INDE 4372 Operation Control
Quality Function Deployment Report

Paola Salinas Gil, Alexandra Bayona, Miguel A. Rodriguez, Luqman Ismat

Instructor: Dr. Matthew Hu

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INTRODUCTION

Quality Function Deployment (QFD) is a methodology for identifying customer requirements, determining how the product or service will address them, and linking those requirements to specific product features. QFD is valuable for establishing priority ratings, benchmarking against competitors, and aligning performance with targeted technical specifications.

The purpose of this report is to apply the Quality Function Deployment methodology to analyze an Amazon Echo Dot speaker, identify what will fulfill customer requirements, and convert those needs into concrete design objectives. Amazon Echo Dot is an intelligent speaker powered by Alexa, focused on entertainment, and serves as a smart home control center. Echo Dot serves as a voice assistant, music/audio streamer, smart control, and a daily organization tool, automating users' simple tasks without the need for a phone, using voice recognition technology.

CUSTOMER REQUIREMENTS

Task 1: Customer needs and expectations

The method used to collect and analyze customer feedback was to randomly select customer reviews of the Amazon Echo Dot that are posted on Amazon's website. After going through several reviews from all 5 of the ratings (1-5 stars), we found that the customers value and want the following:

CUSTOMER NEEDS/ EXPECTATIONS	RANKING	PRIMARY/SECONDARY NEEDS
Price Point	11	Primary
Sound Quality	10	Primary

Ease of Setup	8	Primary
Connectivity	6	Primary
Proper Functioning	7	Primary
Volume Levels	5	Secondary
Effective voice recognition	9	Primary
Compact Size	3	Secondary
Appealing Design	4	Secondary
Color Variety of Product	1	Secondary
Light Weight	2	Secondary

QUALITY	**DESIGN**
• Sound • Proper Functioning	• Compact Size • Appealing Design • Color Variety • Light Weight
FUNCTIONALITY	**CAPACITY**
• Ease of Setup • Effective Voice Recognition	• Volume Levels • Connectivity

TECHNICAL REQUIREMENTS

Explain the correlation between customer requirements and technical requirements.

Provide justification for the selection of these technical parameters.

CUSTOMER AND TECHNICAL REQUIREMENTS AND THEIR CORRELATION FOR AMAZON ECHO DOT		
CUSTOMER NEEDS/ EXPECTATIONS	**TECHNICAL REQUIREMENTS**	**CORRELATION BETWEEN CUSTOMER REQUIREMENTS AND TECHNICAL REQUIREMENTS**
Price Point	Price is proportional to product quality	The price point should be proportional to the quality of the product while being affordable.
Sound Quality	Wattage capacity and Speaker size.	Higher speaker wattage and optimized driver size allow the Echo to deliver clearer sound, better bass, and audio that fills the room that customers perceive as good sound quality.
Ease of Setup	Processor speed.	A faster processor allows the Echo to complete initial setup/ software updates/configuration steps quicker, so that customers experience a smooth and simpler setup process
Connectivity	Wi-Fi and Bluetooth	Wi-Fi and Bluetooth enable the Echo to connect reliably to home networks, phones, and other speakers, giving users the reliable connectivity that is expected.

Proper Functioning	Processor reliability and Software stability.	Reliable processors and stable software ensure that the Echo properly responds to voice prompts, runs Alexa functions, and stays online without frequent crashes, which customers interpret as proper functioning.
Volume Levels	Speaker wattage and amplifier capability.	Adequate amplifier power and speaker wattage allows the Echo to reach high volumes without distortion, thus satisfying users who look for clear audio at different volumes.
Effective voice recognition	Microphone sensitivity and voice recognition algorithms.	Far-field microphones plus advanced noise-cancelling and recognition algorithms let the Echo hear and understand commands from across the room, even with background noise, meeting expectations for accurate voice control.
Compact Size	Device dimensions.	Carefully chosen device dimensions give the Echo a small footprint that fits shelves and desks while still housing its speakers and electronics, matching customers' desire for a compact smart speaker.
Appealing Design	Exterior materials, finishes, and aesthetic design.	The Echo's fabric material, color options and rounded shape make it visually appealing to blend in with home decor while addressing the customer's need for an aesthetically pleasing
Color Variety of Product	Exterior color and finish options.	By allowing multiple exterior colors and finishes, it allows customers to select an Echo that matches their surroundings directly tying color options to the expectation of product variety.

Light Weight	Material selection and internal components.	Using lightweight materials and compact internal components keeps the Echo easy to lift and move, aligning with customer expectations for a light, portable device.

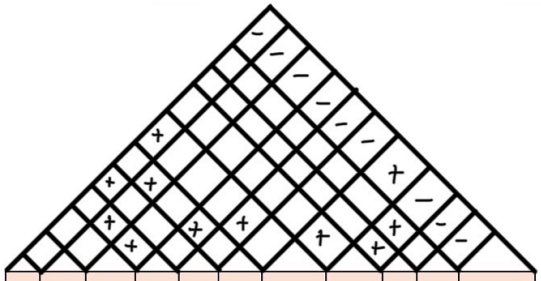
TECHNICAL EVALUATION FOR AMAZON ECHO AND COMPETITORS			
TARGET VALUES FOR TECHNICAL REQUIREMENTS	**AMAZON ECHO DOT**	**GOOGLE NEST MINI**	**APPLE HOMEPOD MINI**
Price Point	$49.99	$49	$99
Wattage capacity	external 15 W power adapter, with single 1.73 in (44 mm) front-firing speaker.	external 15 W power adapter, with single 40 mm (1.58 in) full-range driver.	20 W power adapter (supports 18 W) with one full-range driver and two passive radiators (≈ 3.3 in tall enclosure).
Processor speed.	Amazon AZ2 Neural Edge processor with 2.0 GHz MediaTek MT8516 processor.	Quad-core 64-bit ARM CPU at 1.4 GHz.	Apple S5 SiP (same class chip as Apple Watch Series 5, 64-bit, ~1.6 GHz class
Wi-Fi and Bluetooth	Dual-band 802.11a/b/g/n/ac (2.4 and 5 GHz) Wi-Fi plus Bluetooth for audio and device pairing	802.11b/g/n (2.4/5 GHz) Wi-Fi, Bluetooth support; works as a hub for Google Home/ Matter.	802.11n Wi-Fi, Bluetooth 5.0, Thread, ultra-wideband (U1) for proximity/ Handoff.

Processor reliability and Software stability.	Runs Alexa on Amazon's smart-speaker OS with over-the-air updates; AZ2 offloads some voice processing locally for faster, more reliable responses.	Runs Google Assistant with over-the-air firmware updates; stable platform with Voice Match, ML hardware engine for on-device tasks.	Runs audioOS (fork of tvOS) with automatic updates; supports computational audio, Siri personalization, and long-term support from Apple.
Amplifier capability.	Internal Maxim MAX98396 digital-input Class-DG mono amplifier, capable of about 20 W into 8 Ω / 19 W into 4 Ω, optimized via DSP for small-speaker loudness and protection.	Integrated Class-D amplifier driving 40 mm driver, tuned for 360° sound with DSP limiting to prevent distortion at high volume	Integrated stereo Class-D amplifier IC (e.g., Analog Devices SSM3582-class) driving full-range driver and passive radiators, heavily managed by S5 "computational audio" DSP for dynamic loudness and room-adaptive performance.
Microphone sensitivity and voice recognition algorithms.	Far-field mic array (four microphones) with beamforming and noise reduction for Alexa, supports wake-word detection across room.	Three far-field microphones with Voice Match technology for multi-user recognition and noise-robust wake-word detection.	Four-microphone array for far-field Siri, supports personalized responses for up to six users and sound-recognition (alarms).
Device dimensions.	3.9 in × 3.9 in × 3.5 in (100 mm × 100 mm × 89 mm) spherical "dot" design.	Diameter 98 mm, height 42 mm (wall-mounted puck form factor; Google lists compact "puck" size).	3.3 in × 3.9 in (84 mm × 99 mm) spherical design.

Exterior materials, finishes, and aesthetic design.	Fabric-covered sphere with plastic base; minimal physical buttons plus light ring on top.	Fabric-covered top with plastic shell and wall-mount slot; available in chalk, charcoal, coral, and other region-specific colors.	Acoustically transparent mesh fabric with top touch surface; compact sphere aesthetic in multiple colors.
Exterior color and finish options.	Colors include Charcoal, Glacier White, and Deep Sea Blue (matte fabric and plastic finishes).	Multiple matte fabric colors such as chalk (light), charcoal (dark), sky, and coral (availability varies by market)	Colors include white, blue, yellow, orange, and midnight (space gray replaced), all with color-matched braided cable and tinted touch surface.
Material selection and internal components.	Fabric grille, plastic shell, 1.73 in speaker, far-field mic array, AZ2 Neural Edge processor, temperature sensor, accelerometer, and integrated power/ amp board. mic array, integrated power electronics and Zigbee smart-home hub.	Fabric top, plastic body, 40 mm driver, three far-field mics, capacitive touch sensors, quad-core ARM processor, 15 W PSU.	Mesh fabric, plastic shell, S5 SiP logic board, full-range driver with two passive radiators, four-mic array, integrated temperature/humidity sensor and U1 chip.

Specifications were obtained from the product's respective websites.

HOUSE OF QUALITY MATRIX



		Wattage capacity	Processor speed	Wi-Fi and Bluetooth	Processor reliability and Software stability	Amplifier capability	Microphone sensitivity and voice recognition algorithms	Device dimensions	Exterior materials, finishes, and aesthetic design	Exterior color and finish options	Material selection and internal components	Price is proportional to product quality	Google	Apple	Amazon
Sound Quality	10	•			◯	◉					◉	◉	G	G	G
Ease of setup	8		◯	◉	◉								F	G	F
Connectivity	6		◉	◉	◉								F	G	G
Proper Functioning	7	•	◉	•	◉	◯	◉					◯	G	G	G
Volume Levels	5	•				◉							G	G	G
Effective Voice Recognition	9		•				◉					•	G	P	G
Compact Size	3	◯							•		•		G	G	G
Appealing Design	4	◯						◯	◉	◉			P	G	G
Color Variety	1								◉	◉			G	G	G
Lightweight	2	•						•	•		◉		G	G	G
Price point	11		◯		◉	•	◉					◉	G	P	G
Our Importance Ratings		43	174	133	318	167	243	14	50	45	111	230			
Target Values		15 W	At least 1.6GHz	2.4/5 GHz and Bluetooth 5.0	Regular Software Updates	Has DSP	At least 3 far-field microphones	Max Dimension: 100mm	Plastic and fabric	At least 4 options	Durable	Price Range: $40-$60			
Technical Evaluation	Google	15	1.4	""	Yes	Yes	3	98mm	Plastic and fabric	4	Yes	$99			
	Apple	20	1.6	""	Yes	Yes	4	99mm	Plastic and fabric	5	Yes	$49			
	Amazon	15	2	""	Yes	Yes	4	100mm	Plastic and fabric	4	Yes	$49.99			

Results and Discussion

Key Insights from the QFD Analysis

The QFD matrix revealed that performance-driven technical features dominate customer satisfaction. Among all engineering characteristics, the highest weighted priorities were:

- Processing unit / DSP capability (318)
- Microphone sensitivity & voice recognition hardware (243)
- Price proportional to product quality (230)
- Processor speed (174)
- Amplifier capability (167)

These results indicate that customers place the greatest value on sound quality, effective voice recognition, and overall product value, which aligns with the top customer requirements: price point (11), sound quality (10), effective voice recognition (9), and ease of setup (8).

Lower priorities were assigned to purely aesthetic or dimensional factors (e.g., device size, exterior materials, and color variety), suggesting that while appearance matters, users primarily care about functional performance and affordability.

Competitive benchmarking (Google, Apple, Amazon) showed relatively similar technical capabilities across products, reinforcing that incremental improvements in processing power, microphone arrays, and perceived value could provide meaningful differentiation rather than cosmetic changes alone. Overall, the QFD highlights that investments in internal electronics and signal processing yield the highest return in customer satisfaction.

Challenges in Constructing the QFD Matrix

Several challenges were encountered during the development of the QFD:

- Subjectivity in relationship scoring: Assigning strengths (strong/moderate/weak) between customer needs and technical requirements involved engineering judgment, which introduces potential bias.
- Quantifying qualitative customer needs: Attributes such as “appealing design” or “ease of setup” were difficult to translate into measurable engineering parameters.
- Interdependencies between technical characteristics: The roof matrix revealed correlations (e.g., processor speed vs. DSP capability), making it challenging to isolate independent effects.
- Limited availability of competitor data: Some specifications for Google, Apple, and Amazon products were estimated or generalized, which may affect benchmarking accuracy.

Impact of QFD Findings on Design and Process Improvements

The QFD directly informed design priorities by shifting focus toward core system performance rather than external features.

- Design efforts should prioritize upgrading DSP and processing units to improve sound quality and responsiveness.
- Enhanced microphone arrays and sensitivity tuning are critical for better voice recognition accuracy.

- Pricing strategy must closely reflect performance gains, as customers strongly associate value with technical quality.
- Secondary features (color options, materials, compactness) should be optimized only after core functionality is satisfied.

From a process perspective, the QFD supports:

- Earlier cross-functional collaboration between hardware, software, and marketing teams.
- More data-driven component selection.
- Clear alignment between customer expectations and engineering targets.

Ultimately, the QFD helped transform vague customer preferences into actionable engineering requirements, ensuring that development resources are allocated to features with the greatest customer impact.

Conclusion and Recommendations

Recap of Main Findings and Their Implications

The QFD analysis revealed that the Amazon Echo Dot's ability to satisfy customers is most strongly influenced by its core technical features, particularly digital signal processing, microphone sensitivity, and processing speed. Customers prioritize sound quality, reliable voice recognition, and a price that reflects performance over cosmetic or aesthetic attributes. Competitive benchmarking reinforced that small but meaningful improvements in internal performance can differentiate the product in a market where most smart speakers offer similar external features.

- The implication is that design and development efforts should heavily favor enhancements to core functionality, as they directly drive customer satisfaction and perceived value. Cosmetic improvements or new color variations provide only marginal benefits unless paired with functional improvements.

Recommendations for Design Improvements Based on QFD Analysis

1. Upgrade DSP and processing units to improve audio quality, reduce latency, and support faster Alexa responses.
2. Enhance microphone arrays and optimize voice recognition algorithms for better accuracy in noisy environments.
3. Align pricing strategy with technical performance improvements to reinforce the product's value proposition.
4. Maintain secondary design features—such as size, color, and materials—as optional differentiators, but only after core functional upgrades are addressed.

Suggestions for Further Research and Development

1. Investigate AI-driven voice filtering and noise cancellation technologies to further improve hands-free user experience.
2. Explore energy-efficient processing and low-power modes to reduce operating costs and environmental impact.
3. Evaluate new materials and acoustic enclosures to passively enhance sound quality without increasing device footprint.

4. Conduct longitudinal customer studies to track how improvements in processing, recognition, and audio quality affect long-term satisfaction.

By following the QFD-guided priorities, future iterations of the Amazon Echo Dot can deliver meaningful performance upgrades that strengthen market competitiveness and better meet customer expectations.

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