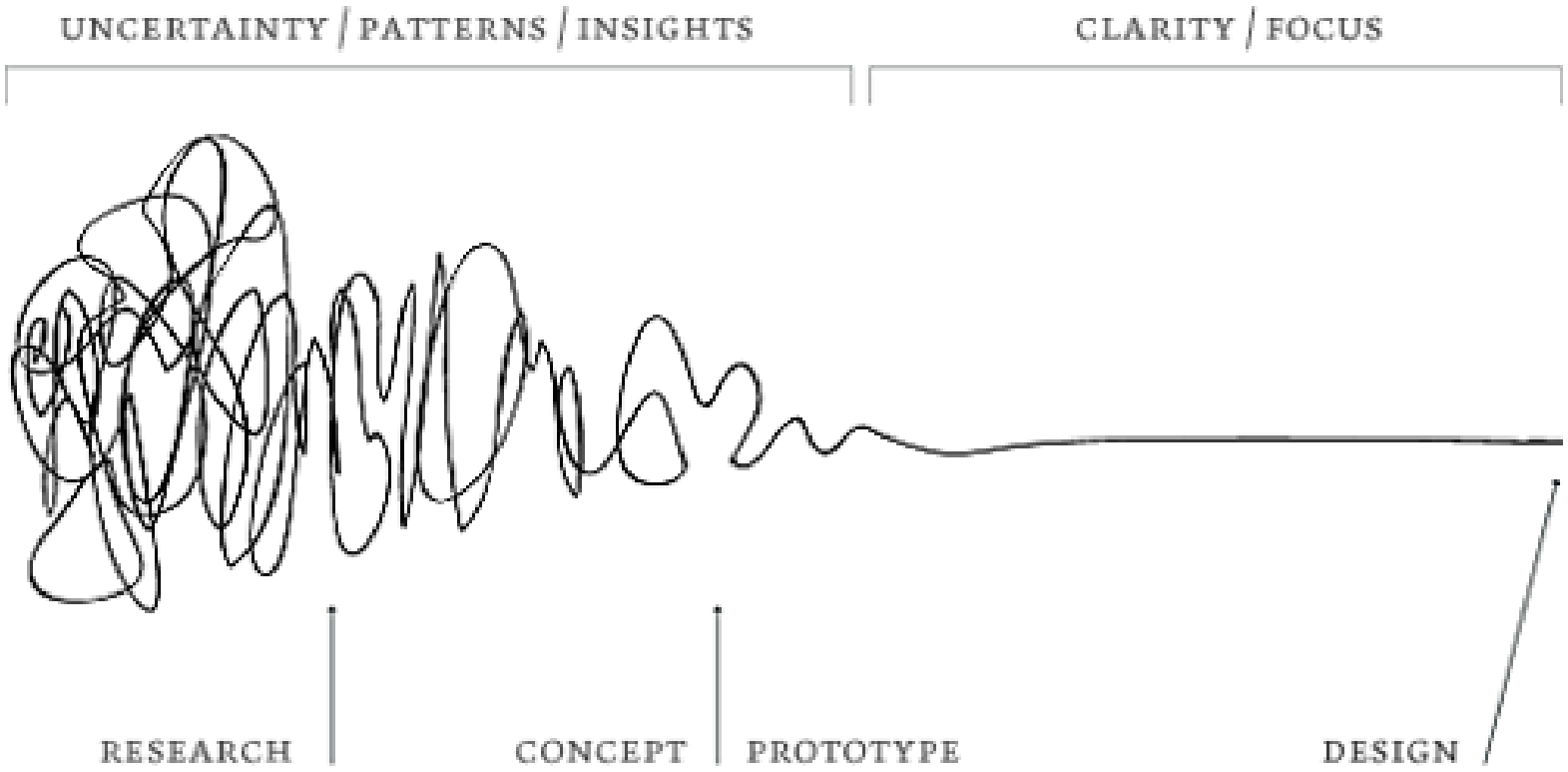
Defining the Design Opportunities

Cassandra Telenko, PhD

Mechanical Engineering

Capstone Design

http://www.resilientbydesign.com/design-thinking/



Damien Newman's Design Squiggle

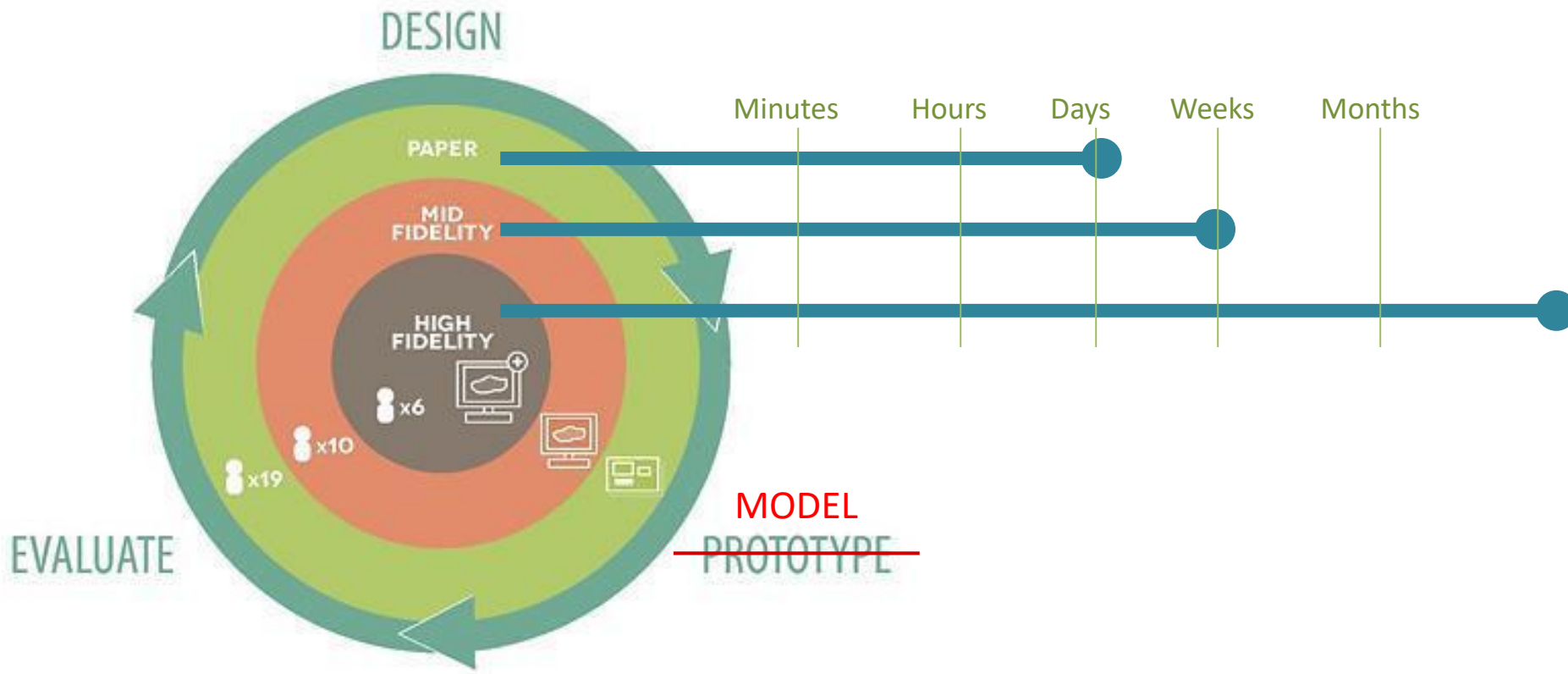
The Design Process Begins With Understanding the “Problem”

- Why are you designing?
- For whom are you designing?
- What are meaningful contributions?

Tools/skills that you might use:

- Time Management: Prioritize Research
- Critical Thinking
- Stakeholder analysis
- Stakeholder Interviews
- Working with people
  - Ethnography
  - Articulated Use Interviews
  - Empathic methods
  - Games
  - Asking Why
- Customer Needs List
- Specifications List

Time spent researching the problem up front saves time later



http://cargocollective.com/ivytsai/Data-Visualization

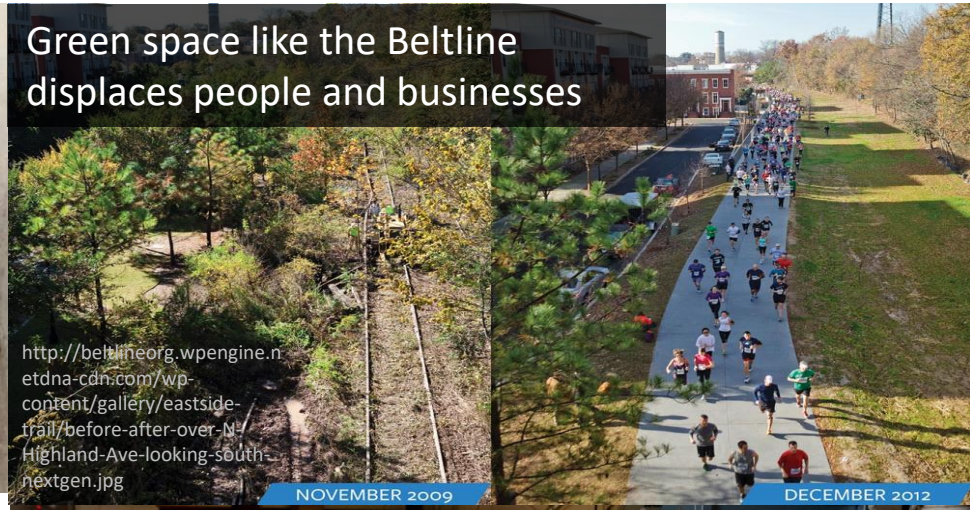
How do you know if your perspective and ideas are good?

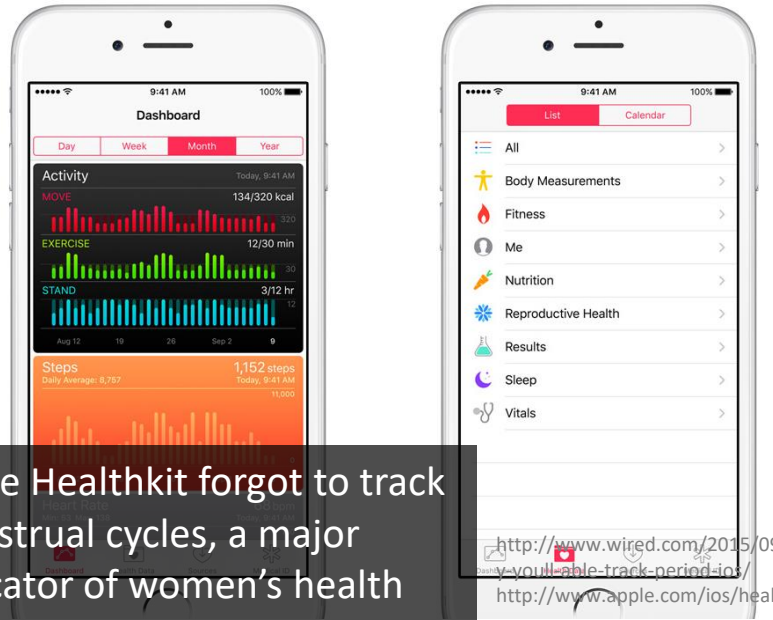
LISTEN – OBSERVE – THINK CRITICALLY

Be thoughtful in how you describe your problem and the needs

Sanitary toilets are uncomfortable, create more work, isolate people

https://www.engineeringforchange.org/why-dont-people-want-toilets-engineering-for-change/





Apple Healthkit forgot to track menstrual cycles, a major indicator of women's health

http://www.wired.com/2015/09/finally-youll-able-track-period-ios/

http://www.apple.com/ios/health/

Baxter wasn't designed with manufacturing procedures and infrastructure in mind

http://[illegible]world24.com/wp-content/uploads/2015/02/NOVEL-1-superjumbo.jpg

Changing your perspective leads to alternative ideas…

Ridesharing seeks to fill excess capacity of cars

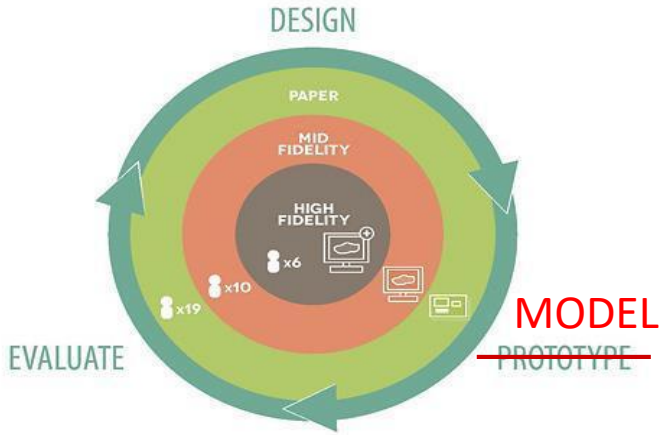
Nintendo recognized increase in mobile gaming market, set out to make mobile games

GPS came about by flipping a satellite tracking exercise around (Steve Johnson TED Talk)

Space that is “just green enough” to keep communities together.
Wolch et al. (2014)

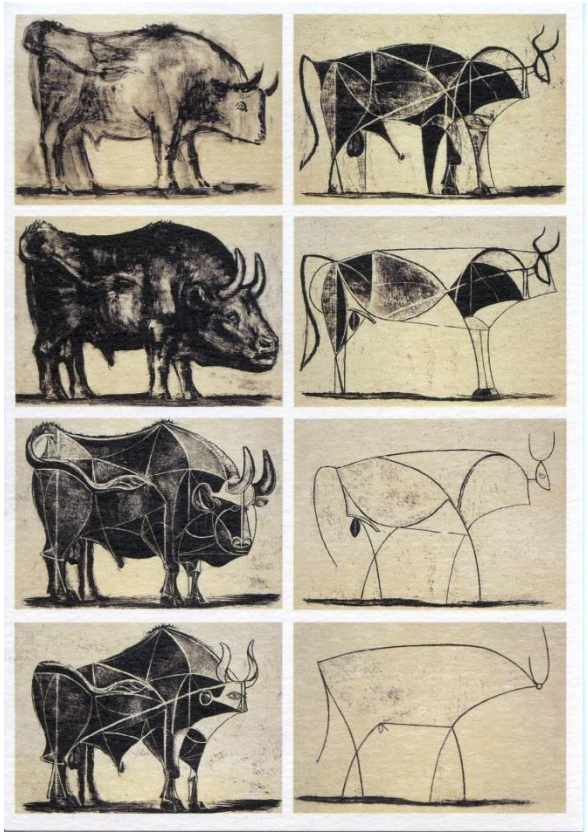
Ideas for early solutions

- Researching precedents
- Alternative problem statements
- Different stories of how something is used
- Different ways something might be used
- Different services that a technology might provide



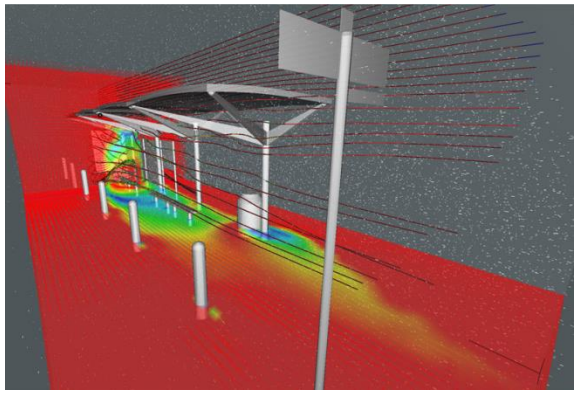
http://cargocollective.com/ivytsai/Data-Visualization

In design we use a number of different types of models of systems and ideas



A Sketch

Picasso's deconstruction of a bull



A Simulation

Sawako Kaijima's comp. fluid dynamics simulation of a cooling bus stop

A Prototype

Cardboard prototype of Wii U Controller

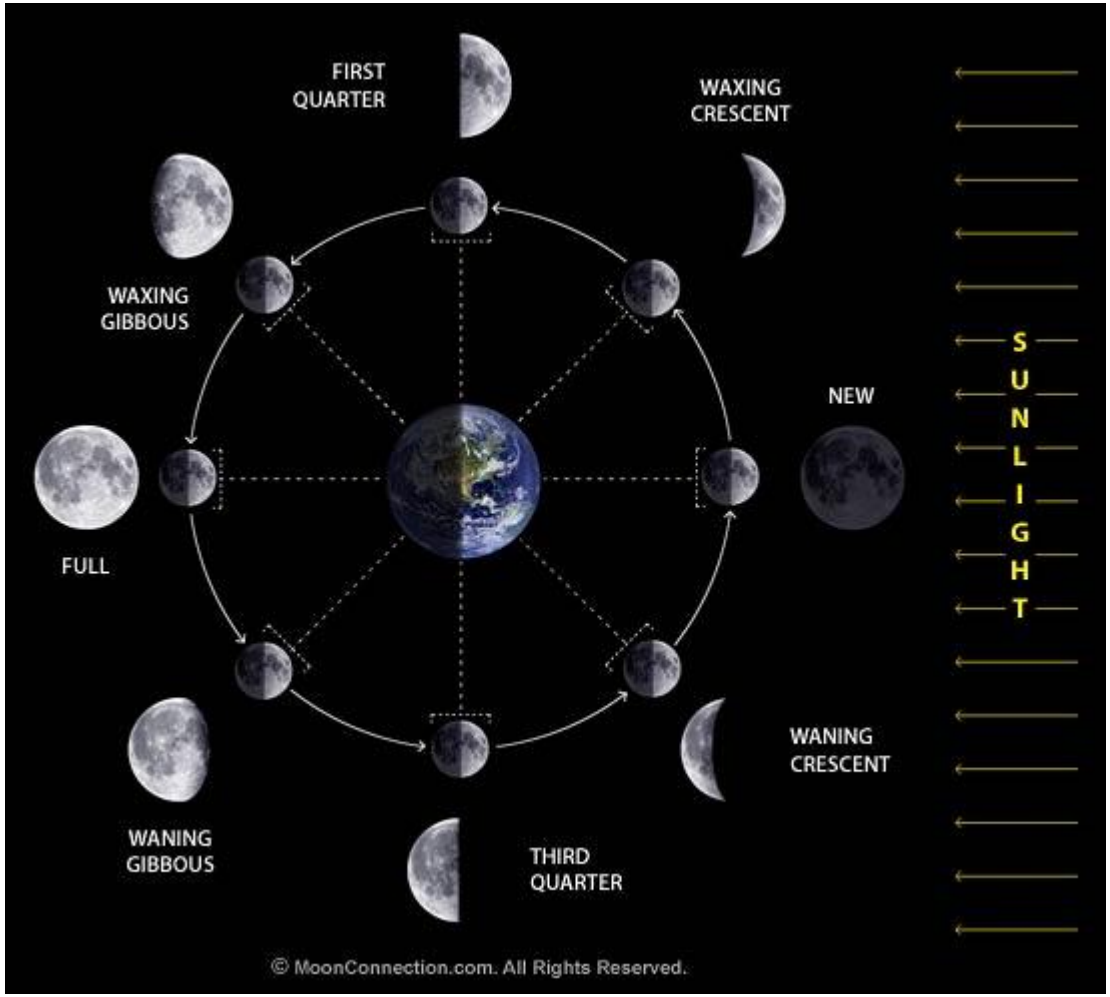
CRITICAL THINKING – The ability to conceive of and examine multiple alternative hypotheses

Why, except during a full moon is part of the moon in a shadow?

Think of two reasons

van Gelder, T. J., 2005, “Teaching Critical Thinking: Some Lessons from Cognitive Science,” Coll. Teach., **45**, pp. 1–6.

One very popular answer is that the earth blocks the sunlight

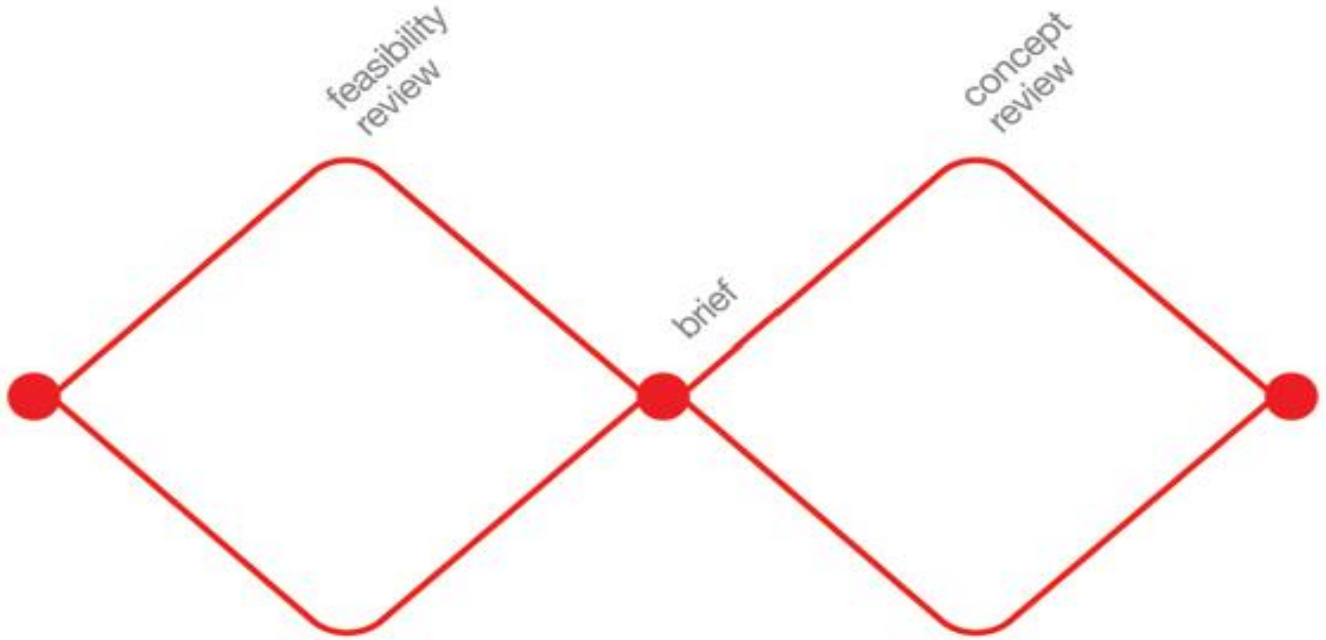


- Wide misconception (e.g. mental model that is not true in this case)
  - How far does a shadow reach?
- Skips critical thinking
  - Need to have an alternative hypothesis/ explanation
- It's the angle we view the moon

van Gelder, T. J., 2005, "Teaching Critical Thinking: Some Lessons from Cognitive Science," Coll. Teach., **45**, pp. 1–6.

Make sure you diverge and converge

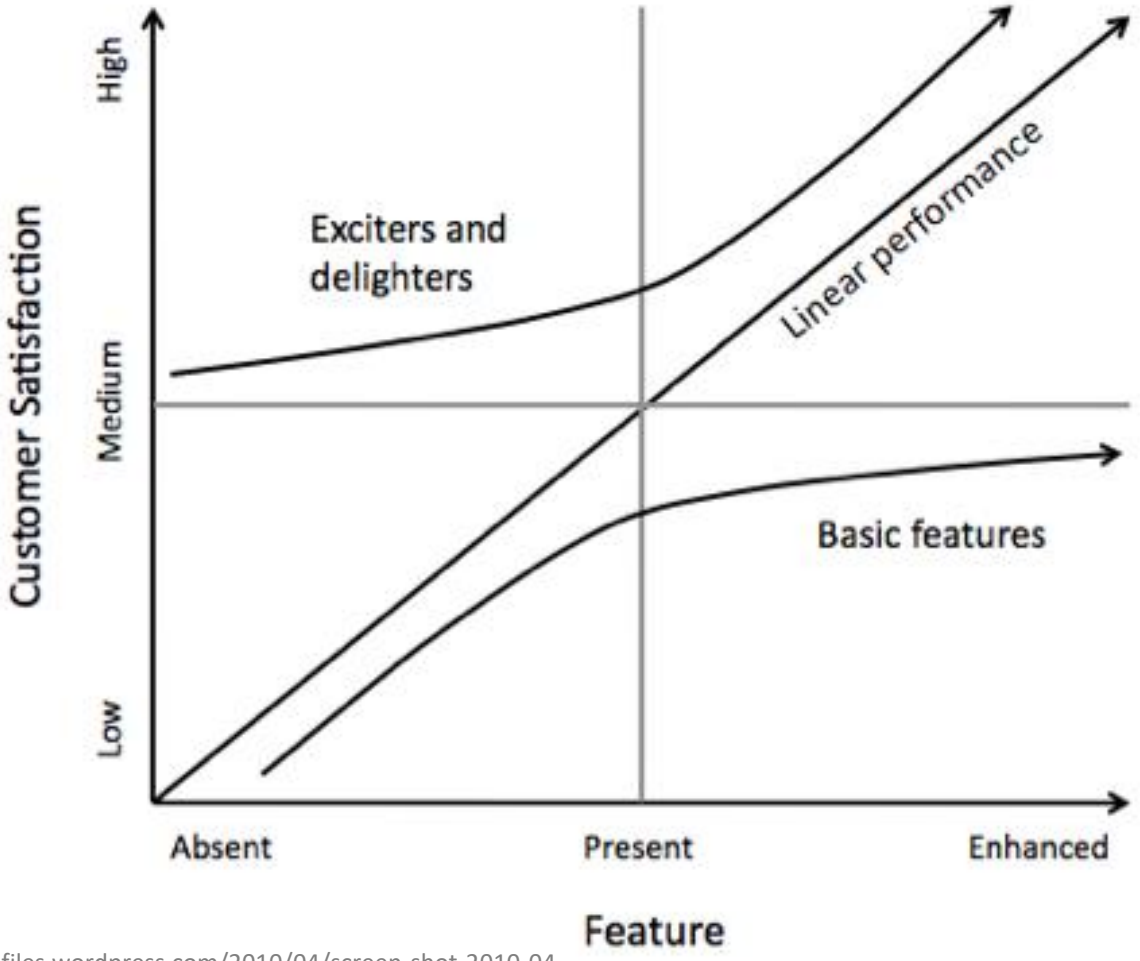
The Double Diamond



Dynamics of divergence and convergence
after Bela H. Banathy (1996)

http://www.designcouncil.org.uk/Documents/Images/Our%20work/Challenges/Health/AandE/Toolkit/DoubleDiamond_580.jpg

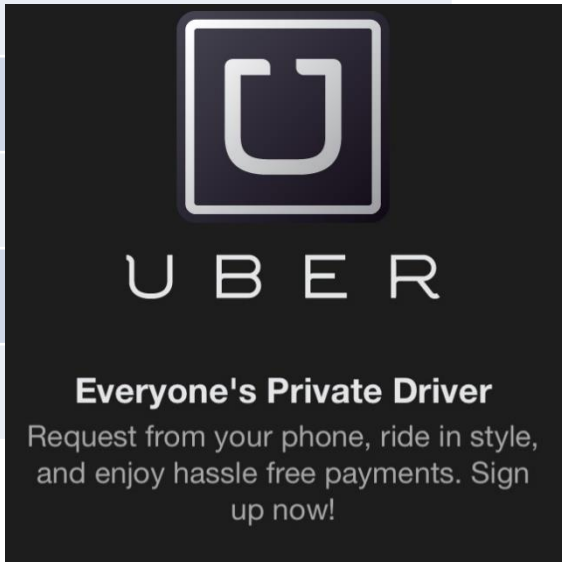
Expectations and exceeding expectations: The Kano Model



https://scalingsoftwareagility.files.wordpress.com/2010/04/screen-shot-2010-04-08-at-9-35-20-am.png

Stakeholder analysis helps you understand the people involved

Primary Who is affected directly?	Secondary Who is affected indirectly?	Tertiary Who else has impact?



Stakeholder categories	Subcategories
Stakeholder "worker"	Freedom of Association and Collective Bargaining Child Labour Fair Salary Working Hours Forced Labour Equal opportunities/Discrimination Health and Safety Social Benefits/Social Security
Stakeholder "consumer"	Health & Safety Feedback Mechanism Consumer Privacy Transparency End of life responsibility
Stakeholder "local community"	Access to material resources Access to immaterial resources Delocalization and Migration Cultural Heritage Safe & healthy living conditions Respect of indigenous rights Community engagement Local employment Secure living conditions
Stakeholder "society"	Public commitments to sustainability issues Contribution to economic development Prevention & mitigation of armed conflicts Technology development Corruption
Value chain actors* not including consumers	Fair competition Promoting social responsibility Supplier relationships Respect of intellectual property rights

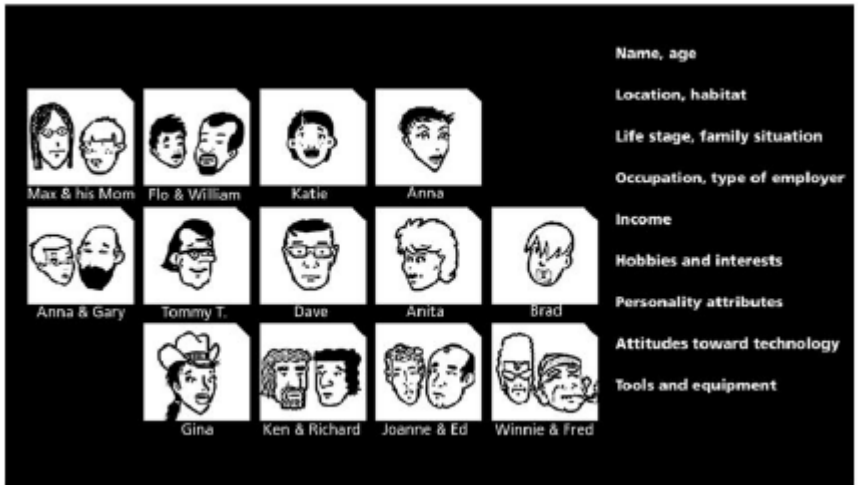
Table 3 – Stakeholder categories and subcategories

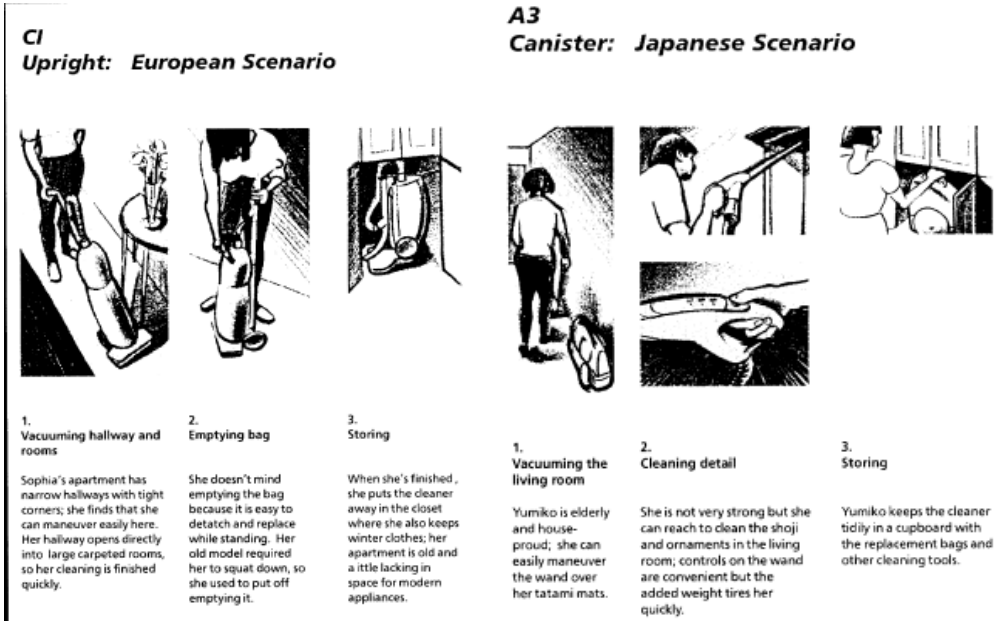
UNEP Setac Life Cycle Initiative. (2009). *Guidelines for Social Life Cycle Assessment of Products. Management*.

Brainstorm stakeholders, research their needs and influence, and rank them

Primary Who is affected directly?	Secondary Who is affected indirectly?	Tertiary Who else has impact?

Stakeholder profiles and scenarios



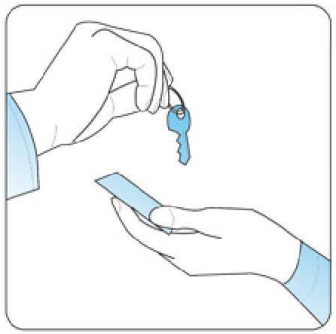


Suri, J. F., and Marsh, M., 2000, "Scenario building as an ergonomics method in consumer product design.," Appl. Ergon., **31**(2), pp. 151–7.

Activity diagrams and storyboards help expand understanding of problems

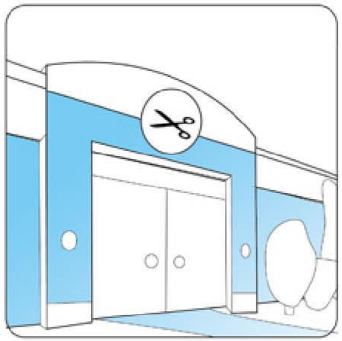
An ideal scenario like this is less helpful for understanding

Arrival



Greg gives his keys to the valet upon arrival, receiving a plastic card in return

Greg goes to his appointment to have his hair cut

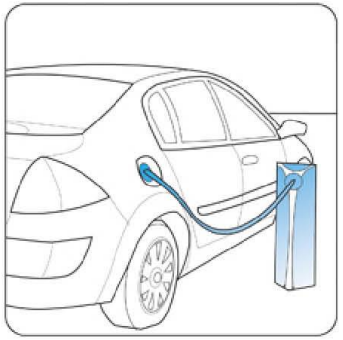


10 min

The valet attendant parks the EV and plugs it in to charge

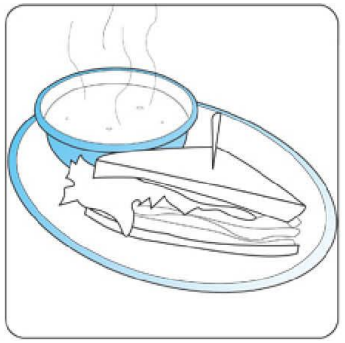
After leaving the hair salon, he buys some lunch

20 min

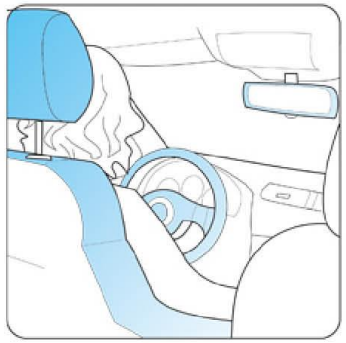


The EV is still charging

Greg takes his time, not having to worry about moving his car

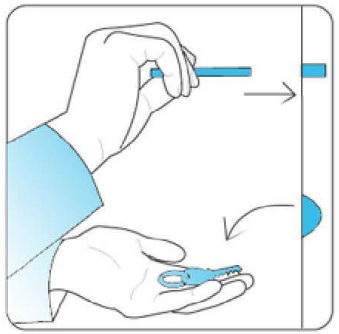


30 min



The car is fully charged and moved to a parking space. Valet drops off the key in a machine

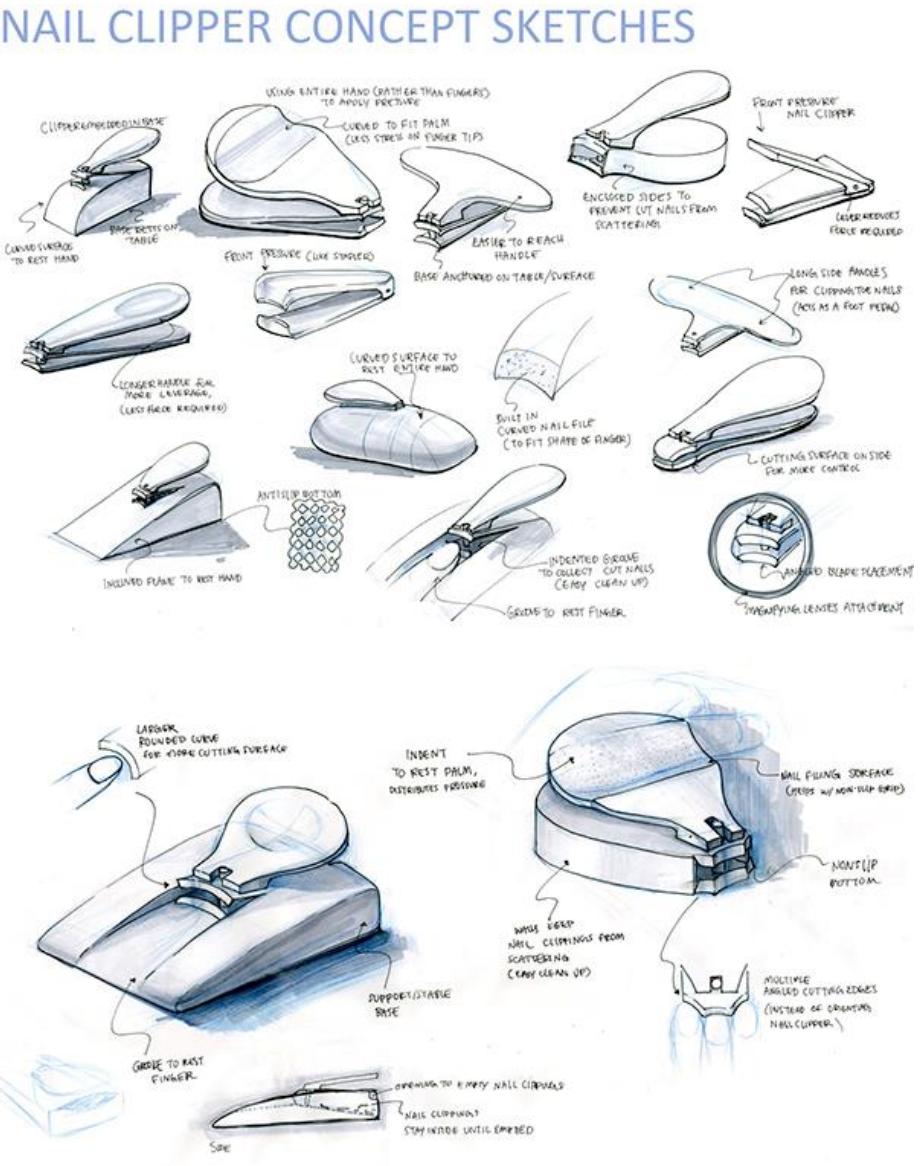
40 min

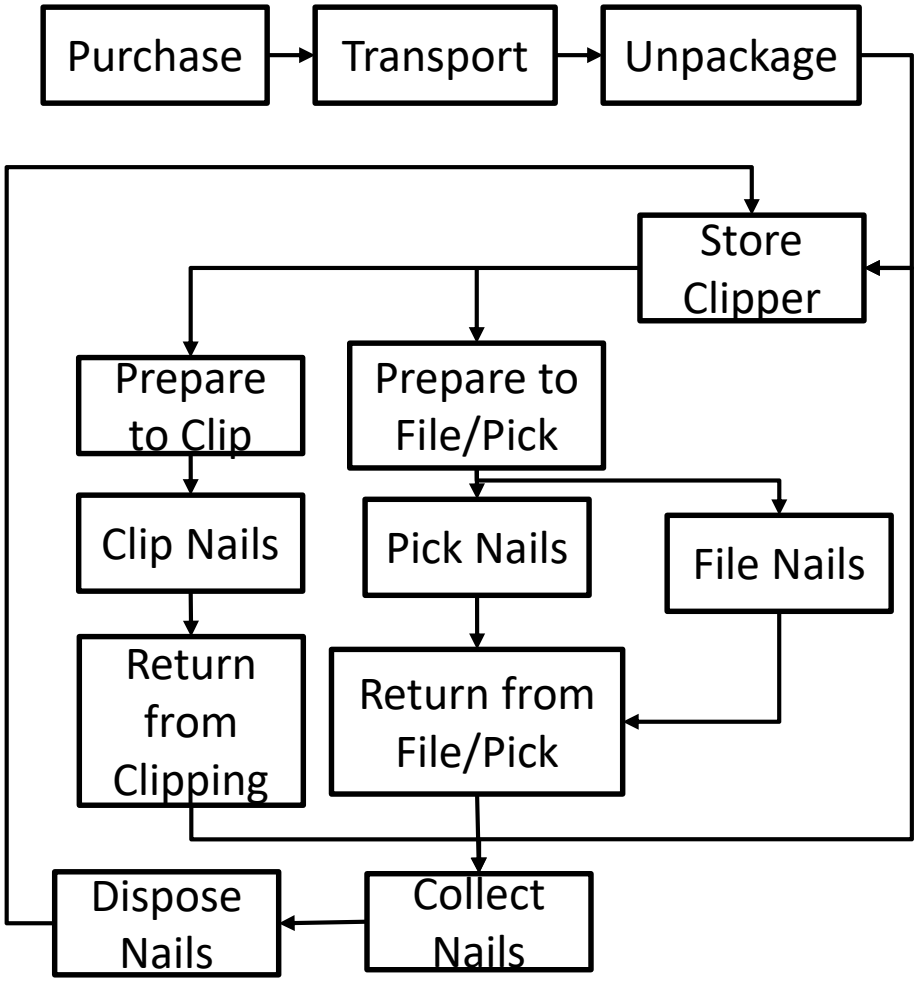


Greg inserts his valet card to a machine to receive his keys to his fully charged EV

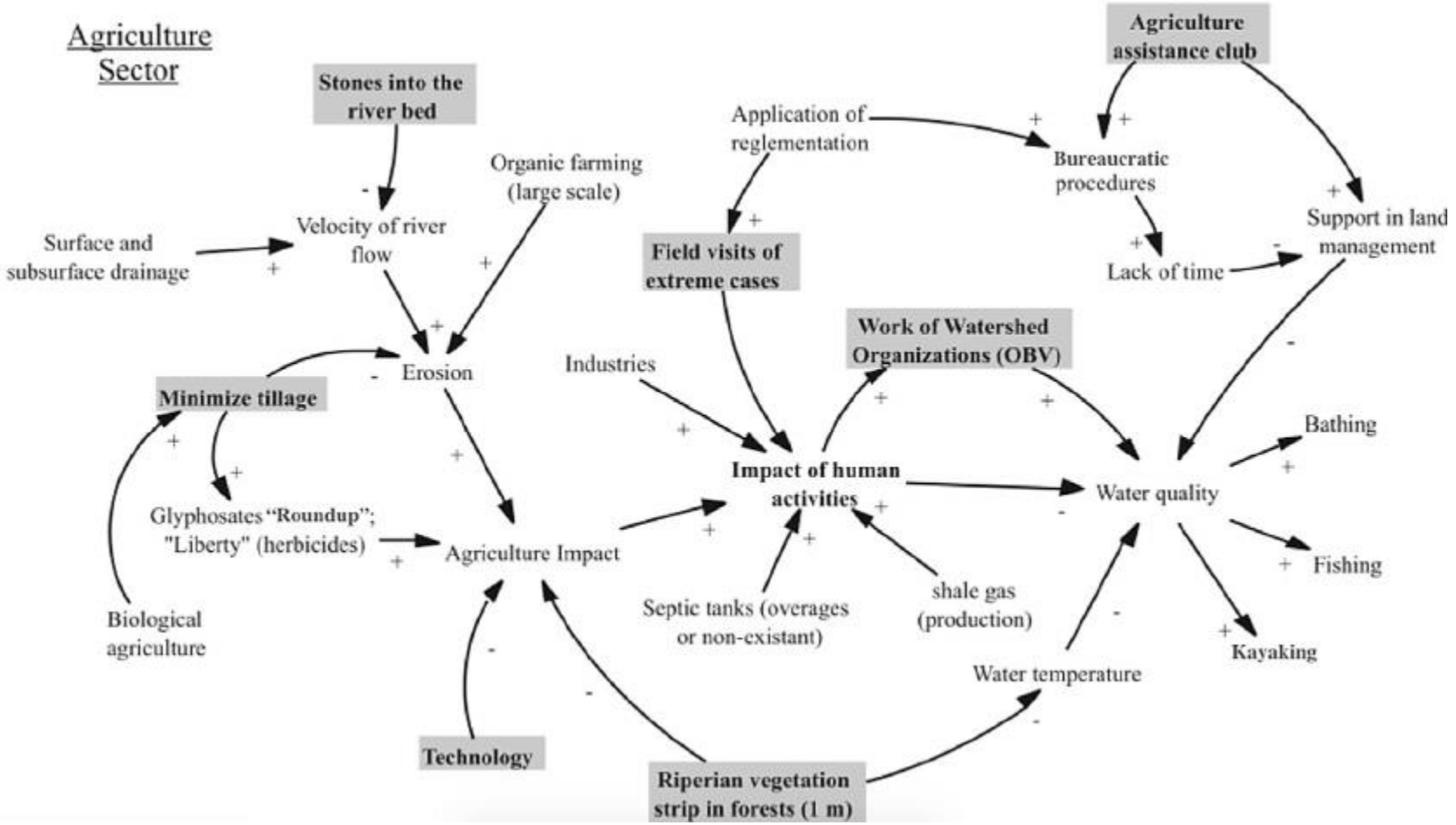
http://mocosubmit.com/ev-centre-a-thirty-minute-solution/

Activity diagrams and storyboards help expand understanding of problems



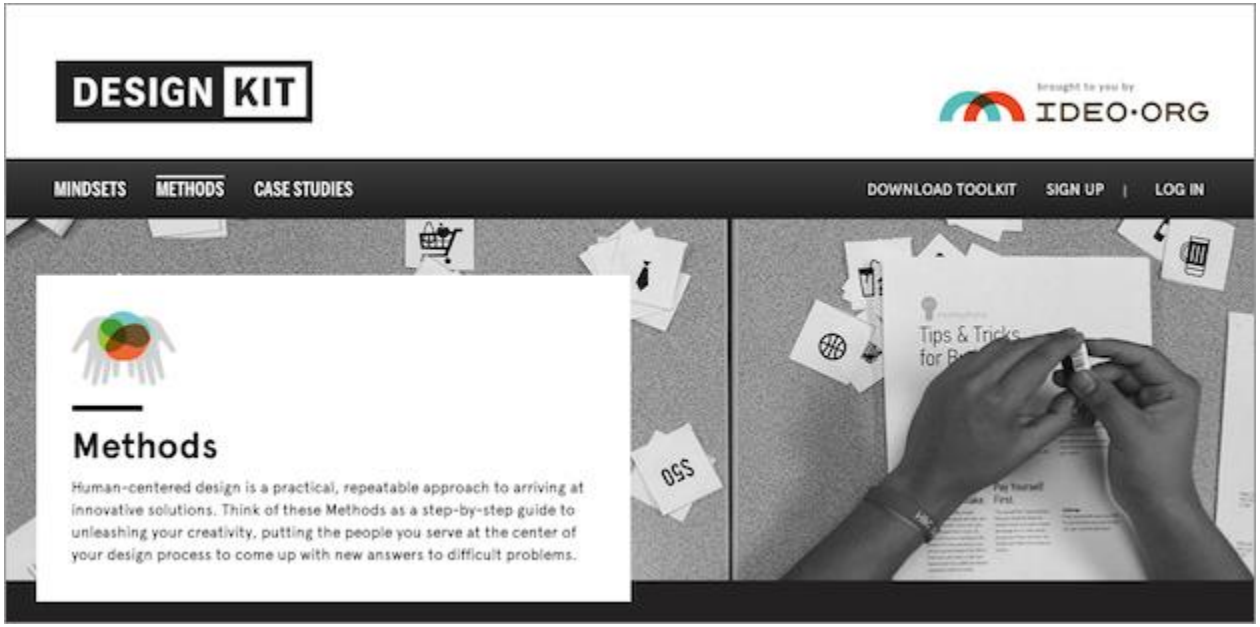


Engaging stakeholders authentically can lead to insights



Example of a causal loop diagram created with stakeholders from the agriculture sector in a case study for the Du Chêne, Quebec watershed.
http://epubs.icar.org.in/ejournal/index.php/JAE/article/view/14654

Design Kit: The Field Guide to Human-Centered Design



http://www.designkit.org/

Identify the users you can interview or observe or engage

	Lead Users	Users	Retailer or Sales Outlet	Service Centers
Homeowner (occasional use)	0	5	2	3
Handy person (frequent use)	3	10		
Professional (heavy-duty use)	3	2	2	

Ulrich, K., and Eppinger, S., 1995, Product design and development, McGraw-Hill/Irwin.

the best way to design paths “is to not design them at all”, but allow them to be revealed by the users – Carl Myhill, GE

Flicker. CogDog. Life Philosophy.

http://www.37days.com/2005/12/follow_your_des.html

Ethnography

http://www.lieveld.com/the-role-of-ux-research-in-designing-a-mobile-app/

“Empathic” Approaches

https://www.youtube.com/watch?v=pp_FkS5lzqM

https://www.rddusa.com/wp-content/uploads/2015/07/glorope.jpg

Articulated Use Interviews

1. Identify User Profiles
2. Schedule Use Interviews (10-30)
3. Bring Product and Ask Customer to Use the Product
   - Pay attention to pauses, noises
   - Ask “I just saw you X, why?” “Why did you sigh just now?” “What is it you are doing right now?”
   - Take Notes
4. Wrap Up Questions
   - Ask likes first
   - Ask dislikes last

Customer:	Bill Esposito	**Interviewer(s):**	Jonathan and Lisa
Address:	100 Memorial Drive Cambridge, MA 02139	**Date:**	19 December 2010
Telephone:	617-864-1274	**Currently uses:**	Craftsman Model A3
Willing to do follow-up?	Yes	**Type of user:**	Building maintenance

Question/Prompt	Customer Statement	Interpreted Need
Typical uses	I need to drive screws fast, faster than by hand.	The SD drives screws faster than by hand.
	I sometimes do duct work; use sheet metal screws.	The SD drives sheet metal screws into metal duct work.
	A lot of electrical; switch covers, outlets, fans, kitchen appliances.	The SD can be used for screws on electrical devices.
Likes—current tool	I like the pistol grip; it feels the best.	The SD is comfortable to grip.
	I like the magnetized tip.	The SD tip retains the screw before it is driven.
Dislikes—current tool	I don’t like it when the tip slips off the screw.	The SD tip remains aligned with the screw head without slipping.
	I would like to be able to lock it so I can use it with a dead battery.	The user can apply torque manually to the SD to drive a screw. (!)
	Can’t drive screws into hard wood.	The SD can drive screws into hard wood.
	Sometimes I strip tough screws.	The SD does not strip screw heads.
Suggested improvements	An attachment to allow me to reach down skinny holes.	The SD can access screws at the end of deep, narrow holes.
	A point so I can scrape paint off of screws.	The SD allows the user to work with screws that have been painted over.
	Would be nice if it could punch a pilot hole.	The SD can be used to create a pilot hole. (!)

EXHIBIT 5-6 Customer data template filled in with sample customer statements and interpreted needs. SD is an abbreviation for screwdriver. (Note that this template represents a partial list from a single interview. A typical interview session may elicit more than 50 customer statements and interpreted needs.)

Ulrich, K., and Eppinger, S., 1995, Product design and development, McGraw-Hill/Irwin.

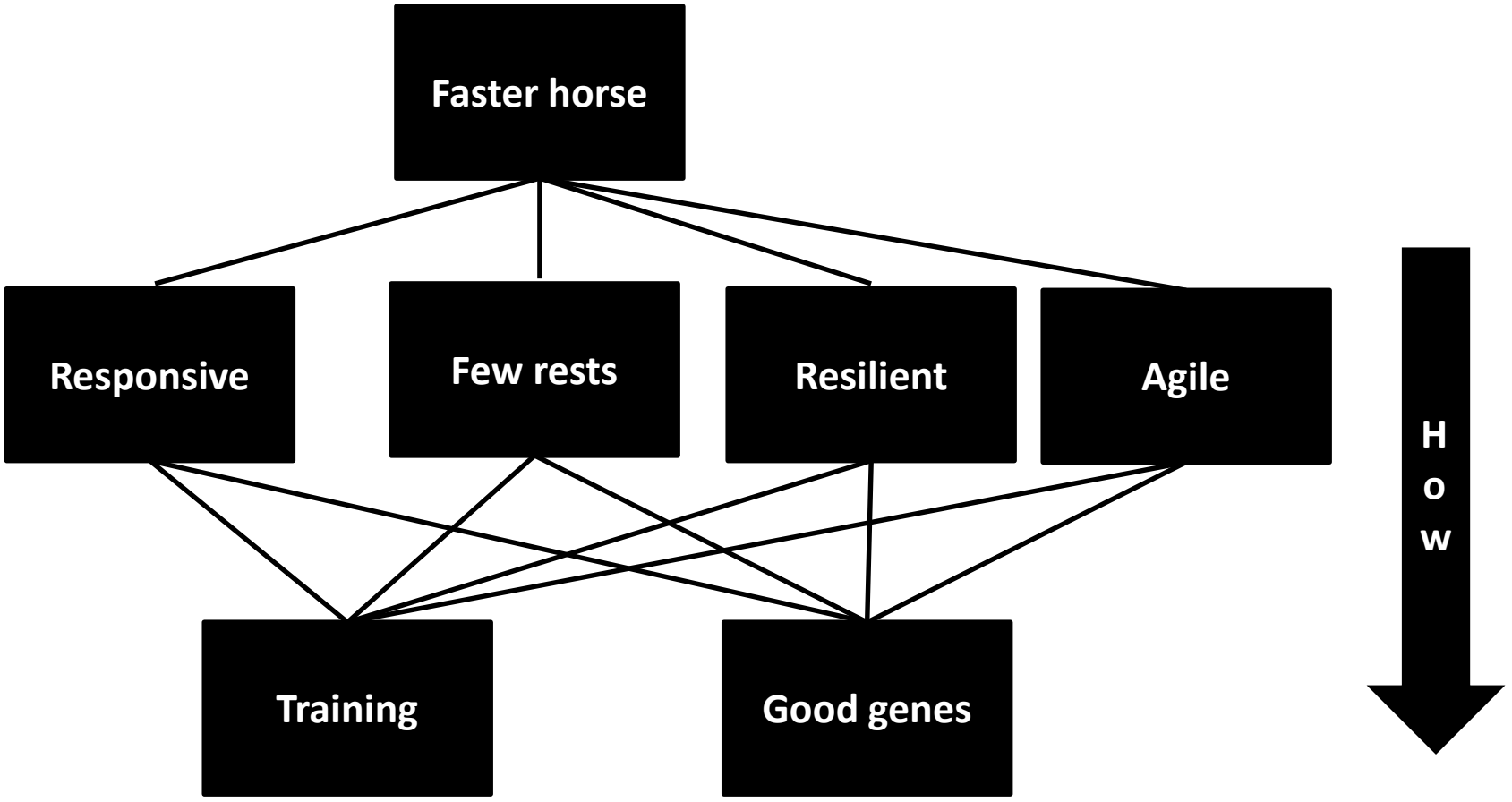
There are many ways to investigate products and systems related to your design

"On the first day they ran it, the goal of the game wasn't to actually design financial products on the spot, but to grasp how members of this community felt about loans and what factors made them willing to take them on. The team learned about how bank loans were perceived as inaccessible to those with little income, but also how getting money from a loan shark was easy, but caused significant anxiety. They also used the game to probe deeper into what kind of financial support people most wanted. By getting participants to change some of the variables, they were able to see what kind of loans were attractive and which sort would never work…" – The Field Guide to Human Centered Design (DesignKit)

Needs finding helps you formulate goal statements and requirements

“If I had asked my customers what they wanted they would have said a faster horse.”
– Henry Ford

Converging:
Asking How Narrows Your Options



Diverging:
Asking Why Opens Possibilities

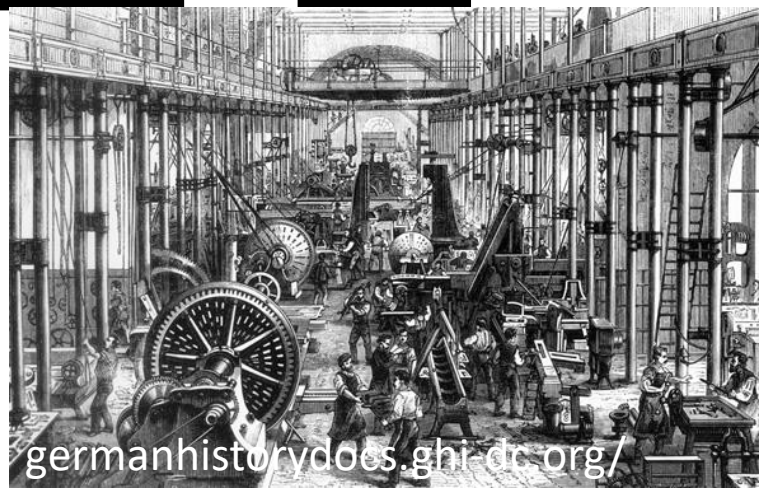
Feel powerful

See more in less time

Do more in less time

Machines

WHY?



Formulating User/Human Needs

Guideline	Customer Statement	Need Statement—Right	Need Statement—Wrong
"What" not "how"	"Why don't you put protective shields around the battery contacts?"	The screwdriver battery is protected from accidental shorting.	The screwdriver battery contacts are covered by a plastic sliding door.
Specificity	"I drop my screwdriver all the time."	The screwdriver operates normally after repeated dropping.	The screwdriver is rugged.
Positive not negative	"It doesn't matter if it's raining; I still need to work outside on Saturdays."	The screwdriver operates normally in the rain.	The screwdriver is not disabled by the rain.
An attribute of the product	"I'd like to charge my battery from my cigarette lighter."	The screwdriver battery can be charged from an automobile cigarette lighter.	An automobile cigarette lighter adapter can charge the screwdriver battery.
Avoid "must" and "should"	"I hate it when I don't know how much juice is left in the batteries of my cordless tools."	The screwdriver provides an indication of the energy level of the battery.	The screwdriver should provide an indication of the energy level of the battery.

Ulrich, K., and Eppinger, S., 1995, Product design and development, McGraw-Hill/Irwin.

Keep track of the observed and stated needs and their importance

The SD provides plenty of power to drive screws.
- * The SD maintains power for several hours of heavy use.
- ** The SD can drive screws into hardwood.
- The SD drives sheet metal screws into metal ductwork.
- *** The SD drives screws faster than by hand.

The SD makes it easy to start a screw.
- * The SD retains the screw before it is driven.
- *! The SD can be used to create a pilot hole.

The SD works with a variety of screws.
- ** The SD can turn Phillips, Torx, socket, and hex head screws.
- ** The SD can turn many sizes of screws.

The SD can access most screws.
- The SD can be maneuvered in tight areas.
- ** The SD can access screws at the end of deep, narrow holes.

The SD turns screws that are in poor condition.
- The SD can be used to remove grease and dirt from screws.
- The SD allows the user to work with painted screws.

The SD feels good in the user's hand.
- *** The SD is comfortable when the user pushes on it.
- *** The SD is comfortable when the user resists twisting.
- * The SD is balanced in the user's hand.
- ! The SD is equally easy to use in right or left hands.
- The SD weight is just right.
- The SD is warm to touch in cold weather.
- The SD remains comfortable when left in the sun.

The SD is easy to control while turning screws.
- *** The user can easily push on the SD.
- *** The user can easily resist the SD twisting.
- The SD can be locked "on."
- **! The SD speed can be controlled by the user while turning a screw.
- * The SD remains aligned with the screw head without slipping.
- ** The user can easily see where the screw is.
- * The SD does not strip screw heads.
- * The SD is easily reversible.

The SD is easy to set up and use.
- * The SD is easy to turn on.
- * The SD prevents inadvertent switching off.
- * The user can set the maximum torque of the SD.
- *! The SD provides ready access to bits or accessories.
- * The SD can be attached to the user for temporary storage.

The SD power is convenient.
- * The SD is easy to recharge.
- The SD can be used while recharging.
- *** The SD recharges quickly.
- The SD batteries are ready to use when new.
- **! The user can apply torque manually to the SD to drive a screw.

The SD lasts a long time.
- ** The SD tip survives heavy use.
- The SD can be hammered.
- * The SD can be dropped from a ladder without damage.

The SD is easy to store.
- * The SD fits in a toolbox easily.
- ** The SD can be charged while in storage.
- The SD resists corrosion when left outside or in damp places.
- *! The SD maintains its charge after long periods of storage.
- The SD maintains its charge when wet.

The SD prevents damage to the work.
- * The SD prevents damage to the screw head.
- The SD prevents scratching of finished surfaces.

The SD has a pleasant sound when in use.

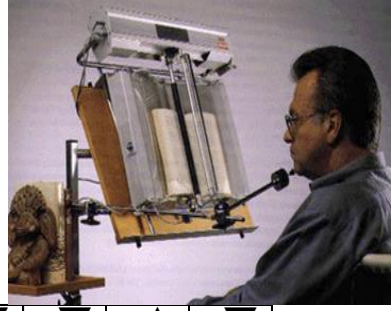
The SD looks like a professional quality tool.

The SD is safe.
- The SD can be used on electrical devices.
- *** The SD does not cut the user's hands.

EXHIBIT 5-8 Hierarchical list of primary and secondary customer needs for the cordless screwdriver. Importance ratings for the secondary needs are indicated by the number of *'s, with *** denoting critically important needs. Latent needs are denoted by !.

Ulrich, K., and Eppinger, S., 1995, Product design and development, McGraw-Hill/Irwin.

Translating human needs to measurable specifications



Direction of Improvement	▲	▼	▼	▼	◇	◇	◇	▼	▼	▼	▼	▲	▼	▼	▲	▼
Customer Requirements (Explicit and Implicit) / Engineering Requirements	tolerance of user-initated motions	grip force required of operator	total mass	carrying dimensions	auditory volume of signals	match signals with user generated action	intensity of visual signals	number of assembly and disassembly orie	error in aligning parts	# specialty components	# tools needed to repair	granularity of page turning control	error rate in page turning	rate of wear of components	adjustable range of dimensions	force on the page
operable by person with disabilities	○	●														
Portable/Mobile			○	○												
Signals when performing desired actions					●	●	●									
lightweight			●													
repairable by staff								▽	●	●	○					
easily replaceable parts										●						
predictable page turning												○	●			
low failure rate													○	●		
safely handles variety of reading materials															●	●

Specification Sheet

Requirement	Target Value	Resp.	Test	Source
Geometry				
Range of book heights	3-12 in	Donnell	Measurements; book sample studies	Book study [1]
Range of book thicknesses	0.5-3 in	Donnell	Measurements; book sample studies	Book study [1]
Range of book widths	5-10 in	Donnell	Measurements; book sample studies	Book study [1]
Forces				
Shear force on the page	< 40g/m^2	Telenko	calculation; book sample studies	TAPPI Newspaper [2]

Requirements List Checklist

Main headings	Examples
Geometry	Size, height, breadth, length, diameter, space requirement, number, arrangement, connection, extension
Kinematics	Type of motion, direction of motion, velocity, acceleration
Forces	Direction of force, magnitude of force, frequency, weight, load, deformation, stiffness, elasticity, inertia forces, resonance
Energy	Output, efficiency, loss, friction, ventilation, state, pressure, temperature, heating, cooling, supply, storage, capacity, conversion.
Material	Flow and transport of materials. Physical and chemical properties of the initial and final product, auxiliary materials, prescribed materials (food regulations etc)
Signals	Inputs and outputs, form, display, control equipment.
Safety	Direct safety systems, operational and environmental safety.
Ergonomics	Man-machine relationship, type of operation, operating height, clarity of layout, sitting comfort, lighting, shape compatibility.
Production	Factory limitations, maximum possible dimensions, preferred production methods, means of production, achievable quality and tolerances, wastage.
Quality control	Possibilities of testing and measuring, application of special regulations and standards.
Assembly	Special regulations, installation, siting, foundations.
Transport	Limitations due to lifting gear, clearance, means of transport (height and weight), nature and conditions of despatch.
Operation	Quietness, wear, special uses, marketing area, destination (for example, sulphurous atmosphere, tropical conditions).
Maintenance	Servicing intervals (if any), inspection, exchange and repair, painting, cleaning.
Recycling	Reuse, reprocessing, waste disposal, storage
Costs	Maximum permissible manufacturing costs, cost of tooling, investment and depreciation.
Schedules	End date of development, project planning and control, delivery date

Pahl, G., and Beitz, W., 1999, Engineering Design: A Systematic Approach, Springer-Verlag, London.

What makes a good specification?

A good specification states something that is **necessary, verifiable**, and **attainable**.

Common Issues

- Making bad assumptions
- Writing implementation (*HOW*) instead of requirements (*WHAT*)
- Describing *operations* instead of writing *requirements*
- Using incorrect terms
- Using incorrect sentence structure or bad grammar
- Missing requirements
- Over-specifying

Task: “customer [stakeholder] needs”

- Identify the stakeholders
- Research the stakeholders, contexts, and prior solutions
- Identify ways of engaging stakeholders
- Prepare and start engaging stakeholders
- Clarify “customer [stakeholder] needs”

Use the Excel templates (stakeholder & specd) on ME Capstone site for data capture…

QUESTIONS?