UNIVERSITY OF TRENTO

ICT Innovation – Spring 2018

MSc in Computer Science and MEng Telecom. Engineering
EIT Masters ITA, S&P,SDE, DMT
MA In Management of Innotion

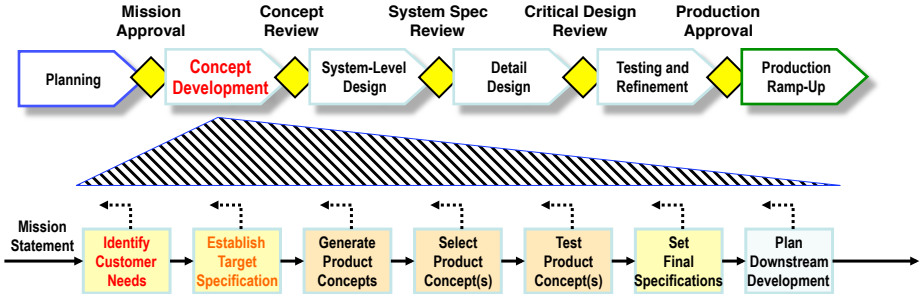
Lecture 06 – Concept Development - Needs

Prof. Fabio Massacci

PD&D Process: Concept Development

UNIVERSITY OF TRENTO

- **Eliminate**
  - Concepts that look unpromising (business-wise)
  - Concepts that are unwieldy to design



Target Specs

Based on customer needs and benchmarking

Final Specs

Based on selected concept, feasibility, models, testing, and trade-offs

Customer Needs & Product Requirements

UNIVERSITY OF TRENTO

- **Define the Scope**
  - Mission Statement
- **Gather Raw Data**
  - Interviews
  - Focus Groups
  - Observation
- **Interpret Raw Data**
  - Need Statements
- **Organize Requirements**
  - Hierarchy
  - Quantified Needs
- **Establish Importance**
  - Surveys
- **Reflect on the Process**
  - Continuous Improvement
  - Multiple perspectives
  - Look for "Evidence"

Example: Cordless Screwdrivers

UNIVERSITY OF TRENTO

Mission Statement: Screwdriver Project

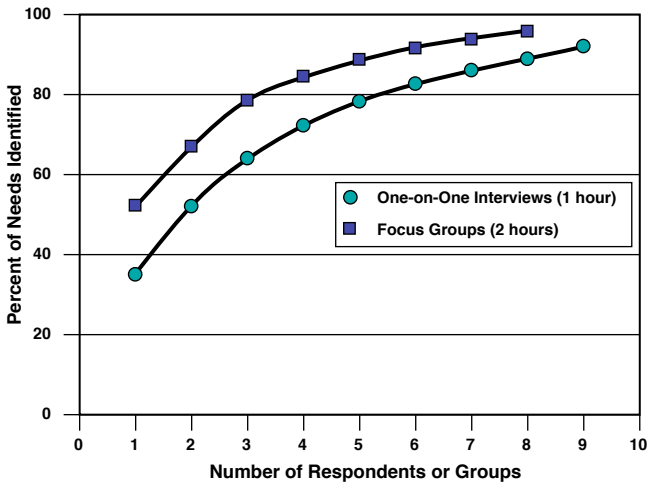
UNIVERSITY OF TRENTO

- **Product Description**
  - A hand-held, power-assisted device for installing threaded fasteners
- **Key Business Goals**
  - Product introduced in 4th Q of 2000
  - 50% gross margin
  - 10% share of cordless screwdriver market by 2004
- **Primary Market**
  - Do-it-yourself consumer
- **Secondary Markets**
  - Casual consumer
  - Light-duty professional
- **Assumptions**
  - Hand-held
  - Power assisted
  - Rechargeable battery technology
- **Stakeholders**
  - User
  - Retailer
  - Sales force
  - Service center
  - Production
  - Legal department

08/03/18 Fabio Massacci - ICT Innovation ► 5

How Many Customers?

UNIVERSITY OF TRENTO



From: Griffin, Abbie and John R. Hauser. "The Voice of the Customer", *Marketing Science*. vol. 12, no. 1, Winter 1993.

08/03/18 Fabio Massacci - ICT Innovation ► 6

Caveats

UNIVERSITY OF TRENTO

- **What to capture?**
  - Capture "What, Not How".
  - Meet customers in the use environment.
  - Collect visual, verbal, and textual data.
  - Props will stimulate customer responses
- **How to Capture?**
  - Interviews are more efficient than focus groups.
  - Interview all stakeholders and lead users.
  - Survey to quantify tradeoffs
- **How to structure?**
  - Develop an organized list of need statements.
  - Look for latent needs.
  - Customers may prioritize "wrong" thing → Use control questions or independent evidence

Writing Customer Needs

UNIVERSITY OF TRENTO

Guideline	Customer Statement	Need Statement 1	Need Statement 2
Specify What, Not How	"Why don't you put protective shields around the battery contacts?"	Prevent damage to the battery and eventually to battery itself, battery never to fall out, safe to handle with hands, prevent electric shock	Battery contacts to be protected, put protective shields around battery contacts
Specificity	"I drop my screwdriver all the time."	must be operational after falling, easy hold in hand in all conditions, prevent scratching of smooth polished surfaces	Physical form to fit into a pocket, outer casing of SD fall-resistant, bumpers, rope
Positive Not Negative	"It doesn't matter if it's raining, I still need to work outside on Saturdays."	Device resistant to getting wet, Has to work in any kind of weather	Waterproof
Attribute of the Product	"I'd like to charge my battery from my cigarette lighter."	Include into the product a battery that can be charged from lighter	SD should be able to recharge with different methods, recharge quickly
Avoid "Must" and "Should"	"I hate it when I don't know how much juice is left in the batteries of my cordless tools."	Battery level has to be seen by the user, liquid indicator	

Writing Customer Needs (II)

UNIVERSITY OF TRENTO

Guideline	Customer Statement	Need Statement-Wrong	Need Statement-Right
Specify What, Not How	"Why don't you put protective shields around the battery contacts?"	The screwdriver battery contacts are covered by a plastic sliding door.	The screwdriver battery is protected from accidental shorting.
Specificity	"I drop my screwdriver all the time."	The screwdriver is rugged.	The screwdriver operates normally after repeated dropping.
Positive Not Negative	"It doesn't matter if it's raining, I still need to work outside on Saturdays."	The screwdriver is not disabled by the rain.	The screwdriver operates normally in the rain.
Attribute of the Product	"I'd like to charge my battery from my cigarette lighter."	An automobile cigarette lighter adapter can charge the screwdriver battery.	The screwdriver battery can be charged from an automobile cigarette lighter.
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 should provide an indication of the energy level of the battery.	The screwdriver provides an indication of the energy level of the battery.

Requirements for a ScrewDriver (Book Exercise)

UNIVERSITY OF TRENTO

- maintains power for several hours of heavy use
- can drive screws into hardwood.
- drives sheet metal screws into metal ductwork.
- drives screws faster than by hand.
- retains the screw before it is driven
- can be used to create a pilot hole
- can turn philips, torx, socket, and hex head screws
- can turn many sizes of screws
- can be maneuvered in tight areas.
- can access screws at the end of deep, narrow holes
- can be used to remove grease and dirt from screws.
- allows the user to work with painted screws.
- is comfortable when the user pushes on it
- is comfortable when the user resists twisting
- is balanced in the user's hand.
- is equally easy to use in right or left hands.
- is warm to touch in cold weather.
- remains comfortable when left in the sun.
- user can easily push on the SD
- user can easily resist the SD twisting
- SD can be locked "on."
- SD speed can be controlled by the user while turning a screw
- SD remains aligned with the screw head without slipping
- user can easily see where the screw is
- SD is easily reversible.
- SD does not strip screw heads
- SD is easy to turn on
- SD prevents inadvertent switching off
- user can set the maximum torque of the SD.
- SD provides ready access to bits or accessories
- SD can be attached to the user for temporary storage.
- SD is easy to recharge.
- SD can be used while recharging.
- SD recharges quickly
- SD batteries are ready to use when new.
- user can apply torque manually to the SD to drive a screw
- tip survives heavy use
- can be hammered.
- can be dropped from a ladder without damage
- fits in a toolbox easily.
- can be charged while in storage.
- resists corrosion when left outside or in damp places
- maintains its charge after long periods of storage.
- maintains its charge when wet.
- prevents damage to the screw head.
- prevents scratching of finished surfaces.
- can be used on electrical devices.
- does not cut the user's hands

Requirements for a ScrewDriver (Book Exercise)

UNIVERSITY OF TRENTO

maintains power for several hours of heavy use	16
can drive screws into hardwood.	23
drives sheet metal screws into metal ductwork.	0
drives screws faster than by hand.	27
retains the screw before it is driven	20
can be used to create a pilot hole	2
can turn philips, torx, socket, and hex head screws	6
can turn many sizes of screws	26
can be maneuvered in tight areas.	4
can access screws at the end of deep, narrow holes	2
can be used to remove grease and dirt from screws.	1
allows the user to work with painted screws.	0
is comfortable when the user pushes on it	0
is comfortable when the user resists twisting	2
is balanced in the user's hand.	11
is equally easy to use in right or left hands.	15
is warm to touch in cold weather.	0
remains comfortable when left in the sun.	2
user can easily push on the SD	2
user can easily resist the SD twisting	3
SD can be locked "on."	0
SD speed can be controlled by the user while turning a screw	3
SD remains aligned with the screw head without slipping	5
user can easily see where the screw is	0
SD is easily reversible.	8

Requirements for a ScrewDriver (Book Exercise)

UNIVERSITY OF TRENTO

SD does not strip screw heads	0
SD is easy to turn on	2
SD prevents inadvertent switching off	10
user can set the maximum torque of the SD.	1
SD provides ready access to bits or accessories	10
SD can be attached to the user for temporary storage.	13
SD is easy to recharge.	24
SD can be used while recharging.	14
SD recharges quickly	18
SD batteries are ready to use when new.	1
user can apply torque manually to the SD to drive a screw	1
tip survives heavy use	10
can be hammered.	0
can be dropped from a ladder without damage	18
fits in a toolbox easily.	13
can be charged while in storage.	2
resists corrosion when left outside or in damp places	13
maintains its charge after long periods of storage.	2
maintains its charge when wet.	0
prevents damage to the screw head.	3
prevents scratching of finished surfaces.	2
can be used on electrical devices.	0
does not cut the user's hands	17

Requirements for a ScrewDriver (Book Exercise)

UNIVERSITY OF TRENTO

- SD prevents inadvertent switching off 10
- SD provides ready access to bits or accessories 10
- SD can be attached to the user for temporary storage. 13
- SD is easy to recharge. 24
- SD can be used while recharging. 14
- SD recharges quickly 18
- tip survives heavy use 10
- can be dropped from a ladder w/o damage 18
- fits in a toolbox easily. 13
- resists corrosion when left outside or in damp places 13
- does not cut the user's hands 17
- maintains power for several hours rs of heavy use 16
- can drive screws into hardwood. 23
- drives screws faster than by hand. 27
- retains the screw before it is driven 20
- can turn many sizes of screws 26
- is balanced in the user's hand. 11
- is equally easy to use in right or left hands. 15

Requirements for a ScrewDriver (2016 Cohort)

UNIVERSITY OF TRENTO

- **The SD provides plenty of power to drive screws.**
  - drives screws faster than by hand - 20
- **The SD makes it easy to start a screw.**
  - retains the screw before it is driven. 17
- **The SD works with a variety of screws.**
  - can turn philips, torx, socket, and hex head screws - 15
  - can turn many sizes of screws. - 17
- **SD feels good in the user's hand.**
  - is equally easy to use in right or left hands . - 14
- **The SD is easy to control while turning screws.**
  - SD does not strip screw heads.- 11
  - SD is easily reversible. 16
- **The SD is easy to set-up and use.**
  - SD is easy to turn on. – 12
- **The SD power is convenient.**
  - SD is easy to recharge. - 10
  - SD recharges quickly - 13
- **The SD lasts a long time.**
  - can be dropped from a ladder without damage. 20
- **The SD is safe.**
  - does not cut the user's hands - 18
- **Lots of not top reqs**
- **…**
- **The SD looks like a professional quality tool → 2**

Requirements for a ScrewDriver (Book Exercise)

UNIVERSITY OF TRENTO

- **The SD provides plenty of power to drive screws.**
  - maintains power for several hours of heavy use (*)
  - can drive screws into hardwood. (**)
  - drives sheet metal screws into metal ductwork.
  - drives screws faster than by hand (***).
- **The SD makes it easy to start a screw.**
  - retains the screw before it is driven. (*)
  - can be used to create a pilot hole. (*!)
- **The SD works with a variety of screws.**
  - can turn philips, torx, socket, and hex head screws (**)
  - can turn many sizes of screws. (**)
- **The SD can access most screws.**
  - can be maneuvered in tight areas.
  - can access screws at the end of deep, narrow holes. (**)
- **The SD turns screws that are in poor condition.**
  - can be used to remove grease and dirt from screws.
  - allows the user to work with painted screws.
- **The SD feels good in the user's hand.**
  - iis comfortable when the user pushes on it. (***)
  - is comfortable when the user resists twisting (***)
  - is balanced in the user's hand.
  - is equally easy to use in right or left hands (!).
  - weight is just right.
  - is warm to touch in cold weather.
  - remains comfortable when left in the sun.
- **The SD is easy to control while turning screws.**
  - user can easily push on the SD (***).
  - user can easily resist the SD twisting (***).
  - SD can be locked "on."
  - SD speed can be controlled by the user while turning a screw. (***!)
  - SD remains aligned with the screw head without slipping. (*)
  - u2ser can easily see where the screw is (**)
  - S2D does not strip screw heads. (*)
  - 1SD is easily reversible. (*)
- **The SD is easy to set-up and use.**
  - SD is easy to turn on. (*)
  - SD prevents inadvertent switching off. (*)
  - user can set the maximum torque of the SD.
  - SD provides ready access to bits or accessories (*!).
  - SD can be attached to the user for temporary storage.
- **The SD power is convenient.**
  - SD is easy to recharge.
  - SD can be used while recharging.
  - SD recharges quickly (***)
  - SD batteries are ready to use when new.
  - user can apply torque manually to the SD to drive a screw. (**!)
- **The SD lasts a long time.**
  - tip survives heavy use. (**)
  - can be hammered.
  - can be dropped from a ladder without damage. (*)
- **The SD is easy to store.**
  - fits in a toolbox easily.
  - can be charged while in storage.
  - resists corrosion when left outside or in damp places
  - maintains its charge after long periods of storage.
  - maintains its charge when wet.
- **The SD prevents damage to the work.**
  - prevents damage to the screw head.
  - 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.**
  - can be used on electrical devices.
  - does not cut the user's hands (***)

Requirements for a ScrewDriver (sorted)

UNIVERSITY OF TRENTO

***** Priority**

drives screws faster than by hand
is comfortable when the user pushes on it
is comfortable when the user resists twisting
Speed controlled by user while turning a screw
recharges quickly
User can apply torque manually to SD to drive a screw.
does not cut the user's hands

**** Priority**

drive screws into hardwood
turn philips, torx, socket, hex head screws
turn many sizes of screws
Tip survives heavy use
access screws at the end of deep, narrow holes
used to create a pilot hole
remains aligned with head without slipping.
user can easily see where the screw is
does not strip screw heads
provides ready access to bits or accessories

*** Priority**

maintains power for several hours of use
is easily reversible
Retains the screw before it is driven
is easy to turn on
prevents inadvertent switching off
is equally easy to use in right or left hands
can be dropped from a ladder without damage

No Priority

drives sheet metal screws into metal ductwork.
can be maneuvered in tight areas.
user can set the maximum torque of the SD.
SD is easy to recharge.
can be hammered.
fits in a toolbox easily.
Maintains charge after long periods of storage.
Maintains charge when wet.
prevents damage to the screw head.
prevents scratching of finished surfaces.
can be used on electrical devices.

Different tools with "close" functionality

UNIVERSITY OF TRENTO

- **A screwdriver set 15 pieces – $18.37**

- **VS**
- **Cordless Drill + 15 pieces - $89.9+5.99**

+

- **Cost is 5 times more!**

- **Key Features**
  - Lithium Ion Battery
  - 11 Position Clutch
  - LED work light
  - Compact and Lightweight
- **Benefits**
  - Always Ready. holds a charge up to 18 months
  - Helps to prevent stripping of screws
  - Illuminates project area
  - For getting into tight spaces
- **What's Included**
  - LDX120 20V MAX Lithium drill/driver
  - (1) LBX20 20V MAX Lithium Ion battery
  - (1) LCS20 charger
  - (1) Double ended bit
- **Uses**
  - Screwdriving though wood, metal, and plastic
- **Extra: buy screw tips**

08/03/18 Fabio Massacci - ICT Innovation ► 17

Requirements for a ScrewDriver (from reality)

UNIVERSITY OF TRENTO

***** Priority**

drives screws faster than by hand
is comfortable when the user pushes on it
is comfortable when the user resists twisting
Speed controlled by user while turning a screw
recharges quickly
User can apply torque manually to SD to drive a screw.
does not cut the user's hands

**** Priority**

drive screws into hardwood
turn philips, torx, socket, hex head screws
turn many sizes of screws
Tip survives heavy use
access screws at the end of deep, narrow holes
used to create a pilot hole
remains aligned with head without slipping.
user can easily see where the screw is
does not strip screw heads
provides ready access to bits or accessories

*** Priority**

maintains power for several hours of use
is easily reversible
Retains the screw before it is driven
is easy to turn on
prevents inadvertent switching off
is equally easy to use in right or left hands
can be dropped from a ladder without damage

No Priority

drives sheet metal screws into metal ductwork.
can be maneuvered in tight areas.
user can set the maximum torque of the SD.
SD is easy to recharge.
can be hammered.
fits in a toolbox easily.
Maintains charge after long periods of storage.
Maintains charge when wet.
prevents damage to the screw head.
prevents scratching of finished surfaces.
can be used on electrical devices.

08/03/18 **Fabio Massacci - ICT Innovation** ► 18

Requirements (contd)

UNIVERSITY OF TRENTO

- **"Customers" do not always state the correct requirements**
- **Never state the "obvious", because it is indeed obvious (for them)**
  - "is easily reversible" has only (*) → should have (+infinity)
    - a screwdriver that is not reversible is just not sellable → because you screw and unscrew…
  - "user can set the maximum torque" of the SD has no star→ should be (***)
    - You naturally apply different torques when screwing through wood or plaster
    - It is the second key feature of the product
- **Don't mention true priorities**
  - "turn many sizes of screws" has only (**)
    - Would you pay 5 times the cost of a set of screwdrivers to be able to screw only one type of screw?
  - "Maintains charge after long periods of storage" has no star
    - First benefit of product…
- **Desire property of the new device as if it was old device**
  - "User can apply torque manually to SD to drive a screw" has (***)
    - Turning a screw with a heavy thing with an electric motor ain't a good idea
  - "can be hammered"
    - Yes, great idea to hammer something with a motor, electronics, lots of turning parts, and a battery
- **Ask cool but impossible things**
  - "Maintains charge when wet"
    - Man, it's an electrical device…
  - "Speed controlled by user while turning a screw" has (***)
    - One hand to hold the screwdriver, one hand to hold the pane or yourself on top of a ladder, a 3rd hand to change speed…

The Product Specs Process

UNIVERSITY OF TRENTO

- **Set Target Specifications**
  - Based on customer needs and benchmarks
  - Develop "product" metrics for each need
  - Set ideal and acceptable values
- **Refine Specifications**
  - For selected concept(s)
  - Use both technical modeling and feasibility testing
  - Understand cost/needs/engineering trade-offs
- **Possibly Market of Goods**
  - Gross Margin may be different → different trade offs
    - M=(P-C)/P
  - Manufacturer:
    - Consumer Software (70-100%), Consumer Electronics (20-40%), Computers (15-50%)
  - Retailers:
    - Electronics (15-35%), Mail Orders (40-75%)

The "whole" product

UNIVERSITY OF TRENTO

08/03/18 Fabio Massacci - ICT Innovation ► 21

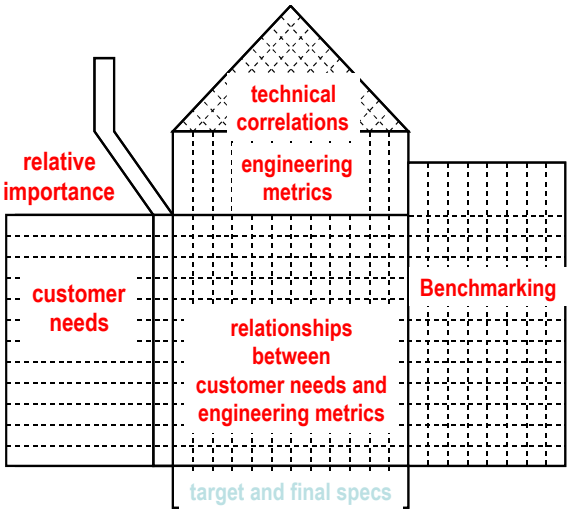
Product Specifications Example: Mountain Bike Suspension Fork

UNIVERSITY OF TRENTO

08/03/18 Fabio Massacci - ICT Innovation ► 22

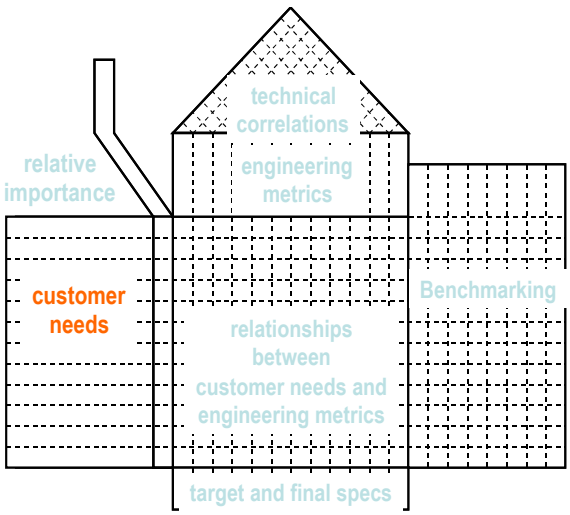
Quality Function Deployment (House of Quality)

UNIVERSITY OF TRENTO



Quality Function Deployment (House of Quality)

UNIVERSITY OF TRENTO



Two user classes

UNIVERSITY OF TRENTO

- **Key (or Lead or Power) users**
  - People who actually own a mountain bike and actually use it (or at least used it) on a cross country track
- **Normal users**
  - People who have used a bike or even a mountain bike (but use the latter only on Piazza Duomo for chasing pigeons)
- **The requirements might be different albeit you may want to sell to both**
  - Beware it might not be possible if the market might be heavily segmented

Start with the Customer Needs (you)

UNIVERSITY OF TRENTO

#	NEED		Im	#	#
1	The suspension	reduces vibration to the hands.	3	14	1
2	The suspension	allows easy traversal of slow, difficult terrain.	2	10	2
3	The suspension	enables high speed descents on bumpy trails.	5	7	3
4	The suspension	allows sensitivity adjustment.	3		
5	The suspension	preserves the steering characteristics of the bike.	4	6	1
6	The suspension	remains rigid during hard cornering.	4	4	1
7	The suspension	is lightweight.	4	1	3
8	The suspension	provides stiff mounting points for the brakes.	2	16	1
9	The suspension	fits a wide variety of bikes, wheels, and tires.	5	2	1
10	The suspension	is easy to install.	1	13	
11	The suspension	works with fenders.	1	7	
12	The suspension	instills pride.	5	10	
13	The suspension	is affordable for an amateur enthusiast.	5	1	2
14	The suspension	is not contaminated by water.	5	4	
15	The suspension	is not contaminated by grunge.	5	13	
16	The suspension	can be easily accessed for maintenance.	3	1	1
17	The suspension	allows easy replacement of worn parts.	1	12	1
18	The suspension	can be maintained with readily available tools.	3	7	1
19	The suspension	lasts a long time.	5	0	2
20	The suspension	is safe in a crash.	5	17	1
				13	

Start with the Customer Needs (2016)

UNIVERSITY OF TRENTO

#	NEED		Imp	#	#
1	The suspension	reduces vibration to the hands.	3	0	10
2	The suspension	allows easy traversal of slow, difficult terrain.	2	4	9
3	The suspension	enables high speed descents on bumpy trails.	5	5	2
4	The suspension	allows sensitivity adjustment.	3	2	5
5	The suspension	preserves the steering characteristics of the bike.	4	2	1
6	The suspension	remains rigid during hard cornering.	4	6	2
7	The suspension	is lightweight.	4	3	3
8	The suspension	provides stiff mounting points for the brakes.	2	0	4
9	The suspension	fits a wide variety of bikes, wheels, and tires.	5	0	11
10	The suspension	is easy to install.	1	0	0
11	The suspension	works with fenders.	1	0	0
12	The suspension	instills pride.	5	1	0
13	The suspension	is affordable for an amateur enthusiast.	5	0	10
14	The suspension	is not contaminated by water.	5	1	8
15	The suspension	is not contaminated by grunge.	5	2	12
16	The suspension	can be easily accessed for maintenance.	3	3	8
17	The suspension	allows easy replacement of worn parts.	1	2	8
18	The suspension	can be maintained with readily available tools.	3	0	5
19	The suspension	lasts a long time.	5	2	12
20	The suspension	is safe in a crash.	5	0	16

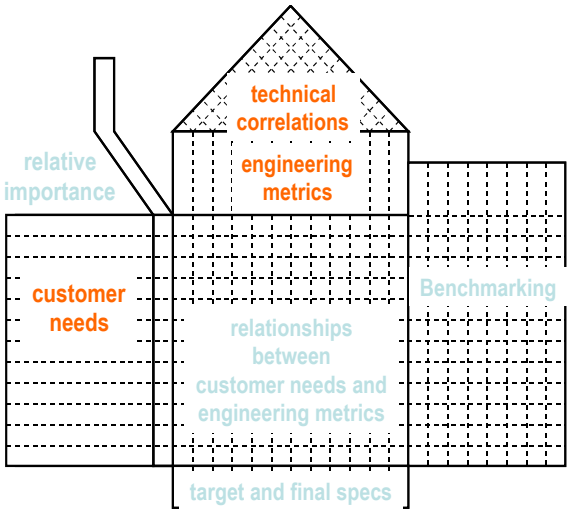
Start with the Customer Needs (2015)

UNIVERSITY OF TRENTO

#	NEED		Imp	#	#
1	The suspension	reduces vibration to the hands.	3	8	7
2	The suspension	allows easy traversal of slow, difficult terrain.	2	0	1
3	The suspension	enables high speed descents on bumpy trails.	5	12	2
4	The suspension	allows sensitivity adjustment.	3	5	6
5	The suspension	preserves the steering characteristics of the bike.	4	7	4
6	The suspension	remains rigid during hard cornering.	4	0	1
7	The suspension	is lightweight.	4	1	2
8	The suspension	provides stiff mounting points for the brakes.	2	1	0
9	The suspension	fits a wide variety of bikes, wheels, and tires.	5	9	9
10	The suspension	is easy to install.	1	0	0
11	The suspension	works with fenders.	1	0	1
12	The suspension	instills pride.	5	0	0
13	The suspension	is affordable for an amateur enthusiast.	5	0	7
14	The suspension	is not contaminated by water.	5	2	1
15	The suspension	is not contaminated by grunge.	5	7	5
16	The suspension	can be easily accessed for maintenance.	3	0	0
17	The suspension	allows easy replacement of worn parts.	1	1	2
18	The suspension	can be maintained with readily available tools.	3	3	2
19	The suspension	lasts a long time.	5	8	12
20	The suspension	is safe in a crash.	5	9	13

Quality Function Deployment (House of Quality)

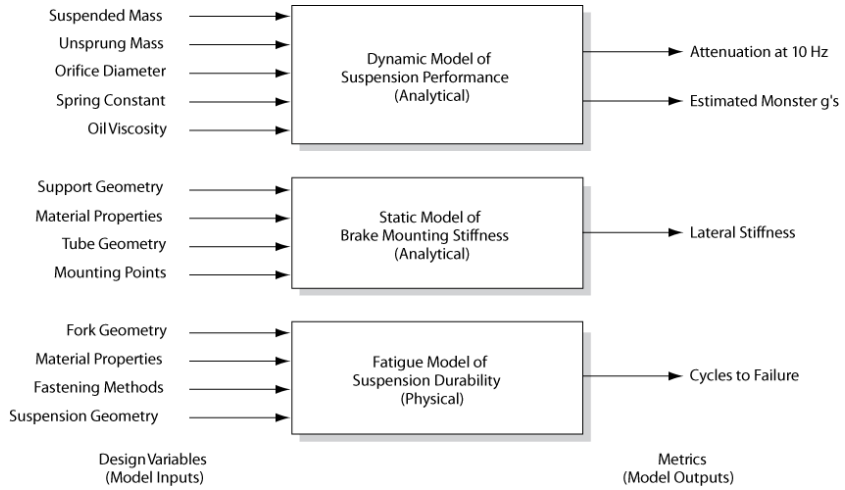
UNIVERSITY OF TRENTO



08/03/18 Fabio Massacci - ICT Innovation ▶ 29

Design Product Model (for ICT performance model)

UNIVERSITY OF TRENTO



From *Product Design and Development* by Karl Ulrich and Steven Eppinger (McGraw-Hill/Irwin)

08/03/18 Fabio Massacci - ICT Innovation ▶ 30

What is the monster g?

UNIVERSITY OF TRENTO

- **The Monster g was a shock test used by Mountain Bike magazine.**
  - The maximum value of the acceleration at the handlebar of a bike when the front wheel is subjected to a significant impulse.
  - Obviously the higher the acceleration the worse the amortization
- **Now you can't find it anymore on the web**
  - Mountain Bike magazine does more "life experience" reviews
  - But at the time useful as a measure well known to power users and wannabees

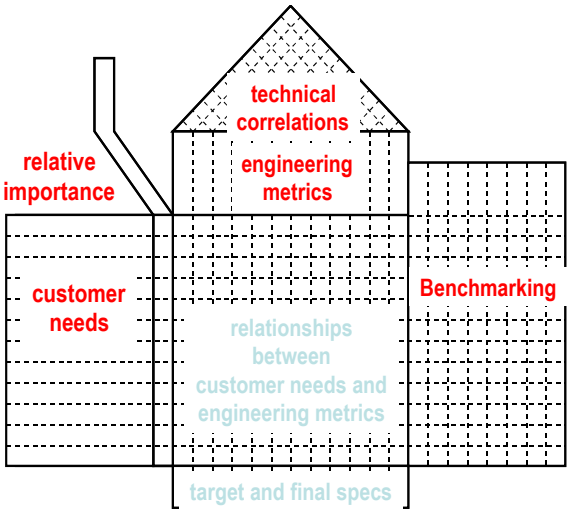
Establish Metrics and Units

UNIVERSITY OF TRENTO

Metric #	Need #s	Metric	Imp	Units
1	1,3	Attenuation from dropout to handlebar at 10hz	3	dB
2	2,6	Spring pre-load	3	N
3	1,3	Maximum value from the Monster	5	g
4	1,3	Minimum descent time on test track	5	s
5	4	Damping coefficient adjustment range	3	N-s/m
6	5	Maximum travel (26in wheel)	3	mm
7	5	Rake offset	3	mm
8	6	Lateral stiffness at the tip	3	kN/m
9	7	Total mass	4	kg
10	8	Lateral stiffness at brake pivots	2	kN/m
11	9	Headset sizes	5	in
12	9	Steertube length	5	mm
13	9	Wheel sizes	5	list
14	9	Maximum tire width	5	in
15	10	Time to assemble to frame	1	s
16	11	Fender compatibility	1	list
17	12	Instills pride	5	subj
18	13	Unit manufacturing cost	5	US$
19	14	Time in spray chamber w/o water entry	5	s
20	15	Cycles in mud chamber w/o contamination	5	k-cycles
21	16,17	Time to disassemble/assemble for maintenance	3	s
22	17,18	Special tools required for maintenance	3	list
23	19	UV test duration to degrade rubber parts	5	hours
24	19	Monster cycles to failure	5	cycles
25	20	Japan Industrial Standards test	5	binary
26	20	Bending strength (frontal loading)	5	MN

Quality Function Deployment (House of Quality)

UNIVERSITY OF TRENTO



Associating Metrics to Requirements

UNIVERSITY OF TRENTO

Metric #	Need #s	Metric	Imp	Units	ST Tritrack	Manray 2	Rox Tahx Quadra	Rox Tahx Ti 21	Tonka Pro	Gunhill Head Shox
1	1,3	Attenuation from dropout to handlebar at 10hz	3	dB	8	15	10	15	9	13
2	2,6	Spring pre-load	3	N	550	760	500	710	480	680
3	1,3	Maximum value from the Monster	5	g	3.6	3.2	3.7	3.3	3.7	3.4
4	1,3	Minimum descent time on test track	5	s	13	11.3	12.6	11.2	13.2	11
5	4	Damping coefficient adjustment range	3	N-s/m	0	0	0	200	0	0
6	5	Maximum travel (26in wheel)	3	mm	28	48	43	46	33	38
7	5	Rake offset	3	mm	41.5	39	38	38	43.2	39
8	6	Lateral stiffness at the tip	3	kN/m	59	110	85	85	65	130
9	7	Total mass	4	kg	1.409	1.385	1.409	1.364	1.222	1.1
10	8	Lateral stiffness at brake pivots	2	kN/m	295	550	425	425	325	650
11	9	Headset sizes	5	in	1.000 1.125	1.000 1.125 1.250	1.000 1.125	1.000 1.125 1.250	1.000 1.125	NA
12	9	Steertube length	5	mm	150 180 210 230 255	140 165 190 215	150 170 190 210	150 170 190 210 230	150 190 210 220	NA
13	9	Wheel sizes	5	list	26in	26in	26in	26in 700C	26in	26in
14	9	Maximum tire width	5	in	1.5	1.75	1.5	1.75	1.5	1.5
15	10	Time to assemble to frame	1	s	35	35	45	45	35	85
16	11	Fender compatibility	1	list	Zefal	none	none	none	none	all
17	12	Instills pride	5	subj	1	4	3	5	3	5
18	13	Unit manufacturing cost	5	US$	65	105	85	115	80	100
19	14	Time in spray chamber w/o water entry	5	s	1300	2900	>3600	>3600	2300	>3600
20	15	Cycles in mud chamber w/o contamination	5	k-cycles	15	19	15	25	18	35
21	16,17	Time to disassemble/assemble for maintenance	3	s	160	245	215	245	200	425
22	17,18	Special tools required for maintenance	3	list	hex	hex	hex	hex	long hex	hex, pin wrnch
23	19	UV test duration to degrade rubber parts	5	hours	400+	250	400+	400+	400+	250
24	19	Monster cycles to failure	5	cycles	500k+	500k+	500k+	480k	500k+	330k
25	20	Japan Industrial Standards test	5	binary	pass	pass	pass	pass	pass	pass
26	20	Bending strength (frontal loading)	5	MN	55	89	75	75	62	102

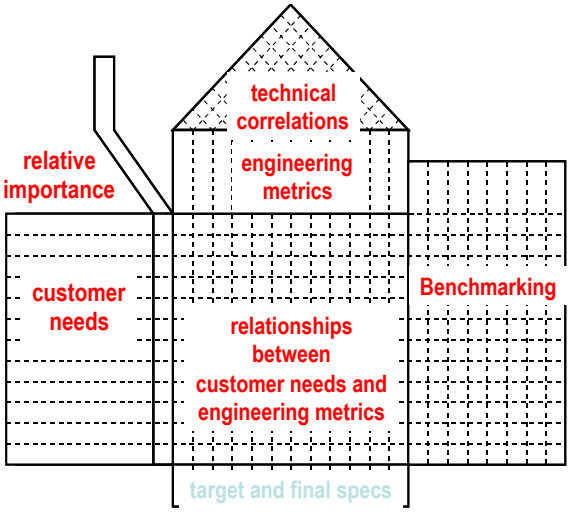
Benchmark on Customer Needs

UNIVERSITY OF TRENTO

#	NEED		Imp	ST Tritrack	Maniray 2	Rox Tahx Quadra	Rox Tahx Ti 21	Tonka Pro	Gunhill Head Shox
1	The suspension	reduces vibration to the hands.	3	•	••••	••	•••••	••	•••
2	The suspension	allows easy traversal of slow, difficult terrain.	2	••	••••	•••	•••••	•••	•••••
3	The suspension	enables high speed descents on bumpy trails.	5	•	•••••	••	•••••	••	•••
4	The suspension	allows sensitivity adjustment.	3	•	••••	••	•••••	••	•••
5	The suspension	preserves the steering characteristics of the bike.	4	••••	••	•	••	•••	•••••
6	The suspension	remains rigid during hard cornering.	4	•	•••	•	•••••	•	•••••
7	The suspension	is lightweight.	4	•	•••	•	•••	••••	•••••
8	The suspension	provides stiff mounting points for the brakes.	2	•	••••	•••	•••	••	•••••
9	The suspension	fits a wide variety of bikes, wheels, and tires.	5	••••	•••••	•••	•••••	•••	•
10	The suspension	is easy to install.	1	••••	•••••	••••	••••	•••••	•
11	The suspension	works with fenders.	1	•••	•	•	•	•	•••••
12	The suspension	instills pride.	5	•	••••	•••	•••••	•••	•••••
13	The suspension	is affordable for an amateur enthusiast.	5	•••••	•	•••	•	•••	••
14	The suspension	is not contaminated by water.	5	•	•••	••••	••••	••	•••••
15	The suspension	is not contaminated by grunge.	5	•	•••	•	••••	••	•••••
16	The suspension	can be easily accessed for maintenance.	3	••••	•••••	••••	••••	•••••	•
17	The suspension	allows easy replacement of worn parts.	1	••••	•••••	••••	••••	•••••	•
18	The suspension	can be maintained with readily available tools.	3	•••••	•••••	•••••	•••••	••	•
19	The suspension	lasts a long time.	5	•••••	•••••	•••••	•••	•••••	•
20	The suspension	is safe in a crash.	5	•••••	•••••	•••••	•••••	•••••	•••••

Quality Function Deployment (House of Quality)

UNIVERSITY OF TRENTO



Link Metrics to Needs

UNIVERSITY OF TRENTO

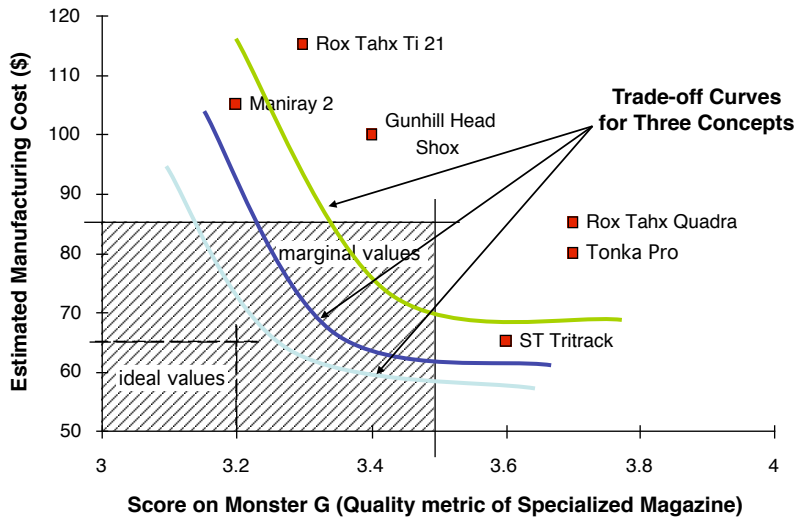
	Need	1 Attenuation from dropout to handlebar at 10hz	2 Spring pre-load	3 Maximum value from the Monster	4 Minimum descent time on test track	5 Damping coefficient adjustment range	6 Maximum travel (26in wheel)	7 Rake offset	8 Lateral stiffness at the tip	9 Total mass	10 Lateral stiffness at brake pivots	11 Headset sizes	12 Steertube length	13 Wheel sizes	14 Maximum tire width	15 Time to assemble to frame	16 Fender compatibility	17 Instills pride	18 Unit manufacturing cost	19 Time in spray chamber w/o water entry	20 Cycles in mud chamber w/o contamination	21 Time to disassemble/assemble for maintenance	22 Special tools required for maintenance	23 UV test duration to degrade rubber parts	24 Monster cycles to failure	25 Japan Industrial Standards test	26 Bending strength (frontal loading)
1	reduces vibration to the hands.	•		•	•																						
2	allows easy traversal of slow, difficult terrain.		•																								
3	enables high speed descents on bumpy trails.	•		•	•																						
4	allows sensitivity adjustment.					•																					
5	preserves the steering characteristics of the bike.						•	•																			
6	remains rigid during hard cornering.		•						•																		
7	is lightweight.									•																	
8	provides stiff mounting points for the brakes.										•																
9	fits a wide variety of bikes, wheels, and tires.											•	•	•	•												
10	is easy to install.															•											
11	works with fenders.																•										
12	instills pride.																	•									
13	is affordable for an amateur enthusiast.																		•								
14	is not contaminated by water.																			•							
15	is not contaminated by grunge.																				•						
16	can be easily accessed for maintenance.																					•					
17	allows easy replacement of worn parts.																					•	•				
18	can be maintained with readily available tools.																						•				
19	lasts a long time.																							•	•		
20	is safe in a crash.																									•	•

Assign Marginal and Ideal Values

UNIVERSITY OF TRENTO

	Metric	Units	Marginal Value	Ideal Value
1	Attenuation from dropout to handlebar at 10hz	dB	>10	>15
2	Spring pre-load	N	480 - 800	650 - 700
3	Maximum value from the Monster	g	<3.5	<3.2
4	Minimum descent time on test track	s	<13.0	<11.0
5	Damping coefficient adjustment range	N-s/m	0	>200
6	Maximum travel (26in wheel)	mm	33 - 50	45
7	Rake offset	mm	37 - 45	38
8	Lateral stiffness at the tip	kN/m	>65	>130
9	Total mass	kg	<1.4	<1.1
10	Lateral stiffness at brake pivots	kN/m	>325	>650
11	Headset sizes	in	1.000 1.125	1.000 1.125 1.250
12	Steertube length	mm	150 170 190 210	150 170 190 210 230
13	Wheel sizes	list	26in	26in 700c
14	Maximum tire width	in	>1.5	>1.75
15	Time to assemble to frame	s	<60	<35
16	Fender compatibility	list	none	all
17	Instills pride	subj	>3	>5
18	Unit manufacturing cost	US$	<85	<65
19	Time in spray chamber w/o water entry	s	>2300	>3600
20	Cycles in mud chamber w/o contamination	k-cycles	>15	>35
21	Time to disassemble/assemble for maintenance	s	<300	<160
22	Special tools required for maintenance	list	hex	hex
23	UV test duration to degrade rubber parts	hours	>250	>450
24	Monster cycles to failure	cycles	>300k	>500k
25	Japan Industrial Standards test	binary	pass	pass
26	Bending strength (frontal loading)	MN	>70	>100

Specification Trade-offs

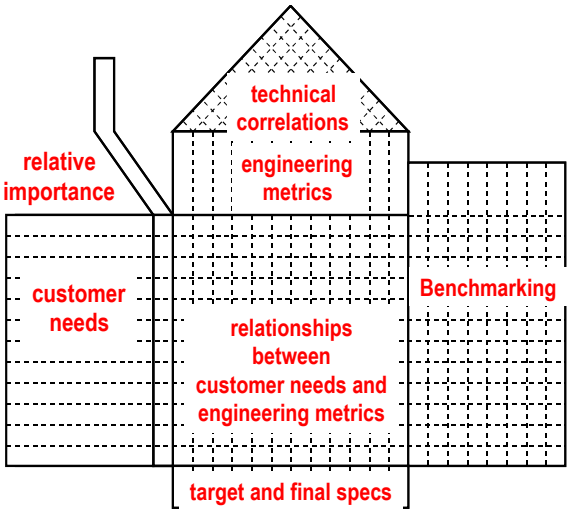


Trade-offs also on reliability

- **Gross Margin i.e. product sector**
  - 50% (eg software)
    - Can afford to recall 1 product out 2 and break even
  - 15% (eg consumer electronics)
    - Can afford only 1 product out of 10 to be faulty
- **Time for fix/production**
  - 1month
    - Can ship a new upgrade to a customer
  - 1year
    - Cannot afford a recall of the product
- **Legal liabilities, competitive market etc.**

Quality Function Deployment (House of Quality)

UNIVERSITY OF TRENTO



Set Final Specifications

UNIVERSITY OF TRENTO

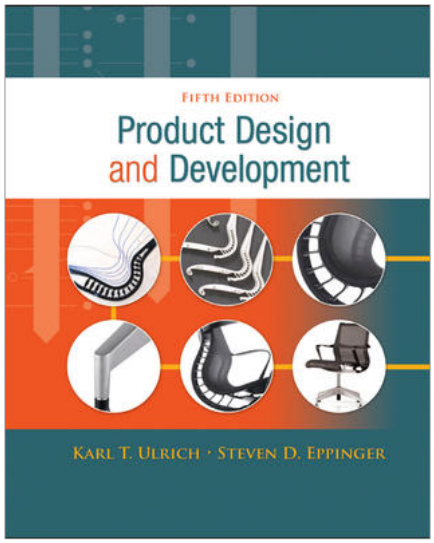
	METRIC	Units	Value
1	Attenuation from dropout to handlebar at 10hz	dB	>12
2	Spring pre-load	N	650
3	Maximum value from the Monster	g	<3.4
4	Minimum descent time on test track	s	<11.5
5	Damping coefficient adjustment range	N-s/m	>100
6	Maximum travel (26in wheel)	mm	43
7	Rake offset	mm	38
8	Lateral stiffness at the tip	kN/m	>75
9	Total mass	kg	<1.4
10	Lateral stiffness at brake pivots	kN/m	>425
11	Headset sizes	in	1.000 1.125
12	Steertube length	mm	150 170 190 210 230
13	Wheel sizes	list	26in
14	Maximum tire width	in	>1.75
15	Time to assemble to frame	s	<45
16	Fender compatibility	list	Zefal
17	Instills pride	subj	>4
18	Unit manufacturing cost	US$	<80
19	Time in spray chamber w/o water entry	s	>3600
20	Cycles in mud chamber w/o contamination	k-cycles	>25
21	Time to disassemble/assemble for maintenance	s	<200
22	Special tools required for maintenance	list	hex
23	UV test duration to degrade rubber parts	hours	>450
24	Monster cycles to failure	cycles	>500k
25	Japan Industrial Standards test	binary	pass
26	Bending strength (frontal loading)	MN	>100

Concept Selection Exercise: Mechanical Pencils

UNIVERSITY OF TRENTO

Textbook

UNIVERSITY OF TRENTO

Product Design and Development
Karl T. Ulrich and Steven D. Eppinger
5th edition, Irwin McGraw-Hill, 2012

1. Introduction
2. Development Processes and Organizations
3. Opportunity Identification
4. Product Planning
5. **Identifying Customer Needs**
6. **Product Specifications**
7. Concept Generation
8. Concept Selection
9. Concept Testing
10. Product Architecture
11. Industrial Design
12. Design for Environment
13. Design for Manufacturing
14. Prototyping
15. Robust Design
16. Patents and Intellectual Property
17. Product Development Economics
18. Managing Projects