Literature Review for Best Practices Framework for Procurement of Mobile Devices for People with Speech Loss

Last Revision: May 23, 2023

Contents

Introduction

People are different. We are short, tall, young, old, quick and slow. Our abilities to see, to hear, to react and to move vary between people and with age. By not taking this into consideration, businesses can inadvertently make it difficult for 15% of their potential customers to use their products and services, specifically older adults and people with disabilities. This number is only growing as consumers collectively grow older, but many products and services remain inaccessible to them. An accessible product or service is one which can be used by all its intended users, taking into account their differing capabilities and abilities.

This document puts forward a framework to allow designers of mobile devices to understand the needs of people with mobility impairments and provides a framework for existing best practices in regards to the design of solutions that would accommodate the needs of those people with disabilities. Though the abilities of people with disabilities, whether they have a mobility impairment or one of the other four main disability categories (sight, hearing, speech loss and cognitive) exist along a continuous spectrum, most solutions can be categorized into three main categories (mild, moderate and severe). There is an overlap in the range of the abilities to interact with technology of the individual within each of these broader categories. This document uses three main categories (mild, moderate and severe) in order to simplify the task for the designers. It is possible to use other categorizations, but the authors of this paper have tried to balance the need for usability and choice for the end users with the overall complexity burden that would be put on the designers if more categories are used.

Where technical considerations are discussed, effort was made to keep them at a very generic level without reference to a specific platform so that they can be more universally applied.

Definitions

- "Accessibility" – Accessibility is the "extent to which a consumer or user can obtain a good or service at the time it is needed." Accessibility as it applies to people with disabilities recognizes that individuals have differing levels of physical and mental capabilities, and that in order to deliver goods or services in an efficient and timely manner that can be easily consumed or used by these individuals, that these products and services must take into account those individual differences.

- "Disability" – Any restriction or lack (resulting from an impairment) of the ability to perform an activity in the manner or within the range considered normal for a human being.

- "Handicap" – A disadvantage for a given individual, resulting from an impairment or a disability, that limits or prevents the fulfillment of a role that is normal (depending on age, sex, and social and cultural factors) for that individual.

- "Impairment" – A loss or abnormality of psychological, physiological, or anatomical structure or function.

- "Appropriateness" – Measures how well the assistive technology solution maximizes the user's ability by helping the user complete his or her intended task in the most efficient manner.

    The appropriateness of a solution measures whether the solution's use is obvious, predictable and consistent, and whether the design matches the anthropomorphic and biomechanical capabilities (essentially, the abilities) of users while providing sufficient feedback, controllability and responsiveness to meet the users' expectations in regard to the efficiency of completing the task.

Appropriateness of a solution can be measured by the following dimensions:

- "Operability" - Its intended use should be obvious, predictable and consistent;

- “Obvious” - Easily seen, recognized or understood; intuitive;

- “Predictable” - It should match user expectations;

- “Consistent” - It should behave in the same manner when used in similar situations;

- “User compatible” - The design should match the anthropomorphic and biomechanical capabilities (essentially abilities) of users;

- “Feedback” - The device should let the user know when it is responding to the user’s actions;

- “Controllability” - the device should be responsive;

- “Responsiveness” quick to respond or react appropriately

- “Bio-mechanical load” - the force that must be applied to do a task, the duration of the force applied and the frequency of which the task is performed

- “Parallax” - the apparent displacement of an observed object or point of interest due to a change in the position of the observer.

- “Suitability for the widest range of use” – Designed with the objective of producing solutions that will be useful, acceptable and available to the widest range of users within the user population, taking into account their special abilities, variations in their capabilities, the diversity of their tasks, and their differing environmental, economic and social circumstances.

- “Equitable use” - Achieving equitable use will ensure that solutions designed to increase accessibility do not result in loss of privacy, increased risks to personal safety or security, or the stigmatization of individuals, and

that solutions provide the same means of use for all users that are identical whenever possible; equivalent when not.

- "Robustness" – Supporting a wide range of options both in terms of the features provided by ICT equipment or services and in terms of the ability to connect additional ICT equipment, software, and/or services

- "User interface Layer" - This layer of the system's operating system deals with aspects of the way the user perceives and interacts with the device.

- "Element" - An element is a logical representation of a user interface component. Some elements may be interactive, so that the user may interact with them. Some elements may be passive in that the user cannot interact with them, but they convey useful information to the user. A set of elements typically are combined to create an instance of the user interface. An element could be a single pixel, or a set of pixels makes up a logical visual grouping such as a single point, a button, an icon, an edit field, list box, etc. An element can be a physical representation of the potential user interactions available, such as an icon.

- "Point of Interest/Points of Interest (POI)" - A Point of Interest or a set of Points of Interest corresponds to an element, or to a set of elements that makes up a logical grouping. Points of interest are targets for potential user interaction. A POI focuses perception of the user interface and narrows the scope of potential interactions.

- "Action" - An action is performed on an element or series of elements. An action may change the status of a single property or multiple properties of an element. An action asks an element to perform an interaction.

- Shortcut: Achieves the same result as an action or series of actions without requiring that the user interact directly with elements or sets of elements.

- “Properties” - Properties describe individual parameters that describe an element, such as position (x and, y), if position exists for the element, width and height if they exist for the element, and various other status states of the element. The properties of an element depend on the nature of the element. For example, an element may have no visual representation, and therefore have no height and width properties.

- “State” - A State defines the status of a property which has multiple states (e.g., On and Off might be states of a Backlight On/Off property).

- “Events” - Changing the status of a property of an element can generate an Event that tells operating system of the device that a property or properties have changed state.
- “Narrow the range of a point of interest” An action can narrow the range of a point of interest (e.g., change the number entries in a list box that are highlighted).

1. Definition of Accessibility

In its simplest, most generic form, accessibility is the “extent to which a consumer or user can obtain a good or service at the time it is needed.” Accessibility as it applies to people with disabilities recognizes that individuals have differing levels of physical and mental capabilities and skills. In order to deliver goods or services in an efficient and timely manner, those goods and services must take into account those differences between individuals. In practical terms, it means all users can perceive, understand, navigate, and interact with the technology.

From the perspective of a product designer or a business manager without an extensive knowledge of the issues faced by people with disabilities, this can

appear to be a daunting task, but it does not have to be. People with disabilities fall into five main categories:

- Mobility-impaired
- Vision-impaired
- Hearing-impaired
- Cognitive condition
- Speech loss

People with disabilities also have a range of impairment, ranging from very mild to very severe. They can also have multiple forms of disabilities. This document breaks the issues down into easy-to-understand concepts, provides a basic understanding of the types of disabilities and the characteristics that define the abilities associated with people with disabilities, and provides guidance on how to identify and design for the needs of these consumers in the design or procurement processes.

2. Definition of Impairments

The World Health Organization (WHO) characterized impairments as follows in 1980:

> "Impairments, a restriction of one's capabilities and disabilities, the lack of the ability to perform tasks due to an impairment or impairments, may be temporary or permanent, reversible or irreversible, and progressive or regressive. The situation people find themselves in may determine to what degree a disability is handicapping for them. A handicap can be the result of both an impairment and of environmental conditions. If environmental barriers are taken away, the person will still be impaired, but not necessarily handicapped."

Breaking down the Users Within Each Disability Group

Within each of these four disability groups are people with impairments of varying levels of severity ranging from very mild to very severe. By reviewing the abilities across the range of users, a smaller number of types of solutions emerge. These solutions will meet the needs of users with typically only minor adjustments necessary to customize the solutions to their needs.

Categorization of Major Disability Groups

People with disabilities can have impairments with varying levels of severity ranging from very mild to very severe. They can also have multiple forms of disabilities. To simplify the process of categorizing features that can support specific disabilities, we can categorize impairments into five distinct groups:

- Vision
- Mobility
- Hearing
- Cognitive
- Speech Loss

In order to simplify the number of approaches for dealing with the requirements of people with disabilities with respect to technology, each one of these disability categories can be further broken down into three broad sub-categories of users based on the level of severity of their disability– mild, moderate and severe. While the capabilities and skills of any specific individual who has a disability are unique to that individual, typically the number of feasible and practical technology-based solutions can be classified by these broad categories of users–mild, moderate and severe.

Support for Individuals Who Have Multiple Disabilities

An individual may have multiple disabilities and, as such, assistive technology (AT) solutions must be able to co-exist and operate on the same device at the same time.

The five communities of users identified in this document are identified as:

- Mobility Loss
- Vision Loss
- Hearing Loss
- Cognitive Loss
- Speech Loss

Within each of these communities are identified three levels of disability:

- Mild
- Moderate
- Severe

While it is difficult to cover every combination of disabilities, there are combinations of disabilities that are common and therefore will be described explicitly. Devices provided under the procurement process should be able the support at least the following common combinations of disabilities:

- Mobility Loss and Speech Loss
- Mobility Loss and Cognitive Loss
- Hearing Loss and Vision Loss

and may support the following combinations of disabilities:

	Mobility	**Vision**	**Hearing**	**Cognitive**	**Speech**
Mobility	N/A	Aging,	Aging	Stroke	CP, MS,

		Diabetes			ALS
Vision	N/A	N/A	Aging	Traumatic Brain Injury	Usher's Syndrome, Aging, Cerebral Palsy
Hearing	N/A	N/A	N/A	Traumatic Brain Injury	Born Deaf
Cognitive	N/A	N/A	N/A	N/A	Aphasia
Speech	N/A	N//A	N/A	N/A	N/A

All levels of severity of a single disability t6ype within a community must be supported. Device manufacturers and suppliers are encouraged to ensure the coexistence of all AT solutions that can be implemented on the mobile device if technically feasible.

Background on Speech Loss

For the purposes of this document, the following definition of speech loss derived from the American Speech-Language Hearing Association (ASHA) definition is being used. The definition focuses on a subset of what ASHA defines as conditions covered under the definitions of Communication Disorders and Variations, [1]

> "A speech loss is an impairment of the articulation of speech sounds, fluency and/or voice.

[1] "Definitions of Communication Disorders and Variations". https://www.asha.org/policy/rp1993-00208/

An articulation disorder is the atypical production of speech sounds characterized by substitutions, omissions, additions or distortions that may interfere with intelligibility.

A fluency disorder is an interruption in the flow of speaking characterized by atypical rate, rhythm, and repetitions in sounds, syllables, words, and phrases. This may be accompanied by excessive tension, struggle behavior, and secondary mannerisms.

A voice disorder is characterized by the abnormal production and/or absences of vocal quality, pitch, loudness, resonance, and/or duration, which is inappropriate for an individual's age and/or sex." [2]

- Members of this community are typically defined by the characteristics of their voice, more specifically their acoustic volume, intelligibility, consistency of their speech and speaking rate of their speech. Intelligibility, consistency, and speaking rate are typical measures through listening tests and a standards list of vocabulary words, phrases and sentences. There is no widely-accepted, predominant, standardized test for these dimensions. A number of testing methods and validated tests exist but the actual test used varies by the speech and language pathologist training and regional norms.

The acoustic level refers to how loud a person sounds to a listener. It is a measurable and objective sound level.

"We measure sound intensity (also referred to as sound power or sound pressure) in units called decibels. Decibels (dB) are named in honor of Alexander Graham Bell, the inventor of both the telephone and the audiometer. An audiometer is a device that measures how well a person can hear certain sounds. A modern[3] version of it is still used today to diagnose hearing loss.

"Decibels are different from other familiar scales of measurement. While many standard measuring devices, such as rulers, are linear, the decibel scale

[2] "Definitions of Communication Disorders and Variations". https://www.asha.org/policy/rp1993-00208/

[3] https://www.noisyplanet.nidcd.nih.gov/have-you-heard/how-is-sound-measured#:~:text=We%20measure%20sound%20intensity%20(also,person%20can%20hear%20certain%20sounds.

is logarithmic. This kind of scale better represents how changes in sound intensity actually feel to our ears. To understand this, think of a building that is 80 feet tall. If we build up another 10 feet, the building will be 12.5 percent taller, which would seem just slightly taller to us; this is a linear measurement. Using the logarithmic decibel scale, if a sound is 80 decibels, and we add another 10 decibels, the sound will be ten times more intense, and will seem about twice as loud to our ears.

"Sometimes we use different versions of decibels. A-weighted decibels, or "dBA," are often used when describing sound level recommendations for healthy listening. While the dB scale is based only on sound intensity, the dBA scale is based on intensity and on how the human ear responds. Because of this, dBA gives us a better idea of when sound can damage your hearing."

For example, 60 dB sound pressure level is the equivalent of normal conversational speech at 1 meter[4,5], while a whisper is typically characterized as 30 dB or less at 1 meter.[6] Above 85 dB, the acoustic level is considered to be harmful if a person is exposed to it for an extended period of time. Below is a table showing the sound levels of some typical situations.

The following is a table of the decibel level of a number of sounds.

Noise levels

Noise	Average decibels (dB)
Leaves rustling, soft music, whisper	30
Average home noise	40
Normal conversation, background music	60
Office noise, inside car at 60 mph	70
Vacuum cleaner, average radio	75
Heavy traffic, window air conditioner, noisy restaurant, power lawn mower	

[4] https://www.quora.com/Normal-conversation-60-dB-sounds-like-soft-whisper-10dB-for-hard-hearing-What-increase-in-sound-levels-must-hearing-aid-provide-50-dB-40-60-30
[5] https://www.healthlinkbc.ca/health-topics/tf4173
[6] https://www.healthlinkbc.ca/health-topics/tf4173

	80–89 **(sounds above 85 dB are harmful)**
Subway, shouted conversation	90–95
Boom box, ATV, motorcycle	96–100
School dance	101–105
Chainsaw, leaf blower, snowmobile	106–115
Sports crowd, rock concert, loud symphony	120–129
Stock car races	130
Gun shot, siren at 100 feet	140

As loudness increases, the amount of time you can hear the sound before damage occurs decreases. Hearing protectors reduce the loudness of sound reaching the ears, making it possible to listen to louder sounds for a longer time.

7

The following is a table of the decibel level of a number of sounds.

Table of sound levels L (loudness of noise) with corresponding sound pressure and sound intensity

Sound sources (noise) Examples with distance	Sound pressure Level L_p dB SPL	Sound pressure p N/m² = Pa Sound field quantity	Sound intensity I W/m² Sound energy quantity
Jet aircraft, 50 m away	140	200	100
Threshold of pain	130	63.2	10
Threshold of discomfort	120	20	1
Chainsaw, 1 m distance	110	6.3	0.1
Disco, 1 m from speaker	100	2	0.01
Diesel truck, 10 m away	90	0.63	0.001
Kerbside of busy road, 5 m	80	0.2	0.000 1
Vacuum cleaner, distance 1 m	70	0.063	0.000 01
Conversational speech, 1 m	60	0.02	0.000 001
Average home	50	0.006 3	0.000 000 1
Quiet library	40	0.002	0.000 000 01
Quiet bedroom at night	30	0.000 63	0.000 000 001
Background in TV studio	20	0.000 2	0.000 000 000 1
Rustling leaves in the distance	10	0.000 063	0.000 000 000 01
Hearing threshold	0	0.000 02	0.000 000 000 001

http://www.sengpielaudio.com/TableOfSoundPressureLevels.htm[8]

"Speech intelligibility refers to how well someone can be understood when they're speaking. The factors that determine someone's clarity include knowing what sounds to make and how to pronounce them, the rhythm (also known as prosody), the volume, staying on topic, formulating syntax, and more. There's a lot that goes into our conversations without us even realizing it!

"There are a variety of methods SLPs use to measure a client's speech intelligibility. Some use their trained experience to listen and estimate the percentage of speech that can be understood. A more formalized method involves:
1) recording the client saying a list of pre-selected words/sentences
2) providing a second person with a list of similar sounding words
3) the second person will listen to the recordings and select from the list which word they think was being said.

[8] https://www.quora.com/Normal-conversation-60-dB-sounds-like-soft-whisper-10dB-for-hard-hearing-What-increase-in-sound-levels-must-hearing-aid-provide-50-dB-40-60-30

"This helps eliminate the bias that family members can have since they hear the client speak every day and might understand them better than a stranger would." [9]

"There is no definite tool to measure intelligibility. A number of different measurement tools exist/ One of the more widely used tools is the Assessment of Intelligibility of Dysarthric speech (AID) by Yorkston (David) Beukelman and Trainer. This tool measures how well single words and sentences are understood and speaking rate.

"There is no tool for measuring consistency. It is left up to the Speech and Language Pathologist to determine what percentage of words are consistently repeated by the user.

"The rate of speech refers to the rate at which someone can understand the words or sentences being spoken by the speaker. If a word or phrase needs to be repeated a number of times before the listener understands what the person is saying then the rate of speech goes correspondingly.

"Rather than focus on tests that have to be administered and interpreted by individuals that are trained speech and language pathologists, this document takes a more pragmatic view and applies two functional definitions that are more useful for people that know little or nothing about the field. These two functional definitions will be used to define the key performance metrics for members of the community. The two performance metrics are:

- *Acoustic intensity*
- *Effective Rate of Communications*

Acoustic Intensity

Acoustic intensity is defined above and measured in dB or dBa. If the individual can not generate speech with an acoustic intensity equivalent to a whisper that can be heard and understood at 1 metre, that individual; is classified as not having sufficient acoustic intensity to carry one a conversation without assistive technology of some sort.

[9] https://www.andalusiaspeech.com/post/speech-intelligibility-how-clear-is-your-child-s-speech

A whisper is between 20 and 30 dB in acoustic intensity. [10]

"A whisper is speech in which the vocal cords are held rigid, preventing the vibration that produces normal sounds. In whispering, voiceless sounds are produced as usual; but voiced sounds (e.g., vowels) are produced by forcing air through a narrow glottal opening formed by holding the vocal cords rigid and close together"[11]

"A whisper typically involves speaking softly with little or no vibration of the vocal cords." [12]

"The sound of your voice is created when air vibrates the larynx's vocal folds. The pitch depends on how tightly these folds are stretched by your throat muscles. When you whisper, the vocal folds are held apart a short way and stretched so tightly that they can't vibrate. The air passes through in a turbulent rush that creates a mix of lots of different frequencies, which we hear as a high-pitched hiss." [13]

"Whispered speech is a naturally produced mode of communication that lacks a fundamental frequency. Several other acoustic differences exist between whispered and voiced speech, such as speaking rate (measured as segment duration) and formant frequencies. Previous research has shown that listeners are less accurate at identifying linguistic information (e.g., identifying a speech sound) and speaker information (e.g., reporting speaker gender) from whispered speech. " [14]

"One can measure sounds in dBA yourself with a sound level meter, such as this app made by the National Institute for Occupational Safety and Health. The app can measure sounds from 0 dBA (sounds so quiet you can barely hear them) to whispering (30 dBA), normal conversation (60-70 dBA), and even a jet taking off (140 dBA). Just remember to turn down the volume, move away from the noise, or wear

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[10] https://www.nps.gov/teachers/classrooms/sound-intensity-and-loudness.htm

[11] Britannica, The Editors of Encyclopaedia. "whisper". *Encyclopedia Britannica*, 18 Dec. 2014, https://www.britannica.com/topic/whisper. Accessed 14 January 2022.

[12] https://www.merriam-webster.com/dictionary/whisper

[13] https://www.sciencefocus.com/the-human-body/why-do-we-lose-the-sound-of-our-voice-when-we-whisper /

[14] https://onionplay.se/episodes/peacemaker-season-1-episode-3/

hearing protectors, especially when the sound level is at or about 85 dBA!" [15]

Effective Rate of Communication

Even though there are specific tools to measure intelligibility and the rate of speech, this document takes a pragmatic view. The concept of Effect Rate of Communication will refer to the rate at which a listener can understand the speech of someone who is speaking. The Effective Rate of Communication will be measured as the average words-per-minute that the speech of a speaker can be understood by an unfamiliar listener, i.e., someone who is not used to the speech of the speaker. The Effective Rate of Communication is affected by the intelligibility, consistency and rate of speech. In any given instance, a combination of those factors can affect the Effective Rate of Communication. The Effective Rate of Communication can also vary depending on the situation. Around people who are used to your speech patterns, even if the intelligibility or consistency may vary, the Effective Rate of Communication can be higher than in a situation with unfamiliar listeners. Your close acquaintances are used to filling in the gaps in your speech because they know your speech patterns. Generally, the rates of conversation using Augmentative and Alternative Communication (AAC) systems, including word prediction and letter abbreviation, were found to be **12–18 WPM**, [16] [17] Natural speech from someone who has no speech loss issues has a rate of 125–185 words per minute (WPM) [104]. Direct selection techniques, including eye gaze systems, where what the user is looking at is tracked, are found to provide conversational rates of about 8–10 WPM. Similarly, mechanically-activated AAC switches and keyboards also affect conversation rates. The automatic, step, and inverse activation of switches often requires the users to wait until the desired selection is displayed, introducing conversation delays.

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[15] https://www.noisyplanet.nidcd.nih.gov/have-you-heard/how-is-sound-measured#:~:text=We%20measure%20sound%20intensity%20(also,person%20can%20hear%20certain%20sounds.

[16] Waller A. Telling tales: Unlocking the potential of AAC technologies. *Int. J. Lang. Commun. Disord.* 2019:1–11. doi: 10.1111/1460-6984.12449.

[17] Yasmin Elsahar, Sijung Hu,* Kaddour Bouazza-Marouf, David Kerr, and Annysa Mansor. "Augmentative and Alternative Communication (AAC) Advances: A Review of Configurations for Individuals with a Speech Disability". Sensors (Basel). 2019 Apr; 19(8): 1911. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6515262/#:~:text=Generally%2C%20the%20rates%20of%20conversation,of%20natural%20speech%20%5B104%5D.
Published online 2019 Apr 22. doi: 10.3390/s19081911.

Scanning methods are reported to allow communicative rates of around 2 WPM.

Introduction to Performance Metrics

For this document, we are using the concept of "performance metrics". Performance metrics are measurable characteristics or dimensions of a person or process. They are typically used as an objective way to measure a person's ability to complete a task or series of tasks or a process. There is no absolute set of performance metrics that can be used for all situations. Usually, the performance metrics are selected to represent key dimensions or characteristics of what needs to be measured for a specific task or series of tasks. In this document the metrics have been selected to represent interactions with mobile devices. A combination of performance metrics can be used to represent the abilities of the sub-groups of users within a community. Subsequently, a particular accessibility solution usually addresses one subgroup of users grouped by their unique combination of abilities as described by the performance metrics. While there may be cases where a solution addresses the needs of multiple subgroups of users, the appropriateness of a solution as measured by efficiency (time to perform the task) usually helps to define the sub-group of users the solution is most appropriate for. The definition of appropriateness takes into consideration the end users' abilities so that they can complete a task in the most effective and efficient manner possible given their abilities.

For this document, all members of the speech loss community can be defined by the following two key performance metrics:

#	**Performance Metric**	**Level of Performance**
1	Acoustic Intensity Measure at 1 metre (decibels)	**30 dB of less at 1 meter designate mild speech loss**

2	Effective Rate of Communications (Words Per Minute – WPM)	**Less than 12 to 18 words per minute [18] designates whether a person should be an AAC user as their unaided communication rate would be less than that achievable using an AAC device**

There are measures that can be used by speech and language pathologists to describe people with speech loss. Acoustic volume, intelligibility, consistency and speaking rates are typical parameters. Consistency can be measured using tools such as the Assessment of Intelligibility of Dysarthric Speech (AIDS) by Yorkston, Beukelman and Traynor for single word, sentence and speaking rate. There are no standardized tests for consistency that are recognized. Speaking rates assume that the speech is affected by intelligibility, so it typically measures the number of words per minute that unfamiliar listeners can understand. If the person needs to repeat a word or words, then the words per minute understood is reduced accordingly.

For simplicity, these specifications will refer only to the Speaking Rate as defined by the average understandable words per minute. It does not refer to consistency or intelligibility directly. This is a very pragmatic approach. In practice, no one will deliberately choose a less efficient method of communication over a more efficient one, but the speaking method may be situation-specific. For an individual who has people who are around them a lot (familiar listeners), those people may be able to understand the slurred or distorted speech of that individual; when they are speaking to strangers or people who are only around them on occasion, they may prefer an AAC device, so as to not have to repeat what they are saying multiple times to be understood. Depending on the situation and the user, two people with the same intelligibility and consistency score may choose different communication methods.

Speech loss may be due to laryngectomy, vocal cord paralysis, ventilator dependency, Parkinson's Disease, MS, ALS, vocal nodules, diminished lung

[18] Yasmin Elsahar, Sijung Hu,* Kaddour Bouazza-Marouf, David Kerr, and Annysa Mansor. "Augmentative and Alternative Communication (AAC) Advances: A Review of Configurations for Individuals with a Speech Disability". Sensors (Basel). 2019 Apr; 19(8): 1911. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6515262/#:~:text=Generally%2C%20the%20rates%20of%20conversation,of%20natural%20speech%20%5B104%5D.

capacity, use of esophageal speech, or tracheoesophageal puncture (TEP). This document will not get into the specifics of each of these conditions.

Underlying Theme for Solutions for the Speech Loss Community

A number of accommodation strategies for people that have particular conditions were suggested in a research paper by the Florida Department of Education.

> *"Speech impairments are disorders of speech sounds, fluency, or voice that interfere with communication, adversely affect performance and/or functioning in the educational environment, and result in the need for exceptional student education.*
>
> *"Speech sound disorder – A speech sound disorder is a phonological or articulation disorder that is evidenced by the atypical production of speech sounds characterized by substitutions, distortions, additions, or omissions that interfere with intelligibility. A speech sound disorder is not primarily the result of factors related to chronological age, gender, culture, ethnicity, or limited English proficiency.*
>
> *"Phonological disorder – A phonological disorder is an impairment in the system of phonemes and phoneme patterns within the context of spoken language.*
>
> *"Articulation disorder – An articulation disorder is characterized by difficulty in the articulation of speech sounds that may be due to a motoric or structural problem.*
>
> *"Fluency disorder – A fluency disorder is characterized by deviations in continuity, smoothness, rhythm, or effort in spoken communication. It may be accompanied by excessive tension and secondary behaviors, such as struggle and avoidance. A fluency disorder is not primarily the result of factors related to chronological age, gender, culture, ethnicity, or limited English proficiency.*
>
> *"Voice disorder – A voice disorder is characterized by the atypical production or absence of vocal quality, pitch, loudness, resonance, or duration of phonation that is not primarily the result of factors related*

to chronological age, gender, culture, ethnicity, or limited English proficiency. This definition is found in State Board of Education Rule 6A-6.03012, F.A.C"[19]

4.2.11 Privacy
Where ICT provides features for accessibility, the ICT maintains the privacy of users of these features at the same level
as other users.
NOTE: Enabling the connection of personal headsets for private listening, not providing a spoken version of
characters being masked and enabling user control of legal, financial and personal data are examples of
design features that may contribute towards meeting this clause

Personas and Use Cases

One of the most effective ways to communicate the needs of specific groups of users is through the use of personas. A persona assumes a defined set of characteristics about a set of users. A fictional person is used to represent the goals, motivations, capabilities and lifestyle characteristics of a group of users. Personas allow designers and procurement managers to understand the needs of the end users by simplifying the issues. Rather than having thousands or millions of individual end users, end users are categorized into a smaller number of end user groups with common characteristics. In most cases, personas are created from data collected from interviews with users. They are captured in one- to two-page descriptions that include behaviour patterns, goals, skills, attitudes, and the environment, with a few personal details to make the persona realistic and relatable.

Use cases describe the responses of a product or service to a series of related requests from an end user. A use case covers a common task that the user may try to achieve through the product or service. Together, personas and use cases

[19] Florida Department of Education." Speech Impairment (SI)".
https://www.fldoe.org/academics/exceptional-student-edu/ese-eligibility/speech-impairment-si.stml

help to guide decisions about a product or service such as features, interactions, and visual or acoustic design. These tools are important to designers and procurement managers as they help to define who will use the end product or service to complete the end goal.

For the simplicity of this document. We are only referring to subgroups of users within the cognitive community in order to classify individuals regarding assistive technology needs. We have used the generic terms Group 1, Group 2 and Group 3, and have defined user characteristic (performance metrics) for each group. This community of users does not like the traditional medical and academic classifications as they have negative connotations. The more generic Group 1, 2, and 3 terms do not predispose readers to a predetermined expectation of each user group. Each group needs to be evaluated based on their characteristics and performance metrics.

Also below are personas representing users with Low Acoustic Intensity and Low Effective Communication Rate. These are the two subgroups within the Speech Loss community.

Definition of Best Practices

A best practice is the best-in-class assistive technology solution or practice that provides an appropriate and optimum way for a given user, defined by a set of unique characteristics and performance metrics, to complete a task or series of tasks. There is often an existing solution, but in this document we have not referred to specific mobile device platforms. In some cases, there may be a mixture of features from different platforms that implement similar solutions. Where possible the best practice has been determined to be technically feasible. In some instances, a best practice may describe a solution with a feature or features that do not actually exist.

Best practices are not mandatory requirements. They are designed to be illustrative examples of what would be acceptable. In some cases, they describe a solution that is based on an existing partial solution but that has been determined to not provide a complete solution that allows the user to complete all tasks or all steps of a task. In those cases, the best practice

describes what needs to be implemented to make the solution a complete solution without going into a detailed technical discussion. Technical details are omitted except where absolutely necessary so as to not predetermine a specific technical requirement. Best practices typically describe the operational interaction of the solution with the users at an abstract level to allow flexibility for multiple and competing implementations.

There have been a number of studies over the years looking at the issues that need to be addressed to accommodate the needs of people labelled with intellectual disabilities and other cognitive conditions, but there is still a lack of comprehensive testable criteria that designers can use to develop accessible mobile devices in all but a few areas. In some cases, it is due to lack of formal definition for criteria; in other cases the criteria exist, but the pass or fail conditions are not defined.

1.

Prescriptive Specifications versus Performance Specifications

Many of the accessibility standards that exist are prescriptive in nature. Prescriptive design specifications set out precise measurements, tolerances, materials and other specific information about a product or service. A button being a specific color or size and shape is an example of a prescriptive specification. By contrast, performance specifications tell what the end user wants to do and how he wants to do it, while leaving a level of technical detail open. Being able to operate a device without twisting one's wrist, or being able to perceive a device's output given a specific field of view by the user, are two examples of performance specifications. The specific nature of the design, the measurements, and other specific details are not stated, nor are they considered important so long as the performance requirement is met. Performance specifications give the designer more flexibility in how they are to achieve the end performance result. Performance specifications describe the result that is required from a particular end goal and leave it to the designer or supplier to satisfy that requirement. In effect, they require the designer or supplier to complete the design. To be effective, performance-based specifications must clearly outline how the performance is to be measured.

The information below uses performance specifications as the primary method of communicating the end goal of each category of user within each

disability community. The performance specifications are composed of a set of abilities or performance metrics that describe users within each of the subgroups within a community, and a set of tasks that they are required to perform. If the user within a subgroup can complete all the tasks using the abilities which they have, then an accessibility solution is considered appropriate. There are some classes of accessibility solutions that already exist on mobile devices. Not all accessibility solutions within a class are implemented the same or have the same features on all devices. In some cases, the features of the solution and the user interface to operate the solution are different intentionally in order to create product differentiation. The authors have developed the concept of "Best Practices" to describe best-in-class solutions for a specific class of accessibility solutions. While a best practice solution may describe an existing implementation on a specific mobile device platform, in some cases the best practice may combine features from solutions from multiple mobile platforms to describe a solution. The authors have used their own technical knowledge about individual platforms to evaluate whether the combination of features from the various platforms are achievable. Not all solutions implement their features in the most optimal manner. nor do they necessarily have the breadth of features required. Best practices are not mandatory, required solutions--they represent the best implementation of a solution that exists currently or should exist, with additional specific enhancements on mobile devices for a specific group of users. If a mobile device manufacturer can provide an alternative solution that can complete all the tasks on the Primary Task list using the performance metric of the specific subgroup in the same or faster time than the current best practice, the time for a user to complete a task being typically considered an indication of the efficiency of the solution, then that solution is considered an equivalent solution.

Where prescriptive standards exist, they have been documented and mapped back the best practices under each subgroup of users. The existing prescriptive standards that typically apply are:

- Section 508 of the Rehabilitation Act of the United States,
- the European EN 301 549 standard,
- the World Wide Web consortium (W3C) Web Content Accessibility Guidelines,
- and the 21st Century Video Accessibility Act (CVAA) of the United States.

With the exception of the CVAA, note that the other standards are generic information and communications technology standards and are not necessarily specific to mobile devices. Some mappings of the new prescriptive standards in this document to these existing standards are provided to establish a familiar framework for designers of mobile devices and procurement staff who are familiar with those existing standards.

Accessibility is about ensuring people can perceive, understand and interact with a device and the content that it hosts, regardless of their abilities. In this document, accessibility is measured against a series of tasks in order to eliminate the need to look at and evaluate the accessibility of a single feature of the device in isolation. Rather, the sequence of interactions with features of the phone that make up steps needed to complete a task are evaluated for accessibility. In looking at the list of tasks for this community, it is recognized that not all tasks are part of the practical goals of every user in the community. For example, individuals with limited literacy skills and problems processing information do not necessarily want to send and receive emails, nor may they want to navigate detailed maps with lists of points of interest. Some users only need to practically interact with a smaller subset of tasks or only some features of a task.

Due to a range of abilities within the cognitive community, not all tasks are going to be goals of all users. This section recognizes that certain tasks can only be completed without a prerequisite set of abilities. The personas developed for the cognitive community are unique in that there is a set of task goals associated with each of the personas for accessibility compliance purposes. The personas for this community assume some users will have a shorter task list made up of a subset of tasks from the longer list. The other disability communities (vision, mobility, hearing and speech loss) assume a fixed task list and that all users will want to complete the tasks on the list.

Tasks

To characterize and sort relevant tasks, five accessibility operational tasks (perceive, recognize, monitor, reach, operate) can be used (Table 6). For people from the cognitive community, the most frequent task barriers that

arise when using their mobile devices are difficulties with the informative tasks, i.e., 'perceiving', 'recognizing', 'monitoring' events or changes to the mobile device and interacting with the context by entering text or completing steps in a chain of actions necessary to complete a task. The most common issues creating these barriers are insufficient modes of providing feedback and incompatible modes of input and interaction with content.

2. Specific tasks the user wants to accomplish

The focus of this document is to define the accessibility of mobile devices with a focus on the primary function of a mobile device: communications. Communications include the concept of "advanced communications".

> 'Advanced Communications Services' is a descriptor for newer, internet-based communication systems that were not regulated by existing communications laws. There are four types of Advanced Communications Services covered by the CVAA:
>
> - I**nterconnected Voice over Internet Protocol (VoIP) services-** allows users to make and receive traditional phone calls. Examples include RingCentral, Vonage and MagicJack, as well as some phone services offered through cable and internet providers.
> - **Non-interconnected VoIP services-** provides voice-control without traditional telephone systems. Examples include Siri, Alexa, and other voice chat services.
> - **Electronic messaging services-** offer real-time or near real-time text-based messaging, including text messaging, instant messaging, text-based chat, and email. Examples include Facebook Messenger, IOS voice-to-text, Slack, and Google's Gmail.
> - **Inter-operable video conferencing services-** provides real-time video communications. Examples include Zoom, Join.me, Google Hangouts, FaceTime, and other video conferencing/video chat services".[92,93]

The definition above is derived from the American 21st Century Communication and Video Accessibility Act (CVAA). More detail can be seen in Appendix A. The Appendix summarizes the key points of the CVAA. The CVAA was the first attempt in legislation to define the concept of

“advanced communications”. Previous to this new definition, mobile devices were considered only voice communication devices in regards to accessibility requirements. This new definition recognized that the usage of the phone and more specifically mobile devices had changed to encompass more forms of communication than just voice over a telephone connection.

The mechanism to apply an accessibility requirement was through the regulatory power of the FCC. Therefore, the scope of accessible requirements applied to communication- and broadcast-related services, and more specifically to mobile devices (hardware and software), as it enforced implementing advanced communication interactions.

The best practices of how to achieve accessibility are best described for specific use cases. The individual steps that make up a complete task then can be generalized to other methods of interaction and other use cases. The steps are usually agnostic of the app being used. For example, making a phone call requires that the user complete the following specific steps or interactions:

- Locate and identify the phone (by shape or texture)
- Orientate the phone so that one can perceive the display and controls (for instance, identify the top of the phone)
- Turn on the device or unlock it (locate and interact with power button, interact with biometric and/or password system)
- Perceive the output and controls of the device
- Interact with the device applications and controls
- Launch the phone app
- Enter a phone number
- Acknowledge a proper connection
- Communicate with the person being called and respond to the person
- Terminate the call when finished

Embedded in these steps are the needs to select a point of interest on the phone’s display, set that point of interest as the “focus” (the element to which the phone’s operating system will apply future actions), activate the point of interest, and enter data into the point of interest or perceive output from that point of interest. Different combinations of these interactions are embedded in commonly-performed tasks on a mobile device.

Rather than test for each of these individual interactions for their degree of accessibility compliance for the different personas presented in this document, a series of tests around end-user goals was created. The details of the interaction may change over time, but the larger end-user goals will change slowly. For example, voice assistants can now do some tasks or parts of tasks more efficiently than touch-centric interactions for those users that can perform touch interactions, but users still want to achieve the same higher-level goal of making a phone call whether they use touch or voice.

The list of tasks is derived from several research studies looking at the usage patterns of end users.

> "The existing works could be generally categorized into either standard ethnographic and user studies, based on questionnaires, diaries and self-report, or studies based on automatic recording and subsequent analysis of phone activity logs.[94] In the first category, Reid and Reid (2004) study the differences of call and SMS usage preference using an online questionnaire which involved 982 users.[95] Grinter and Eldridge (2001) investigate how British teenagers incorporate text messaging into their daily lives.[96] They collected data by asking the teenagers involved in a study to manually log their texting activity for seven consecutive days. In a more recent example, Barkhuus and Polichar (2011) investigate how users integrate multifunctional mobile phones into their everyday lives.[97] The study was based on interviews and daily diaries and involved 21 users over 3 weeks. The study by Mutchler, Shim, & Ormond (2011) shows another recent work based on data collection from interviews to explore the factors that motivate college students in the U.S. to use smartphones.[98] However, the study results discussed above have their limitations. Also, no justifiable conclusion can be derived from their results as the studies were conducted on a small number of subjects. Thus, the ability to collect and record mobile phone usage automatically on a large scale is needed where longitudinal analyses of phone application logs is collected by combining automatic collection of smartphone data and human-centric data analysis.[99] According to the results of studies carried by Parslow, Hepworth, & McKinney (2003), over 93 volunteers were asked to report on the number of their call activities during different periods of time (day, week, or month) and their responses were then compared to log data collected from the mobile phone operators. There was only a moderate correlation between log data and self-report, indicating that self-report

measures do not fully represent actual usage patterns.[100] Verkasalo and Hammainen (2007) use data collected by Symbian-based monitoring to present a study of voice calls, SMS, email, and Bluetooth messages usage based on a population of 562 subscribers, during seven months.[101] Another study by Wehmeier (2012) was done on a larger scale, based on the data collected from 180,000 smartphone users on the Android platform during a period of one month, to analyze the user behavior trends across cellular networks in domestic and roaming scenarios and through Wi-Fi-based access.[102] Shye et al. (2010) present a comprehensive analysis of real smartphone usage involving 25 subscribers during a 6-month study of real user activity on the android smartphone. The study covers general usage behavior, power consumption interaction with the battery and network activity.[103] Another study by Rahmati and Zhong (2013) uses logging software that runs in the background to perform a four-month field study of usage of 14 smartphones and reported what applications were used, and how the phones were used.[104] Erman et al. (2011) present summaries of their analysis based on anonymized data set from a tier-1 cellular network provider in the U.S. over a week of how, where, and when smartphone apps are used from spatial, temporal, and user perspectives and attempt to understand the impact of location, time, user, and app interest accordingly.[105]

Other existing studies, like those done by Falaki et al. (2010)[106] and Xavier et al. (2012)[107], have addressed specific aspects of mobile phone design, such as mobility, to enhance user experience under mobility, phone application such as statistics of popular apps and the impact of user activities on the network. However, studies that have been carried out are still unable to gain adequate understanding of the behavior of smartphone usage. Furthermore, most of the previous studies focused on the usage of specific countries and with limited time period and number of users, so the overall picture of smartphone usage is still inadequate. To the best of our knowledge, the authors believe this work will help fill major gaps in forming a better picture of the smartphone usage evolution".[108]

A study of 255 users in 2010 identified the following usage patterns ranked by frequency of usage on Android devices:

Table 1. Relative rankings: Frequency of usage of Tasks for Android Devices.

Rank	**Active Process**
1	Alarm Clock
2	Talk
3	Contacts
4	Maps
5	MMS
6	Phone
7	Music
8	Browser
9	Camera
10	Vending
11	Calendar
12	Settings
13	Games - Tetris

Table 2. Relative rankings: Frequency of usage of Tasks for Windows Mobile Device

Rank	**Active Process**
	Explorer
	Tmail

	Bubble breaker
	Poker
	Live Search
	Calendar
	Google Maps

.[110]

Table 3. Breakdown of percentage usage by process type for Android Devices [111]

No	Process	Relative Percent of Usage
1	Communications	44%
2	Productivity	19%
3	Other	11%
4	Browsing	10%
5	Media	5%
6	Maps	5%
7	System	5%
8	Games	2%

Table 4. Breakdown of percentage usage by process type for Windows Mobile Devices [112]

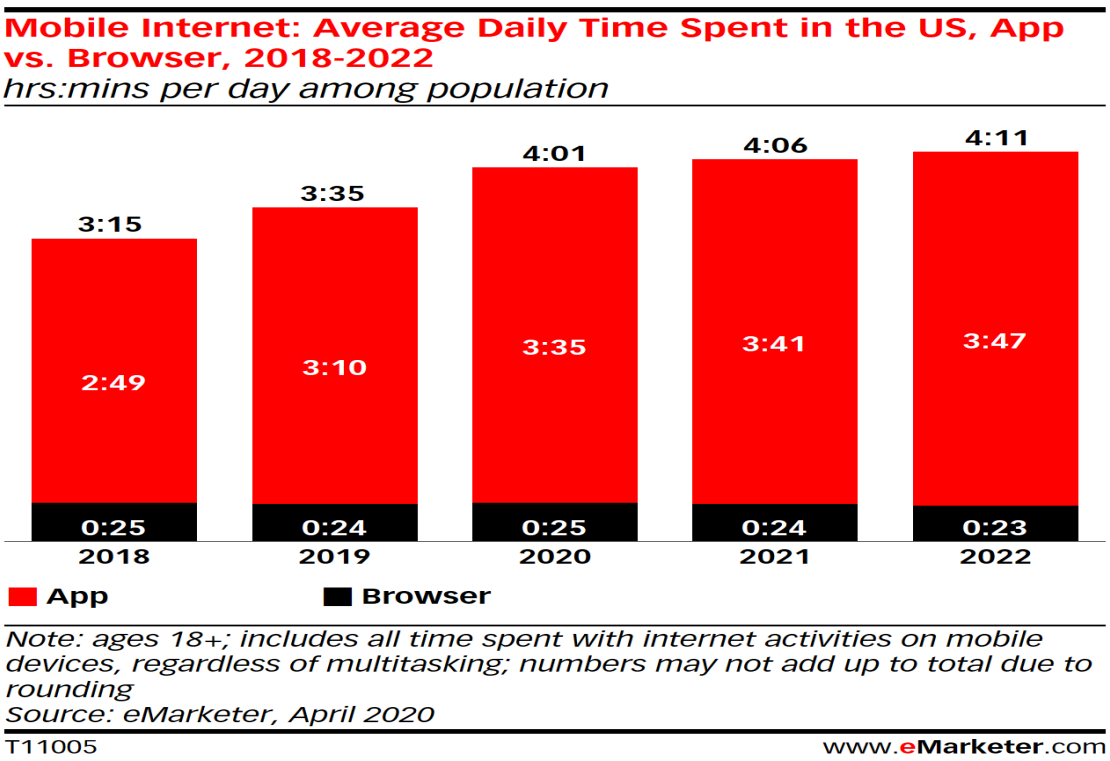
No	Process	Relative Percent of Usage

1	Communications	49%
2	Other	15%
3	Browsing	12%
4	Games	10%
5	Media	9%
6	Maps	2%
7	Productivity	2%
8	System	1%

"To provide an aggregate view of what users use their smartphones for, we categorize applications into eight distinct categories: i) communication contains applications for exchanging messages (e.g., email, SMS, IM) and voice calls; ii) browsing contains Web browser, search, and social networking applications; iii) media contains applications for consuming or creating media content (e.g., pictures, music, videos); iv) productivity contains applications for calendars, alarms, and for viewing and creating text documents (e.g., Office, PDF Reader); v) system contains applications for changing user preferences and viewing system state (e.g., file explorer);vi) games; vii) maps; and viii) other contains applications that we could not include in any of the categories above, e.g., because we did not know their function.

"[Tables 1 and 2 show] the mean relative popularity of each application category across all users in each dataset. While the results are not identical across the two datasets, they are similar to a first order. Communication dominates in both. Browsing is another major contributor in both datasets. Maps, media, and games have a comparatively lower but nevertheless substantial share of user attention "[113]

We note there are limitations to the 2010 study. More recent data from Inside Intelligence suggest that the vast majority of mobile time is spent while connected to the internet, with 88% of that time within apps. [114]



[115]

> "The distinction between app and browser time, however, continues to blur. According to a 2019 study conducted by Kargo and Verto Analytics, at least 9% of time on Facebook took place within embedded browsers. Moreover, advanced websites can deliver an experience that's broadly similar to an app." [116]

As a result, access to the browser in an accessible way takes on greater significance. Data on app downloads from the Apple app store can also provide additional insight. A list of the most popular apps can be found at this link:

https://www.statista.com/statistics/270291/popular-categories-in-the-app-store/

From this list, the tasks that are related directly or indirectly to business and productivity related tasks have been identified and extracted. Tasks such as social media may only apply to a small number of employees tasked with maintaining government accounts and monitoring relevant government-related, third-party accounts. Similarly, photos and video are relevant as they apply to the ability to record and document professional development sessions and related government or work events.

Similarly, the ability to play music is related to being able to play audio files from a work-related event or activity. There are some dual-purpose tasks that do not seem business-related at first glance but do have applications outside of their category that are directly or indirectly related to work activities.

Table 5. App categories that have been identified as work related.

App Category	**Percent of downloads**
Business``	10.7%
Education	8.66%
Utilities	6.39%
Productivity	3.21%
Social Networking	2.33%
Book	2.24%
Music	2.24%
Photo and Video	1.97%
Reference	1.89%
News	1.78%

3. Specific Primary Tasks for mobile devices

The table below lists the primary tasks that people of all abilities should have access to, including people with cognitive impairment. The list is derived from the tasks identified in the studies above.

Table 6. Primary

#	Task
1	Reading the instructions on how to use the device that comes with the device packaging or is available from an online source
2	Setting up the device for the first time
3	Making and terminating a communications session (phone call, video call or text message session)
4	Receiving communication session (phone call, video call or text message session)
5	Sending text messages to a person in a contact list and to a specific phone number
6	Receiving text messages
7	Send and receiving email using an app
8	Using a web browser to navigate to a URL, scroll from top to bottom of the URL, interact with the controls on the webpage, enter text into the edit controls on that web page (such as filling in the text boxes of an online contact form) and the browser controls (reload, forward and back, menu for browser).
9	Using a calendar, including entering a new appointment for a date in the future and looking up an appointment already scheduled.
10	Taking pictures/video and saving it to the mobile device
11	Watching videos or listening to music, including changing volume
12	Complete a video call or meeting, such as FaceTime on Apple phones

	or Google Duo on Android phones
13	Receive low battery notification
14	Change setting one the mobile device such as display brighten, default font size
15	Perceive and acknowledge a notification

Note: The end goals of the user must be taken into consideration when selecting a mobile device for their needs. Personalization and the need to achieve goals that are not directly related to the accessibility of the device are critical in preventing device abandonment. [117,118]

Comparison of Technical Accessibility Requirements

Section 508 of the U.S. Rehabilitation Act and European Standard EN 301 549 both contain many technical accessibility requirements, which offer details that go beyond the high-level functional performance statements. Technical accessibility requirements should describe objective and measurable outcomes for ICTs, without being overly prescriptive. In order to meet a high-level performance statement, an ICT solution must conform to all relevant technical accessibility requirements.

Checklist of Differences Between Standards

It has been proposed that EN 301 549 should be adopted as the generic, accessible information and communication technology (ICT) standard for all ICT for the government of Canada. Though not officially approved as of the writing of this document EN 301 549 potentially will form the baseline specification for any procurement of ICT for the government ofCanada when approved. A working group is currently being formed by Accessibility Standards Canada.

The section of the document will highlight exceptions (additions, changes and omissions) being proposed specifically for mobile devices to the individual EN 301 549 requirements as mobile devices are a distinct sub-category of ICT

that may not require all the specific individual requirements, may require additional specifications or may require modified version of specification within EN 301 549 standard.

This section is also intended to provide a quick summary of changes being proposed for the modified EN 301 549 standard as it is applied to mobile devices. This section is being provided specifically for procurement staff and regulatory staff from mobile device manufacturers that are tasked with keeping up with new standards. It is important that procurement and regulatory staff also look at how the standards and the exceptions are applied in the proposed procurement process discussed below in Section xx. For information on where the recommendation comes from refer to the Technical Discussion under each Best Practice for each persona. The recommendations are presented here without reference to the specific personas and best practices that they apply to keep this part of the document focused.

Reviewers: Please add any additions, omissions and modifications the authors have missed. Additions, purposeful omissions and modifications are being made to the EN 301 549 standard in order to support the inclusion of existing and new best practices that need to be improved or added to the list of solutions that need to be available to the community to fulfill a specific need. The authors have tried to be as complete as possible; they know that there is always room for improvement. While EN 301 549 is the baseline that will be adopted, from the work related to the framework in the other disability communities the authors have found specifications with the EN 301 549 standard that do not apply specifically to the accessibility of mobile devices appropriately.

The table below refers to existing standards using their reference number in the standards document. The standard can be follow here:

ETSI EN 301 549 - V3.2.1 - Accessibility requirements for ICT products and services

For users with speech loss the majority of the issues refer to specifications covered under the broader Functional performance section and more specially Section 4.2.6.

"4.2.6 Usage with no or limited vocal capability

Where ICT requires vocal input from users, the ICT provides at least one mode of operation that does not require them to generate vocal output. This is essential for users with no or limited vocal capability and benefits many more users in different situations.

NOTE 1: Vocal output includes speech and other orally generated sounds, such as whistles and clicks.

NOTE 2: Keyboard, pen or touch user interfaces may contribute towards meeting this clause."

The table below refers to existing standards using their reference number in the standards document. The standard can be follow here:

ETSI EN 301 549 - V3.2.1 - Accessibility requirements for ICT products and services

For more details on the standards you will need to refer to the appropriate section in the document. The entries in the table refer to revisions, deletions and additions to the existing specifications within the EN 301 549 standard. The government of Canada is intending to adopt the EN 301 549 standard. The working group has been formed to start the evaluation and ratification process. Note that the new text of the revised version is only being presented here. Where there is a deletion only the reference number is presented with information on the rationale for the deletion. New specifications drafted to enhance the existing specification will not have reference numbers.

Revision/Addition /Deletion	**Description**	**Comments**

4.2.11 Privacy	Where ICT provides features for accessibility, the ICT maintains the privacy of users of these features at the same level as other users. NOTE: Enabling the connection of personal headsets for private listening, not providing a spoken version of characters being masked and enabling user control of legal, financial and personal data are examples of design features that may contribute towards meeting this clause	Refer to best practices for Persona 1, 2,3 and 4 in regards to policies around privacy for each of these personas.
8.1.2 Standard connections	Where an ICT provides user input or output device connection points, the ICT shall provide at least one input and/or	Refer to Best Practice Persona 2,3 and 4 for description of required supported standard hardware connections.

	output connection that conforms to an industry standard non-proprietary format, directly or through the use of commercially available adapters. NOTE 1: The intent of this requirement is to ensure compatibility with assistive technologies by requiring the use of standard connections on ICT. NOTE 2: The word connection applies to both physical and wireless connections. NOTE 3: Current examples of industry standard non-proprietary formats are USB and Bluetoot	

Personas

In other places, the mobility, vision, and hearing communities are divided into three broad categories of mild, moderate and severe, and the cognitive community is divided into Group 1, Group 2, and Group 3. Unlike the other disability categories, the speech loss community is being divided into two categories, Low Effective Communication Rate and Low Acoustic Intensity, based on the technology solutions that can help.

The first category of users has Low Effective Communication Rate, as their effective communication rate with the use of assistive technology is well below that of typical, non impaired speakers. As mentioned above, these users' communication rate with the use of augmentative and alternative communication (AAC) solutions is typically between 12 and 18 words per minute. This may also be below the rate they are capable of using their natural voice, but they choose to use AAC because it is more intelligible than using their natural voice, is less fatiguing than using their natural voice, or for other reasons.

The second category of users is affected by Low Acoustic Intensity. This group is defined by the fact that the volume of their speech is difficult to hear if they speak in their normal voice. They typically have an auditory intensity of less than 30 dB.

Within the Low Effective Communication Rate group, the users are categorized based on their Access Method. Low Effective Communication Rate users typically use two forms of communication: "no-tech" (i.e., high technology is not required) and "technology-based solutions". For example, a no-tech solution may consist of a pencil and a piece of paper where the user writes out what they want to say, or a printed sheet of paper containing common words, sentences, phrases, drawings or photographs that the user points to in order to communicate.

No-tech methods of communication will not be considered directly in this discussion as they do not involve "advanced communication" applications. However, no-tech solutions can often be recreated by apps on mobile devices. Such apps fit the definition of technology-based solutions, and are part of the solution set expected for mobile devices, and may require specific adaptations on the part of the mobile device.

The workflow and quality of these solutions or applications themselves will not be discussed in detail in this document, nor will we discuss in detail the

process of selecting the right solution for a given user. There are numerous publications on these topics, such as the one quoted below. Technology-based solutions for Low Effective Communication Rate users typically fall under the category of Augmentative and Alternative Communication (AAC) Devices. [20]

> *"Augmentative and alternative communication (AAC) is an area of clinical practice that supplements or compensates for impairments in speech-language production and/or comprehension, including spoken and written modes of communication. AAC falls under the broader umbrella of assistive technology, or the use of any equipment, tool, or strategy to improve functional daily living in individuals with disabilities or limitations.*
>
> *AAC uses a variety of techniques and tools to help the individual express thoughts, wants and needs, feelings, and ideas, including the following:*
>
> - *manual signs*
> - *gestures*
> - *finger spelling*
> - *tangible objects*
> - *line drawings*
> - *picture communication boards and letter boards*
> - *speech-generating devices*
> - *AAC is augmentative when used to supplement existing speech, alternative when used in place of speech that is absent or not functional, or temporary as when used by patients postoperatively in intensive care (Elsahar et al., 2019)."* [21]

When we refer to AAC in general, we are referring to all technology-related solutions for people with speech loss. This may consist of assistive technology built into the mobile device, assistive applications installed on the mobile device, assistive hardware interfaced to the mobile device, or other means of making the mobile device usable by the AAC user.

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[20] Lisa Furlong ,Meg Morris,Tanya Serry,Shane Erickson. "Mobile apps for treatment of speech disorders in children: An evidence-based analysis of quality and efficacy". https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0201513

[21] Augmentative and Alternative Communication (asha.org)

When we refer to AAC devices in this document, we are referring to speech generating devices that are external to the mobile device and have to be interfaced to the mobile device.

AAC users can be further categorized by the method they use to access AAC devices and solutions.

For some users, other than their speech capacity being impaired, they can interact with the mobile device using their hands and arms the same as or similarly to individuals that have no disabilities. For example, after a stroke, a user may have speech loss and their mobility may only be affected on one side of their body. Such a user may be able to use the unaffected side of their body to interact with the mobile device in a typical fashion, while also needing speech assistance. The speech assistance by itself may impose requirements on the mobile device.

In other cases, the user may be using a specialized, external AAC device to speak for them and they require that the AAC device be interfaced to the mobile device. At a minimum, the audio channels of the mobile device may have to interface to the AAC device to carry on a conversation or to control a voice assistant application. In a further use case of carrying on a conversation in private, the audio output channel of the mobile device might have to be controlled so the output can be heard on a headset.

The AAC device may also accommodate the limited mobility of a user who cannot use their hands to operate a keyboard or touch screen in the typical manner. The AAC may do this by providing specialized inputs ("access methods"), such as head tracking or eye tracking. In such cases, the AAC device may have to interface to the mobile device to communicate the user's selections on the AAC device so that the AAC device can control the mobile device. Various interface methods are discussed in this document, such as Bluetooth.

4. Low Effective Communication Rate Individuals

A broad set of users is covered under the Low Effective Communication Rate Individuals description. Unlike the other disability groups where the level of

severity is determined by degrees of loss of the key performance metrics that define the abilities of that group, Low Effective Communication Rate Individuals are grouped by their use of AAC solutions to provide solutions to their challenges. Within the AAC category, the solutions are defined by the method of accessing the device. The Access Method is defined by not only their physical access method (input and output) but by the presentation of the AAC interface to use the AAC device.

AAC users may have some level of mobility related issues that affect how they physically interact with the device. They may also have a cognitive-related condition that affects the way they compose sentences and phrases that are part of the speech generation process. They may also have hearing and vision loss issues that affect how they perceive and interact with the output of the AAC device while they are composing sentences and phrases to be spoken by the speech generation system. While not common, it is also possible for someone who is Deaf-Blind, who has a vision loss and a hearing loss, to use an AAC device.

The modes of access for these users are defined under the appropriate disability group description in this document. The access method is relevant to the mobile device when the AAC solution is hosted on the mobile device in the form of an application. For solutions that require the user to access an external AAC device in order to access the mobile device, the key technical issues are in how the AAC device interfaces and interacts with mobile device, such as how speech generated by the AAC device gets conveyed to the audio channel of the phone on the mobile device, or how the AAC device controls specific functions of the mobile device.

For completeness, this document provides examples of personas to act as a guide to designers, but there is no typical combination of disabilities that defines the subcategory of users within a group easily. These personas may represent a combination of disabilities for each of the five key disability groups (mobility, cognitive, vision, hearing and speech loss) but the personas are not an exhaustive list nor will the persona necessarily present a common combination of coexisting disabilities.

One persona describes someone who has had their throat box removed due to a medical condition, and has no other physical ability loss. The user can operate a mobile device without any assistance in regard to the physical access

to the device. So, their only loss of functionality is the ability to create vocal sounds.

The second persona describes a person who has had a stroke, who is paralyzed on the left side of the body and has slurred and hard-to-understand speech. As a result, they have a low effective communication rate. They require an AAC solution hosted on the mobile device. Typically, this consists of an application that may use either a physical or on-screen alphanumeric keyboard which the user uses to type out their message, or a set of on-screen symbols that represent common words, phrases or sentences the user might use to drive a text-to-speech utility that produces auditory speech.

The third persona describes a person with advanced Amyotrophic Lateral Sclerosis.

> "Amyotrophic Lateral Sclerosis (ALS), commonly known as Lou Gehrig's disease, is a progressive neuromuscular disease. ALS is characterized by a progressive degeneration of motor nerve cells in the brain (upper motor neurons) and spinal cord (lower motor neurons). When the motor neurons can no longer send impulses to the muscles, the muscles begin to waste away (atrophy), causing increased muscle weakness. ALS does not impair a person's intellectual reasoning, vision, hearing or sense of taste, smell and touch. In most cases, ALS does not affect a person's sexual, bowel or bladder functions." [22]

Due to the advancement of the condition, they have lost use of their hands, arms, and their ability to speak. They use an Augmentative and Alternative Communication (AAC) device to speak for them. They operate the AAC device using a single switch that they activate using eye blinks. The output of the AAC device is interfaced to the mobile device so they can make phone calls and use the voice assistant features on the device. The display of the phone is mirrored on the screen of the AAC device and the user can interact with the mirrored version of the phone to control the phone features through their AAC device.

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22 https://www.hopkinsmedicine.org/neurology_neurosurgery/centers_clinics/als/conditions/als_amyotrophic_lateral_sclerosis.html#:~:text=Amyotrophic%20Lateral%20Sclerosis%20(ALS)%2C,cord%20(lower%20motor%20neurons).

Persona 1: Low Acoustic Volume

Condition: Post-Operative Throat Cancer Patient

#	Performance Metric	Level of Performance
1	Acoustic Volume measure at 1 metre (decibels)	**30 dB or less**
2	Effective Communication Rate	**Greater than 18 words per minute**

Simon (54) had throat cancer a few years ago. As a result of the treatments, his vocal cords were damaged. He can speak intelligibly and has a consistent ability to articulate words, but the volume of his speech is low. He speaks at the volume of a whisper (30 dB), so you need to be very close to hear him speak. In more simplistic terms, in a quiet room and a listener with average hearing, the listener's ear has to be 12 inches from the speaker's mouth to hear them. [23] (When testing, the listener should close their eyes to avoid lip reading.)

Simon was an executive at a technology company before his cancer but has taken early retirement as a result of the throat cancer. He and his wife live downtown in a condo as their children had left home a long time ago. They still like to enjoy the activities available as a result of living downtown in a vibrant city but they are not as active as they were before his throat cancer.

Simon spent most of his life around technology, so he keeps in touch with his children and their families using SMS, social media and weekly video calls. He does this on his smartphone and on his personal computer.

[23] Speech Assistive Devices (luminaud.com)

He carries a small personal amplifier device (examples can be found at https://www.luminaud.com). By using a headset, he can speak using his natural voice and his voice is amplified so people around him can hear him.

When he is making a phone call while he is out of the house, he needs to use speaker phone mode on the phone as the phone has problems picking up his voice when he is not using the amplifier device. Though not always necessary, there are times when he is talking to his doctor or a close family member where it is important to him to have a degree of privacy. In those situations, he needs to have the phone in handset mode and swap between listening through the handset and holding the phone up to the speaker of his voice amplifier to speak to the person at the other end of the line. It is an inconvenient but pragmatic approach to completing a private conversation that is equivalent to what people without a speech loss issue can achieve.

He owns a Smartphone and uses it to keep up with his personal emails and phone calls throughout the day. He also uses text messaging to keep in touch with his children and close friends. His children, who live in distant cities, text him every day.

5. Best Practices

A voice amplifier might be used as an accommodation for an individual who has difficulty speaking loudly enough to be heard in noisy environments or who has a medical need to speak softly due to voice limitations. Amplifiers can be personal, portable, hand-held or body-worn systems, or large area sound field or public address systems. Examples of voice amplification systems can be seen here.[24] The device referred to in this document only focuses on the personal hand-held or body worn systems in regard to use with a mobile device. Most voice amplifiers require the person to use a headset. In the case where the person has had part or all of their larynx removed, they may use a Larynx Speech Aid. [25] [26] The most common artificial voice source

[24] https://askjan.org/solutions/Voice-Amplification.cfm

[25] https://www.brucemedical.com/serinspeecai.html

[26] Rachel KayeChristopher G TangCatherine F SinclairCatherine F Sinclair. "The electrolarynx: Voice restoration after total laryngectomy
June 2017 Medical Devices: Evidence and Research Volume 10:133-140
DOI: 10.2147/MDER.S133225.
https://www.researchgate.net/publication/317817988_The_electrolarynx_Voice_restoration_after_total_laryngectomy

for post-laryngectomy speech rehabilitation is the handheld buzzer or electrolarynx (EL). EL speech is often described as mechanical-sounding (robotic), and typically lacks pitch variation, making it monotonic and unnatural. [27] There is also a degree of variability in the intelligibility of the speech. [28]

"An electrolarynx, sometimes referred to as a 'throat back', is a medical device about the size of a small electric razor used to produce clearer speech by those people who have lost their voice box, usually due to cancer of the larynx. The most common device is a handheld, battery-operated device pressed against the skin under the mandible which produces vibrations to allow speech;[29] other variations include a device similar to the 'talk box' electronic music device, which delivers the basis of the speech sound via a tube placed in the mouth.[30] Earlier non-electric devices were called mechanical larynxes. Along with developing esophageal voice, using a speech synthesizer, or undergoing a surgical procedure, the electrolarynx serves as a mode of speech recovery for laryngectomy patients. [31]"

6. Technical Requirements

Depending on coexisting disabilities, the person may have other considerations that need to be addressed. If the Low Acoustic Volume is due to a stroke, the stroke may have also affected their ability to process information, for example, so they may need additional accommodations that are covered in the section on Cognitive Loss.

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[27] James HeatonMark RobertsonCliff Griffin. "Development of a wireless electromyographically controlled electrolarynx voice prosthesis
August 2011Conference proceedings: ... Annual International Conference of the IEEE Engineering in Medicine and Biology Society. IEEE Engineering in Medicine and Biology Society. Conference 2011:5352-5 DOI: 10.1109/IEMBS.2011.6091324"
https://www.researchgate.net/publication/221757418_Development_of_a_wireless_electromyographically_controlled_electrolarynx_voice_prosthesis

[28] Steven R. Cox,Kimberly McNicholl,Christine H. Shadle,b and Wei-rong Chenb. "Variability of Electrolaryngeal Speech Intelligibility in Multitalker Babble".
https://haskinslabs.org/sites/default/files/files/Reprints/hl2003.pdf

[29] Department of Otolaryngology. "Electrolaryngeal Speech". Eastern Virginia Medical School. Archived from the original on 2012-08-24. Retrieved 2013-03-14.

[30] *Only Human; Cineflix (2018-06-20). Speaking with a Dead Man's Voice by Organ Transplant Surgery | Only Human. YouTube. Retrieved 2019-08-06.*

[31] Only Human; Cineflix (2018-06-20). Speaking with a Dead Man's Voice by Organ Transplant Surgery | Only Human. YouTube. Retrieved 2019-08-06. https://www.youtube.com/watch?v=5j2tQPhOHGc

The person described in the persona can perform all tasks from the primary task list without any additional accommodations except for having a private phone call, but private phone calls can be accommodated without making modifications to the design of the phone.

When privacy is not needed, in speakerphone mode, the user can use the output of the speech amplifier to create their end of the conversation. They can hear the person they are calling as the person at the other end of the line will have their voice spoken aloud through the speaker phone.

In the case of semi-private conversation, the individual with the speech loss can use a typical phone by coordinating their call similar to a communication system where only one person can speak at a time. The individual with the speaker amplifier can hold the phone up to the speaker amplifier to speak. The user at the other end of the line will need to pause briefly to give a chance for the caller to then switch the mobile device to their ear in order to hear the caller at the other end of the line. Using a cable that routes the output of the phone to a headset without disabling the microphone on the phone, so the phone can still hear output from the speaker amplifier, would be another alternative.

In the case where a totally private conversation is required, the individual must find a private room or location where people outside of the room cannot hear the conversation, just like typical phone users who do not have characteristics that affect their speech.

A secondary consideration is how synthetically generated speech of the voice amplifier or electro-larynx device interacts with voice assistants.

“The electro-larynx device (EL) offers the possibility to re-obtain speech when the larynx is removed after a total laryngectomy. Speech produced with an EL suffers from inadequate speech sound quality, therefore there is a strong need to enhance EL speech. When disordered speech is applied to Automatic Speech Recognition (ASR) systems, the performance will significantly decrease. ASR systems are increasingly part of daily life and therefore, the word accuracy rate of disordered speech should be reasonably high in order to be able to make ASR technologies accessible for patients suffering from speech disorders. Moreover, ASR is a method to get an objective rating for

the intelligibility of disordered speech. In this paper we apply disordered speech, namely speech produced by an EL, on an ASR system which was designed for normal, healthy speech and evaluate its performance with different types of adaptation. Furthermore, we show that two approaches to reduce the directly radiated EL (DREL) noise from the device itself are able to increase the word accuracy rate compared to the unprocessed EL speech." [32]

There have been recent advances but the speech recognition rate is still lower than for people who do not use assistive technology to help them speak. [33] [34] [35] For those users that want to use voice assistants, the accuracy of the speech recognition may affect their ability to successfully use that class of solutions. Given that voice recognition is not considered a primary solution currently for any of the disability communities due to the lack of ability to complete all aspects of a task, this is currently not a required accommodation. If that changes in the future, then this requirement will have to be reviewed for inclusion as a requirement.

In addition, having a private phone conversation is currently not seamless. Voice amplifiers and electro-larynxes currently do not provide a way to interface directly to the voice input channel of the mobile device. By alternating between listening and holding the mobile device up to the speaker of the voice amplifier or Electro Larynx it is possible to have semi-private conversation but it requires some coordination.

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[32] Katharina Fuchs. Juan A. Morales-Cordovilla. Martin Hagmüller "ASR for electro-laryngeal speech December 2013 DOI:10.1109/ASRU.2013.6707735 Conference: Automatic Speech Recognition and Understanding (ASRU), 2013 IEEE Workshop on".
https://www.researchgate.net/publication/261200329_ASR_for_electro-laryngeal_speech

[33] Fatchul Arifin. Electrolarynx Voice Recognition Utilizing Pulse Coupled Neural Network June 2010IPTEK The Journal for Technology and Science 21(3)
DOI: 10.12962/j20882033.v21i3.45.
https://www.researchgate.net/publication/269435600_Electrolarynx_Voice_Recognition_Utilizing_Pulse_Coupled_Neural_Network

[34] Petr StanislavEmail authorJosef V. PsutkaJosef Psutka. "Recognition of the Electrolaryngeal Speech: Comparison Between Human and Machine". International Conference on Text, Speech, and Dialogue TSD 2017: Text, Speech, and Dialogue pp 509-517| Cite as.
https://link.springer.com/chapter/10.1007/978-3-319-64206-2_57

[35] Anna K. Fuchs, Juan A. Morales-Cordovilla, Martin Hagmuller. "ASR FOR ELECTRO-LARYNGEAL SPEECH". http://www.ugr.es/~jamc/Files/Fuchs13_ELSpeechASR.pdf

Persona 2: AAC User – AAC Hosted on Mobile Device

#	Performance Metric	Level of Performance
1	Acoustic Volume measure at 1 metre (decibels)	**Greater than 30 dB**
2	Average understandable Speaking rate	**Less than 18 words per minute**

Condition: Intermediate stages of cerebral palsy (CP) [36]

Image from: https://www.ottobock.co.uk/wheelchairs-seating/kids/

Phillip is an active sixteen-year-old with cerebral palsy. He was born with the condition and it affects his motor skills. He has a spastic form of CP so his muscles are stiff, and as a result, his movements can be awkward in addition to suffering from occasional spasms. He uses an electric wheelchair to get around as he does not have the coordination to walk by himself. He has enough gross motor control of his forearms so that he can drive the electric wheelchair using a joystick on the wheelchair. His speech is slurred so he has difficulty articulating certain words and sounds and his speech is not always consistent. Most people have a difficult time understanding him, but his family and close friends who are around him a lot have learned to understand most of what he is trying to say.

[36] https://www.cdc.gov/ncbddd/cp/features/cerebral-palsy-11-things.htm

He has an AAC device which he uses to communicate with people outside of the close circle of people who can understand him when he speaks. It can be frustrating for strangers, so he uses his AAC device mainly in those situations.

He has some use of his right hand, wrist and arm. He uses that mobility to drive this electric wheelchair using a joystick and to control his AAC solution which he uses to help him communicate. The AAC solution is an application that runs on his phone. He controls his phone using the pointing device support that is on the mobile device. The pointer is controlled by the joystick on his wheelchair via a Bluetooth link. He can switch the joystick from controlling his wheelchair to generating Bluetooth mouse output to the mobile device.

Phillip attends a high school for teenagers with special needs. He attends classes regularly every day and spends a good deal of his time doing class work on this computer. Like most teenagers, he has an active social life which revolves around his smartphone and many social media communities like TikTok. He is on Facebook as his grandparents use that platform to connect with their family members. He is also an active email and text message user. His parents use text messages to keep in touch with him throughout the day and to coordinate activities such as when to pick him up from his extracurricular activities.

When making a phone call, he has to use the AAC application on his mobile device, which uses the audio channel on the phone, unless the phone call is to someone within his close circle of friend that understands his natural speech patterns.

7. Best Practices

This individual is using the mobile device to host an AAC application. The AAC application may use a keyboard to allow the user to type their message and then use text-to-speech to speak those words, phrases or sentences aloud. Alternatively, the AAC application (App) may use icons or symbols to represent common words, phrases or sentences the user might want to say. The symbolic system in some cases is more efficient than composing messages a letter at a time by entering them on a keyboard.

The mobile device needs to have the capability to run the features of the App. Typically, the technical requirements are no different from typical applications that run on the phone and support text-to-speech capability. There are many text-to-speech voices on the market, so a user can often select a voice built into the phone or add a voice to the phone that sounds the way the user would like to sound, such as providing for various ages, genders, body types, foreign languages, etc. Some mobile devices are limited to the voices supported by the operating system's text-to-speech capabilities. Some entry level mobile devices may not support text-to-speech capabilities.

In addition, the mobile device must support the routing of the output of the AAC application to the audio channels of the phone so the recipient of the call can hear the output of the AAC application. The AAC output can potentially be used to control voice-assistant-enabled features on the phone. Many mobile devices suppress sounds from the device such as alerts in order to not interfere or disrupt the phone call via their noise cancellation algorithms. [37] The one implementation of this that we know exists today has the limitation that the AAC App can only use the default text-to-speech voices on the mobile device. [38]Third-party text-to-speech voices are not supported on that mobile device.

8. Technical Requirements

AAC App Audio Passthrough Requirement

The mobile device must support the capability to route audio output from an App to the voice input channels of the phone or other advanced communications App on the phone, including but not limited to video calls and Voice over Internet Protocol (VoIP) calls.

In a typical assistive configuration, the mobile device has an AAC app installed. Typing in the text input field in the AAC App will cause a sentence to be read out. Wired or Bluetooth earbuds may be connected for the user to monitor what the AAC App is saying on the user's behalf.

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[37] https://www.assistiveware.com/blog/proloquo2go-dark-mode-split-screen-phone-support

[38] Proloquo2Go https://apps.apple.com/ca/app/proloquo2go/id308368164

Mobile phone operating systems must provide public APIs for developers to route text-to-speech audio into phone calls. The AAC App's audio speech output must either be internally routed into the microphone input or directly merged with the call's digital audio stream. In addition, the AAC App's audio speech output must be capable of being routed to other Apps on the phone such as voice assistants.

For the AAC app to be used in private, semi-private and public conversations, public APIs are needed to toggle between sending audio to the phone's speakers or the phone's TRRS jack, if it has a TRRS jack. This toggle needs to allow audio to be played on the phone's speakers even when headphones are connected. This toggle must be easily accessible on-screen with a tap, with switch scanning, and with one press of an external switch.

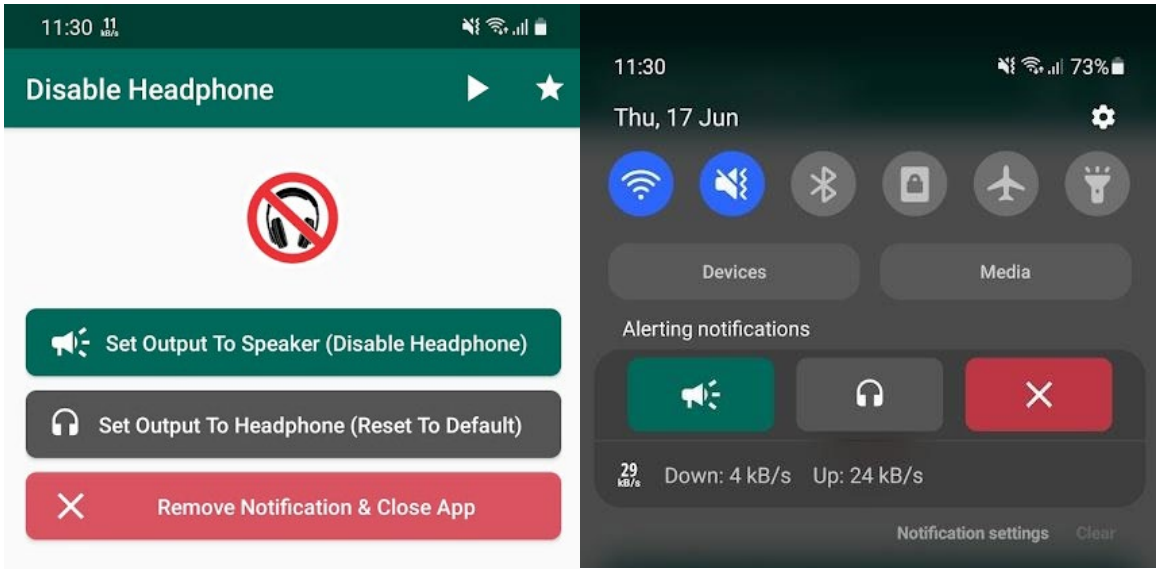

Figure 6: Example of a software-based audio toggle switch

Mobile phones without a headphone jack must provide a way to connect a wired headset for monitoring. This can be done by supporting an adapter that allows TRRS headsets to be used. If the headset has a mic, it must be usable during the call as well.

The mobile device operating system must support text-to-speech capability and have the ability to support multiple voices and languages. Where the operating system does not support text-to-speech capability it must allow third party text-to-speech functionality to operate as part of the functionality of an AAC App.

Persona 3: AAC User – AAC Device Hosted External to Mobile Device

Condition: Advanced Stages of Amyotrophic lateral sclerosis (ALS) [39]

Image from: https://www.alamy.com/stock-photo-disabled-woman-in-electric-wheelchair-74689857.html

#	Performance Metric	Level of Performance
1	Acoustic Volume measure at 1 metre (decibels)	**Not applicable**
2	Average understable Speaking rate	**Not applicable**

[39] https://www.mayoclinic.org/diseases-conditions/amyotrophic-lateral-sclerosis/symptoms-causes/syc-20354022

Sophia is 42 years old and has amyotrophic lateral sclerosis (ALS). ALS is a progressive nervous system disease that affects nerve cells in the brain and spinal cord, causing loss of muscle control. ALS is often called Lou Gehrig's disease, after the baseball player who was diagnosed with it. Doctors usually don't know why ALS occurs. Some cases are inherited. ALS often begins with muscle twitching and weakness in a limb, or slurred speech. Eventually, ALS affects control of the muscles needed to move, speak, eat and breathe.

Sophia was a school teacher before she exhibited any of the symptoms of ALS. ALS symptoms typically do not appear in childhood or young adulthood, and that was the case for Sophia. Sophia was diagnosed at age 40. Her condition progressed quickly after she was diagnosed and she lost her ability to move her limbs independently and speak intelligibly in a very short period of time.

She now needs to use an AAC device to communicate. She scans an array of letters, words and phrases organized in rows and columns on the AAC device's screen, using a switch plugged into the AAC device that is activated by the blinking of her eyes.

She blinks to start the scanning process. Each row in the array is highlighted in sequence. When the row with the letter, word or phrases she wants is highlighted, she blinks again. Each column in that row is then highlighted sequentially. When the right row and column cell is highlighted, she blinks again to activate the cell. If that cell contains text, that text is added to a buffer of text she is building, or that text can be injected into any other App running on the AAC device. Through this method she is able to assemble words, phrases and sentences, to speak, text message, email, add to a longer document she is editing, send to a mobile device, etc.

There is usually a cell in the row-column array that corresponds to a "Speak" command, and when she selects this cell through the row-column scanning process, the text she has collected is then spoken aloud using a text-to-speech synthetic voice. The audio speech output of the AAC device is routed to audio input on the mobile device in order for her to carry on a phone conversation and to control the voice assistant features on the mobile device. Having her AAC device command the voice assistant on the mobile device is a more effective way for her to do certain tasks, such as calling her husband by simply making her AAC device say, "Call Jim," just as using the voice assistant is often more efficient for nondisabled users.

She can also control the mobile device through her AAC device through multiple mechanisms:

- Screen mirroring
- Voice assistant
- Direct commands

9. Screen Mirroring

The mobile phone allows her to mirror the display of the mobile device on the display of her AAC device. She can then interact with the representation of the mobile device screen on her AAC device using her scanning method. When she activates a point of interest or enters data into a control on the represented mobile device screen, that activation information is sent to the mobile device and the equivalent action occurs on the mobile device. She can launch applications, place a phone call and send and receive a text message or email on the mobile device through this mechanism.

10. Voice Assistant

Sophia can generate words and sentences on her AAC device that she can then speak using the text-to-speech capability of her AAC device. The spoken output may consist of commands to her mobile device's voice assistant, and the mobile device will follow her instructions as it would for an able-bodied user.

The mobile device's voice assistant must be able to understand synthesized speech, and the local environment must be sufficiently noise-free. This is usually not a problem. A more common problem is that synthesized speech out of AAC devices is often not loud enough to trigger a mobile device's voice assistant. However, since Sophie has both her AAC device and her mobile device mounted to her wheelchair in close proximity, this is not a problem for her.

11. Direct Commands

For Sophia, another very effective means of controlling her mobile device is for her AAC device to send the mobile device direct commands, such as through a Bluetooth Hands-Free Profile.

A sample situation in which this is her best means of accessing the phone might be calling her husband, a repetitive task, or calling the 911 emergency line, a time-critical task. Using screen mirroring to perform either of these tasks takes significant time and effort to make multiple selections. Using a voice assistant to perform either of these tasks also takes significant time and effort to make multiple selections, and has the additional chance that the voice assistant will not interpret the command correctly, such as in a noisy room.

Using a direct command interface between the AAC device and the mobile device allows Sophia to activate a pre-set selection on her AAC device which sends a direct command of one or more steps to the mobile device to dial the given phone number.

Direct commands must be able to accomplish at least basic operation of the phone (dialing, answering, hanging up, etc.). It would be of additional benefit for direct commands to be able to control text messaging and emailing on the mobile device. It would be ideal for direct commands to be able to perform every operation possible on the mobile device, such as running third-party applications on the mobile device, which may or may not be. One possible implementation of this would be for the direct commands to send text directly to the mobile device's voice assistant rather than through audio channels.

12. Non-Mirroring Users

As a high-functioning AAC device user, Sophie is able to use all three modes, screen mirroring, voice assistant, and direct commands. Screen mirroring imposes a particularly high cognitive load, as the user has to understand the relationship between the AAC device and the phone, and use the accessibility features of the AAC device to access the mirrored screen of the phone.

Not all users are capable of the level of cognition needed to make use of screen mirroring, and would only use the other two modes, voice assistant and direct commands.

While we won't develop an entire persona here, an example would be a person with severe cerebral palsy with both mobility impairment and cognitive limitations, including illiteracy. Such a user may communicate using large pictures on an AAC device, arranged into rows and columns, that the user touches to activate. Pictures can be used individually or in combination to produce words, phrases, or sentences. Pictures can also execute macros.

One such picture for a young student might be a picture of the student's mother talking on the phone. When the student touches this picture, the picture could command the mobile device to call the student's mother in several ways:

- The picture could speak the sentence, "Siri, call Mom," from the AAC device's voice synthesizer. This would be heard by the mobile phone's voice assistant and the voice assistant would dial the student's mother on the speakerphone.
- The picture could send a direct command consisting of the text, "Siri, call Mom," through Bluetooth or another means, and Siri, which has a text mode, would interpret the text, and dial the student's mother on the speakerphone.
- The picture could send a direct command consisting of a hands-free phone dialing command containing the mother's phone number, and the hands-free profile on the mobile device then dials the student's mother on the speakerphone.

13. Best Practices

Audio Routing

The mobile device must provide a mechanism to route the audio output of an external AAC device to the audio input channel of the phone (not via speaker phone mode) on the mobile device and to the audio input of the voice-activated features of the mobile device. At the same time, the mobile device must preserve the ability to use the existing audio channel to hear the caller at the other end of the line using the existing audio channels on the device. This

must include hearing the caller at the other end through the existing phone speaker when in handset mode, and also through the speaker of the AAC device. This will facilitate private conversations when the user requires it.

Note that this is different from the technical requirements of the persona of Phillip, the teenager with cerebral palsy who requires routing of audio from Apps on the mobile device to other Apps and the telephone audio circuitry of the mobile device, also on the phone. Phillip's AAC App and other Apps only need to communicate within the phone, whereas Sophia requires bidirectional routing of audio between her AAC device and her mobile device, either through wireless means or through physical cables.

Screen Mirroring

The mobile device must provide a way to mirror the screen of the mobile device on the screen of an AAC device.

> "Screen mirroring means that you see content on your phone mirrored onto a larger screen like a TV. Whatever action you do on your phone will appear on the other screen in real time.
>
> "Screen mirroring works by turning one device into the sender and the other the receiver. In most cases, your smartphone acts as the sender and your smart TV as the receiving device.
>
> "The Difference between Screen Mirroring, Casting and Sharing
> "These three technologies all allow you to see one screen on another in some way, but they have differences.
>
> "Screen mirroring acts just like when you look in a mirror. Whatever you see on one device is exactly what you see happening on the other in real time.
>
> "Screen casting is similar to mirroring except that you no longer see it on both. For example, content casted from your phone to your TV will only appear on your TV.

> "Screen sharing is most similar to screen mirroring, but instead of displaying content from one device to another in the same room, the content displays from one device to another in a separate room or remote location." [40]

In Sophia's case, the mobile device's screen is mirrored onto her AAC device's screen, not to a TV. A wired or wireless interface must be provided in the form of a cable, typically USB, or a wireless connection like Wi-Fi or Bluetooth.

The mirroring must provide at least:

- Lightness native, displays only the device screen
- Performance: >30 fps, depending on the device
- Quality: 1920x1080 or higher
- Low start-up time: <1 second to display the first image
- Low latency: <70ms lag for continuous images
- Non-intrusiveness: Nothing is left installed on the device

The image of the screen must be able to update with at most 700 milliseconds of lag to provide an up-to-date image of the state of the mobile device and allow real-time, bidirectional interaction from the user to the AAC device to the elements on the mobile device screen and back.

A command set or API must be provided that allows a device to remotely control the phone features, specifically, being able to pick and activate a point of interest represented by the mirrored image of the phone display and being able to enter data on a virtual representation of the keyboard on the device. Through this interaction method the user must be able to perform all the tasks on the Primary Task List including making and receiving a telephone call and interacting with voice activated features on the phone via the external AAC device.

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[40] https://www.screenbeam.com/learn-more/wireless-display/screen-mirroring-explained-how-screen-mirroring-works/

14. Technical Requirements

The following configurations must be supported to facilitate the equivalent of a semi-private call on a mobile device using an AAC device and a mobile device. Semi-private calls assume that the output of the AAC device or App can be heard in the AAC user's room, but the response of the person being called cannot be heard by a third party in the AAC user's room.

Reviewers: These configurations have been tested on a number of mobile devices. They work on most of those tested devices but not on all of them.

Audio Routing Standards for Private AAC Calls

There are certain configurations that mobile phones need to support in order to facilitate semi-private or private phone conversations using augmentative and alternative communication (AAC) devices. The following standards will ensure AAC users have consistent ways to make private phone calls across all major mobile phone manufacturers.

These configurations will enable equal or better level of access for AAC users compared to nondisabled users in regard to private phone calls. We define "equal level of access" for semi-private calls as bystanders in the same room as the AAC user being able to hear the AAC device side of the conversation, but not hear the called party, a level of privacy that nondisabled users also experience when making a semi-private call. We define "better level of access" as bystanders not being able to hear either the AAC device or the called party.

Y-Splitter Cable with Mic & Headset

This solution uses a 3.5-millimeter tip, ring, ring, sleeve (TRRS) Y-splitter cable that follows the American Headset Jack (AHJ) standard. The cable splits a TRRS input into separate headset and microphone inputs.

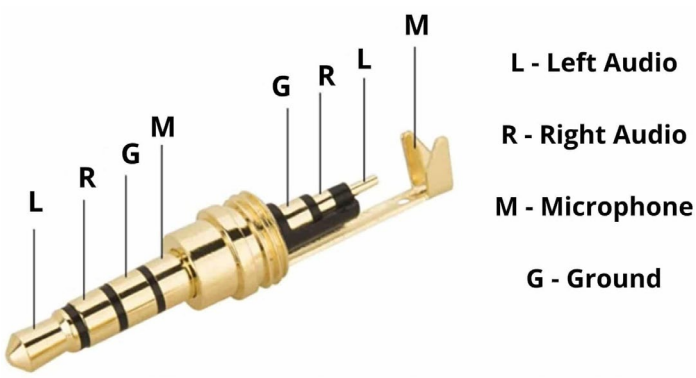
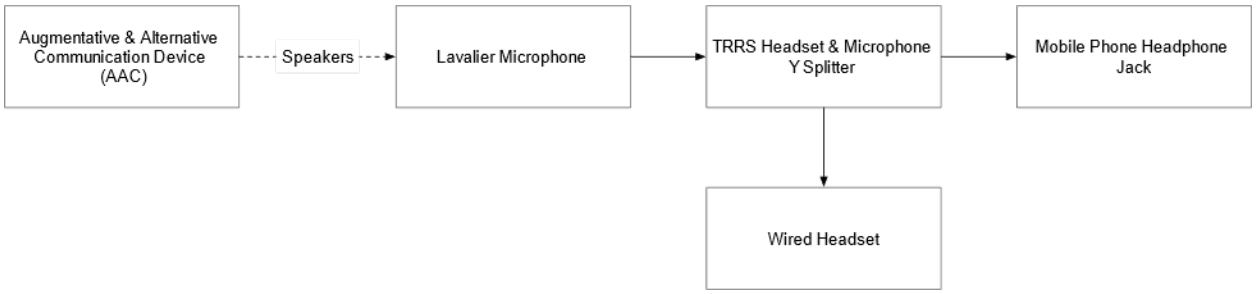


Figure 1: AHJ 3.5 mm TRRS configuration

Figure 2: TRRS headset & mic Y-splitter

Speech output from the AAC device is captured by a lavalier microphone attached to the Y-splitter's microphone input. A wired headset is attached to the Y-splitter's headset output for monitoring.



This configuration allows the AAC device to be used for both private and public conversations. A caveat is that only the audio of the called party is private, which is equivalent to the way an able-bodied person has a semi-private phone call.

Mobile phones without a headphone jack must enable equivalent functionality. This can be accomplished using a wired connection, such as by including an adapter, such as a Lightning-to-TRRS adapter or USB-C-to-TRRS adapter, that allows the TRRS Y-splitter to be used. Or it can be accomplished wirelessly by including a Bluetooth-to-TRRS transceiver (transmitter & receiver) to allow the microphone and headset to communicate with the phone wirelessly at the same time. If the headset has a mic, both mic inputs of the Y-splitter cable must be usable concurrently.

15. Better Level of Access Solutions

Y-Splitter Cable with Mic Passthrough & Headset

This solution uses a 3.5-millimeter tip, ring, ring, sleeve (TRRS) Y-splitter cable that follows the American Headset Jack (AHJ) standard. The cable splits a TRRS input into separate headset and microphone inputs.

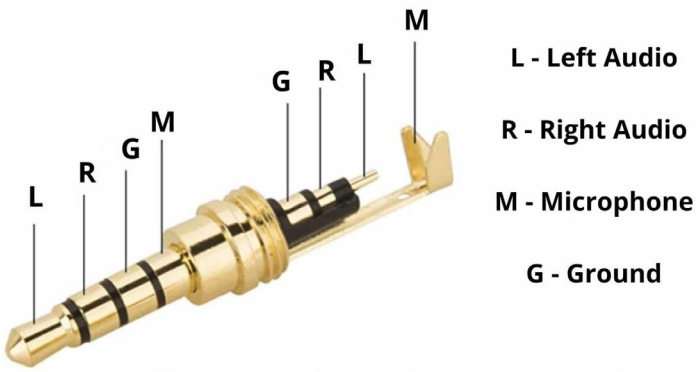
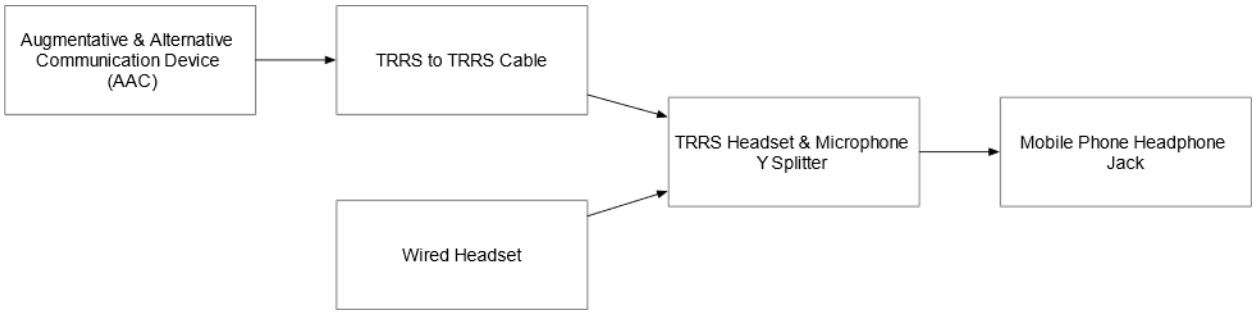


Figure 3: AHJ 3.5 mm TRRS configuration

Figure 4: TRRS headset & mic Y-splitter

Speech output from the AAC device is redirected to the mobile phone as microphone input using a Y-splitter cable. A wired headset is attached to the headset output in the Y-splitter cable for monitoring.



To allow for easy switching between using the AAC for private conversations and public conversations, AAC devices must have a software toggle to switch between sending audio to the TRRS jack or to the AAC's speakers. This toggle needs to allow audio to be played on the phone's speakers even when headphones are connected. This toggle must be easily accessible with an on-screen tap, with switch scanning, and with one press of an external switch.

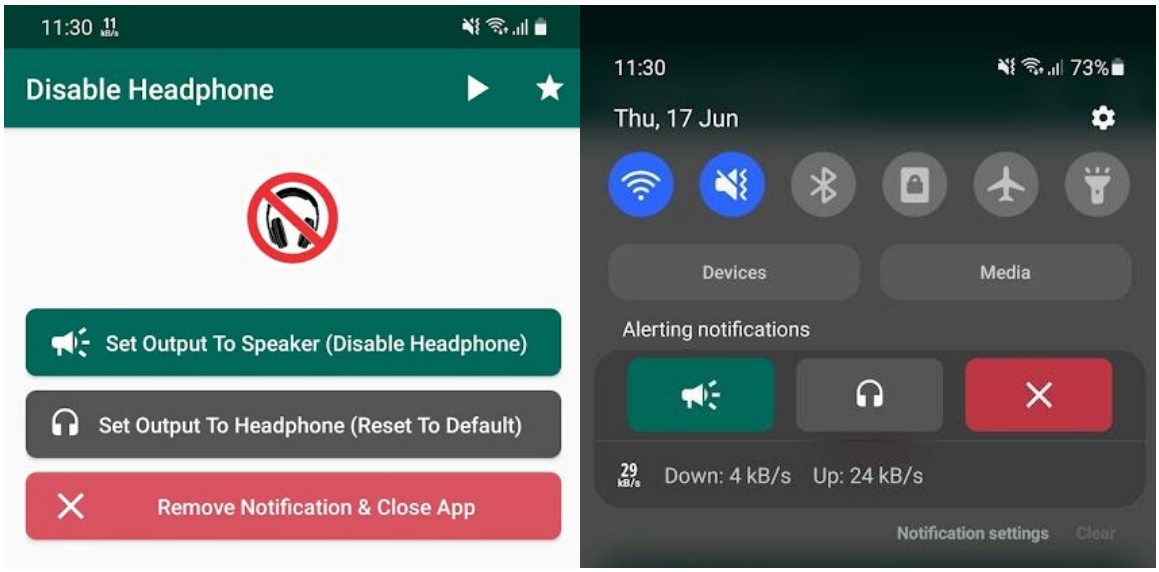


Figure 5: Example of a software-based audio toggle switch

Mobile phones without a headphone jack must enable equivalent functionality. This can be accomplished using a wired connection, such as by including an adapter, such as a Lightning-to-TRRS adapter or USB-C-to-TRRS adapter, that allows the TRRS Y-splitter to be used. Or it can be accomplished wirelessly by including a Bluetooth-to-TRRS transceiver (transmitter & receiver) to allow the microphone and headset to communicate with the phone wirelessly at the same time. If the headset has a mic, both mic inputs of the Y-splitter cable must be usable concurrently.

16. Other Requirements

Microphones connected to the TRRS jack are typically disabled when speakerphone mode is enabled, and the phone typically switches to using only the built-in microphone. This behavior must be changed to allow all connected microphones to still be used. This change will make it easier for an AAC user to toggle between a private phone call and letting a bystander participate in a public phone call, such as if the user needs help explaining something to the called party.

Persona 4 AAC user with cognitive condition

#	Performance Metric	Level of Performance
1`	Acoustic Volume measure at 1 metre (decibels)	30 dB or less
2	Effective Communication Rate	Less than 18 words per minute

Aphasia is a disorder that affects how you communicate. It can impact your speech, as well as the way you write and understand both spoken and written language.
Aphasia usually happens suddenly after a stroke or a head injury. But it can also come on gradually from a slow-growing brain tumor or a disease that causes progressive, permanent damage (degenerative). The severity of aphasia depends on a number of things, including the cause and the extent of the brain damage.
The main treatment for aphasia involves treating the condition that causes it, as well as speech and language therapy. The person with aphasia relearns and practices language skills and learns to use other ways to communicate. Family members often participate in the process, helping the person communicate

Aphasia is a symptom of some other condition, such as a stroke or a brain tumor.

A person with aphasia may:

- Speak in short or incomplete sentences
- Speak in sentences that don't make sense
- Substitute one word for another or one sound for another
- Speak unrecognizable words
- Have difficulty finding words
- Not understand other people's conversation
- Not understand what they read
- Write sentences that don't make sense

17. Cognitive Communications

Cognitive-communication disorders are problems with communication that have an underlying cause in a cognitive deficit rather than a primary language or speech deficit.
A cognitive-communication disorder results from impaired functioning of one or more cognitive processes, including the following:

- Attention (selective concentration)
- Memory (recall of facts, procedures, and past & future events)
- Perception (interpretation of sensory information)
- Insight & judgment (understanding one's own limitations & what they mean)
- Organization (arranging ideas in a useful order)
- Orientation (knowing where, when, & who you are, as well as why you're there)
- Language (words for communication)
- Processing speed (quick thinking & understanding)
- Problem-solving (finding solutions to obstacles)
- Reasoning (logically thinking through situations)
- Executive functioning (making a plan, acting it out, evaluating success, & adjusting)
- Metacognition (thinking about how you think)

These cognitive processes are not isolated abilities. They work together. A problem with one or more cognitive functions can cause difficulty performing activities of daily living safely & efficiently as well as communicating effectively. An evaluation by a speech-language pathologist can determine where impairments exist & how to treat them.

A person with a cognitive-communication disorder may have difficulty paying attention to a conversation, staying on topic, remembering information, responding accurately, understanding jokes or metaphors, or following directions.

Cognitive-communication disorders vary in severity. Someone with a mild deficit may simply have difficulty concentrating in a loud environment, whereas a person with a more severe impairment may be unable to communicate at all.[41]

[41] "Aphasia". Mayo Clinic. https://www.mayoclinic.org/diseases-conditions/aphasia/symptoms-causes/syc-20369518

Procurement Process

The goal of this document is to provide a mechanism for procuring accessible mobile devices either for an individual, a group of individuals with a specific class of disabilities, or a mobile device that meets the needs of all users across all disability communities, to be used by a department, agency, or ministry that is part of the government. The section will explain how to use the various sections of this document within the procurement process of a department, agency, or ministry. Ultimately, any procurement process is intended to produce formal procurement text that can be inserted into a procurement document for potential vendors to review and bid on to provide a product or service. The process is made up of the following steps:

- Identify the end user and determine the needs of the individual or groups of individuals the department is buying the mobile device/devices for
- Confirm the goals of the end users
- Collate the performance metrics and best practice guidance for each of the classes of user the mobile devices are intended for
- Collate the accompanying technical requirements and specifications that define each best practices
- Enter the information on user personas, performance metrics, best practices and technical requirements and specifications into the procurement template for your department
- Acceptance of the Delivered Product
- Functional testing
- End user acceptance process

18. Identifying the Stakeholders

The procurement process may be purchasing an accessible mobile device for a specific individual, a group of individuals with the same specific needs, or all potential users within a disability community accounting for the various levels of severity or a mobile device that is intended to meet the needs of a cross section of people from all disability groups and with all levels of disabilities.

Even if purchasing for an individual, the procurement specifications may extend way beyond the accessibility needs of the individual and the mobile device itself. There may be specific needs associated with the infrastructure and policies of the office, department, ministry, or government agency the user works for. Security and privacy concerns, and the type of applications and services the department's information technology division uses and can support must also be taken into consideration. Similarly, the policies and needs of the office, department, ministry, or agency need to be taken into consideration. It may take time to train the user on a device he is not familiar with. The office or department may use applications that are not available on the mobile device with the recommended accessibility features. All these factors must be taken into consideration when putting together the text for the procurement document.

Make sure to identify all stakeholders related to the usage of the mobile device and make them part of the specification development, testing, and acceptance processes.

The document only deals with the specifications that are necessary to generate the text for the procurement and testing of a mobile device or devices that have the appropriate accessibility features. Procurement personnel will have to work with the other stakeholders to ensure their needs are met.

19. Confirming Goals of the End Users

A list of representative tasks is provided in Section xxxx. That list was intended to incorporate the majority of the individual actions that are required to interact with a mobile device. While the interaction may change over time, the activities the end-user wants to achieve will change at a slower pace. For example, using a voice assistant to compose a text message is distinctly different from:

- Finding the text message app icon
- Selecting that icon and activating it
- Find the contact phone number of the person you want to send a text message to in the contact list
- Selecting and activating that contact name from the contact list
- Enter the text of your message
- Selecting and activating the "send" button or editing the text message again before sending it

Currently both methods are supported but one may fade from usage, or a third method may dispatch one of them.

The list is not exhaustive. The individual, office, department, ministry, or agency may have specific applications (apps) or services it wants the end user to be able to interact with. It is important to include those apps as part of the task list that will be used as a part of the testing procedure. It is possible to procure a mobile device that is technically accessible but does not allow the user to fully interact with the specific apps. Correspondingly, it is possible to procure a mobile device that allows the user to interact with the specified apps that is not fully accessible to all the features of the phone. It is thus important to reflect all the stakeholder requirements in the procurement document.

20. Collate Performance Metrics and Best Practice for Each End Users

Once the end user or end users are identified the personas and best practices for each end user or end users will be the high-level guidance that will be provided in the procurement document. The best practices make up the best classes of solutions identified by the authors and currently implemented in mobile devices that exist today. The best practices are not necessarily associated with one specific brand or model of mobile device. The authors have tried to be agnostic and not be biased to one specific brand or model of device. In some cases, the best of class solution may be existing in different brands and models of mobile devices. The authors have chosen the best practices based on the most effective and efficient solution for the end-users' ability level.

21. Collate Technical Requirement and Specifications

Associated with each best practice is a list of technical requirements and a list of prescriptive specifications pulled from existing accessibility standards regarding information and communications technology and specifically applied or modified to apply to mobile devices. Most existing accessibility standards and guidelines reference the broader class of information and communications technologies (ICT). ICT encompasses everything from automatic banking machines and fax machines to mobile

devices and their respective apps. None of the standards and guidelines are specific to mobile devices. This document has drawn heavily from those guidelines and standards, and applied them specifically to mobile devices and apps, as they apply to the advanced communication functionality of mobile devices. The authors have, where possible, used the existing prescriptive standard or guideline specifications by referencing the appropriate standard, paragraph, and section. Where the standards and guidelines were insufficiently detailed, the authors have made additions to the specification. Where there were competing specifications or parts of specification that were in conflict or offered contradictions, the authors have tried to resolve the issues and make a definite recommendation with a rationale for the change.

Note that the specifications were drawn from accessibility standards around the world. The final specifications included in this document is a combination of mainly the European EN 301 549, Section 508 of the Rehabilitation Act of 1973 (USA), and W3C WCAG 2.0. While these standards should be familiar to most major mobile device manufacturers, they are often treated as a separate regional checklist to be complied with. As the specifications in this document include the most current and relevant specification from each standard, it is important that potential suppliers not simply defer to one regional standard and assume all the specifications are the same.

22. Generate Procurement Template

The actual format of the procurement document will depend on the policies and procedure of the particular office, department, agency, or ministry. The major sections have been described above. A sample template of a procurement document is shown in Appendix B. It is based on the American Section 508 procurement template which can be seen here:

https://assets.section508.gov/files/ART%20Contract%20Language%20Template.pdf

23. Acceptance of the Delivered Product

There are three phases to the acceptance process:

- Declaration of Compliance by suppliers/manufacturers
- Functional testing to confirm compliance by the purchaser

- End user acceptance process

The Declaration of Accessibility Compliance (DAC) by supplier/manufacturers is based on the American Voluntary Product Accessibility Template (VPAT) 2.0. The DAC is a report attesting to the accessibility of an information and communication technology (ICT) product or service. To maintain a level of compatibility with the long established VPAT, the DAC used many of the same sections, descriptions, and definitions. The goal is to make the transition easier for suppliers and manufacturers to adopt this new format.
The DAC may potentially be adopted as the official document that should be required on all federal solicitations. The DAC combines elements from the standards and guidelines from the American Section 508, the European EN 301 549, the American CVAA, G3ICT and the W3C WAG (ISO/IEC 40500:2012). As detailed in the document the standard combines all the best practices from all the standards and guidelines.

In the DAC the vendor is asked to provide some basic information:

- Name of Product/Version
- Product Description
- Date
- Contact Information
- Notes
- Evaluation Methods Used determine compliance with the procurement document specifications
- Applicable Standards/Guidelines
- Terms
- Tables for Each Standard or Guideline

A key portion of this section is the "Notes" field. The DAC instructions provide guidance on this field, which includes:

- Additional information about the product version that the document references
- Any revisions to the document
- Links to any related documents
- Additional information describing the product
- Additional information about what the document does or does not cover
- Information suggested by the WCAG 2.0 Conformance Claim if applicable, at http://www.w3.org/TR/WCAG20/#conformance-claims

- Information needed to satisfy ISO/IEC 17050-1:2004, Supplier's Declaration of Conformity

Note that the procurement language will have "best practices" for each disability community and level of disability. If the supplier product does not contain a solution that implements the recommended best practice for a specific disability community and level of disability they can provide information on an equivalent solution that provides an equivalent level of access. Details on how to determine if a solution provides an equivalent level of access is covered in Section 12: "Test Process for New Accessibility Solutions" of the Accessible Procurement Mobile Device Standards document.

The next key addition is the field, "Evaluation Method Used." The DAC provides the following suggestions as responses:

- Testing is based on general product knowledge
- Similar to another evaluated product
- Testing with assistive technologies
- Published test method (provide name, publisher, URL link)
- Vendor proprietary test method
- Other test method

This section is intended for the supplier to present a purchaser with the significant details of how accessible a product is. For example, when attesting to the accessibility of a product or service the supplier may have used automated accessibility testing. This type of testing only catches a faction of the accessibility errors for this product or service class. Therefore any declaration that does not include manual and automated testing may require further examination by the purchaser. Suppliers are encouraged to provide as much detail as possible to ensure the product or service is not unnecessarily delayed in the evaluation and acceptance process.

The next key field is "Applicable Standards/Guidelines." It explicitly asks the level of conformance reporting. This typically applies to WCAG 2.0 criteria. WCAG 2.0 asks the supplier to state which sections have been included. For most products, the purchaser will be looking for WCAG Level A or Level AA. Level AAA is a highly specialized category and is not required for most organizations at this time.

The DAC does allow vendors to specify conformance to the previous Section 508 standards, before its 2017 update. This allows the vendor to include

documentation using the older VPAT® 1.3 standard. The vendor may also apply the European EN 201 549 standards.

Table 2. Applicable Standards/Guidelines table for DAC

Standard/Guideline	Included In Report
Web Content Accessibility Guidelines 2.0, at *www.w3.org/TR/2008/REC-WCAG20-20081211/*	Level A (Yes/No) Level AA (Yes/No) Level AAA (Yes/No)
Section 508 as published in 2017, at *www.Section508.gov*	(Yes/No)
EN 301 549 Accessibility requirements suitable for public procurement of ICT products and services in Europe, at *http://mandate376.standards.eu/standard*	(Yes/No)

The next major area is the WCAG 2.0 Report (Table 3). Each conformance level—Level A, Level AA, Level AAA—is broken into a standalone section. Like the VPAT® 1.3 template, each section has a Criteria, Conformance Level, and Remarks and Explanations section.

Table 3. First row of VPAT® 2.0 WCAG 2.0 Report table, "Success Criteria, Level A"

Criteria	**Conformance Level**	**Remarks and Explanations**
1.1.1 Non-text Content (Level A) Also applies to:EN 301 549 Criteria 9.2.1 (Web)10.2.1 (Non-web Document)11.2.1.1 (Software)11.2.2.1 (Closed Functionality Software)11.6.2 (Authoring Tool)12.1.2 (Product Docs)12.2.4 (Support Docs) 2017 Section 508501 (Web)(Software)504.2 (Authoring	Web: Electronic Docs:Software:Closed:Authoring Tool:	Web: Electronic Docs: Software: Closed: Authoring Tool:

Tool)602.3 (Support Docs)		

Within the "Criteria" column, both the older Section 508 standards and the EN 201 549 are mapped to the WCAG requirement. This is to reduce ambiguity for the vendor when mapping these older standards to WCAG. Within "Conformance Level," ITI breaks down the components that could conceivably make up a product. It is the vendors responsibility to use one of the following conformance levels on all components that apply:

- **Supports**: The functionality of the product has at least one method that meets the criterion for each level of disability in the required disability communities without known defects or meets with equivalent facilitation.
- **Supports with Exceptions**: Some functionality of the product does not meet the criterion.
- **Does Not Support**: The majority of product functionality does not meet the criterion.
- **Not Applicable**: The criterion is not relevant to the product.
- **Not Evaluated**: The product has not been evaluated against the criterion. This can be used only in WCAG 2.0 Level AAA.

The instructions for the final column, "Remarks and Explanations," attempt to further tighten reporting with the following suggestions:

- When the conformance level is "Supports with Exceptions" or "Does Not Support," the remarks should identify:
    a. The functions or features with issues
    b. How they do not fully support
- If the criterion does not apply, explain why.
- If an accessible alternative accommodation is available, describe it. This is key to responding to this section. A failure without a secondary alternative (accommodation) may at the discretion of the purchaser disqualify the product from consideration.

The next major field is the 2017 Section 508 Report (Table 4). There is still value in addressing older Section 508 requirements since the older Section 508 has sections that cover hardware (WCAG, to which the updated Section 508 more closely aligns, focuses primarily on content).

Table 4. First few rows of VPAT® 2.0 table, "2017 Section 508 Report Chapter on Hardware"

Criteria	**Conformance Level**	**Remarks and Explanations**

402 Closed Functionality	Heading cell – no response required	Heading cell – no response required
402.1 General	Heading cell – no response required	Heading cell – no response required
402.2 Speech-Output Enabled	Heading cell – no response required	Heading cell – no response required
402.2.1 Information Displayed On-Screen		
402.2.2 Transactional Outputs		
402.2.3 Speech Delivery Type and Coordination		
402.2.4 User Control		
402.2.5 Braille Instructions		

The next field, "EN 301 549 Report," is a European standard and has some interesting additions. Vendors with European concerns must incorporate the relevant sections.

The final area is "Legal Disclaimer." While the area is vaguely described, we believe vendors will produce good faith language that states that an effort has been made to accurately and completely describe the accessibility of the product, but that there may be minor technical flaws that will not impede the use of the product or service by a person with vision, hearing or mobility challenges. These disclaimers usually contain a clearly stated commitment to ensuring equal access for all users and a summary of the overall level of compliance with accessible technology standards. Key to this section is a wide belief that 100% accessibility is not achievable as there are a myriad of technical failures that would not hinder the use of the product but would violate the WCAG 2.0.

Like the VPAT®, the DAC is not a certification of compliance nor is it intended to be a pass/fail tool. The DAC is intended to provide an opportunity for the supplier or manufacturer to provide significant insight into the degree

to which a product will be perceivable and usable by a person with vision, hearing, mobility, or cognitive challenges to the purchasing officer. Completing the form only attests to the degree to which it complies with the prescribed standards or guidelines. The purchaser must evaluate the responses in the DAC and determine if the product as stated meets the accessibility needs of the organization or individuals. It is not a replacement for the next step which is compliance testing by the organization procuring the product or service and a review process by the final end user/users and stakeholders. In the compliance declaration a supplier and/or manufacturer must provide information about the degree of compliance with a standard or guideline, the testing process they used to confirm it and a list for any exceptions in regard to the accessibility of the product or service in very specific test conditions. For the later disclosure it will be up to the organization procuring the mobile device to ensure the exception will not materially affect the intended end user from completing the list of tasks they need to perform their job.

24. Conformance Testing of Solutions for Compliance with the Guidelines Above

To test if a product complies with the technical requirements that define the accessibility for this community manufacturer and procurement department can use the following procedure:
https://www.section508.gov/test/testing-overview
Manual testing is suggested as being more complete and effective. More details are provided in the Section 12: Testing Process for a New Accessible Solution.

Testing Process for a New Accessible Solution

Mobile devices are consistently being improved and updated to add new features and services. As their capabilities improve new accessibility solutions may be developed. It is impossible to develop strict, prescriptive criteria that determines the accessibility of a device or the suitability of a new accessibility solution before it is created. As an alternative this section presents a framework for testing a new accessibility solution for a specific device or classes of device for a specific subgroup of a community of users. The sub-

groups are determined by the severity levels described in this document as most solutions are not designed to address the consideration of all severity levels.
The testing process is constructed around a list of tasks as described in Section 9.2: Specific tasks for mobile devices. That list is repeated here to make it easy to reference.

#	**Task**
1	Reading the instructions on how to use the device that comes with the device packaging or is available from an online source
2	Setting up the device for the first time
3	Making and terminating a communications session (phone calls, videos call or text message session)
4	Receiving communication session (phone calls, videos call or text message session)
5	Sending text messages to a person in their contact list and to a specific phone number
6	Receiving text messages
7	Send and Receiving email using an app
8	Using a web browser to navigate to a URL, scroll to the end of the URL, interact with the controls on the webpage, enter text in the edit controls on that webpage and the browser controls (reload, forward and back, menu for browser).
9	Using a calendar including entering a new appointment for a date one month in the future and looking up an appointment already scheduled for this week.
10	Taking pictures/video and save it to the mobile device
11	Watching videos or listening to music including changing volume

12	Complete a video call or meeting (FaceTime, no equivalent in Android that is shipped with phone - Duo).
13	Receive low battery notification
14	Change setting one the mobile device such as display brighten, default font size

When testing a new class of accessibility solutions considerations must be taken to address the list of performance metrics supplied with each of the personas that represent levels of severity and correspond to key sub-groups of users within a particular disability community. Combinations of those performance metrics represent the abilities of the sub-groups of users within each community. A particular accessibility solution usually addresses one sub-group of users due to their unique combination of abilities described by the performance metrics. While there may be cases where a solution addresses the needs of multiple sub-groups of users, the appropriateness of a solution as measured by efficiency (time to perform the task) usually helps to define the sub-group of users the solution is most appropriate for. The concept of it being "not impossible" to complete a task using an particular solution historically has led to supplier creating or providing only a solution for the most severe level of a disability community and assumption anyone with more ability can also use the same solution. The definition of appropriateness takes into the consideration of the end users' abilities so that they can complete a task in the most effective and efficient manner possible given their abilities.

For the evaluation process the supplier is assumed to be providing a solution or solutions that meet the needs of each one of the levels of severity described in the personas section. A solution can then be evaluated against users with the combination of performance metrics provided for each severity level. The solution must be able to complete each task in the primary task list plus any additional tasks specified in the purchasing document that are critical to the end user's needs. This will include those needs dictated by the employer of the end user. Examples are applications the end user must complete as part of their job or any technical compatibility issues required by the information technology division of the organization.

To be accepted as a solution for a particular subgroup or sub-groups, a user with the related performance metrics for that sub-group must be able to

complete all the tasks on the list without having to resort to additional features of applications that are not directly part of the solution. Completing part of the tasks using one accessibility solution and another part of the part using another accessibility solution are not considered an appropriate solution that passes the test criteria.
For simplicity the following reporting format will be used.

#	**Task**	**Result of test with accessibility solution**	**Notes**
1	Reading the instructions on how to use the device that comes with the device packaging or is available from an online source		
2	Setting up the device for the first time		
3	Making and terminating a communications session (phone calls, videos call or text message session)		
4	Receiving communication session (phone calls, videos call or text message session)		
5	Sending text messages to a person in their contact list and to a specific phone number		
6	Receiving text messages		
7	Send and Receiving email using an app		
8	Using a web browser to navigate to a URL, scroll to the end of the		

	URL, interact with the controls on the webpage, enter text in the edit controls on that webpage and the browser controls (reload, forward and back, menu for browser).		
9	Using a calendar including entering a new appointment for a date one month in the future and looking up an appointment already scheduled for this week.		
10	Taking pictures/video and save it to the mobile device		
11	Watching videos or listening to music including changing volume		
12	Complete a video call or meeting (FaceTime, no equivalent in Android that is shipped with phone - Duo).		
13	Receive low battery notification		
14	Change setting one the mobile device such as display brighten, default font size		

The results of an attempt to complete a task from the list can have one of three outcomes:

- Pass
- Fail
- Pass with exceptions

Pass denotes that the solution could complete each phase of the task without relying on features or applications that are not part of the solution and available to users that do not have the restrictions imposed by the performance metrics of the end user.
Fail denotes the solution was not able to complete all phases of the task.

Pass with exceptions denotes the solution could most but not every phase of the task without relying on features or applications that are not part of the solution and available to users that do not have the restrictions imposed by the performance metrics of the end user. The nature of the exception and the reason the solution failed should be described in detail in the Notes section of the reporting table. Purchases may determine the phone is intended for a subset of the users and then they may deem the exception acceptable to their end users.