, Case-based Reasoning.

INSTRUCTIONS Design by analogy requires the re-representation of the problem at hand into a high level of abstraction used to map it into a different domains that inform, inspires or challenges current solutions or assumptions.

SUGGESTIONS Analogy maps the causal structure between the source product or system to the target problem being solved. Alternative definitions of the problem at hand using analogies to a different problem or domain. New keywords to search patent and product databases.

OUTCOME Concepts based on analogies that are converted into a form that solve the problem at hand.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Concept Variants

DO Combine concepts variants from the range of previously brainstormed solutions while discarding ideas that have intrinsic incompatibilities.

INSTRUCTIONS Although many combinations of concepts are possible, there can be feasibility issues of combining them in terms of compatibility and function sharing. Create a large number of divergent alternative designs that can be created.

SUGGESTIONS This process is nonlinear and requires iteration and continued refinement. Concept variants should be sketched as solutions that are “added” together. Product architecture should be maintained and alternative arrangements and layouts should be explored as ideas develop.

OUTCOME A handful of concept variants based on previous ideas.

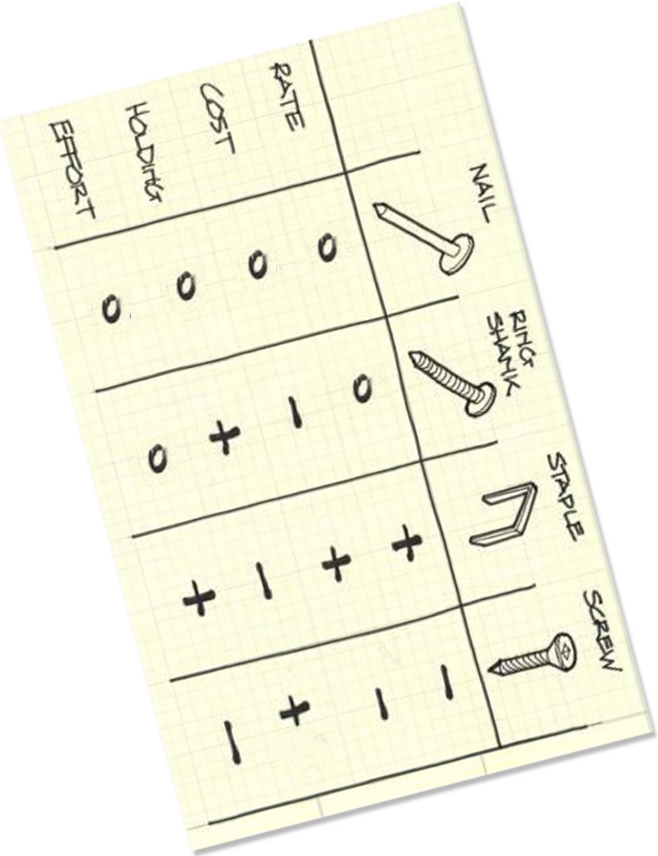

Image: MIT

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Pugh Method (Concept Selection)

DO Use this tool to form team consensus make design decisions.

INSTRUCTIONS Arrange the concepts in a matrix with a sketch along each column and design criteria from QFD or specification along the rows. Then evaluate each of the concepts on a scale of +, -, or 0 relative to a reference concept in the matrix.

KEYPOINTS Choose an appropriate datum to measure against. Use different datums to compare themselves against each other. Combine concepts by attacking negatives identified during evaluation.

OUTCOME Improved concepts and preferred concepts as chosen by team consensus.

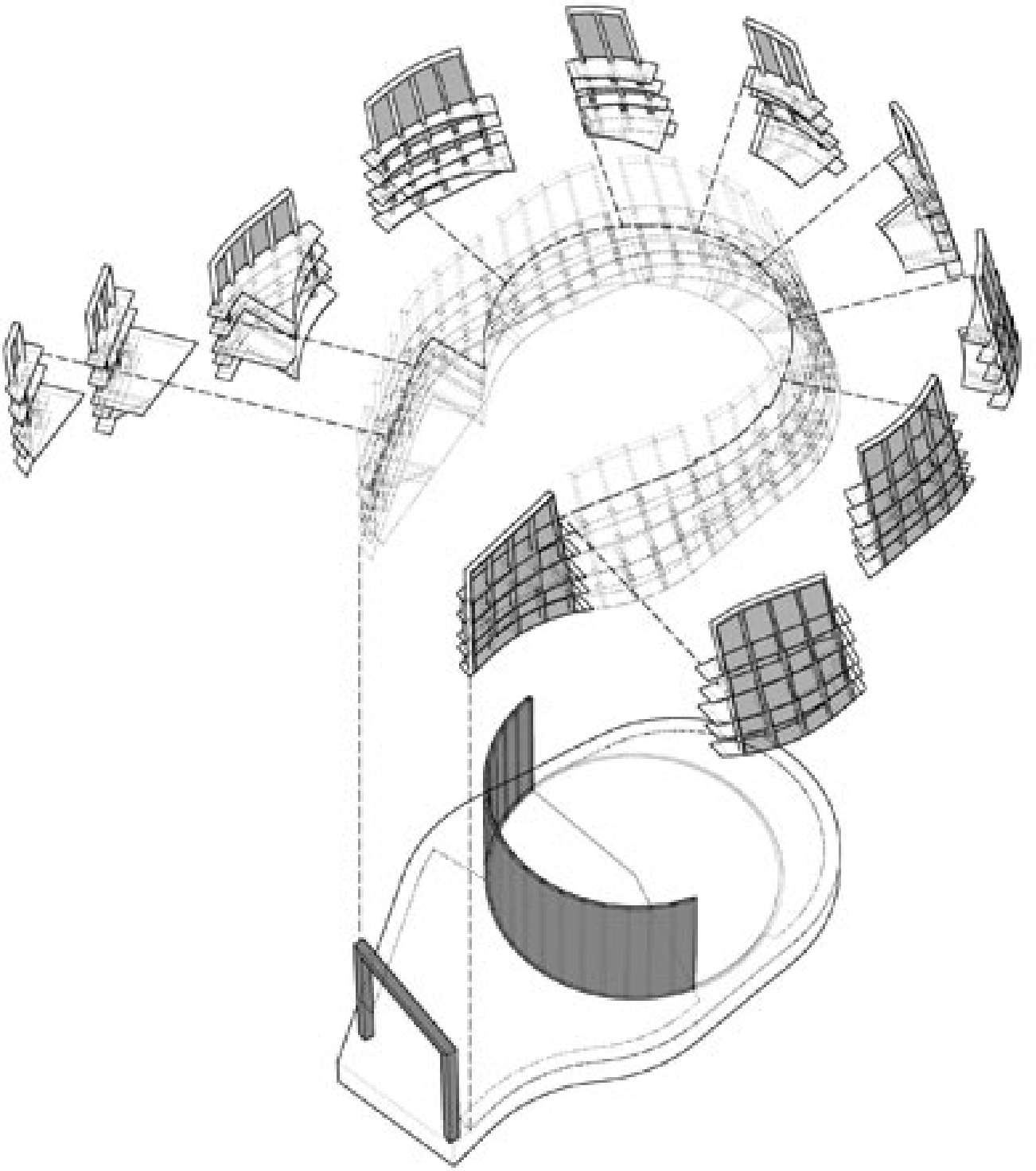

Image: SHoP Architects

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Component Design

DO Model, Prototype, Draw

INSTRUCTIONS Developing a working component is harder than it sounds. Consider how components connect to each other, and how different spatial configurations can be achieved (e.g. a corner). Try to allow for variation with and between components (Closed/Open, Size, Geometry). Think both from the component to the whole ("bottom up), and from the whole to the component ("top down").

KEYPOINTS Allow for manufacturing tolerances! Avoid exceptions through variable components.

OUTCOME Models, prototypes and drawings of several components forming a spatial configuration

Concept Selection

Develop Structure and Joints

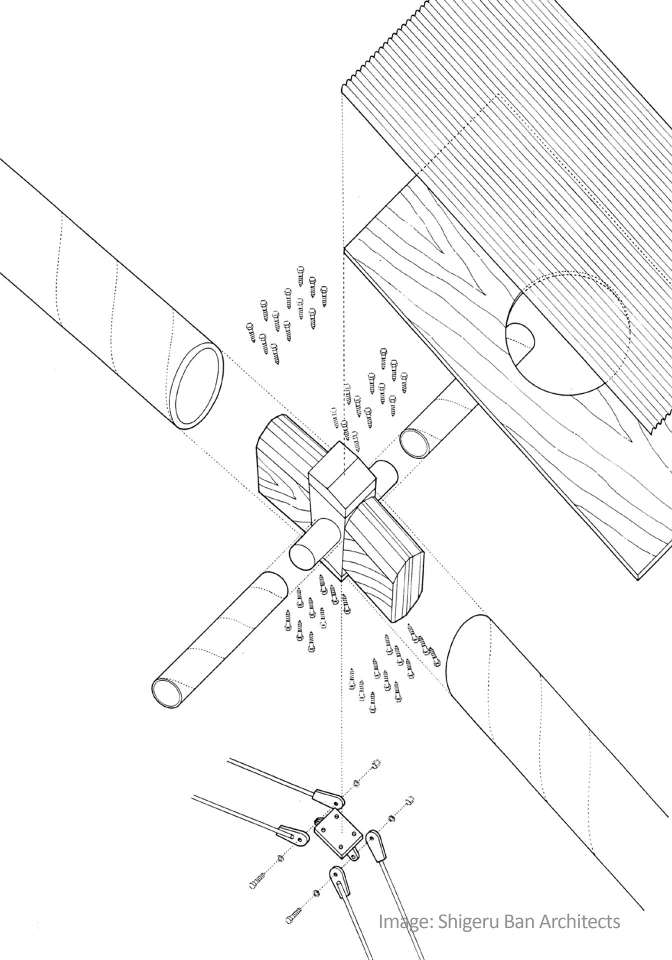

Image: Shigeru Ban Architects

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Develop Structure and Joints

DO Model, Prototype, Draw

INSTRUCTIONS What makes the design hold up? Is it standing (like a column), bending (like a beam or cantilever) or hanging (like a tent). How do the components connect? Are the joints made explicit (emphasizing the parts) or hidden (emphasizing the whole)?

KEYPOINTS Structure and Joints are not only technical issues, but a crucial part of architectural expression. Mind different material behaviours and tolerances.

OUTCOME Detail drawings, prototype joints, structural calculations

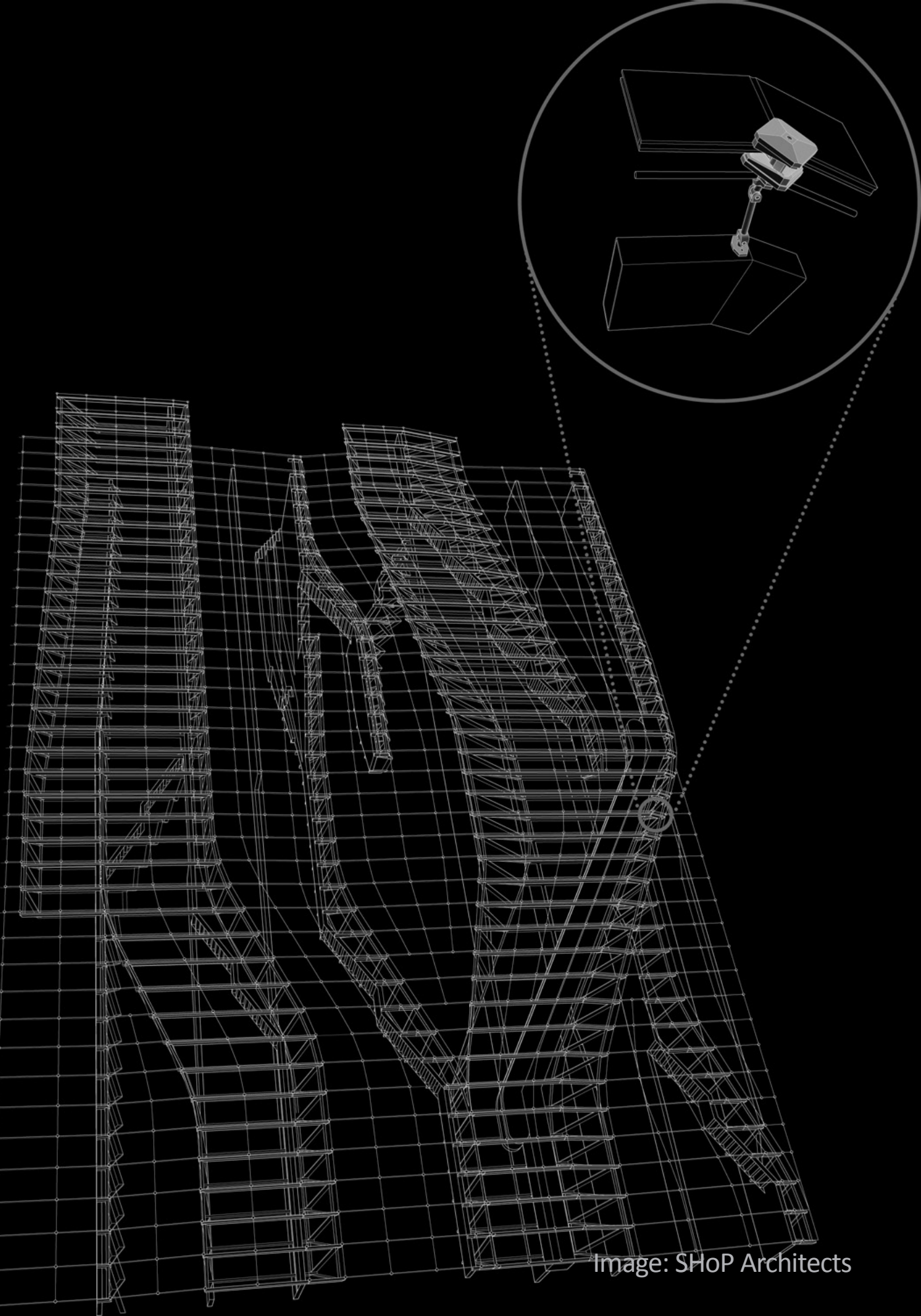

Image: SHoP Architects

• MAKE

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Concept and Systems Integration

DO Search for overlaps and synergies

INSTRUCTIONS Collect and survey ideas for different design aspects (Concept, Site, Function, Aesthetics, Structure, Connections etc. etc.). Identify ideas that support each other. Which aspects can be changed to make the design into a more coherent whole? Which aspects should be (de-) emphasized?

KEYPOINTS Kill your darlings! I.e., don't stick to your favorite ideas if they don't support the design concept. The more different aspects of your design support each other, the better!

OUTCOME Sketches, drawings and scale models that document and detail your design decisions

Develop Structures and Joints

Functional Proof of Concept

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Functional Proof of Concept

DO Determine the feasibility of a particular functional aspect of your product in an isolated way.

INSTRUCTIONS Determine key functions to be prototyped such as moving parts and important technical features. Create a physical model of the components (individually if necessary) to understand capabilities and issues for feasibility.

KEYPOINTS Use available items to make a rough version of your idea. Understand difficult or complex functionality of a concept. The more true to form it is, the more insight it will bring. It does not have to be pretty or made of the final materials.

OUTCOME Understand unresolved issues and refinements needed for a design concept.

Concept and Systems Integration

Appearance Proof of Concept

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Appearance Proof of Concept

DO Have a good understanding of customer needs. Looks at the aesthetic theme and ergonomic aspect of the system.

INSTRUCTIONS Create your model to scale in terms of look and feel. You do not need to include working parts. Use such models to get key feedback from target users.

KEYPOINTS Choose materials that are representative of chosen materials for the design concept.

OUTCOME Have a better understanding of form and understanding strengths and weaknesses in the current design.

BILL OF MATERIALS

Module/ Part #	Description/Name	Qty	Mfg. Process	Dimensions	Mass	Material
A-1: Spherical Thrust Bearing (Top)						
A-1-1	FAG Spherical Thurst Bearing: FAG 29252E.MB	1	FAG Supplier	Bore = 260 mm; OD = 360 mm; Width = 60 mm	W=17.1 kg	

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BOM (Bill of Materials)

DO Know all of your components in your system.

INSTRUCTIONS Create a list of all of your components. Include part name, quantity, function, mass, finish, manufacturing process and dimensions.

KEYPOINTS Use this list to keep track of every piece. Break down items to the level they were purchased at.

OUTCOME Know all parts and vendors for your system.

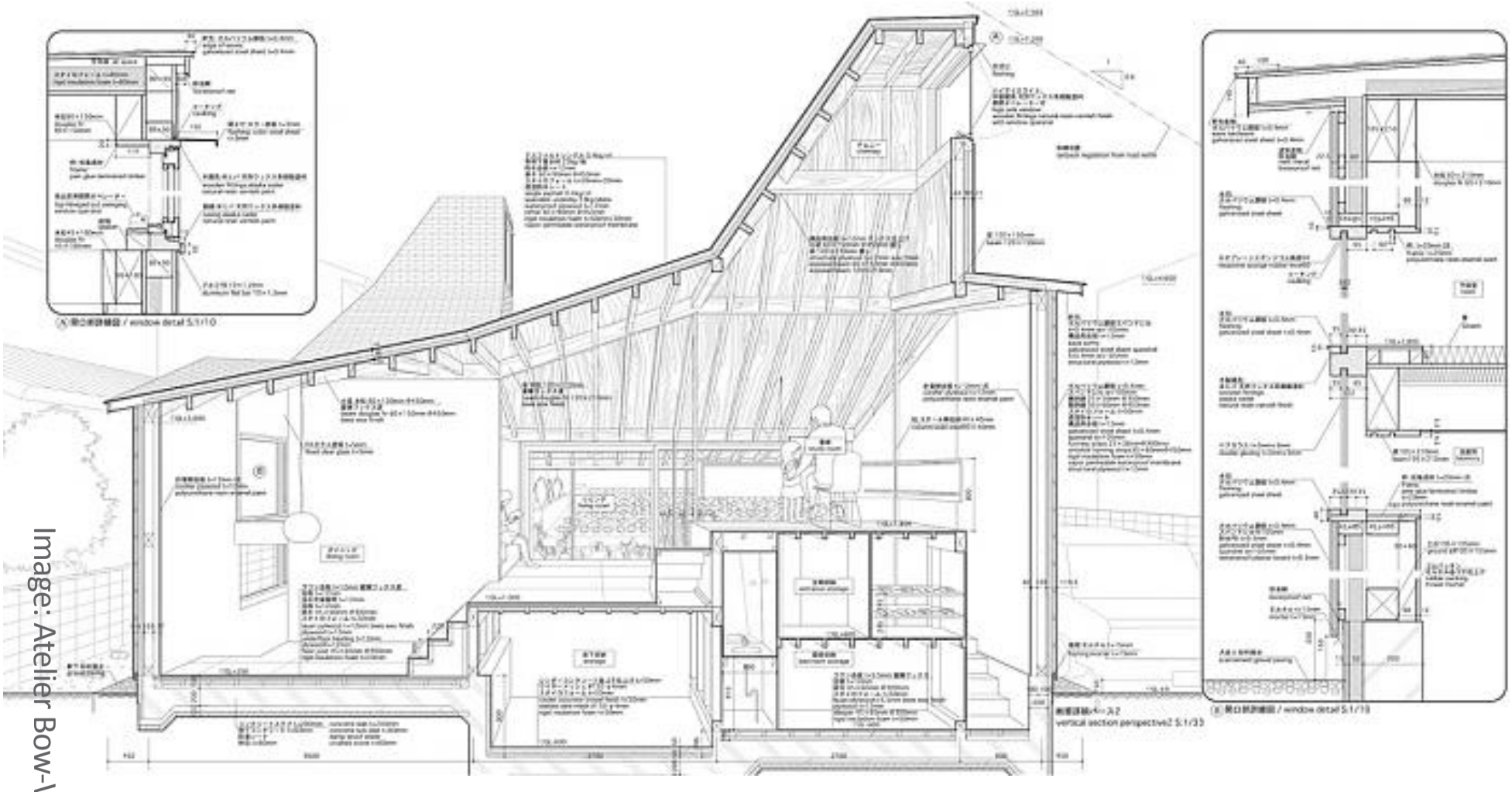

Image: Atelier Bow-Wow

• COMMIT

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Design Integration and Development

DO Be paranoid and remember Murphy's law

ALTERNATIVES Convergent Thinking

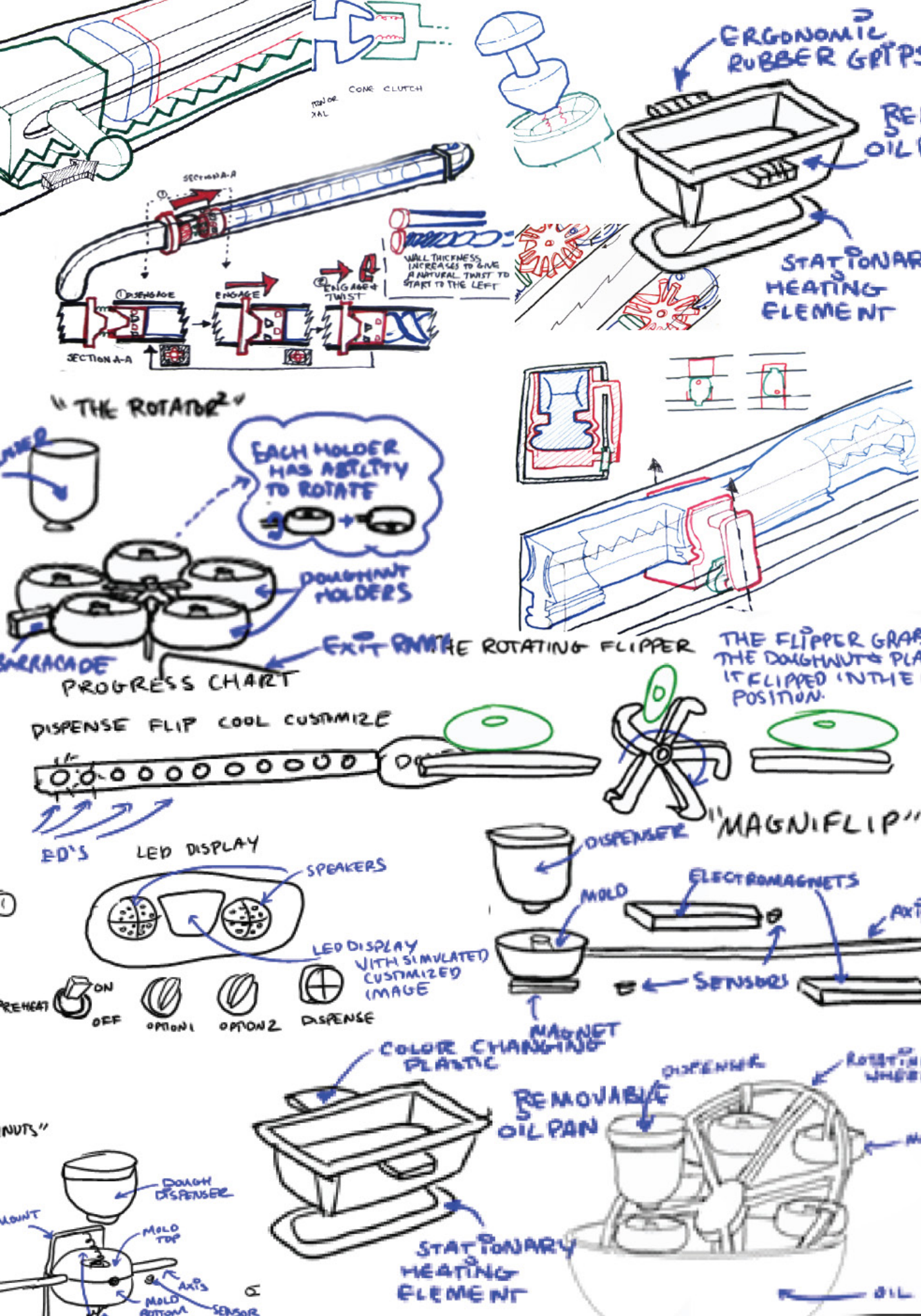
INSTRUCTIONS Fill in the details: How will this work? What is it made of? How can it be manufactured? How will it be assembled? What additional information is needed? Identify and address risks. What aspects have not been thought through yet? Quantify expected material use and manufacturing times.

KEYPOINTS Test often and early! Double-check and use early prototyping to detect mistakes before it's too late.

OUTCOME A detailed and correct set of drawings/files usable for implementation. Bills of quantities and specifications.

BOM

Beta Prototype


CONE CLUTCH
ERGONOMIC RUBBER GRIPS
STATIONARY HEATING ELEMENT
SECTION A-A
WALL THICKNESS INCREASES TO GIVE A NATURAL TWIST TO START TO THE LEFT
"THE ROTATOR"
EACH HOLDER HAS ABILITY TO ROTATE
DOUGHNUT HOLDERS
PROGRESS CHART
THE ROTATING FLIPPER
THE FLIPPER GRA
THE DOUGHNUTS PLA
IT FLIPPED IN THE
POSITION.
DISPENSE FLIP COOL CUSTOMIZE
LED'S
LED DISPLAY
SPEAKERS
LED DISPLAY WITH SIMULATED CUSTOMIZED IMAGE
PREHEAT
ON
OFF
OPTION1
OPTION2
DISPENSE
"MAGNIFLIP"
DISPENSER
MOLD
ELECTROMAGNETS
SENSORS
MAGNET
COLOR CHANGING PLASTIC
REMOVABLE OIL PAN
STATIONARY HEATING ELEMENT
DOUGH DISPENSER
MOLD TOP
AXIS
MOLD BOTTOM
SENSOR

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Idea Sketching

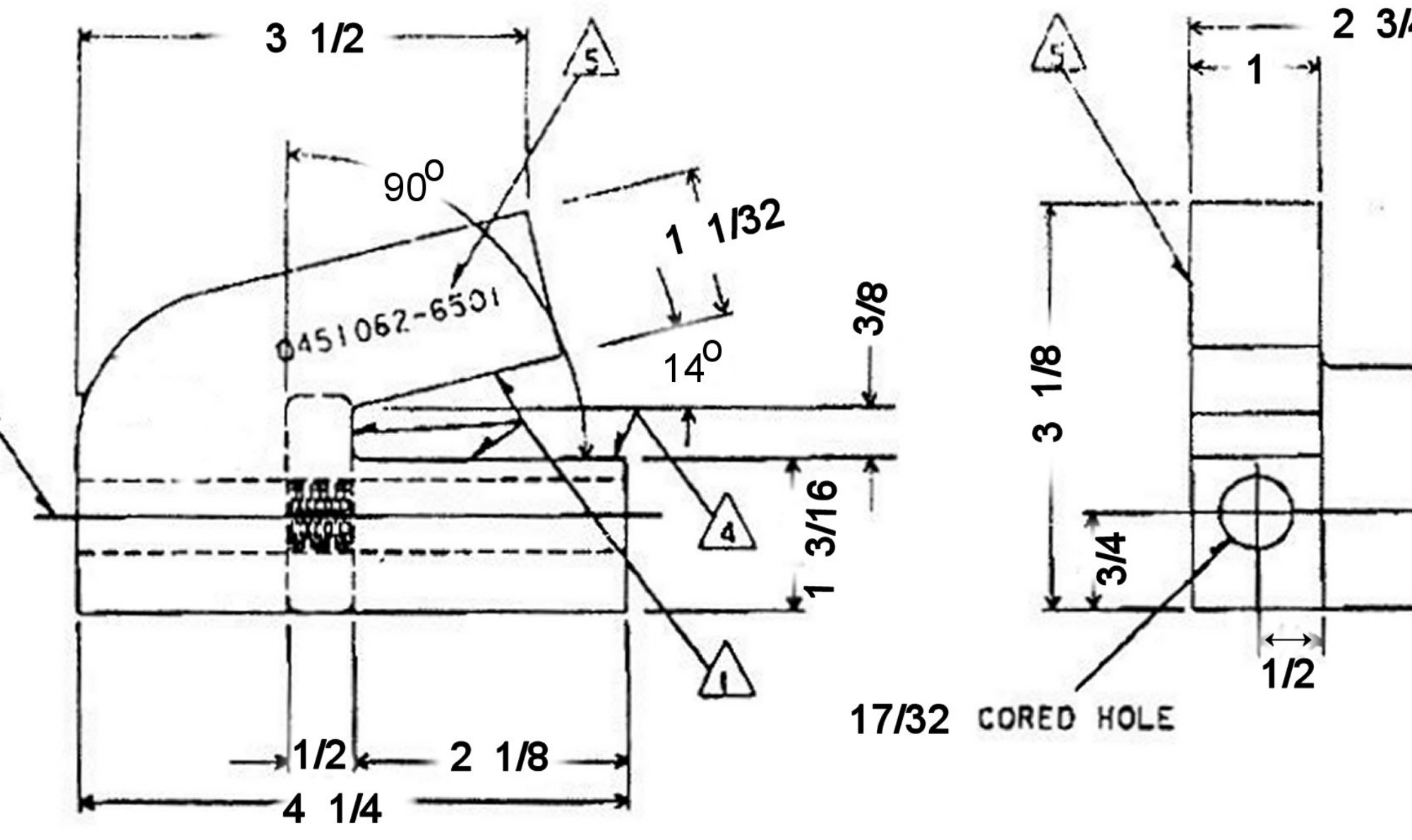
DO Use sketches to help you think through your concepts.

ALTERNATIVES Rapid Viz, Freehand sketches.

INSTRUCTIONS Learn to draw fast enough to support your thinking process. Practice regularly. Sketch in your class notes, doodle ideas and messages. Idea sketching needs fluency and clarity.

KEYPOINTS Forget about nice, artistic landscapes and portraits. Idea sketching is about facilitating your ideation and communication skills.

OUTCOME Quick and dirty sketches that only take a few seconds to do. Add text labels, diagrams and dimensions as necessary.


3 1/2
90°
0451062-6501
1 1/32
14°
3/8
1 3/16
1 1/2
2 1/8
4 1/4
2 3/4
1
3 1/8
3/4
1/2
17/32 CORED HOLE

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Technical Drawing

DO Use technical drawings to understand specifications.

ALTERNATIVES Engineering drawings.

INSTRUCTIONS Learn and practice multi-view(orthographic) drawings and general conventions such as dimensioning, line types, exploded views, list of materials.

KEYPOINTS An easy way to develop your technical drawing skills is to build models and prototypes from engineering drawings.

NEXT STEPS Consult standards and best practices of engineering drawing.

• RESOURCE

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Photography

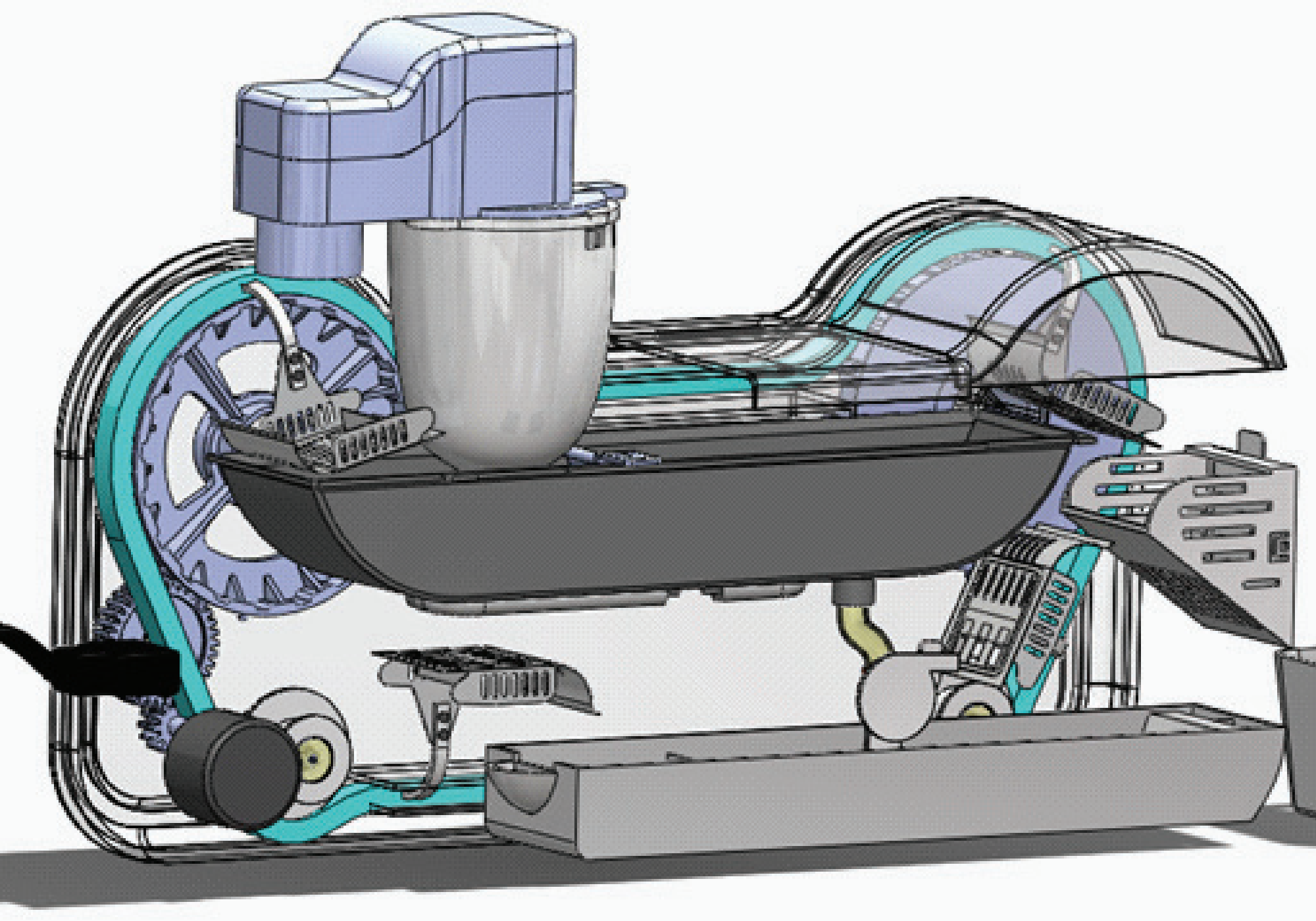
DO Keep track of all your progress through photos.

ALTERNATIVES Sketching, Video/voice recording.

INSTRUCTIONS Throughout the design process, develop the habit of snapping quick photos/videos of important results and evidence for decision making. Use a professional camera and adequate lighting conditions to prepare high quality images.

KEYPOINTS Lighting, background and focus are the main elements for a professional photograph. Use a macro lense for small details.

NEXT STEPS Print the main photographs for your experiential wall, reports and design portfolio.



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3D Modeling (Parametric)

DO Use to understand relationships between parts within systems.

INSTRUCTIONS Start from a 3D primitive solid or by creating a 2D sketch in SolidWorks to build a custom 3D solid by extrusion or revolution. Define dimensions and relations. Apply boolean operations between solids.

KEYPOINTS Use solid modeling for the more simple geometries, i.e. those derived from primitive solids or extrusion/revolution construction.

OUTCOME .stl files for rapid prototyping. Also, engineering drawings and CAD files for rendering.

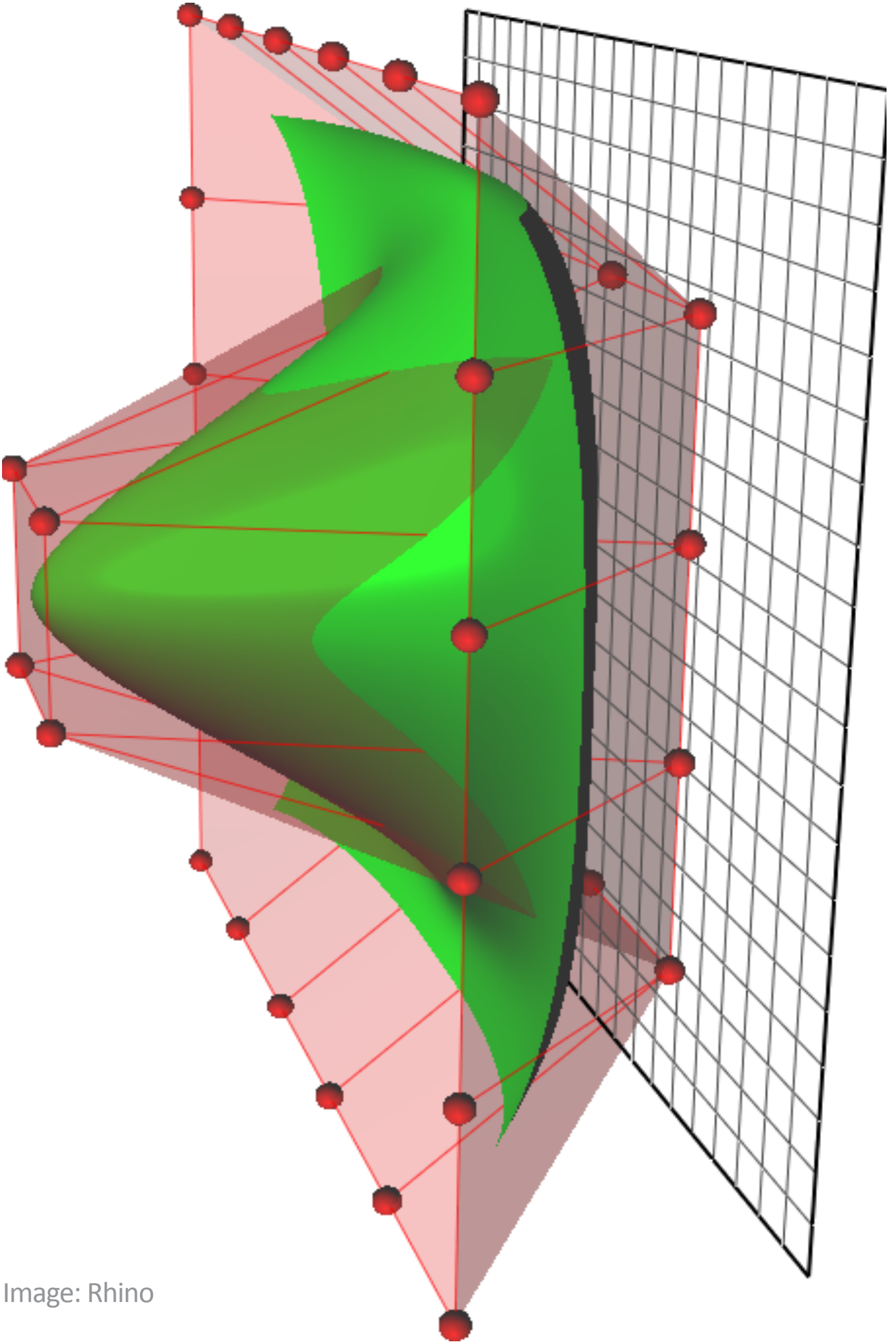

Image: Rhino

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3D Modeling (Surface)

DO Use surface modeling to gain better understanding of form and feel.

ALTERNATIVES NURBS Modelling.

INSTRUCTIONS Start by locating points and curves where the curvature of your design changes. Use the three views (front, top and side) in order to build the envelope or boundary of your surfaces. Develop surfaces that intersect, then trim their boundaries.

KEYPOINTS Use surface modeling for more complex or irregular geometries. Be careful to offset and “stitch” surfaces to avoid 3D printing problems.

OUTCOME Usually CAD files for rendering. Also, engineering drawings and .stl files for rapid prototyping.

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3D Printing

DO use the 3D to make a quick mock up of a concept.

ALTERNATIVES Laser Cutting.

INSTRUCTIONS Achieved using additive processes, where an object is created by laying down successive layers of material. Start by making three dimensional solid objects from a digital model.

SUGGESTIONS Avoid overuse. Do not print solids or simple geometries that you can build more effectively with simple tools.

KEYPOINTS Use appropriate solid models, check for proper settings on the 3D printer.

OUTCOME 3D prototypes for either functional or appearance testing.


UNIVERSAL

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Laser Cutting/ Water Jet

DO use the 3-D to make a quick mock up of a concept.

ALTERNATIVES 3D Printer, exacto knife.

INSTRUCTIONS Start by preparing 2D vector graphics of a cut path. Adjust laser intensity suitable to the material of choice.

SUGGESTIONS Avoid overuse. Do not use laser cutting for straight and simple cuts that you can do more rapidly with simple tools.

KEYPOINTS Make sure you adjust the reference point for the cutter to accommodate material thickness.

OUTCOME Planer cut material usually for assembly.

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Metal Shop

DO Have your plans, your own materials to cut, and a buddy.

INSTRUCTIONS Time to get making! Go into the metal shop with a clear plan of your parts you need to make and what needs to be done to make them. Before you start cutting, think about how you want to break down your materials to get the most out of them.

SUGGESTIONS Follow all the safety guidelines and avoid machinery if tired or in a rush.

KEYPOINTS Give yourself a lot of time to make parts... mistakes can be detrimental in metal! Don't be afraid to ask for help in the metal shop if you aren't sure how to do.

OUTCOME Parts.

Wood Shop

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Wood Shop

DO use the wood shop as a quick way to try out your ideas. Have a good idea of your plans and a buddy.

ALTERNATIVES 3-D Printing, Laser Cutting

INSTRUCTIONS Go into the wood shop with a plan of your parts you need to make and what needs to be done to make them. Before you start cutting, think about how you want to break down your materials to get the most out of them. The woodshop is an easier place to improvise, try ideas, and have imperfect parts work, compared to the metal shop.

SUGGESTIONS Follow all the safety guidelines and avoid machinery if tired or in a rush.

KEYPOINTS Although quicker than machining metal, the wood shop is not effortless. Be patient and give yourself enough time.

OUTCOME Your parts.

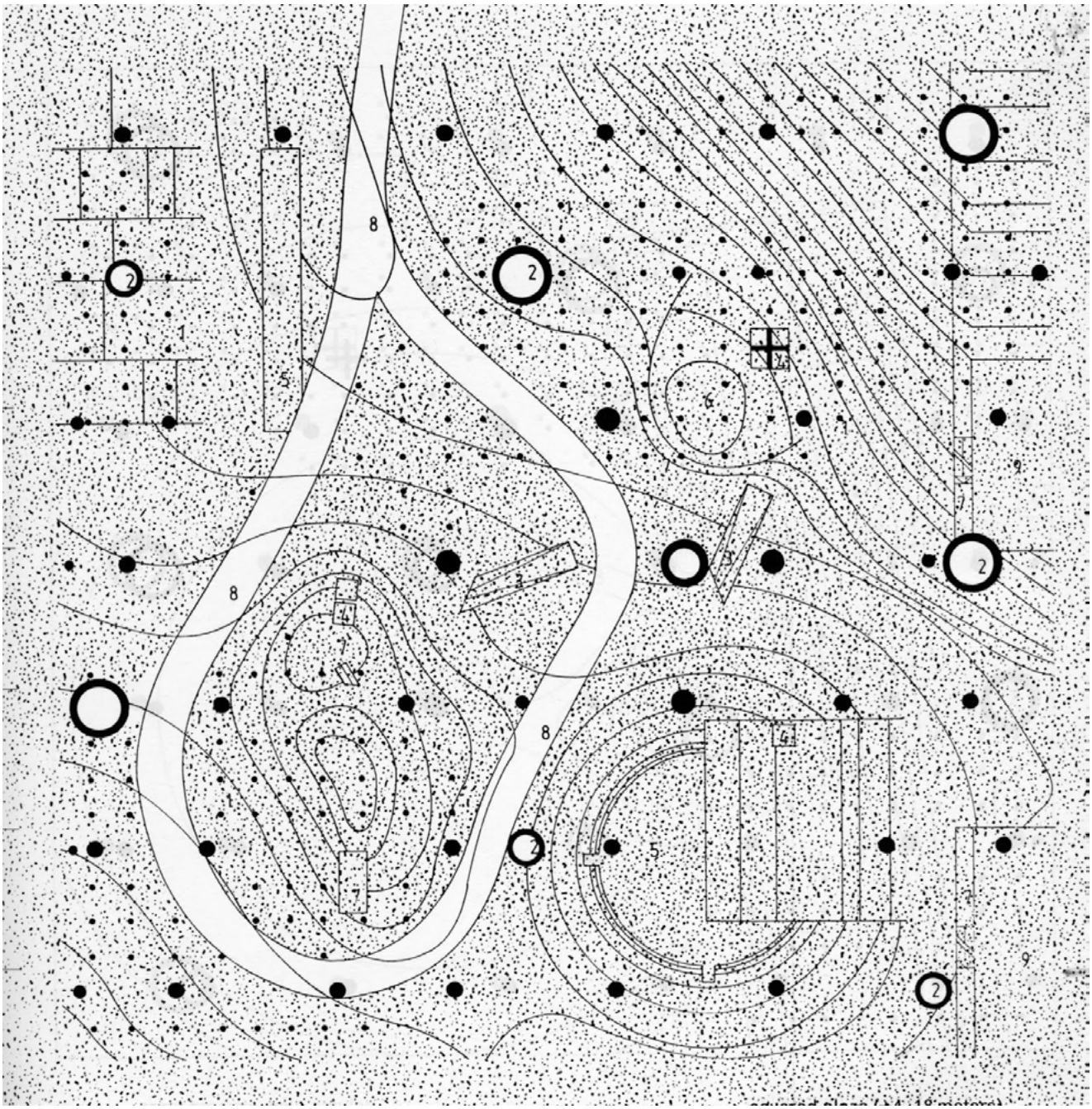

Image: Koolhaas, Rem; *S, M, L, XL;* 1998

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Representation

DO Visualize, Order and don't be afraid of White

INSTRUCTIONS Representation is central to architectural design. Since the object of design cannot be perceived before implementation, great care should be given to how the design is represented (in diagrams, drawings and models of different kinds, from 3D to mathematical). Beyond the content the manner of representation usually conveys design intentions.

KEYPOINTS The medium is the message! A page should be designed with the same care as your project. Be careful to use colors, fonts and materials meaningfully: Often, less is more. Strive for balance between images and drawings, as well as between black and white. Introduce hierarchy and order, to guide the unfamiliar observer.

OUTCOME Meaningfully arranged drawings and diagrams and well-built models.

Evaluation
and discussion

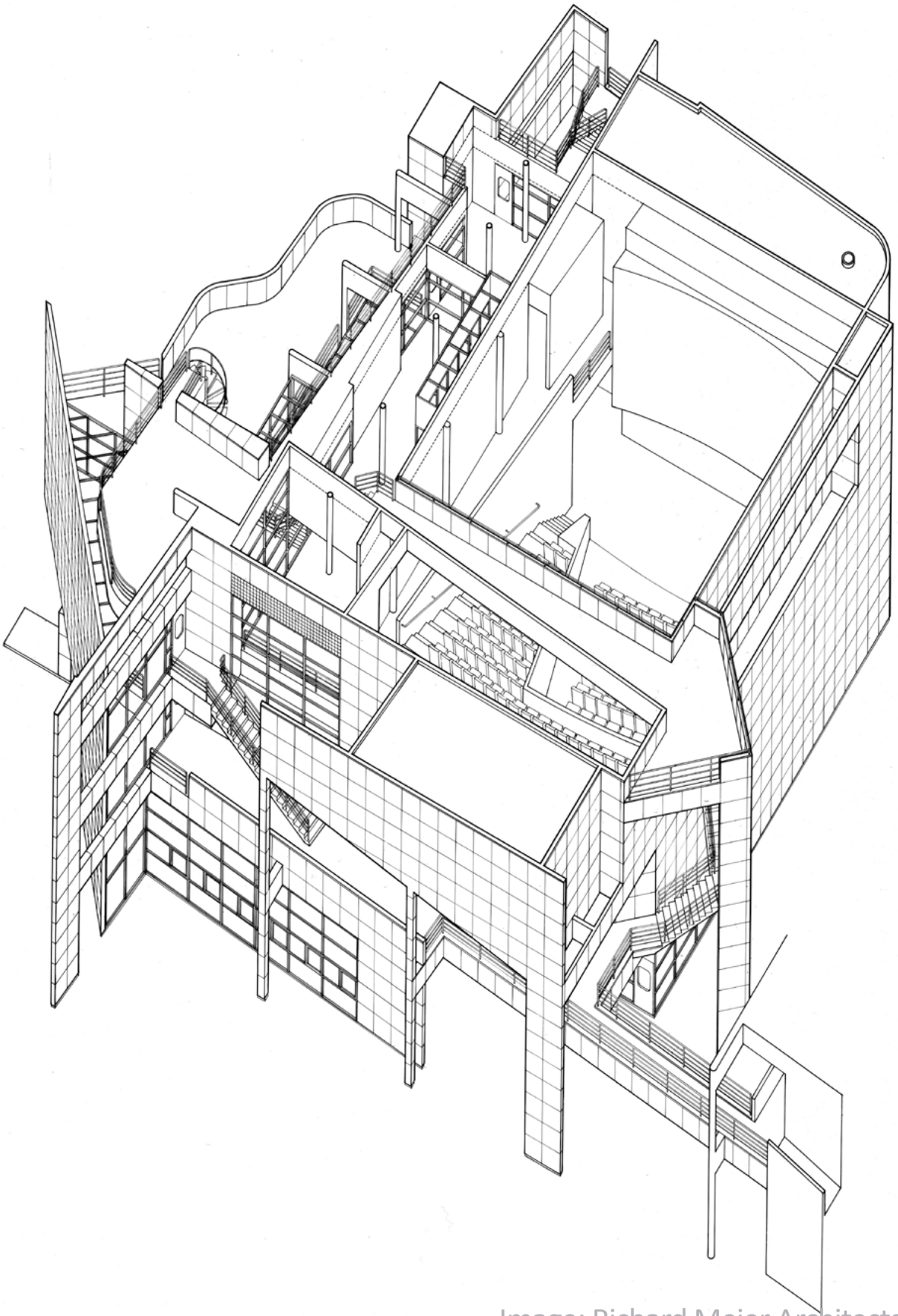

Image: Richard Meier Architects

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Analytical drawings

DO Draw

ALTERNATIVES Mapping, Diagramming, Conceptual Models

INSTRUCTIONS Explicitly drawing design constraints or particular design aspects often leads to a better understanding of the problem and new solutions. Focus on relevant pieces of information and how they are connected. Leave out unnecessary detail. Abstraction is key!

KEYPOINTS Don't think or debate too much. When in doubt, draw! Try different scales/projections/techniques.

OUTCOME Clear, original and aesthetic drawings

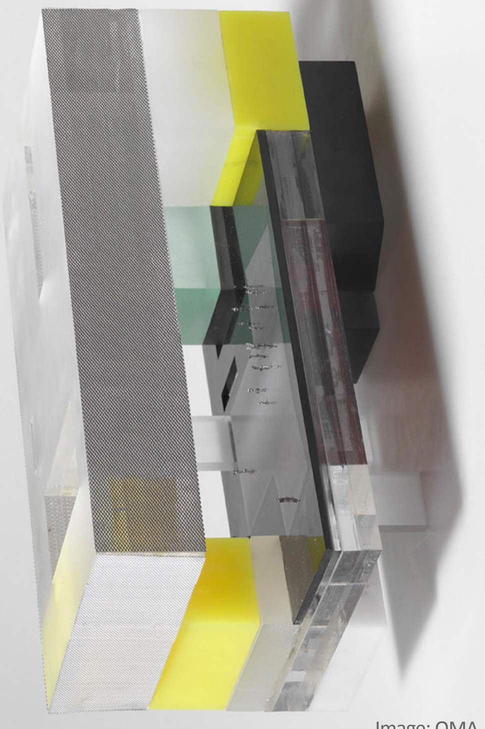

Image: OMA

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Conceptual models

DO Build models

ALTERNATIVES Analytical Drawings

INSTRUCTIONS Abstract models are an excellent way to quickly explore and communicate a spatial idea. You can build a model of the site, your design or parts of it, or even of a purely conceptual idea.

KEYPOINTS Building models is a key technique in design exploration. Don't hesitate to build several iterations of one model. Be precise in your craftsmenship: Avoid pen and glue marks, and use sharp blades.

OUTCOME Interesting and well-crafted models, that clearly convey the design intentions.

Image: Zaha Hadid Architects

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Site Documentation

DO Sketches, plan, section, diagrams, photographs

INSTRUCTIONS Keeping your project brief in mind, concentrate your site analysis into a few key drawings - a plan and a section of its physical features; a diagram of key movement flows that explain its typical use patterns; and annotated diagrams of the sensual (e.g. material) and cultural (e.g. meaning) references of the site, as they relate to your task at hand.

KEYPOINTS Select which site features are most important to addressing your design problem at hand, avoid documenting things that will not help you with your project. If you deal with an indoor space, then a section is often important as it helps you describe the ground and ceiling constraints you face.

OUTCOME A site plan, section, a movement flow diagram, and annotations diagrams showing specific site qualities that stand out to you. The site influences that you document often suggest the first design decisions you take.

Analytical Drawings