I. INTRODUCTION

Sound is an important source of information. Most face-to-face communication is by sound signals in the form of speech. However, persons who are deaf or hard of hearing may not be able to make use of sound signals for communicating effectively. Technology plays an important role in supporting the communication and information needs of people with hearing impairment. These include hearing aids, induction loop and infrared listening devices, text and video telephones and visual or vibrating alarms and alerting devices.

The dream of both hearing-impaired consumers and audiologists alike is for an amplification system to resolve the handicap of hearing loss. Ideally, this system would meet all hearing needs. It would reduce background noise while enhancing the quality of speech. It would be cosmetically appealing and easy to handle. It could be used in all listening environments whether they will be in living rooms, boardrooms, restaurants, or even, Yankee Stadium with the same level of success. Presently, however, there is no such device. Although hearing aids continue to improve in quality and versatility, they typically do not meet all of the communication needs of this population with hearing impairment.

Multiple factors, both acoustic and non-acoustic, influence an individual’s success and failure with amplification. It is only through assessment and counseling that we learn about their communication needs. The information we obtain regarding the client’s communication function will be pivotal when considering amplification. Amplification selection is a crucial component of the successful aural rehabilitation program. Also amplification choices are bountiful & are not limited to the hearing aid only.

Assistive listening devices (ALDs) are the one which facilitate the auditory activities of daily living by providing viable rehabilitation options.

II. ASSISTIVE LISTENING DEVICES AS REHABILITATION TECHNOLOGY

The term assistive listening device has typically been used to refer to systems that (a) improve the signal-to-noise ratio by transmitting amplified sound directly to the hearing impaired listener and (b) transforms sound into a visual or tactile signal.

The available technology is no limited to listening alone; many provide valuable visual and tactile representations of sound. Hence, the term rehabilitation technology for hearing impaired people is more appropriate. These systems are classified into following four functional categories:

4) Sound Enhancement Technology: Specific amplification systems used to assist in the reception of sound. Included are traditional systems, such as hearing aids, as well as personal and group hardwire, infrared, induction loop and frequency modulation (FM) systems.

5) Television Enhancement Technology: Equipment used to improve the auditory perception of televised signal. This category includes telecaption decoding and many sound enhancement devices.

6) Telecommunication Technology: Systems used to enhance telephone communication. Included are text telephones (TT), built in and portable amplifiers and induction system.

7) Signal/Alerting Technology: The group of devices used to signal the presence of sound to a hearing impaired listener. Included are visual and tactile hardwire or wireless systems as well as hearing ear dogs.

III. SOUND ENHANCEMENT TECHNOLOGY

Assistive listening devices are primarily classified under sound enhancement technology. The goal of these devices is to transmit sound directly from the source to the hearing impaired listener, in effect decreasing the distance between the two. By negating the effects of distance, the intensity of the sound source maintained at a constant and optimal listening level. This results in an improved signal-to-noise ratio.

All sound enhancement technology contains the same basic components. Microphone first picks up and convert the incoming signal. An amplifier then increases the intensity of the signal. Last, the receiver converts the amplified signal back into acoustic information.

A. Induction Loop Systems

The audio induction loop is one of the oldest forms of assistive listening technology in use today. These systems provide large area access to those hearing impaired individuals who have a telecoil in their hearing aids. Audio induction loop systems are often used in schools for the hearing impaired as well as in public building and auditoriums.

Audio loop system requires the use of a microphone, an amplifier, a loop of wire, and a receiver. The wire surrounds an intended audience. For a large group of people, the wire may surround an entire room or a portion of a room. For individual use, an induction neck loop (a loop of shielded wire worn round the individual’s neck) can be used by the hearing impaired listener. The input signal is picked up by a microphone, amplified and transmitted through the loop of wire. The wire generates a magnetic field the strength of which proportional
input signal. The placement of other wire within the effective electromagnetic filed results in the reception of the input signal. The signal is usually amplified further and subsequently, converted into the original sound. The electromagnetic coupling is accomplished through the use of the T-coil of the individual’s hearing aid or through a personal induction amplifier. Induction loop systems are a cost effective device in providing sound enhancement. Installation of these systems is practically easy with little mechanical knowledge necessary in addition, homemade induction systems can be used from component equipment purchased at electronic supply stores. This can result in a significant financial savings.

However, there are certain disadvantages associated with the use of an audio induction system.

Spill over effect is the major problem where magnetic field in one room is picked up by a telecoil in an adjacent room. This can be particularly troublesome in settings where more in than one room is looped especially in schools for the hearing impaired.

A second possible problem is that induction systems are vulnerable to interference from a variety of sources within the designated area. These include: fluorescent lights, transformers, and electric power wires. The resultant interference may take the form of a low frequency hum or increased distortion.

The placement of the loop of wire within a listening environment is also extremely important. Within a given setting, there may be areas that are not reached by the electromagnetic field. This will result in “dead spots.” That is, areas of no sound.

Audio induction loop systems have a variety of applications such as:

1) They are used successfully in situations where groups of hearing impaired individuals gather for community meetings, consumer group meetings etc.
2) Induction loop technology can be used to couple other assistive device system to personal hearing aids. This is accomplished through the use of neckloop that is coupled directly to assistive devices such as hardwire, infrared and FM systems.

Telecoil capability between the various styles of hearing aids can also vary greatly, with the performance of the telecoil having a direct relationship with the successful use of induction technology. Historically, post auricular hearing aids have possessed superior induction capability. This is primarily due to the availability of space within the hearing aid. Most in-the ear and canal-style hearing aids, because of space limitations, do not possess a telecoil, thus, eliminating their use in an induction loop environment. Even when a telecoil is present, their effectiveness is often limited. This problem can sometimes be overcome through the use of an individual induction receiver that is interfaced between the hearing aid and the electromagnetic field.

B. Hardwire Systems

Hardwire personal amplification systems provide a direct physical connection from the sound source to the listener. These systems couple the sound source via a microphone, amplifier, and external receiver through the use of hardwires. The microphone is placed by the desired sound source. The signal is amplified through the body of the instrument and transmitted to the listener. The hardwire coupling can be achieved through the use of earphones, ear buds or if the listener wears hearing aids with a telecoil, via an induction neck loop.

Direct audio input (DAI) is considered a manner of hardwire coupling. The connection from the sound source to the listener is achieved by plugging an input cord from the sound source or subsequent amplification system, directly into a hearing aid via a boot or audio shoe. DAI systems are currently available for many post auricular style hearing aids, as well as certain in-the-ear-style, aids.

Hardwire systems may provide an economical means of amplification. Personal hardwire amplification systems can be used clinically in number of ways. They can be used as a source of temporary amplification in such places as schools, hospitals, nursing homes, and physicians’ offices. Their case of operation, generally large volume controls and batteries make them simpler to manage than many hearing aids. This can be a significant advantage when considering amplification options for individuals with manual dexterity problems and physically handicapping conditions. The major disadvantage to the use of hardwire system is the limitation imposed by the direct wire connections. Although the systems are small and portable, direct wire coupling from the sound source to the listener may contraindicate their use in such large areas like auditoriums and meeting halls.

C. Infrared Systems

Infrared systems do not use a hardwire section. The sound that is picked up by the microphone is converted into infrared light waves through the listening environment. The receiver, worn by hearing-impaired listener, transforms the infrared waves back into an auditory signal. The receiver serves as an amplifier and can be adjusted to a listening level. Infrared systems can be coupled in a variety of ways such as: First standard headsets or insert earphones can worn by individuals who have a mild hearing loss and do not wear hearing aids. Second, those individuals who have hearing aids equipped with telecoils can use induction technique. Third, direct those individuals whose hearing aids have the necessary interfacing boot can use input. Infrared systems can be used for large area or personal amplification.

Infrared systems are frequently used clinically as a recommended device to enhance the sound from a television. One of the most beneficial aspects of this technology is its usage in theaters. This has allowed many hearing impaired individuals to pursue an entertainment option previously unavailable to them.
The major disadvantage of infrared systems is that they can be used only in enclosed rooms. This is because infrared light waves cannot pass through or bend around obstacles. They also cannot be used outdoors. The transmitted light waves would intersperse among the naturally occurring light waves present outdoors, thus, destroying the transmitted signal.

D. FM Systems

FM systems provide a wireless means of transmitting the sound source to the listener. The auditory signal is picked up by a micro phone and is transmitted in the form of radio frequency modulated carrier waves to a personal receiver that is worn by the hearing impaired listener.

Each FM system consists of a translator with a specific radio carrier frequency, an amplifier and a compatible receiver.

The Federal Communication Commission (FCC) has allocated the frequency region of 72 to 76 MHz as the Auditory Assistance Band for assisting hearing impaired persons with communication.

This frequency region has typically been divided into 32 sub regions, thus allowing for 32 different transmitting frequencies.

There are essentially two types of FM systems. The first of these is a complete system consisting of

1) An FM microphone located on the transmitter with associated antenna;
2) An environmental microphone on the FM receiver; and
3) An amplifier sufficiently powerful to allow the receiver to function as a hearing aid.

The complete FM system is frequently the amplification system of choice for use in educational settings.

The second type of FM system, often referred to as a personal FM system, involves the coupling of the FM system to the client’s personal hearing aids. The FM system in this case functions as an assistive listening device. Direct or indirect coupling can be used with personal FM systems. Direct coupling includes the use of earphones; insert ear buds, external receivers with ear molds, or direct audio input to the hearing aid.

Recently, FM systems have been developed that use sound field technology as a means of providing amplification. In this situation the speaker wears a microphone and portable transmitter. The speaker’s voice is transmitted on the FM carrier signal and is picked up by a receiver-amplifier that is somewhere in the room. The receiver-amplifier in turn, is connected by hardwire to a number of loud speakers strategically placed within the room to produce an equally loud signal throughout the room. This system provides non-intrusive systems of increasing the signal-noise ratio. Another advantage of this system is that it can be more cost effective than other FM systems. FM systems have been used successfully with various hearing and listening impaired populations.

They have not only been shown to be effective with severe to profound hearing-impaired populations but also with children who exhibit unilateral hearing loss, central auditory dysfunction, minimal hearing loss and children with developmental disabilities.

Increasingly they are becoming the ALD of choice in schools for the hearing impaired, mainstream settings, early intervention programs, as well as among hearing impaired adults. Recently, the American Speech-Language and Hearing Association (1991) recommended use of complete FM systems with hearing impaired to enhance direct language stimulation. Because of the use of radio waves, FM systems are not subject to the limitations found with hardwire and infrared systems. They can be used outdoors as well as in classrooms, auditoriums, and living rooms. They can be used for interpersonal communication or linked with tape recorders or televisions.

There are, however, some disadvantages to the use of this system FM systems can pick up interference from signals passed along with same FM carrier waves.

For example, many paging systems (beepers) have their Carrier frequency within the FCC designated band of 72-76 MHz and thus, may interfere with the FM transmission. Another problem may occur if duplicate FM channels are used. In these cases, only the receiver will pick up the stronger signal. This is known as the “captive effect". Also, proper training is necessary for teacher to ensure appropriate usage of these systems. “Finance" is another problem with FM system where they are significantly more expensive than other systems like hard wire and loop induction. However, FM systems can be used in a variety of ways, from primary amplification to as assistive listening device for use in a classroom or teacher.

IV. TELEVISION ENHANCEMENT TECHNOLOGY

Television plays an important role in the lives of many individuals. It can be a source of information and education as well as provide an economical means of entertainment. It can provide daily activities for individual confined to home or can be the source for creative play in a child’s schoolyard. Nevertheless for hearing impaired individuals and their families, it can be a source of great frustration.

Television enhancement technology consists of those devices that are used to improve a hearing impaired individual’s perception of a televised auditory signal. These devices, may within the sound enhancement technology classification described earlier, can transmit a television’s audio signal directly to a listener, while maintaining a normal television volume, or produce a visual representation of the auditory signal. Systems that do not interrupt the normal television volume are especially practical as they allow family and friends to watch television at their own preferred loudness level.

Sound enhancement technology can be easily adapted for use in television viewing. The signal can be transmitted to the listener via hardwire, infrared, of FM systems and
can linked to the hearing aid through the use of an output jack from television.

For many individuals with severe/profound hearing impairment or poor speech recognition ability, the use of sound enhancement technology is not sufficient. These individuals require visual information to supplement or replace the audio signal.

The process by which this is accomplished is known as closed captioning. Closed captions are hidden subtitles that are provided in one band of the televised signal. To visualize these subtitles with an external decoder or a decoder chip built into the television is required. Tele-caption decoders are commercially available at major departmental stores as well as through the National Captioning Institute (NCI). The NCI is a nonprofit corporation that provides closed captioning services to the television and movies industry.

A. The Video Phone

There are two main areas where a videophone could assist a deaf or hard of hearing person.

1) It is used to convey sign language and
2) It also assists in lip reading/speech-reading by adding visual cues to speech.

The core component of a videophone is the video "codec" or coder that encodes and decodes the signal. The encoder takes video signal from a camera, converts it to a digital form, and compresses it to a bit-rate suitable for transmission on any available network. The decoder receives this compressed signal from the network and expands it again to a moving video signal for display.

V. TELECOMMUNICATION TECHNOLOGY

Telephone communication is major component of the auditory activities of daily living. In the past the only amplification option available to hearing aids users was via magnetic induction. A telecoil loop was present within the handset of the telephone, the presence of which resulted in magnetic field leakage of the ongoing telephone signal. Activation of the T switch on the hearing aid allowed the listener to pick up the magnetic field convert it to an electric signal and amplify it through the hearing aid. An additional benefit of this system was the reduction of environment noise since the use of the T switch disengaged the environmental microphone. Today however, there are varieties of amplification methods available to hearing impaired individuals.

This fact has created a greater demand for alternative amplification products.

Today, there is a variety of amplification system available for telephone use.

There are three common styles of telephone amplifiers: amplified handsets, in-line amplifiers and portable strap-on amplifiers. Amplified handsets require the use of a modular telephone. These devices increase the loudness of the incoming telephone signal. They contain a volume control located in the body of the handset and the listener makes adjustments. Typical amplified handsets have either a rotary or touch panel volume control. Other models may come equipped with an additional push button volume boost to increase the signal.

In line amplifiers are interfaced are interfaced between the body of the telephone and the handset.

A standard handset is then connected directly to the amplifier. As with the amplified handsets volume control is used to adjust the desired of the signal.

Table strap on amplifier are available for use on phones. They are small, individual who travel and who use different telephones can use portable system. This style of amplifier requires the use of an induction system to amplifier requires the use of an induction system to hearing aid compatible telephones.

Amplification devices may not always be able to provide the necessary amplification for individuals with server/profound hearing loss or poor speech recognition. For these individuals, visual systems are available to help to make telephone communication accessible. Text Telephones (TTO) also known as Telephone Devices for the Deaf (TDD) or Teletypewriters (TTU) are based on teletypewriter technology lie and transmit visual signals over the standard telephone line. It is necessary that both parties have TT systems to communicate. As one person types his message, the signal is transmitted along the telephone line and is decoded at the other end by the TT receiver. The message is seen on a line screen built into the TT.

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that is available currently.

VI. SIGNAL/ALERTING TECHNOLOGY

Auditory activities of daily living such as hearing a doorbell or a telephone ring waking to an alarm clock, or listening for a baby cry may not be heard by many hearing impaired individuals and may therefore be a source of great anxiety and frustration. This has led to the development of signal alerting technology for the purpose of alerting hearing-impaired persons to the presence of environmental sounds. Alerting can be done though the use of auditory, visual, or tactile signals.

There are three methods of sound pick up used in alerting device technology

1) Sound activated systems
2) Direct connect system and
3) Induction system

Sound activated system detects the presence of sound through nearby microphone placement.

The microphone is connected to an electronic switching mechanism. Any sound that is picked up by the microphone and exceeds a predetermined level results in the activation of the electronic switching mechanism. This in turn, causes electric current to flow to an interfaced signal device such as a lamp or vibrator.

Direct connect systems are electronically interfaced to the signal source and are activated directly by the electrical system of the equipment (such as those of a telephone and doorbell.

It is a permanently installed system, and therefore reduces its portability. Induction sound pick up utilizes electromagnetic field energy created by the signal source. These systems are generally interfaced with the desired signal through the use of a suction cup. These systems are frequently portable and suitable for travel.

A. Signal/Alerting Technology

Clocks can be set up to activate a lamp or strobe light to waken a hearing impaired person. A pillow vibrator or bed taker can also be used in needed. Telephone systems can be designed to activate lights in various rooms in a home. They can also be used to trigger a control service that can activate a vibrotactile wristband. Device systems can be alert a hearing impaired parent to the sound of a crying child. This system can be vibrotactile or visual.

An alarm and alerting device consists of the following four main components:

- Sensors or input transducers, which receive the input, signal and convert it to an electrical signal.
- Signal-conditioning or processing components such as amplifiers
- Output transducers or actuators, which convert an electrical signal to an appropriate form and output it to the user;
- A transmission system, generally consisting of a radio frequency transmitter and receiver, for transmitting the electrical signal output by the sensor (s) to the output transducer.

<table>
<thead>
<tr>
<th>Type of Device</th>
<th>Channels</th>
<th>Trigger</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Doorbell</td>
<td>2</td>
<td>110 dB</td>
<td>Voltage or sound</td>
</tr>
<tr>
<td>Baby alarm</td>
<td>3</td>
<td>85 dB</td>
<td>Sound: Unit is placed near to but out of reach or the child</td>
</tr>
<tr>
<td>Alarm Clock</td>
<td>6</td>
<td>95 dB</td>
<td>Sound: Use the external piezo sound sensor or connect directly to a modified clock</td>
</tr>
<tr>
<td>PIR</td>
<td>7</td>
<td>110 dB</td>
<td>Sound: The external piezo is placed on a domestic smoke alarm</td>
</tr>
<tr>
<td>Domestic Fire Alarm</td>
<td>Fixed</td>
<td>110 dB</td>
<td>Sound: The external piezo is placed on a domestic smoke alarm</td>
</tr>
<tr>
<td>Commercial Fire Alarm</td>
<td></td>
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</tbody>
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TABLE I

SIGNAL/ALERTING DEVICES WITH THEIR PROPERTIES

In addition to the above alerting technology, programs have available to train hearing ear dogs. These dogs are professionally trained to alert there hearing impaired owner to a number of different sounds in variety of listening situations.

The hearing dog’s responsibility is to attract the attention of the owner whenever they hear the doorbell, telephone, and fire alarm and lead them to the source of the sounds.

B. Access to Information Technology

Developments in information technology has become a boon for persons with hearing impairment. These developments has opened up a wide range of new opportunities for these persons and enabled them to communicate on equal terms with both hearing and hearing impaired people. For e.g. through e.mail. This has in reality created a barrier free environment for them.

C. Development and Distribution of Devices

Developing assistive technologies and devices, in itself, is insufficient. To be of benefit, devices have to be produced in sufficient numbers and to reach end users. Also in some cases the end users will also require training in the use of the devices so as to get the maximum benefit from them. In order to move from the prototype stage to device in the hands of end users the following are required.

- Sufficient funding to cover the costs of further developments of the prototype, end users tests and initial marketing or distribution
- A distribution network
- A support system for users, including training, information, device and repair facilities.

In the context of assistive technology for deaf and hearing impaired users, end-users includes:

1) older people, who have age-related hearing loss
2) people born deaf or with a hearing loss.
3) People who have acquired a hearing loss through accident or illness

The people who are born deaf require alarm devices that alert them by visual and tactile signals and telephony devices that allow them to communicate through sign language or text.

The hearing impaired person as well as those who have developed hearing loss later in life require devices that will enhance their residual hearing and assist them to behave as though they have no hearing loss.

VII. ETHICAL ISSUES

Ethical issues related to:
- Research aims and application;
- Conduction of research and presentation of results;
- National & international legislation and regulations;
- National and international standards;
- Human communication;
- Confidentially;
- Safety and risk;

The selection of rehabilitation technology should be considered as part of the hearing aid evaluation process.

A number of factors should be considered when determining the rehabilitation technology needs of an individual. These include:

1) Degree of hearing loss:
2) Type of hearing aids to be worn:
3) Hearing aid options (such as inclusion of a T-switch, direct audio input or some special circuitry (CROS aid)
4) Financial concern; and
5) Family support

Rehabilitation technology will play an important role in the creation of barrier-free environments for hearing impaired. Auditoriums and large public places will need to provide with amplification, devices considering listening requirements of these participants.

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Sound enhancement technology can be easily adapted for use in television viewing. The signal can be transmitted to the listener via hardwire, infrared, or FM systems and can linked to the hearing aid through the use of magnetic induction. Microphone placement for use with sound enhancement systems may be at the site of the television’s external speaker or through the use of an output jack.

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