Engineering of Systems 1

Deliverable 4

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Competitor Weed Whackers	
Lower End Market (< $80)	*Why it's Worth Considering*
Expert Gardener	Lightweight 5.2 lbs, adjustable length, shaft rotation for edging, auto-feed head
Worx Electric Trimmer w/ Titling Shaft	Lightweight 6.5 lbs, telescopic shaft, auto-feed head, 4 positions adjustment head
Sun Joe Stringless Electric Trimmer	Lightweight 5.5 lbs, hassel free blade (no string), rotating head for edging
Weed Eater 15" Le CS Gas Trimmer	8.8 Lbs, easy adjust handle
Weed Eater - String Trimmer, 25cc, 17 in. Width	9.8 Lbs
Middle Market ($80 - $125)	*Why it's Worth Considering*
Ryobi Curved Shaft	Centrifrugal clutch, CARB compliant.
Craftsman Gas Trimmer 25cc 2 Cycle Curved Shaft	Attachment compatible, edger capable, blade accessory
Homelite Straight Shaft Trimmer	10.0 lbs 26 cc engine, replacement parts available
Craftsman 25cc Gas Trimmer 2-Cycle Straight Shaft	Attachment capable, edger capable, adjustable shaft
Black and Decker 12" Trimmer	Adjustable handle, tube shaft, converts to edger
High End Market ($125 - $200)	*Why it's Worth Considering*
Craftsman 30cc 4-Cycle Curved Shaft Weedwacker™	Push button start, 4 cycle engine, anti-vibration, attachment capable
Cub Cadet Split-Boom Trimmer	CARB compliant, 30 cc. 4 cycle, attachment capable
Ryobi Curved Shaft	Anti-vibration, attachment capable, CARB compliant, 30cc 4 cycle
Troy-Bilt XP Trimmer	18 in cutting swath (+1 in), electric start capable, spring assist start, attachment capable
Echo GT-225	10.1 lbs, 21.2 cc 2 stroke engine, i-30 start system
Hitachi 21.1cc Commercial Straight Shaft String Trimmer	60.3 in shaft length, anti vibration, centrifugal clutch
Husqvarna Gas Trimmer	4 cycle, 18 cutting swath

Discussion

To achieve a baseline of current weed wacker features, we engaged in an internet search to identify competitor products. In addition to gaining a baseline understanding of the weed wacker market, we strove to find competitor products that address our product's problems of interest. A portion of the products identified will be utilized in the technical benchmarking of our QFD. With such a diverse market of weed wackers we found it necessary to subdivide our findings into three groups; Lower End, Middle, and High End relative to our product. The goal was to look at products that were still within our target audience scope.

NUD-Kano Model

Key
Green Text: Need's Already Fufilled
Red Text: Discarded Need's

NUD \ Kano	Must Have	Linear Satisfier	Delighter
New	1	2	3
Unique	4	5	6
Difficult	7	8	9

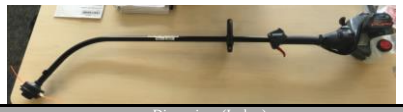
Need's	Matrix Value	NUD	Kano	Importance	Quantifiable
! The weed whacker cuts grass and weeds.					
! The weed whacker trims hedges.	5	Unique	Linear Satisfier	3	N
! The weed whacker cuts shrubbery.					
! The weed whacker has reliable performance.	8	Difficult	Linear Satisfier	9	N
* The weed whacker has an easy edger.	6	Unique	Delighter	3	N
* The weed whacker has a rotatable cutting head to cut at any angle.	9	Difficult	Delighter	1	Y
* The weed whacker has a large cutting head.	5	Unique	Linear Satisfier	6	Y
* The weed whacker has button-press string extension.	3	New	Delighter	1	N
* The weed whacker is easy to start (pull start or push start).	8	Difficult	Linear Satisfier	9	Y
* The weed whacker starts after one pull in cold weather.	8	Difficult	Linear Satisfier	1	N
* The weed whacker has quick, easy, and inexpensive replacement parts.	2	New	Linear Satisfier	6	Y
* The weed whacker has twist on twist off string cartridge.	3	New	Delighter	1	N
* The weed whacker has easy access to the choke.					
* The weed whacker has easy fuel access.					
* The weed whacker has easy spark plug access.	5	Unique	Linear Satisfier	3	N
* The weed whacker has a large gas tank.	6	Unique	Delighter	9	Y
* The weed whacker has a long lasting motor.	8	Difficult	Linear Satisfier	9	Y
* The weed whacker has minimal engine power requirements.					
! The weed whacker has engine ventilation to prevent overheating.					
* The weed whacker has low fuel consumption.	5	Unique	Linear Satisfier	6	Y
* The weed whacker has an easy to squeeze throttle.	6	Unique	Delighter	9	Y
* The weed whacker has adjustable shaft length.	9	Difficult	Delighter	3	Y
* The weed whacker has an adjustable weight balance.	3	New	Delighter	1	Y
* The weed whacker has a more adjustable handle.	6	Unique	Delighter	1	N
* The weed whacker is light weight.	8	Difficult	Linear Satisfier	6	Y
! The weed whacker's exhaust is directed away from the user.					
*The weed whacker has a comfortable grip.	5	Unique	Linear Satisfier	3	N
* The weed whacker has low vibration.	8	Difficult	Linear Satisfier	3	Y
* The weed whacker has a wide handle circumference.	5	Unique	Linear Satisfier	3	Y
+ The weed whacker is collapsible for easy storage and transportation.	3	New	Delighter	1	Y
* The weed whacker has a universal shoulder sling.	5	Unique	Linear Satisfier	1	N
* The weed whacker doesn't break running through small rocks.	7	Difficult	Must Have	9	N
* The weed whacker has corrosive resistant parts.	5	Unique	Linear Satisfier	3	Y
* The weed whacker is scratch resistant.	6	Unique	Delighter	1	N
* The weed whacker won't break when dropped.	8	Difficult	Linear Satisfier	6	N
! The weed whacker is water proof.	8	Difficult	Linear Satisfier	1	N
* The weed whacker starts in any condition.	8	Difficult	Linear Satisfier	3	N
* The weed whacker has long-lasting string.	9	Difficult	Delighter	3	Y
* The weed whacker is dirt/dust resistant.					
* The weed whacker has low noise emissions.	9	Difficult	Delighter	3	Y
* The weed whacker has low fuel emissions.	8	Difficult	Linear Satisfier	6	Y
* The weed whacker has biodegradable cutting string.	2	New	Linear Satisfier	1	N
* The weed whacker is made from non-hazardous materials.	4	Unique	Must Have	9	N
+ The weed whacker is solar powered.	3	New	Delighter	1	N
! The weed whacker has an exhaust cover.					
+The weed whacker has a throttle lock for "cruise control".	5	Unique	Linear Satisfier	3	N
+The weed whacker has a circular saw cutting attachment.	5	Unique	Linear Satisfier	1	N
+The weed whacker has a 4-string cutting head attachment.	5	Unique	Linear Satisfier	1	N
+The weed whacker has a chain cutting head attachment.	5	Unique	Linear Satisfier	3	N
+The weed whacker has a fertilizer spreader function.	3	New	Delighter	1	N
! The weed whacker has a large grass guard.	4	Unique	Must Have	9	Y
! The weed whacker has a Dead Man Switch.					
! The weed whacker has an On/Off Switch.					
! The weed whacker has a string length constraint system.					
+ The weed whacker has a bug spray holster.	3	New	Delighter	1	N
The Weed whacker has a cup holder.	3	New	Delighter	1	N
Tangle Resistent Cutting Head.	2	New	Linear Satisfier	9	N

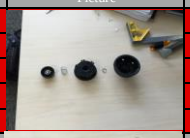
NUD-Kano Model Summary

Specific Needs	Metrics
The weed whacker has a rotatable cutting head to cut at any angle.	Cutting Head Angle of Rotation
The weed whacker has a large cutting head.	Cutting Swath Diameter
The weed whacker is easy to start (pull start or push start).	Energy Required by User
The weed whacker has a large gas tank.	Tank Volume
The weed whacker has low fuel consumption.	Fuel Emissions
The weed whacker has an easy to squeeze throttle.	Energy Required by User
The weed whacker has adjustable shaft length.	Length of Shaft
The weed whacker is light weight.	Total Weight
The weed whacker has low vibration.	Vibration
The weed whacker has long-lasting string.	Product Life Span
The weed whacker has low noise emissions.	Noise Level
The weed whacker has low fuel emissions.	Fuel Emissions
The weed whacker has a large grass guard.	Grass Guard Coverage

Customer Requirements
A Safe Product
Eco-Friendly
Multi-Functional
Durable Product
Ergonomic
Quality Performance
Easy-to-Use

Product Name	2-Cycle 25cc WeedWhacker Gas Trimmer
Product Number	316.71137
Product Dimensions	4' 9" X 16 3/4 " X 9 1/4"



				Dimensions (Inches)				
Sub System	Part #	Part Name	Picture	Length	Width	Height	Diameter	Quantity
Cutting head assembly	710 - 001	Bump Head Knob Assembly				3/4	1 3/4	1
	710 - 002	Inner Reel				1 1/8	3 1/4	1
	710 - 003	Spring		1 1/8			7/8	1
	710 - 004	Outer Spool				1 3/4	3 1/2	1
	710 - 005	Retainer					5/8 X 3/8	1
D-Handle Assembly	720 - 001	D-Handle bolt		2			3/16	1
	720 - 002	D-Handle washer					5/8 X 3/16	1
	720 - 003	D-Handle wingnut					3/16	1
	720 - 004	D-Handle		5 1/2	5 7/8	3/4		1
Shield Assembly	730 - 001	Shield		10 1/2	8 1/2	2 1/4		1
	730 - 002	Blade		1 1/2	3/4	1/16		1
	730 - 003	Shield Bolt		1 7/8			3/16	1
	730 - 004	Shield Wingnut					3/16	1
	730 - 005	Blade Screw		7/16			1/8	2
	730 - 006	Blade Nut					1/8	2
	730 - 007	Shield Washer					5/16 X 3/16	1
Throttle Housing Assembly	740 - 001	Throttle Housing		8	3 3/4	3/4		2
	740 - 002	Switch		3/4	1	5/8		1
	740 - 003	Housing Screws		3/4			1/8	5
	740 - 004	Housing Screw		5/16			1/8	1
	740 - 005	Throttle Trigger Spring		1/2			1/8	1
	740 - 006	Throttle Trigger		2 1/4	1 1/4	5/8		
	740 - 007	Throttle Cable		20 1/2			1/2	1
	740 - 008	Split Lume		11 1/2			1/2	1
	740 - 009	Zip ties						2
Clutch Cover Assembly	750 - 001	Clutch Cover		8 1/8			4	1
	750 - 002	Clamp Screw		1 1/2			3/16	1
	750 - 003	Cover Screw		3/4			3/16	3
	750 - 004	Anti Rotation Screw		5/16			1/8	1
	750 - 005	Clamp Nut					3/16	1
Rear Cover Assembly	760 - 001	Rear Cover		5 1/8	5 1/8	3		1
	760 - 002	Cover Screw		3/4			3/16	1
	760 - 003	Housing Screw		9/16			3/16	2
Fuel Tank Assembly	770 - 001	Fuel Tank Clip		1/2	5/8	3/16	3/16	2
	770 - 002	Tank Screw		7/8			3/16	2
	770 - 003	Fuel Tank		6	2 1/2	3		1
	770 - 004	Fuel Cap				7/8	1 7/8	1
Air Cleaner Cover Assembly	780 - 001	Air Cleaner Cover		4	3	1 1/4		1
	780 - 002	Air Cleaner Filter		2	3 1/4	1/4		1
	780 - 003	Air Cleaner Bolts		2 1/2			3/16	2
	780 - 004	Intake Manifold		2 1/4	3 3/4	5/16		1
Insulator Assembly	785 - 001	Insularot Screw		7/8			3/16	2
	785 - 002	Washers					3/16	2
	785 - 003	Lock Washers					3/16	2
	785 - 004	Carburator O-ring				1/16	11/16	1
	785 - 005	Insulator		2 11/16	2 1/2	2		1
	785 - 006	Insulator Spacers		3/8			3/16	2
	785 - 007	Insulator O-ring		11/16	13/16			1
Clutch Assembly	790 - 001	Clutch Housing		2	2 1/2		9/16	1
	790 - 002	Clutch Friction Weights		1 1/2	3/4	1/2		2
	790 - 003	Clutch Springs		3/4			3/8	2
	790 - 004	Center Clutch Mount		1 1/4	5/8	9/16		1
	790 - 005	Large Washer					1 1/8 X 3/8	1
	790 - 006	Small Black Washer					9/16 X 5/16	1
Flexible Drive Shaft	791 - 001	Flexible Drive Shaft		46			1	1
Carburator	792 - 001	Carburator		2	2 1/2	1 1/8		1
Air Cleaner Gasket	793 - 001	Air Cleaner Gasket		1 3/16	1 11/16		5/8	1

Starter Housing Assembly	794 - 001	Starter Housing		8 1/2	7	5 1/4		1
	794 - 002	Starter Housing Screw		7/16			5/32	3
Cutting String	795 - 001	Cutting String Piece 1		70				1
	795 - 002	Cutting String Piece 2		72				1
Engine Assembly	796 - 001	Piston		2 7/8	1 3/8	1 3/8		1
	796 - 002	Engine		6 1/2	4 3/4	7		1
	796 - 003	Spacer		2			3/8	1
Muffler Assembly	797 - 001	Muffler		5 3/8	5 1/16	2 7/8		1
	797 - 002	Muffler Screws		3/4			1/4	2

Cutting Head Angle of Rotation	
Total Weight	-
Grass Guard Coverage	++ -
Energy Required by User	+ +
Tank Volume	- -
Vibration	- ++
Length of Shaft	- +
Product Life Span	- +
Noise Level	++
Fuel Emissions	+
Cutting Swath Diameter	++ + +
Engine Displacement	- - + - - -
Preferred	↑ ↓ ↑ ↓ ↑ ↓ ↑ ↑ ↓ ↓ ↑ ↑

Correlation Codes	
+ +	Very Positive
+	Positive
-	Negative
- -	Very Negative

Engineering Metrics

Customer Requirements	**Customer Weights**	Cutting Head Angle of Rotation	Total Weight	Grass Guard Coverage	Energy Required by User	Tank Volume	Vibration	Length of Shaft	Product Life Span	Noise Level	Fuel Emissions	Cutting Swath Diameter	Engine Displacement
		Degrees: 90	lbs: < 10	Percent: >= 25%	kcal/min: <= 7	Ounces: >= 12	m/s^2: <= 4	Inches: 60	Years: >= 5	Decibels: < 100	CO [g/kw-hr]: < 603	Inches: 18	Cubic Centimeter: 27
A Safe Product	10%		3	9	6		9	1		3	1		
Eco-Friendly	4%									6	9		
Multi-Functional	8%	9						3					
Durable Product	15%		3	1			6		9				
Ergonomic	15%	3	6		9		9	3		9			
Quality Performance	30%	1			3	1		1	3			3	3
Easy-to-Use	18%	3	6	1	3	3	3	1				3	1
Technical Benchmarking	*Troy-Bilt*	0	12.9	25%	8.5	14	7	52	9	107	520	18	27
	Ryobi	0	11.4	15%	7.9	12	8	49	7	103	536	17	25
	Weed Eater	0	10.5	20%	7	9.9	9	40	5	100	541	15	25
	Craftsman	0	10.5	20%	7.2	9.9	7	52	6	102	530	17	25
	Raw score	2.01	2.73	1.23	3.39	0.84	3.69	1.27	2.25	1.89	0.46	1.44	1.08
	Relative Weight	9%	12%	6%	15%	4%	17%	6%	10%	8%	2%	6%	5%

Customer Perception

1 Worse	*2*	*3*	*4*	*5 Better*
WR	C	T		
CWR	T			
	CWR	T		
	CWR			T
	WR	TC		
W		CR		T
		W		TCR

T	Troy-Bilt
R	Ryobi
W	Weed Eater
C	Craftsman

PHASE II QFD *Weed Whacker*

Part Characteristics

Engineering Metrics	**Phase I Relative Weights**	Cutting Head Assembly	Engine Assembly	Flexible Drive Shaft	Fuel Tank Assembly	Clutch Assmebly	Sheild Assembly	Muffeler Assembly	Starter Housing Assembly				
Cutting Head Angle of Rotation	9%	9		1			3						
Total Weight	12%	3	9	6	1	1	1	1	1				
Grass Guard Coverage	6%	6		1			9						
Energy Required by User	15%	3	6	9					9				
Tank Volume	4%		1		9								
Vibration	17%	3	9	1		3							
Length of Shaft	6%	1		9		1	1						
Product Life Span	10%	1	9	6		1		1	3				
Noise Level	8%	3	9			1		9					
Fuel Emissions	2%		9		3			3					
Cutting Swath Diameter	6%	9	3	1		1	6						
Engine Displacement	5%	6	9		1	9		3	3				
	Raw score	3.749	6.03232	3.5992	0.572	1.363	1.335	1.194	1.94	0	0	0	0
	Relative Weight	19%	30%	18%	3%	7%	7%	6%	10%	0%	0%	0%	0%

QFD 1 Analysis

We used a list of all the customer hierarchical needs from the previous deliverable and assigned each need a matrix value {1-9} to represent a (NUD, Kano) pair for each need. We soon began to realize that certain needs, like *the weed wacker cuts grass*, didn't fit into the NUD-Kano Matrix. These needs are already being fulfilled by our craftsman weed wacker. We also found some needs to be unnecessary, like *the weed wacker is dirt/dust resistant.* In total, 12 needs were removed and two needs were added for a total of 45 customer needs. Each customer need was assigned an importance value based on a {1, 3, 6, 9} scale. From this list we narrowed the group of needs down to the ones that were quantifiable by an engineering metric. We continued to narrow down the group of specific customer needs into a set of customer requirements that best represent the engineering metrics.

The QFD 1 analysis returned a relative weight of importance for engineering metrics. Of all the engineering metrics, vibration reduction had the largest relative weight when it comes to customer requirements. Energy required by user and total weight of the product were two other engineering metrics that we found to have a high relative weight in correlation with customer requirements, exhibiting 15% and 12% respectively. We also found that weight reduction had the largest negative correlations with the other metrics. This is a result of most of the engineering metrics requiring additional material to improve, whereas the total weight is desired to be less. Vibration had a positive correlation with several other engineering metrics since adding more to the product will allow it to absorb more vibration. Therefore looking to reduce vibration by this method gives ground toward adding more to the product in order to meet the desired customer requirements.

From the technical benchmarking we found that our product met two of the technical targets, product lifespan and fuel emissions. Our product met the fewest number of technical targets compared to the three competitor products that were benchmarked. This shows that our product has a large opportunity for improvement in comparison to the market competitors. Multiple technical targets and corresponding product values were assumed based on various sources. These sources can be referred to in the works cited.

QFD 2 Analysis

When breaking down our product we made sure to logically organize the components into subassembly groups as we thought were necessary. The operator's manual was a useful resource when referencing subassembly groups that were difficult to identify. Breaking down the weed wacker required extreme organization as there were many intricate components. The breakdown process allowed us to gain insight into the manufacturing assembly process, as we witnessed how each subassembly pieced together to make the final product.

When developing the Phase 2 QFD chart, we realized that many engineering metrics were affected by multiple subassemblies. Likewise, we realized that each subassembly affected several engineering metrics. Our results showed that the Engine Assembly had the highest relative weight at 30% and is therefore the most influential part characteristic of the engineering metrics. The next two most influential were the Cutting Head Assembly and Flexible Drive Shaft at 19% and 18%, respectively. This means that when trying to meet the engineering metrics for the customer requirements, these part characteristics should get the most attention as their relative weights make up 67% of the total weight.

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http://www.fleetfarm.com/detail/Weed-Eater-25cc-Curved-Shaft-Trimmer/0000000200901?utm_source=googleps&utm_medium=shopping%2Bsearch&utm_campaign=google%2Bproduct%20search&gslfah&gclid=CIuU1p_hqMQCFWRk7AodIkUAMA

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