Creating Specifications for a Product Design

What does the customer want, and what is most important? A list of potential customer needs and design specification categories is given below. Not everything may be relevant to your project.

DESIGN SPECIFICATION CHECKLIST

REQUIREMENTS	CONTRIBUTING FACTORS	POINTS TO CONSIDER
FUNCTIONAL	Overall geometry	Size, height, width, length, diameter, space, number, arrangement
	Motion of parts	Type, direction of motion, velocities, acceleraton, kinematics
	Forces involved	Load direction, magnitude, weight, load, impact, stiffness, inertia
	Energy needed	Heating, cooling, conversion, efficiency, pressure, temperature, storage
	Materials to be used	Flow, transport, properties, implications, regulation, life-cycle
	Control system	Electrical, electronic, hydraulic, pneumatic, mechanical
	Information flow	Inputs, outputs, form, display, computer
SAFETY	Operational	Direct, indirect, hazard elimination, safeguarding
	Human	Warnings, training, instruction, personal protection
	Environmental	Land, sea, air, noise, light, radiation, reaction, transport, emergencies
QUALITY	Quality assurance	Regulations, standards, codes, accreditation
	Quality control	Inspection, testing, measuring tolerances, labeling
	Reliability	Design life, failures, statistics
MANUFACTURING	Production of components	Factory limitations, maximum dimensions, means of production, wastage
	Purchase of components	Supplier quality and reliability, inspection
	Assembly	Special regulations, installation, siting, foundations, bolting, welding
	Transport	Material handling, clearance, packaging
TIMING	Design schedule	Project planning, project control
	Development schedule	Design detailing, in-house tests, compliance tests
	Production schedule	Manufacture, assembly, quality assurance, packing, transport
	Delivery schedule	Delivery date, distribution network
ECONOMIC	Marketing analysis	Size of market, strength of market, distribution, servicing
	Design costs	Design team, computing, information retrieval, reproduction
	Development costs	Design detailing, supplier costs, testing costs
	Manufacturing costs	Tooling, labor, overhead, assembly, inspection, cost to customer
	Distribution costs	Packing, transport,service centers, spare parts, warranty
ERGONOMIC	User needs	Type of operation, instructions, warnings
	Ergonomic design	Man-machine relationships, operation, height, layout, comfort, lighting
	Cybernetic design	Controls, layout, clarity, interactions
ECOLOGICAL	Material selection	Solid, liquid, gas, stability, protection, toxicity, safety
	Working fluid selection	Liquid, gas, flammability, toxicity
AESTHETIC	Customer appeal	Shape, color, texture, form, feel, smell
	Fashion	Culture, history, trends
	Future expectations	Rate of change, trends
LIFE-CYCLE	Distribution	Means of transport, nature and conditions of dispatch, rules, regulations
	Operation	Quietness, wear, special uses, working environments, foreseeable misuse
	Maintenance	Servicing intervals, inspection, exchange and repair, painting, cleaning
	Disposal	Recycle, scrap

From the categories given in the previous figure, develop a list of customer needs and assign them a level of importance in the design in a manner similar to that shown below.

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

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

The SD works with a variety of screws.
4 The SD can turn phillips, torx, socket, and hex head screws.
4 The SD can turn many sizes of screws.

The SD can access most screws.
The SD can be maneuvered in tight areas.
4 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.
2 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.
2 The SD can be locked "on."
4 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.
3 The maximum torque of the SD can be set by the user.
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.
3 The SD can be used while recharging.
5 The SD recharges quickly.
2 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.
2 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.
2 The SD resists corrosion when left outside or in damp places.
3 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.

3 **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 8 Hierarchical list of primary and secondary customer needs for the cordless screwdriver. Importance ratings are shown for some of the needs (using the ranking scheme given in Exhibit 9).

The requirements can be simplified and placed in a spreadsheet in this manner to simplify analysis and future steps that will be shown.

No.		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

Customer needs for the suspension fork and their relative importance (shown in a convenient spreadsheet format).

Measurable characteristics of the design need to be developed that correspond to the customer needs or requirements.

Metric No.	Need Nos.	Metric	Imp.	Units
1	1, 3	Attenuation from dropout to handlebar at 10 Hz	3	dB
2	2, 6	Spring preload	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 (26 in. 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 without water entry	5	s
20	15	Cycles in mud chamber without 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	kN

List of metrics for the suspension. The relative importance of each metric and the units for the metric are also shown.

The metrics can be correlated to needs as shown above, or in a matrix like that shown below.

	Need	1 Attenuation from dropout to handlebar at 10 Hz	2 Spring preload	3 Maximum value from the Monster	4 Minimum descent time on test track	5 Damping coefficient adjustment range	6 Maximum travel (26 in. 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 without water entry	20 Cycles in mud chamber without 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																									•	•

EXHIBIT 5 The needs-metrics matrix.

Target specifications can then be developed to give numbers to the metrics to be analyzed. The complete functional specification would be modified after testing a few prototypes. In our case, they can be estimated as shown below.

Metric No.	Need Nos.	Metric	Imp.	Units	Marginal Value	Ideal Value
1	1, 3	Attenuation from dropout to handlebar at 10 Hz	3	dB	>10	>15
2	2, 6	Spring preload	3	N	480–800	650–700
3	1, 3	Maximum value from the Monster	5	g	<3.5	<3.2
4	1, 3	Minimum descent time on test track	5	s	<13.0	<11.0
5	4	Damping coefficient adjustment range	3	N-s/m	0	>200
6	5	Maximum travel (26 in. wheel)	3	mm	33–50	45
7	5	Rake offset	3	mm	37–45	38
8	6	Lateral stiffness at the tip	3	kN/m	>65	>130
9	7	Total mass	4	kg	<1.4	<1.1
10	8	Lateral stiffness at brake pivots	2	kN/m	>325	>650
11	9	Headset sizes	5	in	1.000 1.125	1.000 1.125 1.250
12	9	Steertube length	5	mm	150 170 190 210	150 170 190 210 230
13	9	Wheel sizes	5	list	26 in	26 in 700C
14	9	Maximum tire width	5	in	>1.5	>1.75
15	10	Time to assemble to frame	1	s	<60	<35
16	11	Fender compatibility	1	list	none	all
17	12	Instills pride	5	subj.	>3	>5
18	13	Unit manufacturing cost	5	US$	<85	<65
19	14	Time in spray chamber without water entry	5	s	>2300	>3600
20	15	Cycles in mud chamber without contamination	5	k-cycles	>15	>35
21	16, 17	Time to disassemble/assemble for maintenance	3	s	<300	<160
22	17, 18	Special tools required for maintenance	3	list	hex	hex
23	19	UV test duration to degrade rubber parts	5	hours	>250	>450
24	19	Monster cycles to failure	5	cycles	>300k	>500k
25	20	Japan Industrial Standards test	5	binary	pass	pass

EXHIBIT 8 The target specifications. Like the other information systems, this one is easily encoded with a spreadsheet as a simple extension to the list of specifications.