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ICT Innovation – Spring 2015

MSc in Computer Science and MEng Telecom. Engineering
EIT Masters ITA, S&P,SDE

Lecture 02 – Concept Development – Customer Needs and Product Specifications

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PD&D Process: Concept Development

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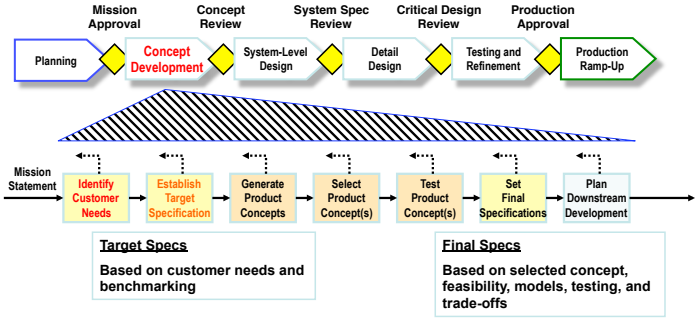
- **Eliminate**
  - Concepts that look unpromising (business-wise)
  - Concepts that are unwieldy to design



Customer Needs & Product Requirements

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- **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

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Mission Statement: Screwdriver Project

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- **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

How Many Customers?

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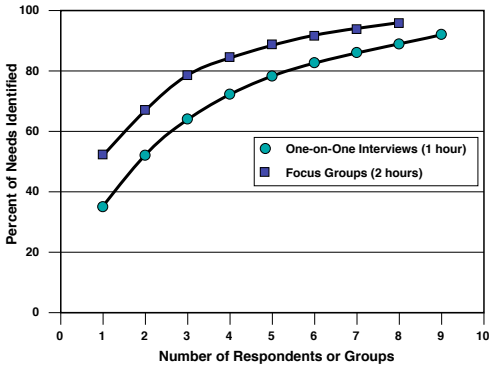

From: Griffin, Abbie and John R. Hauser. "The Voice of the Customer", *Marketing Science.* vol. 12, no. 1, Winter 1993.

Caveats

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- **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

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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 (II), battery never to fall out, safe to handle with hands, prevent electric shock	Battery contacts to be protected/put protective shieldsaround battery contacts (VII)
Specificity	"I drop my screwdriver all the time."	must be operational after falling (II), easy hold in hand in all conditions (IV), prevent scartching oof smooth polished surfaces	Physical form to fit into a pocket (II), outer casing of SD fall-resistant/ bumpers (III), rope (III)
Positive Not Negative	"It doesn't matter if it's raining, I still need to work outside on Saturdays."	Device resistant to getting wet (II) – forget it (II), Has to work in any kind of weather	Waterproof (V)
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 (IX), 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 able to see by the user (IX), liquid indicator	

Writing Customer Needs

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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 (to be prioritized)

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- **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.**
- **The SD feels good in the user's hand.**
  - is comfortable when the user pushes on it.
  - is comfortable when the user resists twisting
  - is equally easy to use in right or left hands .
- **The SD is easy to control while turning screws.**
  - 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 does not strip screw heads.
  - SD 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
- **The SD power is convenient.**
  - SD is easy to recharge.
  - SD recharges quickly
  - 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.
  - 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 (do you agree?)

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- **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. (*) + some ++
  - 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.**
- **The SD feels good in the user's hand.**
  - is comfortable when the user pushes on it. (***) +
  - is comfortable when the user resists twisting (***)
  - is equally easy to use in right or left hands (!). +
- **The SD is easy to control while turning screws.**
  - 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 does not strip screw heads. (*) ++
  - SD 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 (*!).
- **The SD power is convenient.**
  - SD is easy to recharge. +++
  - SD recharges quickly (***) +++
  - 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. ++
  - 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

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- **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.**
  - 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 (!).
  - 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. (*)
  - user can easily see where the screw is (**)
  - SD does not strip screw heads. (*)
  - SD 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)

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***** 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

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- **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**

Requirements for a ScrewDriver (from reality)

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***** 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.

Requirements (contd)

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- **"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

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- **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%)

Product Specifications Example: Mountain Bike Suspension Fork

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Quality Function Deployment (House of Quality)

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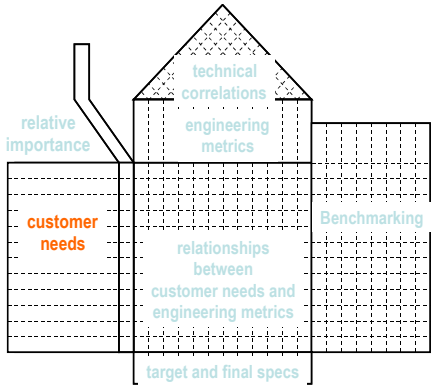

Start with the Customer Needs

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

Start with the Customer Needs

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#	NEED		Imp
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)

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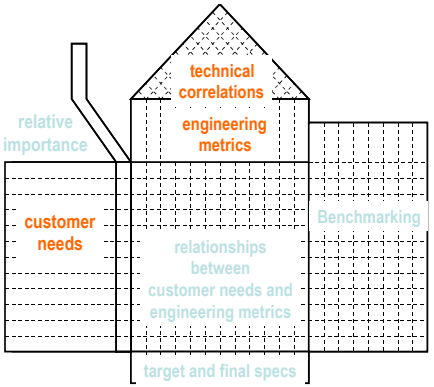

Design Product Model (for ICT performance model)

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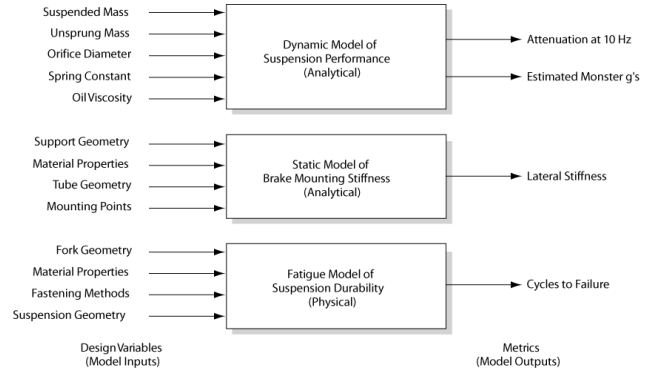

From *Product Design and Development* by Karl Ulrich and Steven Eppinger (McGraw-Hill/Irwin)

Establish Metrics and Units

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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)

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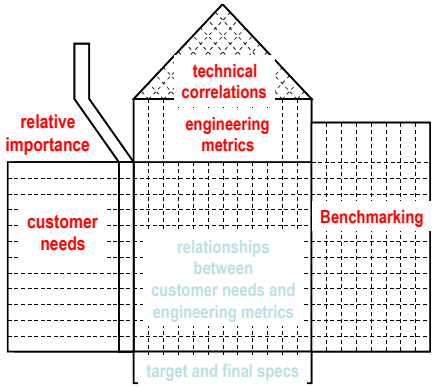

Benchmark on Customer Needs

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#	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	•••••	•••••	•••••	•••••	•••••	•••••

Benchmark on Metrics

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Metric #	Need #s	Metric	Imp	Units	ST Tritrack	Maniray 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

Quality Function Deployment (House of Quality)

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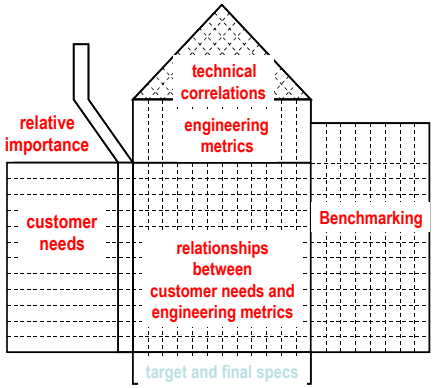

Link Metrics to Needs

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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

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	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

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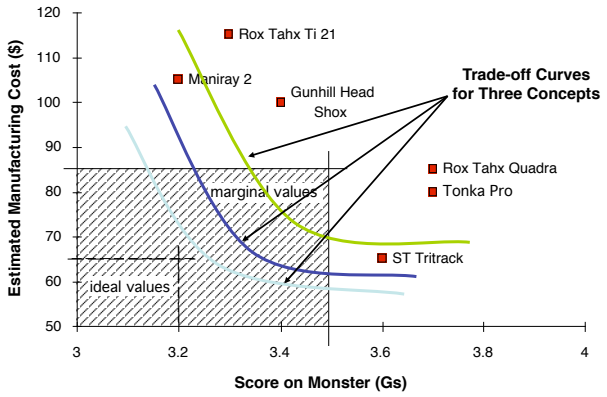

Trade-offs also on reliability

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- **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)

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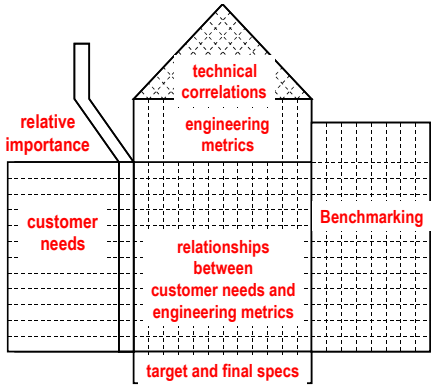

Set Final Specifications

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	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

Textbook

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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