Capstone Product Requirements

1   Purpose

This document presents the functional requirements for the AudIQ mobile phone application that is a product of NJIT BME 496 (Capstone II).

2   REASON FOR RE-ISSUE

ISSUE		REASON FOR RE-ISSUE
1	MR #AUDIQ00004	Previous issue document was vague

3   Overview

AudIQ is a mobile phone application designed to train users in different categories in order to improve their overall auditory function. Auditory function refers to an individual's awareness of the various features of sound: Speech-in-noise and sound location. The main objective of this application is to make the user feel more comfortable and confident in hearing in social settings by providing an entertaining environment in which auditory training is facilitated.

The nomenclature used in this document is as follows:
· **REQxxxx** *denotes a* **specific requirement** *that must be met.*
· **BACKxxxx** *denotes an* **information** *statement that may be useful in interpreting requirements and the numbering should match the requirement number.*
· *Numbers should be displaced by 10 to allow for future requirements to be inserted into the document without re-numbering.*

4   Definitions

Interaural Time Difference (ITD): The difference in time between the left and right channels of the sound signals.

Interaural Level Difference (ILD): The difference in amplitude between the left and right channels of the sound signals.

5   Document References

SQL Manual
SQLite Manual
Praat Manual

Audacity Manual
Matlab Manual

6   AudIQ Functional Requirements

This section entails the functional requirements of the software and programming of the main application.

6.1   Interface Software Requirements

REQ010 The mobile application (AudIQ) shall operate on Apple and Android mobile devices.

> **BACK010** Android and Apple devices refer to tablets and smartphones (of either the Apple and Android brand) that have wireless capabilities and access to online applications.

REQ020 AudIQ shall be programmed in the C# programming language.

> **BACK020** An example of a specific C# program is Unity, a software that creates applications that are available for both Android and Apple devices. C# is a multiple platform language.

REQ030 AudIQ delays shall not exceed 1 second.

6.1.1 Main Menu

REQ030 AudIQ shall have a main menu, where the user can select which part of the mobile application to access. (See Figure 1 for more detail).
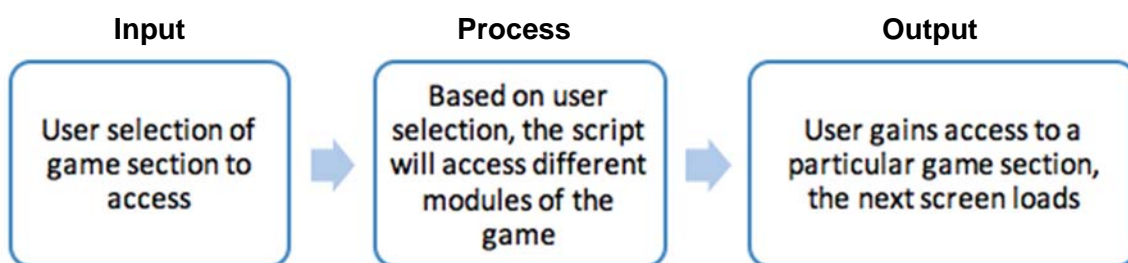

Figure 1

REQ040 The main menu shall consist of 4 different options: a training section, a testing section, a results section, and a demonstration section. (Refer to 6.1.2 for details on training section, 6.1.3 for details on testing section, 6.1.4 for details on the results section, and 6.1.5 for details on demonstration section).
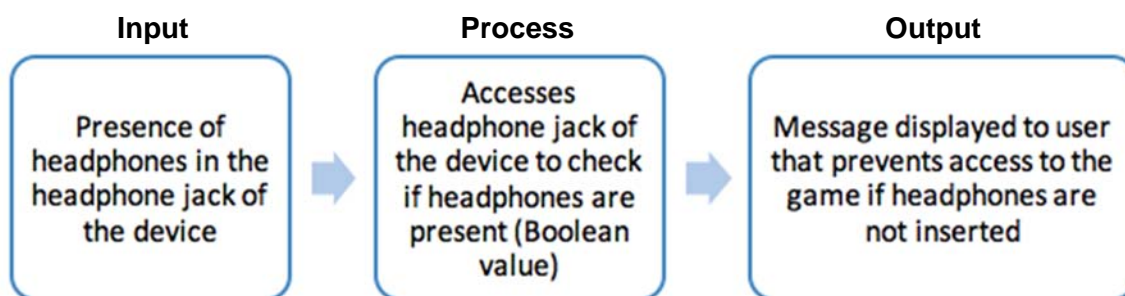
BACK040 In the results section, the user can view recent results.   In the training section, the user can train auditory function in a particular field of training. In the testing section, the user can test auditory function in several different categories at once. In the demonstration section, the user can learn how to play the game.

REQ050 The application shall check that headphones are inserted into the smart device when the training, testing, or demonstration sections load.

BACK050 Periodically check if the headphones are plugged in using the AudioManager.isWiredHeadset(On) is true. If the headphones are unplugged, the function will output false, and the game will be paused.

REQ060 The user shall only be allowed to proceed (play the application) if headphones are inserted.

REQ070 If the headphones are not inserted, the "Headphones Not Inserted" message shall stay on the screen, preventing access to the application. (See Figure 2 for more detail).

Input	**Process**	**Output**
Presence of headphones in the headphone jack of the device	Accesses headphone jack of the device to check if headphones are present (Boolean value)	Message displayed to user that prevents access to the game if headphones are not inserted

Figure 2

REQ080 The application shall have a volume level checker that executes when the main menu loads.

REQ090 The application software shall check the output voltage of the headphone jack to determine if the volume level exceeds 85% of the mobile device's maximum volume. (See Figure 3 for more details)

REQ100 If the volume level exceeds 85%, a "Volume is Too Loud" message shall stay on the screen, preventing the user from continuing the game until the volume is lowered again. (See Figure 3 for more detail).

Input	**Process**	**Output**
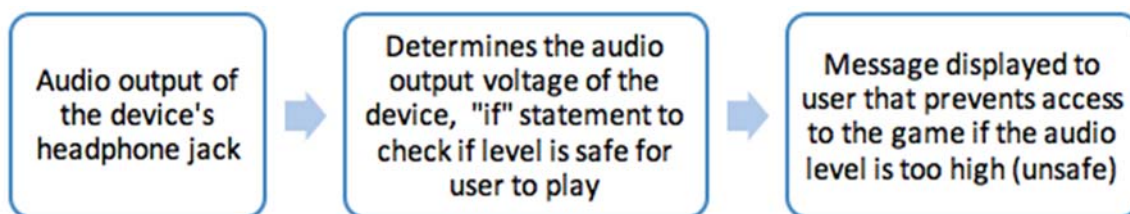
Figure 3

BACK100 Based off Technical Specs of Apple Headphones, the maximum output of the device is 109 dB SPL/mW. (decibel standard pressure level/milliwatts)

6.1.2 Training Section

REQ110 The training section shall consist of a menu containing three buttons leading to three different sections: speech-in-noise, sound localization, and pitch discrimination settings.

BACK110 Each button is associated with a different field of auditory cue training.

REQ120 For the speech in noise section, the application shall present the user with questions related to sounds involving a person speaking with noise in the background.

BACK120 For example a speaker will say "The man in the yellow hat" while static noise plays in the background.

REQ130 For the sound localization section, the application shall play sounds varying in interaural time difference (ITD) and interaural level difference (ILD). (See Definitions Section 4 on ITD and ILD)

BACK130 For example, sound localization can include sounds originating from left of the user or from the right of the user.

REQ140 For the pitch discrimination section, the application shall prompt users to compare sounds of different frequencies.

BACK140 For example, a user will be presented with a low frequency and high frequency sound.

REQ150 After selecting an answer choice, the user shall be informed whether the answer choice was correct or incorrect. (See Figure 4 for more detail).

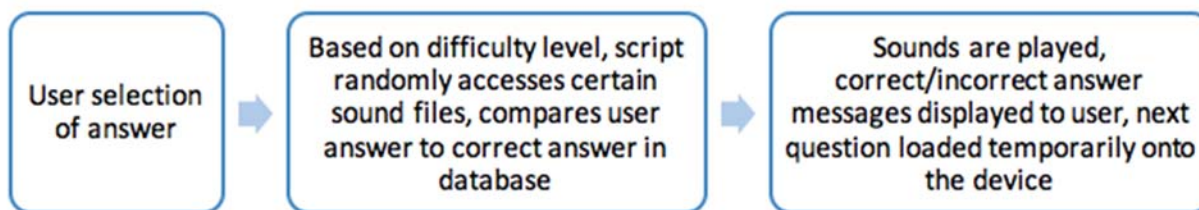| **Input** | **Process** | **Output** |

Figure 4

REQ160 The user shall not be able to replay the sound files for each question.

REQ170 The difficulty level shall only increase by one level if the user correctly answers two questions consecutively.

REQ180 The difficulty level shall decrease by one level if the user answers one question incorrectly. (See Figure 5 for more detail).
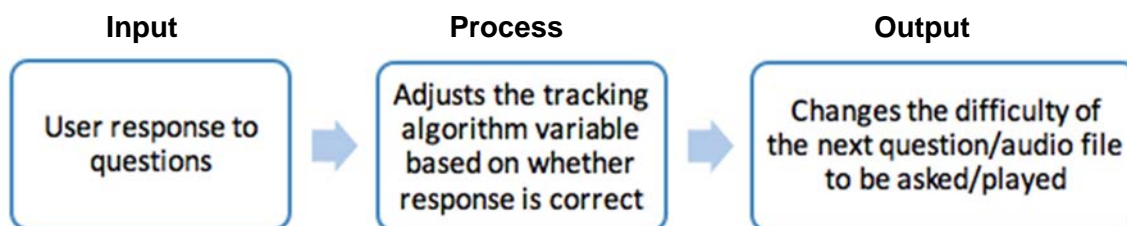

Figure 5

REQ190 The questions presented to the user shall be specific to the section that is being played. The general question format is shown in Table 1.

Table 1. General Question Format

Section	Question	Answer Options	Example
Pitch Discrimination	A sound of one frequency will play and then the frequency will increase or decrease	Player swipes up if sound is a higher pitch Player swipes down if sound is a lower pitch	Sound plays at 100Hz and then changes to 500Hz Player swipes up for correct answer
Location	Where did the sound come from?	Four options: front, back, left, right	A sound plays that has an ITD of 500us

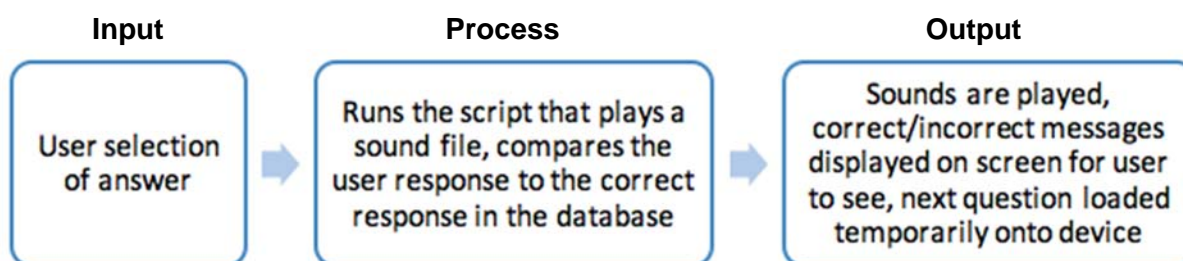|			The sound is coming from the Right so the Right option is correct
Speech-in-Noise	What is the man/woman/child saying?	Four options, each option contains words that sound similar	A man says "Hat" User is presented with options "Cat" "Bat" "Hat" "Fat" "Hat" is the correct option

6.1.3 Testing Section

REQ200 The testing section shall only be accessible once a day, where the start of each day is represented by 12:01AM.

BACK200 Testing is a daily assessment.

**REQ210** The testing section shall terminate after 30 questions are answered.

REQ220 The questions shall be randomly accessed from each of the three question banks in the database.

REQ230 Upon completion of the test, the application shall display the user's results on the screen of the smart device. (See Figure 6).

Input **Process** **Output**

User selection of answer → Runs the script that plays a sound file, compares the user response to the correct response in the database → Sounds are played, correct/incorrect messages displayed on screen for user to see, next question loaded temporarily onto device

Figure 6

REQ240 The displayed results shall consist of the user's percent accuracy for each category that was tested. (a sample of user results is presented in Figure 7).
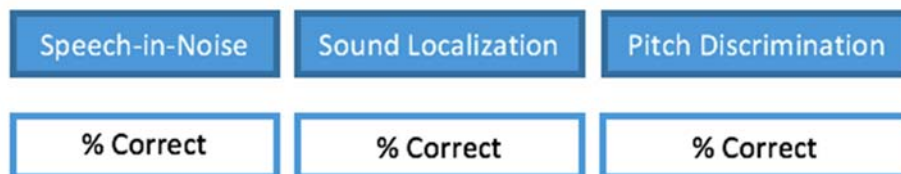
Figure 7

6.1.4 Results for User Section

REQ250 The results section of the application shall consist of a menu consisting of three different options.

REQ260 The first option shall allow the user to view the user's results from the most recent training section.

REQ270 The second option shall allow the user to view results from the most recent testing section.

REQ280 The third option shall allow the user to view results from the past 2 weeks.

REQ290 By interacting with a button associated with each option, the user shall be able to choose which results the user would like to view.

REQ300 For the "past 2 weeks results", the results shall be presented in two different formats.

REQ310 The first results format shall be a graph of the user score vs time.

REQ320 The second results format shall be a percentage correct for each training category as depicted in Figure 7.
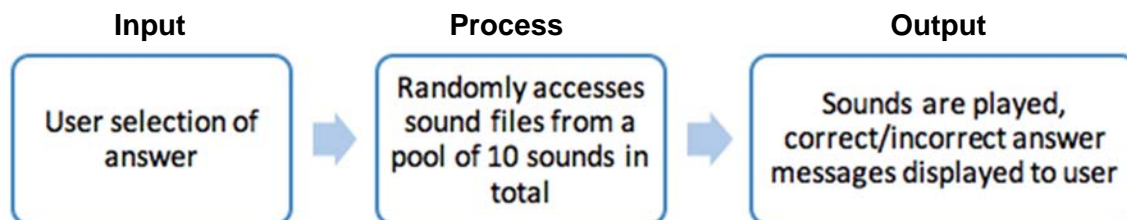
6.1.5 Demonstration (Demo) Section

REQ330 AudIQ shall include a demonstration that shall instruct the user how to use the application.

REQ340 The demonstration section shall consist of a sample training section of the application.

REQ350 The demonstration shall consist of 3 sample rounds of training (same style as the training section of the game).

REQ360 During the demonstration, the user shall be presented with a sound and prompted to answer a question related to the sound that was just played. (See Figure 8 for more detail).

Input	Process	Output
User selection of answer	Randomly accesses sound files from a pool of 10 sounds in total	Sounds are played, correct/incorrect answer messages displayed to user

Figure 8

REQ370 After completing 3 rounds of the demonstration (answering 3 questions about different sound files), the demonstration shall conclude and the user shall be directed back to the main menu of the application.

6.1.6 Registration

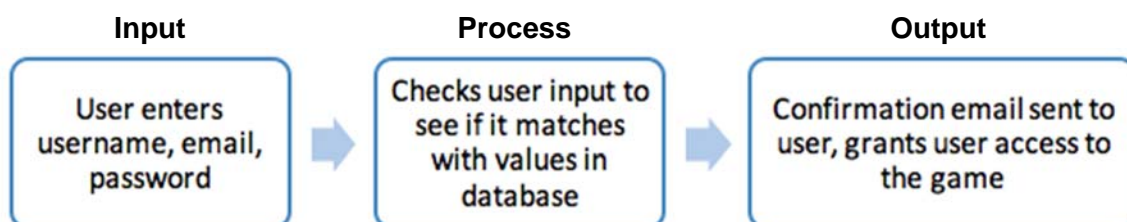**REQ380** AudIQ customers shall register before playing the game.

REQ390 AudIQ registration shall include email, username, password and confirmation password inputs.

REQ400 AudIQ registered information shall be stored in the remote database.

6.1.7 Log-In Menu

REQ410 AudIQ shall accept log-in information from the user and store it in a remote database.

REQ420 Log-in information shall include username and user password. (See Figure 9 for more detail).

Input	Process	Output
User enters username, email, password	Checks user input to see if it matches with values in database	Confirmation email sent to user, grants user access to the game

Figure 9

BACK420 These categories are used to identify specific users so that user information is unique.

REQ430 The user shall only be granted access to the application if the correct log-in information is entered.

REQ440 If the user is not registered (first-time user), the application shall have a registration option that allows the user to create an account.

REQ450 To ensure successful registration, the application shall check that the log-in information does not already exist in the database.

REQ460 The application shall also check that the entered user email is a valid email address before allowing the user to register.

REQ470 Upon registration, the log-in information (email, password, and username) of the new account shall be stored in the remote database.

6.1.8 Data Acquisition

REQ480 AudIQ shall accept user input and store it within the application during the training and testing sections.

REQ490 AudIQ shall transfer data from the application's temporary storage into a remote database and local database.

> **BACK490** This data includes the actual question that was presented to the user, the sound file that was sent to the user, and the user's response to the question.

6.2 Auditory Engineering Requirements

REQ500 The sound wave shall be between 0.5 and 5 seconds with a ±0.05 tolerance.

REQ510 The sampling rate of the sounds shall be 44.1 kHz.

REQ520 The frequencies of sounds shall be no greater than 20 kHz and no less than 20 Hz.

> **BACK520** The frequency range in which humans can hear is between 20 Hz (Hertz) and 20 kHz.

REQ530 Sound files shall be saved in the 16-bit .wav format

> **BACK530** 16-bit provides enough quantization levels to produce the desired sound, without taking up too much memory space. .wav files are uncompressed files so that no data is lost.

REQ540 Sounds specific to frequency discrimination shall be stored in the remote database table specific to the frequency discrimination section.

REQ550 Sounds specific to sound localization shall be stored in the remote database table specific to the sound localization section.

REQ560 Sounds specific to speech-in-noise shall be stored in the remote database table specific to the speech-in-noise section.

REQ570 Sound properties shall be inputted into their respective remote database table. Properties shall include frequency, time duration, interaural level difference, and interaural time difference, amplitude, and signal-to-noise ratio. Refer to REQ650 for more details.

6.3   Remote and Internal Database Requirements

REQ580 The remote database shall allow the AudIQ application to put data into and request data out of the remote database.

> **BACK580** Data will consist of the username, email, password, sound files, and user's response (correct or incorrect response).

REQ590 Before data is added or fetched from the database, a connection between the AudIQ application and the remote database shall be made by passing the hostname, username, password and database name through the MySQL connection function.

REQ600 The hostname, username, password, and database shall be provided by the specific server and database used.

> **BACK600** For example, if using the NJIT server, NJIT will provide the hostname, username, password, and database.

REQ610 The AudIQ application shall contain a local database in order to function offline.

> **BACK610** An example of a local database is the SQLite database.

REQ620 The SQLite database shall allow for the storage of data on the phone if there is no internet connection available.

REQ630 Once there is an internet connection available, new/updated data shall be transferred to the NJIT server.

REQ640 The SQLite database shall also store sound files and a question bank.

> **BACK640** These sound files and questions shall be utilized when the user is playing AudIQ offline.

REQ650 To organize the AudIQ training sections, the remote and local database shall contain a table with a unique ID called AudIQ ID (tinyint 3) and the names of the sections (varchar 25)-- frequency discrimination, sound localization, and speech-in-noise. (Refer to Tables 2 and 3)

Table 2. AudIQ Sections table

TableName	AudIQ Sections	
Column Name	**AudiQ ID**	**AudiQ Name**
Sample Data1	1	Pitch Discrimination
Sample Data2	2	Sound Localization
Sample Data3	3	Speech in Noise

Table 3. Structure of AudIQ Sections table with data types

REQ660 For the user account data, the remote and local database shall contain a table with an unique ID called User ID (BigInt 20), and the user's registration information, such as username (varchar 25), password (varchar 25), email (varchar 25), and registration time (timestamp 4) (Refer to Table 4 and 5).

Table 4. Structure of user account table with data types

Table 5. User Account Table

TableName	User Account				
Column Name	User ID	username	user_pwd	email	registerDT
Sample Data1	12	Cow365	cloud280	joe@example.com	3/22/2016 21:16
Sample Data2	13	Monkey2245	light34	letter34@example.com	4/16/2016 21:59
Sample Data3	14	Teddybear957	stars25	teddy@example.com	5/25/2016 23:17

REQ670 To organize the sound files used for each of the three sections, the remote and local database shall contain the tables: frequency discrimination question bank (Refer to Table 6), sound localization question bank (Refer to Table 7), and speech in noise question bank (Refer to Table 8).

REQ680 Each question bank table on the remote and local databases shall contain a unique ID QBank ID (medium int(8)), the unique ID from the AudIQtraining section table, AudIQ ID (tiny int(3)) , the time the sound file was uploaded(timestamp (4)), whether the sound files are active or not(enum('Y','N')), duration of the sound(int(11)), interstimulus interval(int 11), frequency(int 11), interaural time difference(int 11), amplitude(int 11), sound file name (varchar 100), sound file type (varchar 100), and sound file content (medium blob).

REQ690 To organize the user's responses, the remote and local database shall contain a table with a unique ID called PracticeID (Bigint 20), the User ID (Bigint 20) from the user account table, the AudIQ ID (medium int 8) from the AudIQ training section table, the question number value (medium int 8), user's answer (Bigint 20), time when the user answered the question (Timestamp 4), and whether the question was correct or incorrect (Enum('I','C')) (Refer to Tables 9 and 10).

Table 9. Structure of User Practice Data table with data types

User Practice Data	
PK Practice ID	Bigint (20)
FK User ID	Bigint (20)
FK AudiQ ID	mediu mint (8)
Question Num	mediu mint (8)
User Answer	Bigint (20)
Incorrect or Correct	Enum('I','C') (4)
Timestamp	Timesta mp (4)

Table 10. User Practice Data Table

TableName	User Practice Data							
Column Name	User ID	AudiQues TypeID	QBank ID	Question Num	User Answer	Incorrect or Correct	Timestamp	Practice_OR_Te sting
Sample Data1	3	1	3	1	300	C	3/22/2016 21:15	P
Sample Data2	3	1	2	2	100	I	3/23/2016 21:15	p
Sample Data3	3	1	12	3	500	C	3/24/2016 21:15	p
Sample Data4	3	1	15	4	466	C	3/25/2016 21:15	p
Sample Data5	3	1	46	5	500	C	3/26/2016 21:15	p
Sample Data6	3	1	99	6		I	3/27/2016 21:15	t

|							
Sample Data7	3	1	78	7		C	3/28/2016 21:15 t
Sample Data8	3	1	56	:		I	3/29/2016 21:15 t
Sample Data9	3	1	98	20		I	3/30/2016 21:15 t

REQ700 The AudIQ training section table, user's response table and the three question bank tables shall have the same AudIQ ID.

REQ710 The user account table and the user's response table shall have the same user ID.

REQ 720 The user practice data table shall provide the necessary information of user response, question posed to the user and the correct answer for the client to see.

6.4   Communication Requirements

REQ720 Communication among the modules of the game shall follow Figure 10.
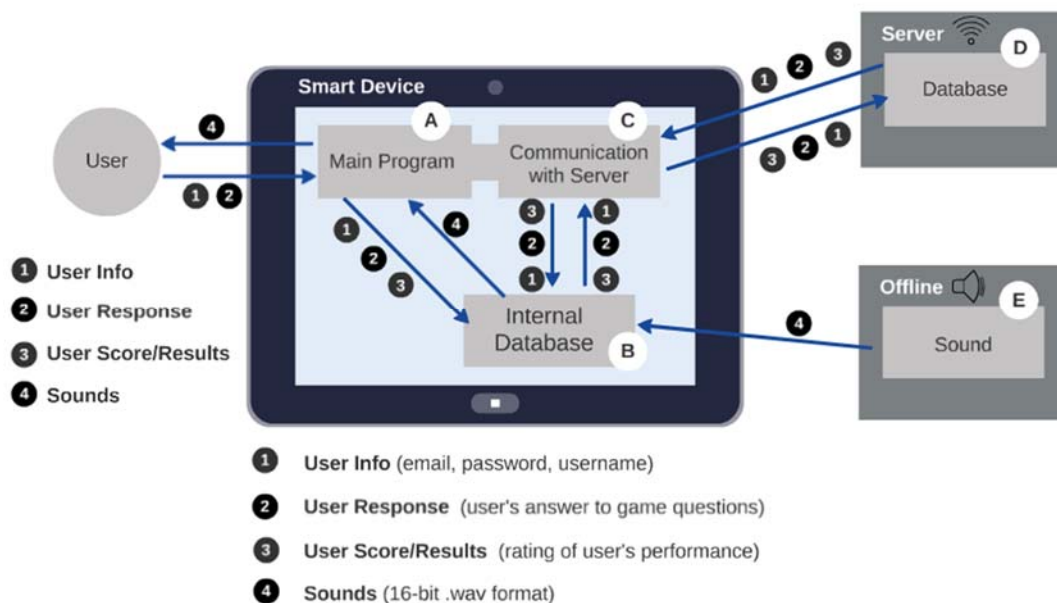
Figure 10

7 Documentation

REQ730 Documentation in the form of appropriate schematic, equipment and/or handbook drawings and certification/qualification procedures shall be provided to support engineering, manufacturing, procurement, installation, operation and maintenance functions.