

# Defining the Design Opportunities

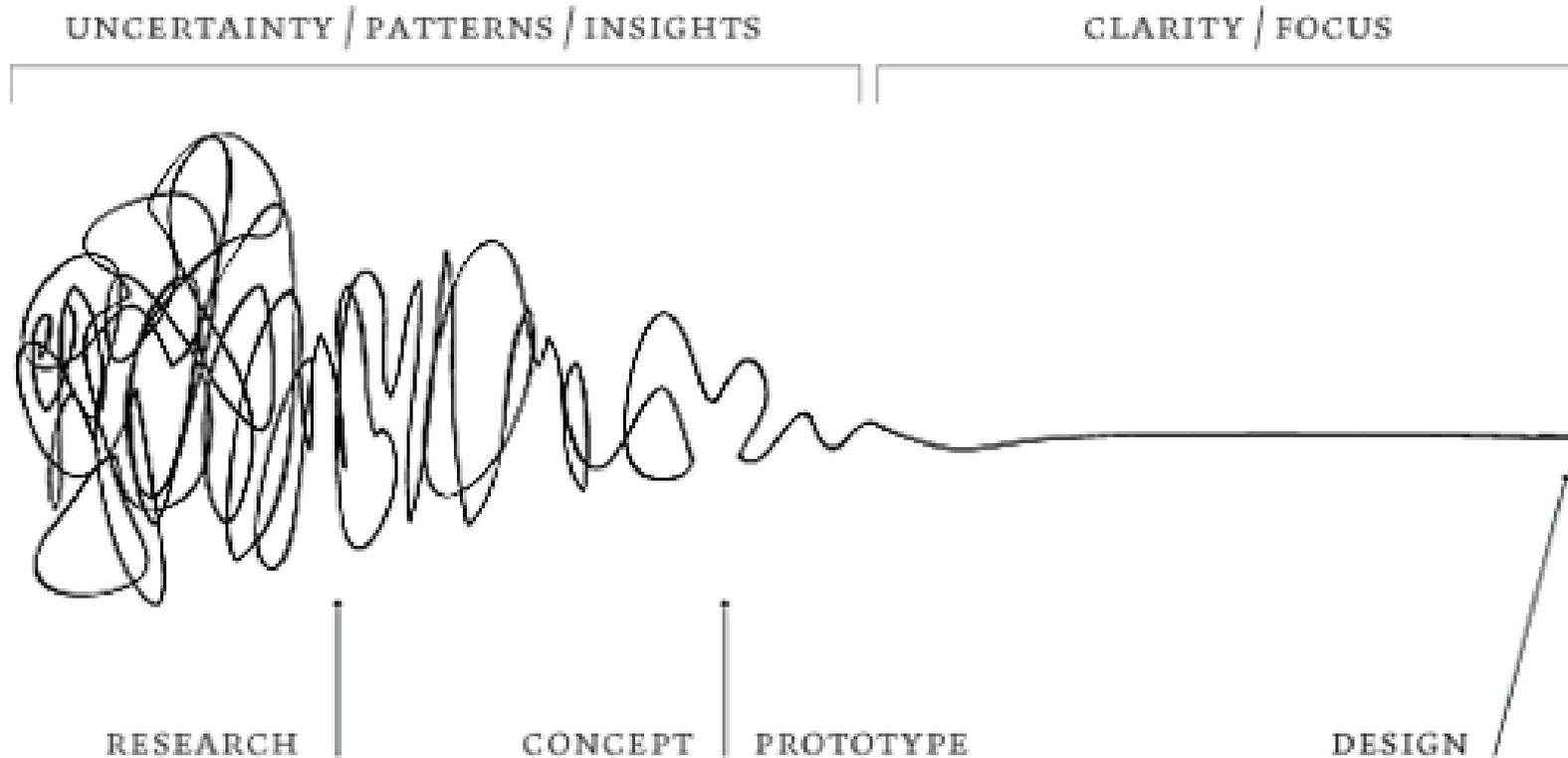
Cassandra Telenko, PhD  
Mechanical Engineering  
Capstone Design  
Fall 2017

# The Design Process Begins With Understanding the “Problem”

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

# The Design Process Continually Develops Understanding of the Goals

## Damien Newman's Design Squiggle



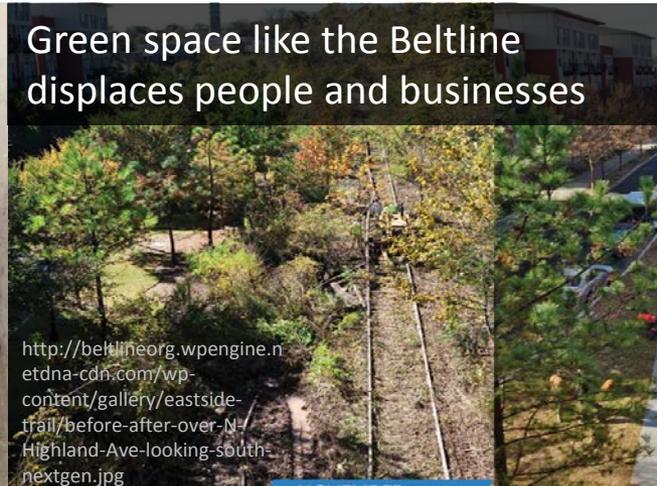
# Be thoughtful in how you describe your problem and the needs



Sanitary toilets are uncomfortable, create more work, isolate people



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



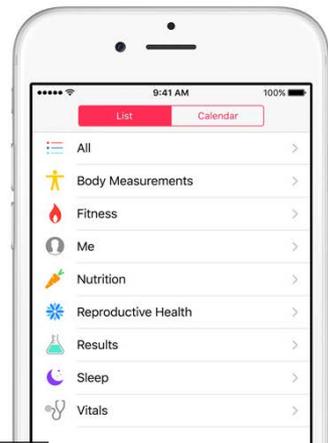
Green space like the Beltline displaces people and businesses

<http://beltlineorg.wpengine.netdna-cdn.com/wp-content/gallery/eastside-trail/before-after-over-N-Highland-Ave-looking-south-nextgen.jpg>

NOVEMBER 2009



DECEMBER 2012



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

<http://www.wired.com/2015/09/finally-youll-be-able-to-track-period-ios/>  
<http://www.apple.com/ios/health/>



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

<http://imgworld24.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)



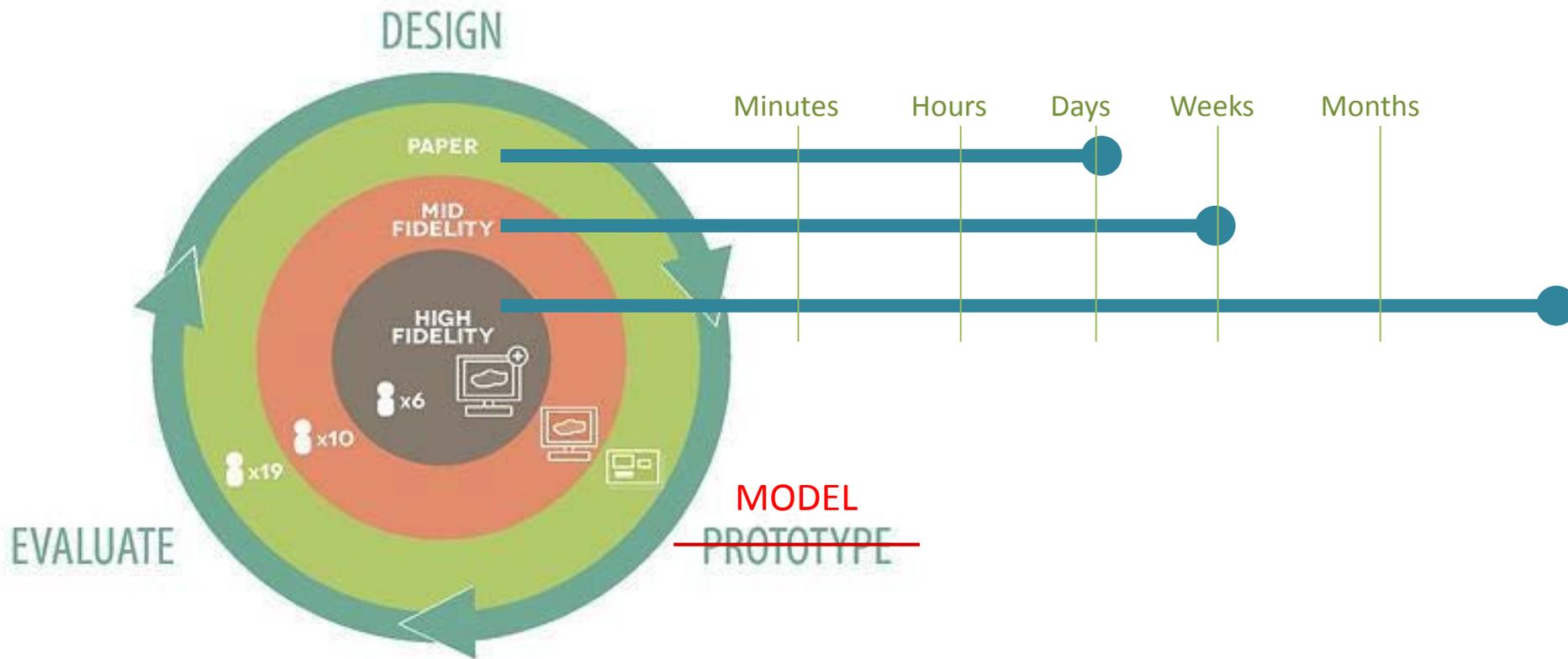
Space that is "just green enough" to keep communities together. Wolch et al. (2014)



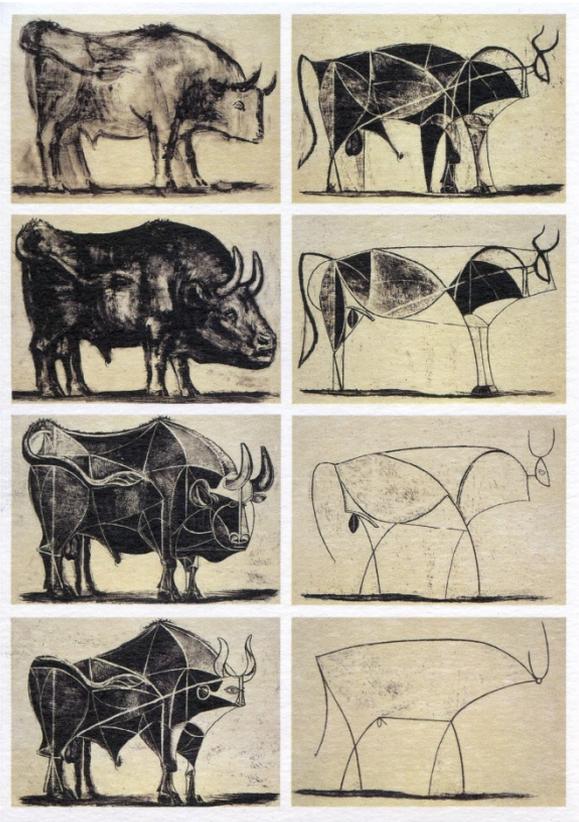
How do you know if your perspective  
and ideas are good?

**LISTEN – OBSERVE – THINK CRITICALLY**

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



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



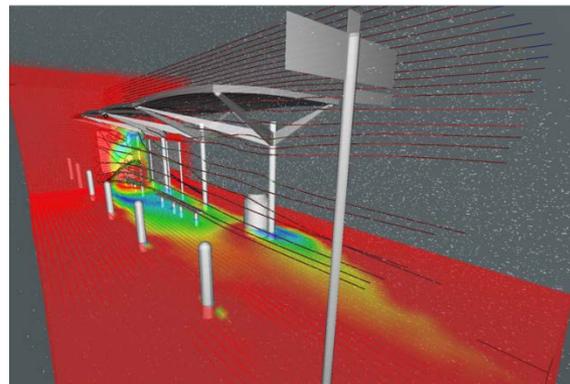
## A Sketch

Picasso's  
deconstruction of a bull



## A Prototype

Cardboard prototype of  
Wii U Controller



## A Simulation

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

# Ideas for early prototyping

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

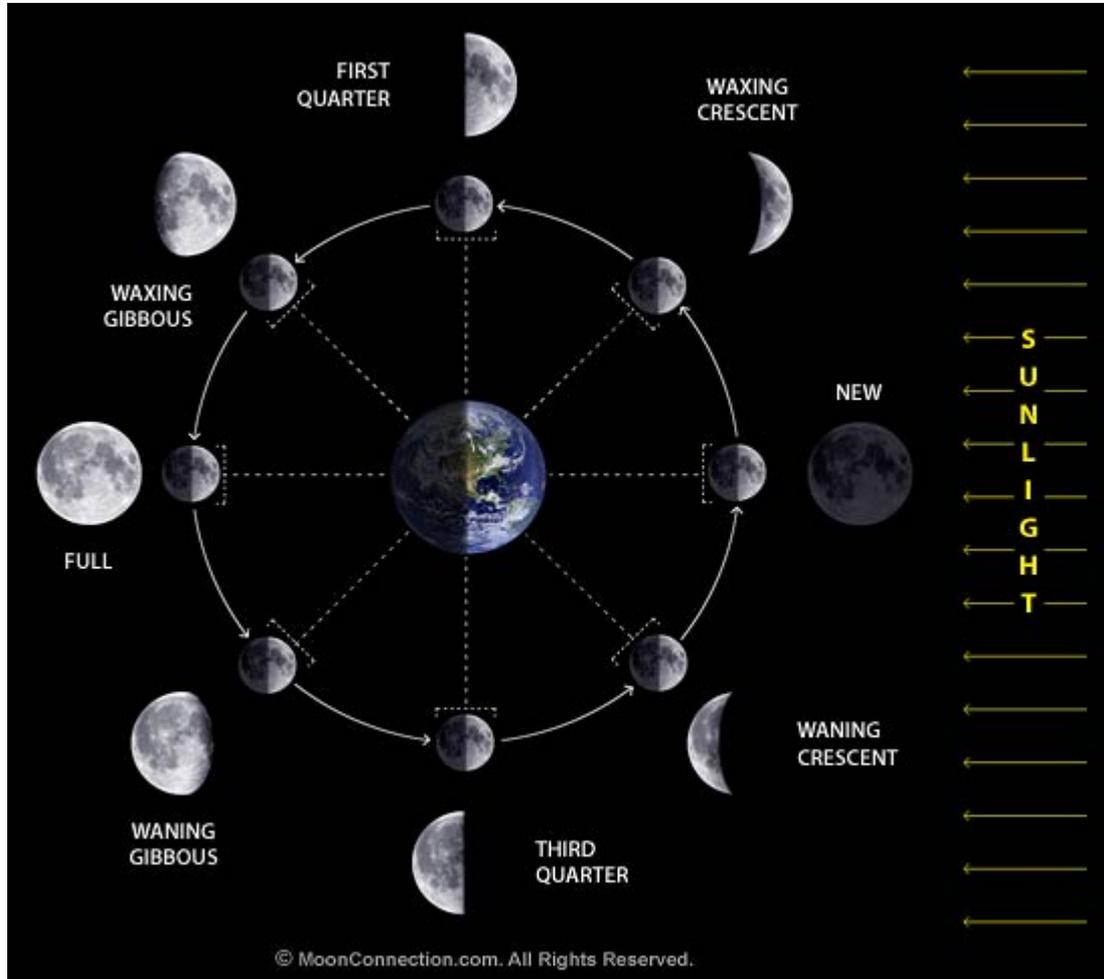
**CRITICAL THINKING – The ability to conceive of and examine multiple alternative hypotheses**

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

Think of two reasons



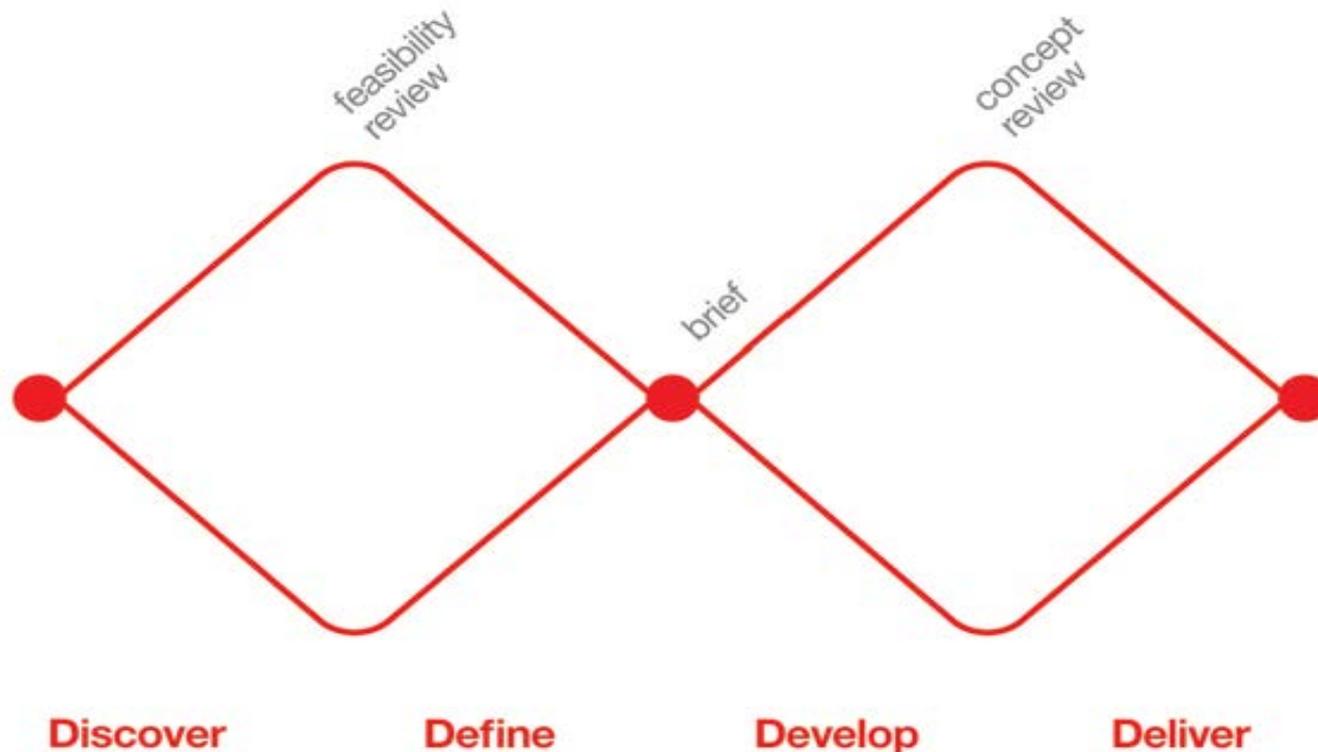
# One very popular answer is that the earth blocks the sunlight



- 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

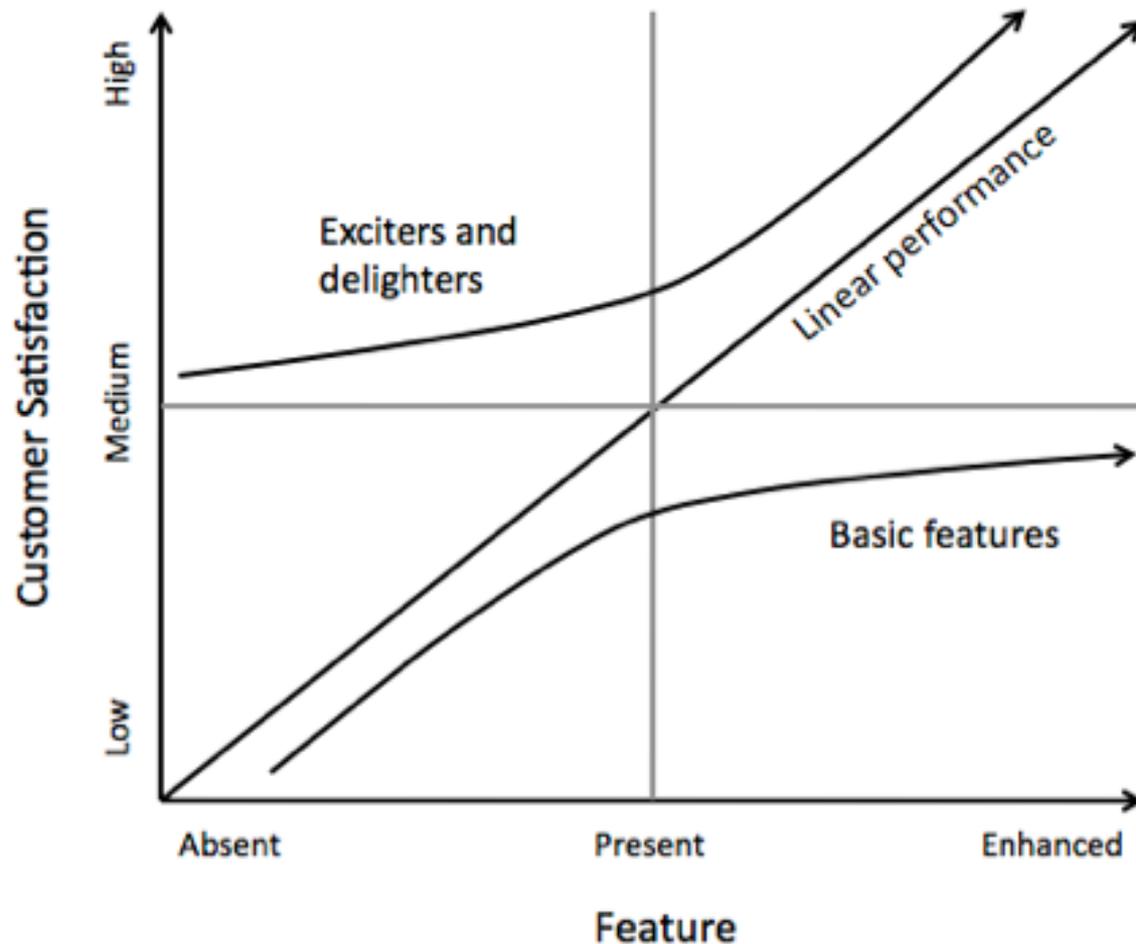
# Make sure you diverge and converge

## The Double Diamond



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

# Expectations and exceeding expectations: The Kano Model





Stakeholder categories	Subcategories
<b>Stakeholder “worker”</b>	<ul style="list-style-type: none"> <li>Freedom of Association and Collective Bargaining</li> <li>Child Labour</li> <li>Fair Salary</li> <li>Working Hours</li> <li>Forced Labour</li> <li>Equal opportunities/Discrimination</li> <li>Health and Safety</li> <li>Social Benefits/Social Security</li> </ul>
<b>Stakeholder “consumer”</b>	<ul style="list-style-type: none"> <li>Health &amp; Safety</li> <li>Feedback Mechanism</li> <li>Consumer Privacy</li> <li>Transparency</li> <li>End of life responsibility</li> </ul>
<b>Stakeholder “local community”</b>	<ul style="list-style-type: none"> <li>Access to material resources</li> <li>Access to immaterial resources</li> <li>Delocalization and Migration</li> <li>Cultural Heritage</li> <li>Safe &amp; healthy living conditions</li> <li>Respect of indigenous rights</li> <li>Community engagement</li> <li>Local employment</li> <li>Secure living conditions</li> </ul>
<b>Stakeholder “society”</b>	<ul style="list-style-type: none"> <li>Public commitments to sustainability issues</li> <li>Contribution to economic development</li> <li>Prevention &amp; mitigation of armed conflicts</li> <li>Technology development</li> <li>Corruption</li> </ul>
<b>Value chain actors* not including consumers</b>	<ul style="list-style-type: none"> <li>Fair competition</li> <li>Promoting social responsibility</li> <li>Supplier relationships</li> <li>Respect of intellectual property rights</li> </ul>

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

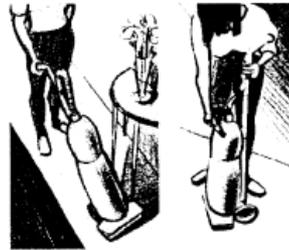
**Table 3** – Stakeholder categories and subcategories



# Stakeholder profiles and scenarios

Name, age	Location, habitat	Life stage, family situation	Occupation, type of employer	Income	Hobbies and interests	Personality attributes	Attitudes toward technology	Tools and equipment
Max & his Mom	Flo & William	Katie	Anna	Anna & Gary	Tommy T.	Dave	Anita	Brad
Gina	Ken & Richard	Joanne & Ed	Winnie & Fred					

## CI Upright: European Scenario

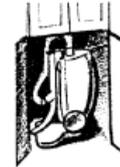


### 1. Vacuuming hallway and rooms

Sophia's apartment has narrow hallways with tight corners; she finds that tight corners; she finds that she can maneuver easily here. Her hallway opens directly into large carpeted rooms, so her cleaning is finished quickly.

### 2. Emptying bag

She doesn't mind emptying the bag because it is easy to detach and replace while standing. Her old model required her to squat down, so she used to put off emptying it.



### 3. Storing

When she's finished, she puts the cleaner away in the closet where she also keeps winter clothes; her apartment is old and a little lacking in space for modern appliances.

## A3 Canister: Japanese Scenario



### 1. Vacuuming the living room

Yumiko is elderly and house-proud; she can easily maneuver the wand over her tatami mats.



### 2. Cleaning detail

She is not very strong but she can reach to clean the shoji and ornaments in the living room; controls on the wand are convenient but the added weight tires her quickly.



### 3. Storing

Yumiko keeps the cleaner tidy in a cupboard with the replacement bags and other cleaning tools.

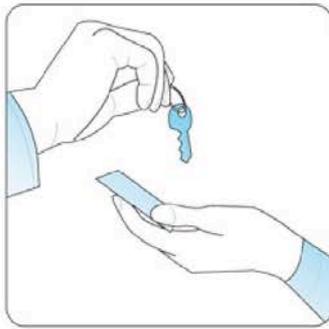


# Activity diagrams and storyboards help expand understanding of problems



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



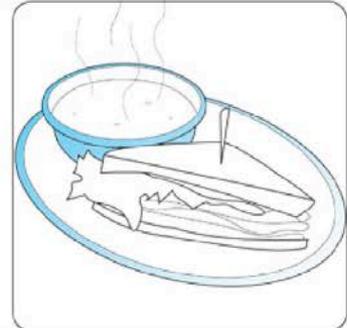
10 min

After leaving the hair salon, he buys some lunch



20 min

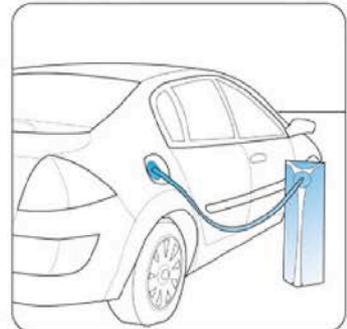
Greg takes his time, not having to worry about moving his car



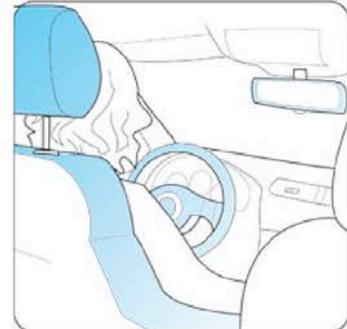
30 min



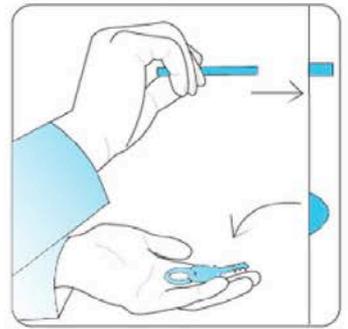
The valet attendant parks the EV and plugs it in to charge



The EV is still charging



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

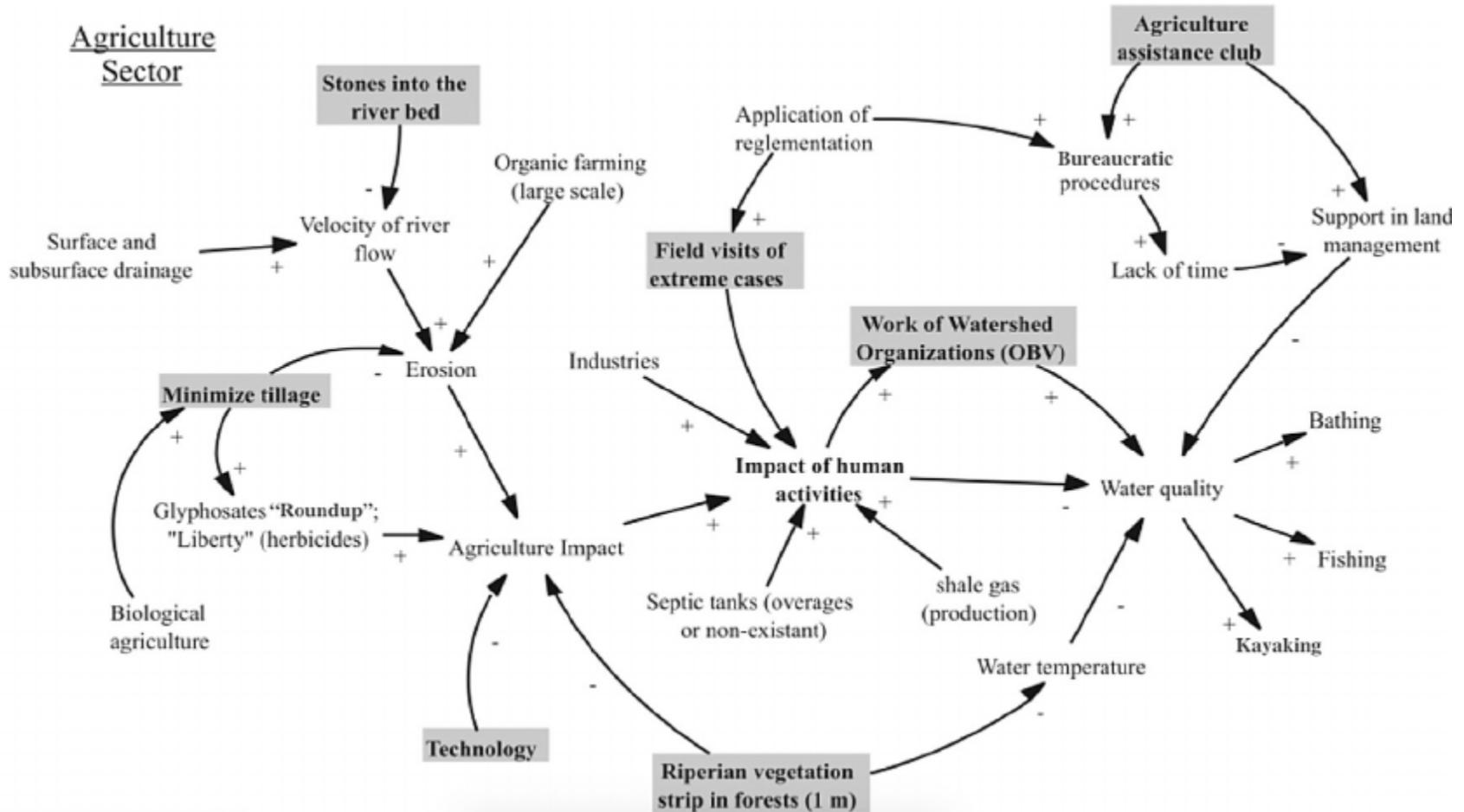


Greg inserts his valet card to a machine to receive his keys to his fully charged EV

40 min



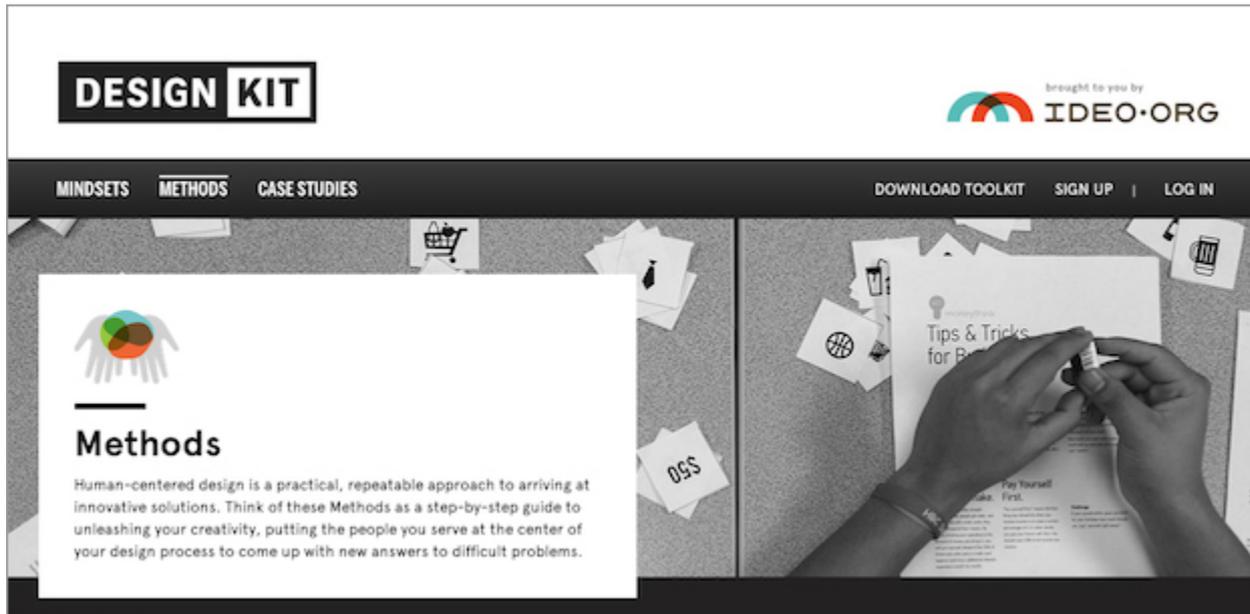
# Engaging stakeholders authentically can lead to insights



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/>

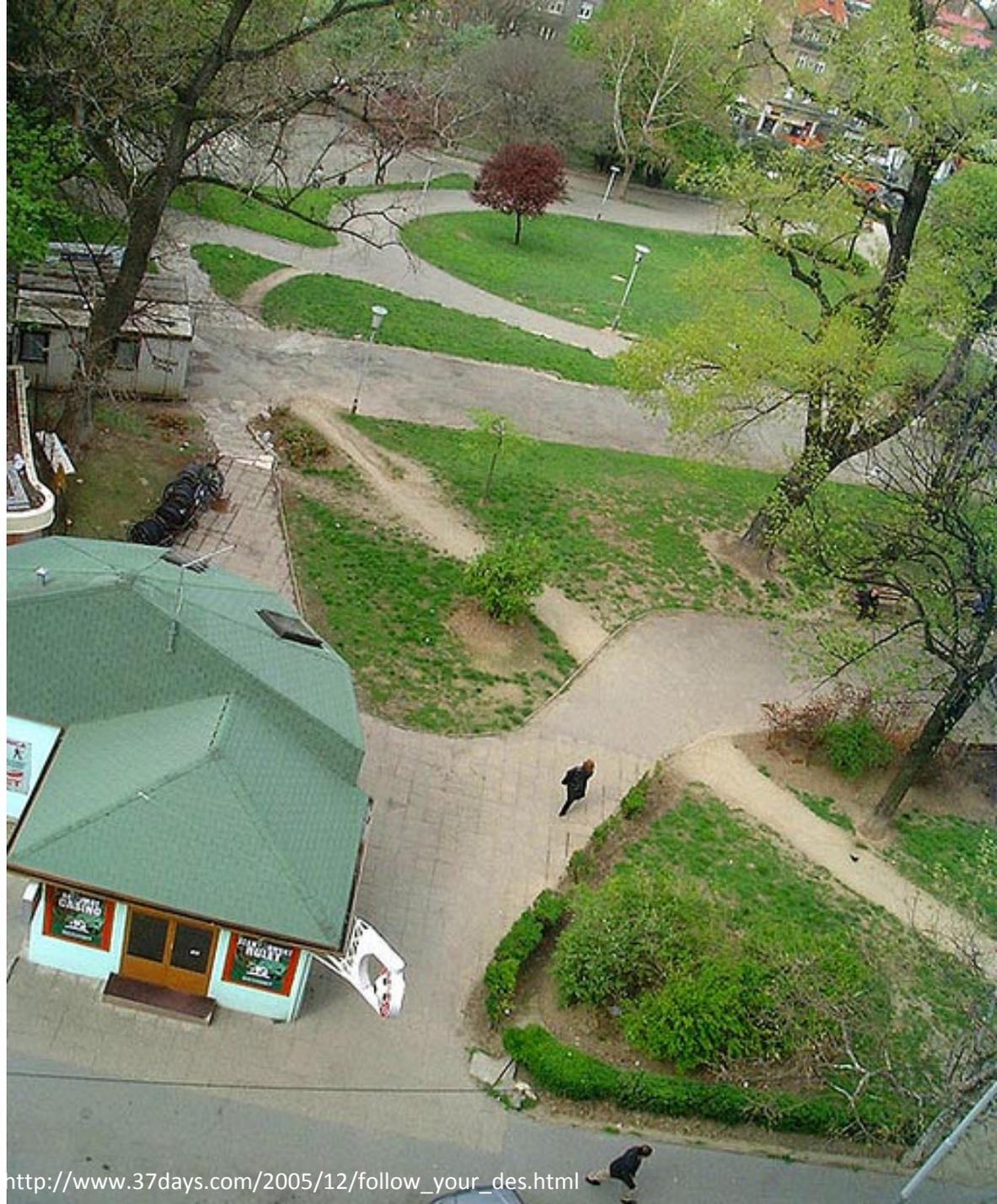
# Identify the users you can interview or observe or engage



	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	

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



TO AVOID  
MAKING A  
PATH  
PLEASE VARY  
YOUR ROUTE

Flicker. CogDog. Life  
Philosophy.

[http://www.37days.com/2005/12/follow\\_your\\_des.html](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\\_FkS5IzqM](https://www.youtube.com/watch?v=pp_FkS5IzqM)



<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

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

# 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

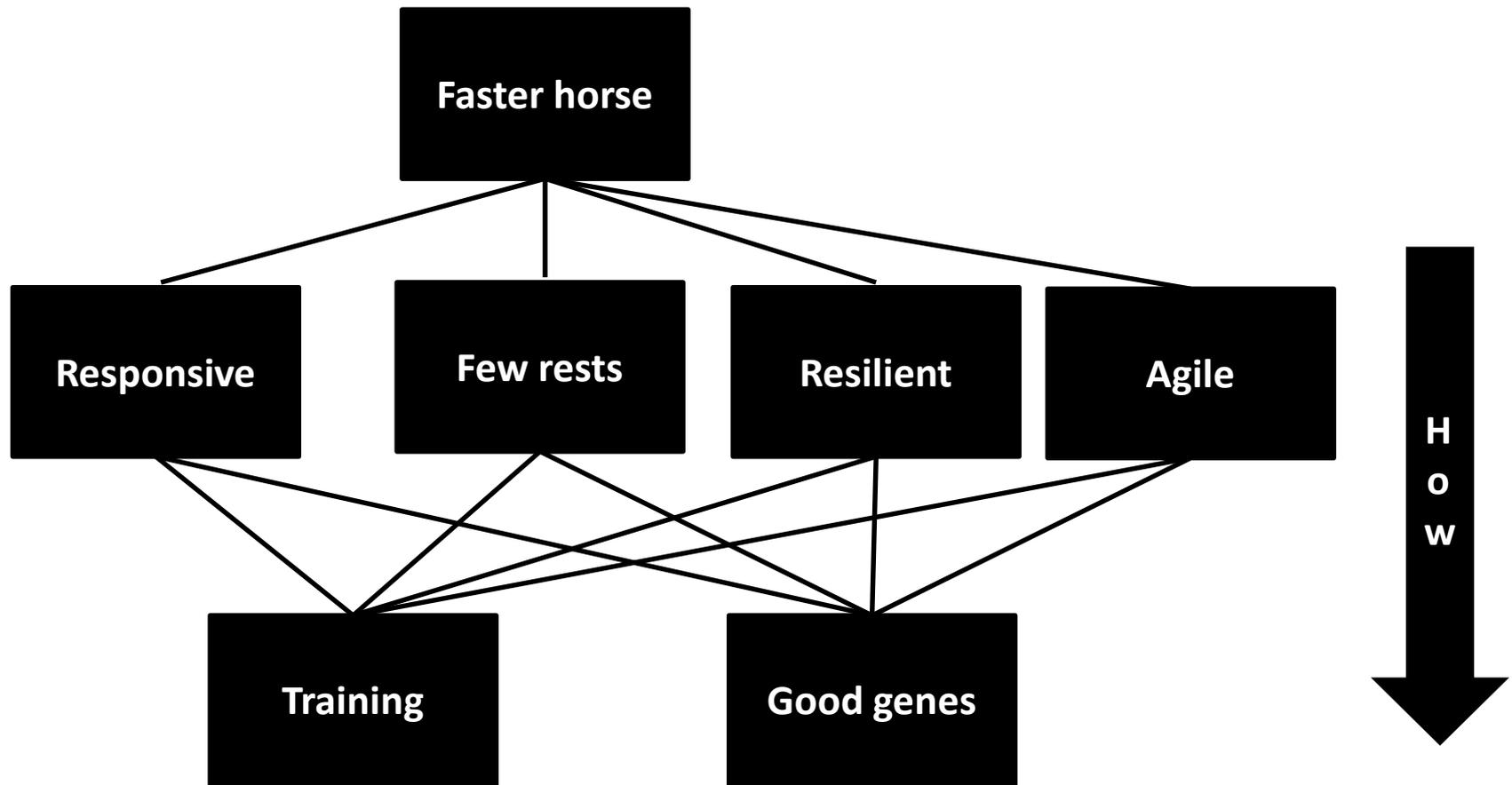
**“If I had asked my customers what they wanted they would have said a faster horse.”**

**– Henry Ford**



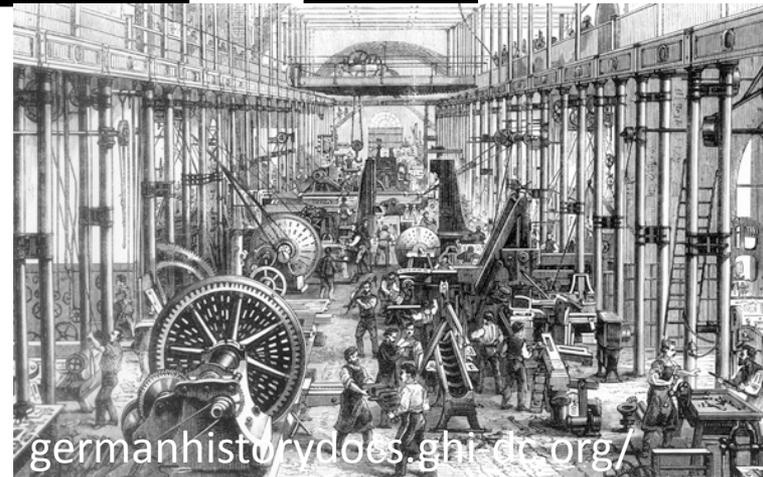
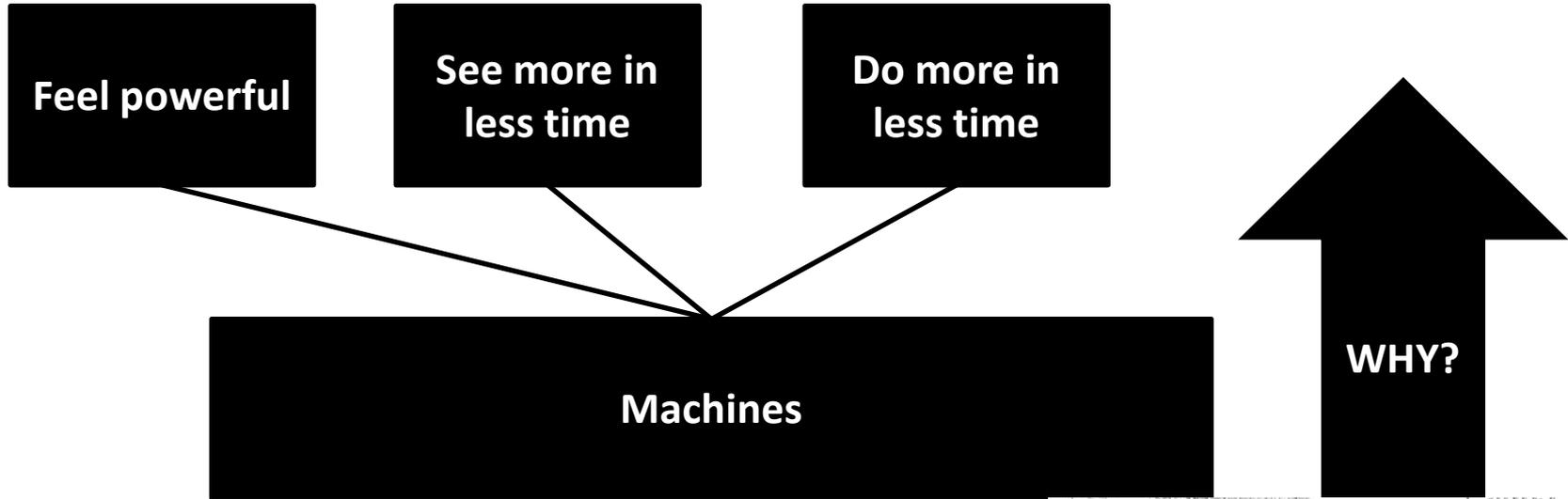


# Converging: Asking How Narrows Your Options





# Diverging: Asking Why Opens Possibilities



# 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.



# 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 !.



# Specification Sheet

<b>Requirement</b>	<b>Target Value</b>	<b>Resp.</b>	<b>Test</b>	<b>Source</b>
<u>Geometry</u>				
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]
<u>Forces</u>				
Shear force on the page	< 40g/m <sup>2</sup>	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)	Quality control	Possibilities of testing and measuring, application of special regulations and standards.
Signals	Inputs and outputs, form, display, control equipment.	Assembly	Special regulations, installation, siting, foundations.
Safety	Direct safety systems, operational and environmental safety.	Transport	Limitations due to lifting gear, clearance, means of transport (height and weight), nature and conditions of despatch.
Ergonomics	Man-machine relationship, type of operation, operating height, clarity of layout, sitting comfort, lighting, shape compatibility.	Operation	Quietness, wear, special uses, marketing area, destination (for example, sulphurous atmosphere, tropical conditions).
Production	Factory limitations, maximum possible dimensions, preferred production methods, means of production, achievable quality and tolerances, wastage.	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

# What makes a good specification?

A good requirement 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
- Overspecifying

cassandra.telenko@me.gatech.edu

**QUESTIONS?**