# NOAH Sound Equipment Guideline

Version 1.0

# Disclaimer

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**C O N T E N T S**

# 1 Introduction

## 1.1 Background

The introduction of advanced technologies such as adaptive directionality, noise suppression and cancellation and multi-channel compression has created improved benefit for patients with hearing loss. These technologies offer dispensers greater ability to meet the needs of their patients, but also present a challenge. Hearing instruments utilizing these advanced features cannot be easily demonstrated or verified using typical equipment and stimuli.

In response to this challenge, hearing instrument manufacturers have developed extensive libraries of recorded sounds designed to demonstrate these features. Implementation of these libraries in certain settings has proven effective in meeting this goal – however, it has been difficult to reproduce these favourable results on a wider scale due to the inconsistency of equipment and acoustics in dispensers' offices.

HIMSA, with a great deal of leading industry involvement, has produced the NOAH Sound Equipment Guideline to help hearing care professionals more effectively select, install, calibrate and use sound equipment in daily practice. This guideline specifically defines the following:

- Acoustic characteristics of the room,
- Sound delivery system (the speakers, sound card and software used to play back and control these sounds).
- A detailed calibration procedure to ensure that the performance of the sound delivery system is adequate.

## 1.2 Purpose

This document is designed to guide hearing care professionals in the selection and set-up of equipment used to deliver sound examples in their offices. Included in this document are descriptions of the physical set-up of the system, and a calibration guide. While this document requires no specific prerequisites, a familiarity with the fundamentals of acoustics, sound reproduction and electro acoustic measurement is helpful.

The NOAH Sound Equipment Guideline supports two levels of quality. While these levels differ in their intended purpose, both provide the dispenser with the ability to predict the performance of the sound equipment in the room and the sounds played into it.

The Level 1 system is intended to be used for the gross demonstration of hearing instrument features and to provide patients with a preview of how the instruments will perform given a variety of sound inputs. It may not be appropriate for fine tuning or verification. The Level 1 system is described in detail in Section 7.1 of this document.

The Level 2 system is configured and calibrated to more exacting specifications and is intended for not only the demonstration of hearing instrument features, but also to be used to fine tune the fitting and collect verification data. The Level 2 system is detailed in Section 7.2 of this document.

## 1.3 Content Summary

This document includes the following sections:

- Definitions of terms used within this document
- Description of the levels of quality supported by the NOAH Sound Equipment Guideline
- Set-up guides for each level of quality
- Calibration guides for each level of quality

Additional related document will be provided as follows:

- NOAH Sound Equipment Guideline Manufacturers' Supplement – Written to HIMSA Licensees to assist in the development of software solutions that take advantage of the NOAH Sound Equipment Guideline.
- NOAH Sound Equipment Guideline End-User Calibration Guide

## 1.4 Definitions

- **A – Weighting:** A frequency-dependent weighting used in the measurement of sound signals, which has the greatest sensitivity in the 1 kHz to 5 kHz range. Abbreviated dBA
- **C – Weighting:** A frequency-dependent weighting used in the measurement of sound signals, which has the greatest sensitivity in the 50 Hz to 8 kHz range. Abbreviated dBC
- **Measurement Device:** Equipment designed to capture sound in a sound field and calculate the sound pressure level in decibels. This may be a commercially available sound level meter, a hearing instrument, a probe microphone system, or other device, which produces the same results as a conventional sound level meter. Acceptable measurement devices for Level 2 Systems must be capable of reporting the sound pressure level (dB SPL) within an accuracy of +/- 3 dB and must contain both A and C weighting. If an end user wishes only to pursue a Level 1 System, then a Measurement Device need only be capable of A-Weighting.
- **Reference Position:** Point in the room where sound level measurements are made. The reference position for the purpose of the NOAH Sound Equipment Guideline is defined by elevation and distance. The tolerances of these parameters are shown in the figure Section 2.4.1.
- **Reverberation Time (RT60):** The amount of time in seconds, required for a sound in a room to reduce in amplitude by 60 dB.
- **Sound Delivery System:** The hardware and software used to produce sound examples to patients. This includes the sound card, speakers and software (player).
- **Room:** The room into which the sound delivery system is installed.
- **Speaker Configuration:** The number of speakers, how they are arranged and the method of assigning segments of the recording to different speakers. Examples include two speaker system (Front-Back), and Surround Sound (5.1 and 7.1).

## 1.5 Abbreviations

| | |
|---|---|
| AEM | Audiological Equipment Manufacturer |
| ALD | Assistive Listening Device |
| dBA | Decibels measured with A weighting |
| dBC | Decibels measured with C Weighting |
| dBSPL | Decibels Sound Pressure Level |
| HIM | Hearing Instrument Manufacturer |
| LDL | Loudness Discomfort Level |
| MCL | Most Comfortable Level |
| MPO | Maximum Power Output |
| OAS | Office Automation System |
| UCL | UnComfortable Level |

## 1.6 Room Acoustics

Delivering recorded sounds into a small room presents many challenges. While it is not possible to create a perfect acoustic environment in a typical dispensing office, it is possible to obtain good results if careful attention is paid to the acoustics of the room. Regardless of the speaker configuration the dispenser chooses to implement the following acoustical considerations are critical to the success of the sound delivery system.

- **Size:** The room selected for playing sound examples should be large enough to accommodate a desk with computer, the patient and a family member or friend, the hearing care professional and the speakers.

- **Damping:** Rooms should be well damped acoustically. This means that whenever possible, rooms with large reflective surfaces such as windows or hard wood floors should be avoided. When this is not possible, reasonable acoustic treating such as carpets or area rugs, drapes and suspended acoustic ceiling tiles should be employed.

- **Ambient Noise:** The ambient noise level in the room should be as low as possible, particularly in the immediate vicinity of the patient. See the calibration sections for the acceptable ambient noise levels for Level 1 and Level 2 systems.

  Experience installing sound systems into small rooms has revealed that due to the way that sound travels and reverberates in small rooms, rooms with dimensions that are whole-number multiples of each other should be avoided. For example, if two rooms are available and one is 10 feet x 8 feet (2.44 meters x 2.74 meters and the second is 9 feet 6 inches x 11 feet 6 inches (2.9 meters x 3.51 meters), the second room should be should be chosen. The point here is not the actual size of the room, but rather the ratio of length to width.

- **Ceiling Height:** Ideally, the ceiling of the room should be between 8 and 10 feet (2.44 meters and 2.74 meters). Higher ceilings will create greater room volumes and longer reverberation times. If the only available room has a ceiling height greater then 2.74 meters, then the reverberation times will likely exceed the tolerances specified in this document. End users striving for Level 1 systems should consider additional acoustic modifications if their ceilings are higher than 9 feet (2.74 meters). Those striving to install Level 2 systems must employ additional acoustic modification of the room to achieve acceptable reverberation times. (Ref Mike Nixon, EA Acoustical Engineering Inc., Plymouth, MN)

### 1.6.1 Room Proportions

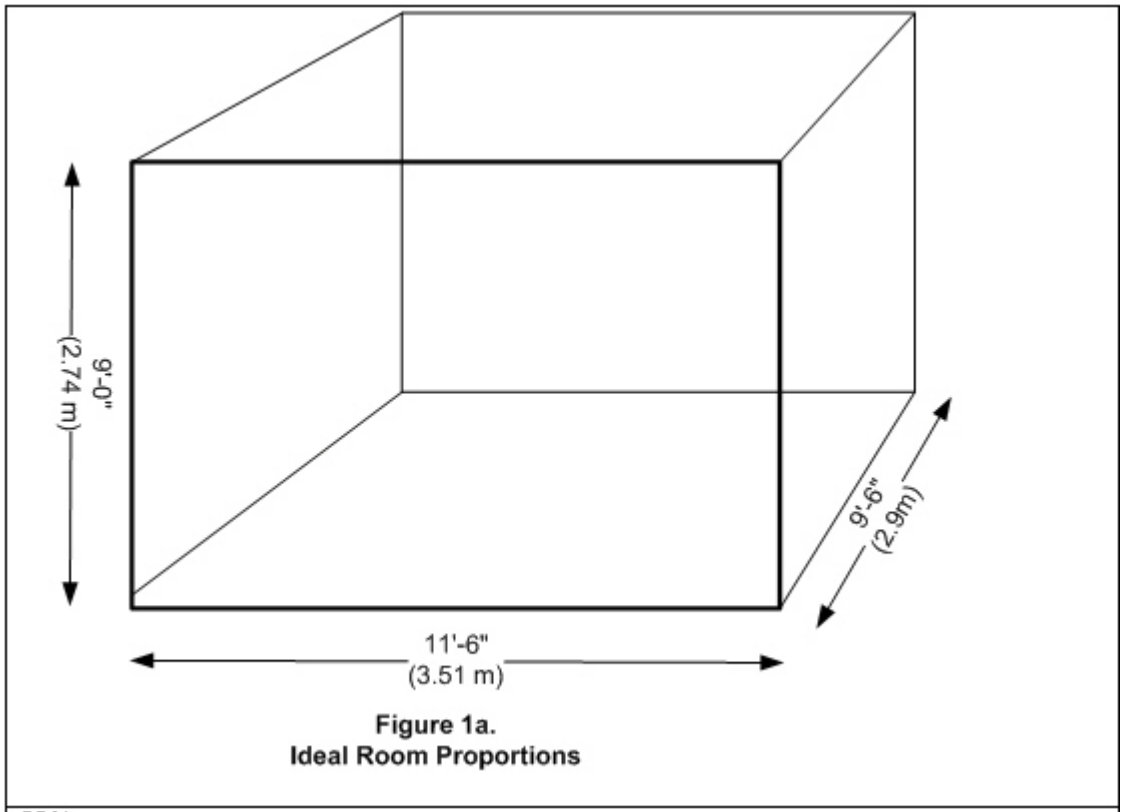



**Figure 1a.**
**Ideal Room Proportions**

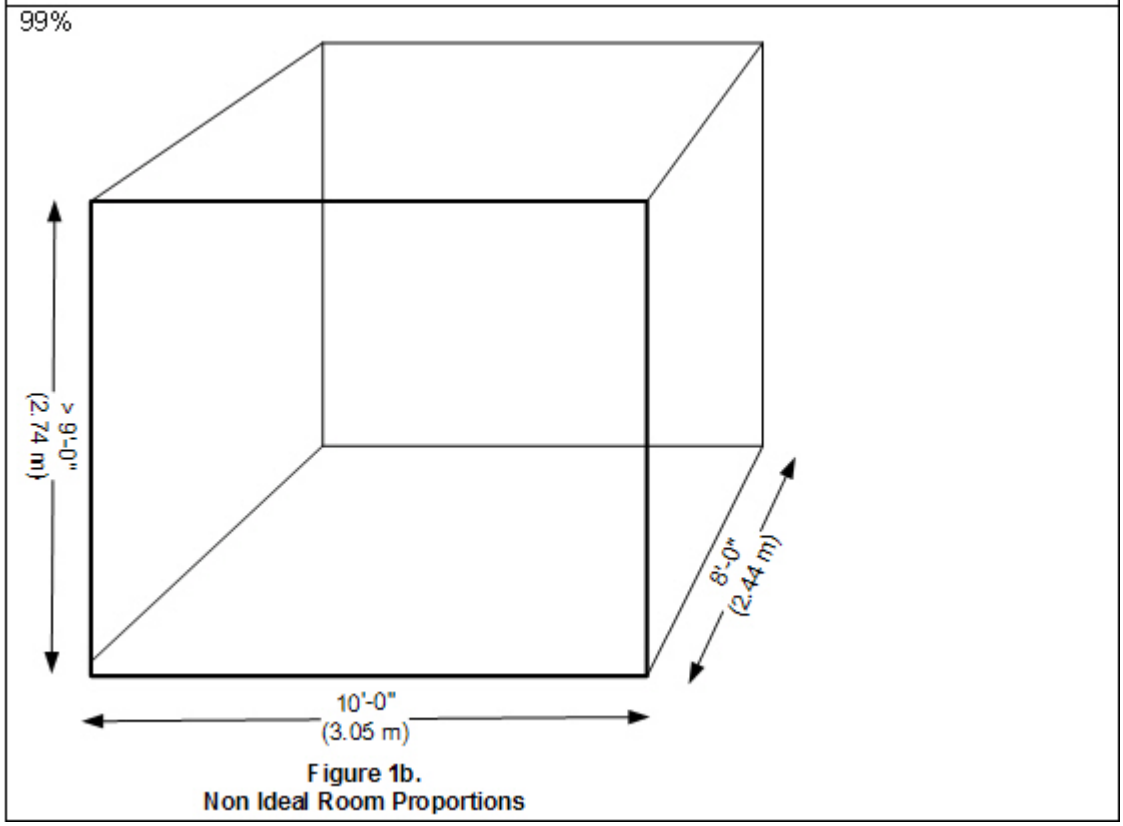



**Figure 1b.**
**Non Ideal Room Proportions**

# 2 Sound Delivery System

## 2.1 Software

Sound playback will occur through NOAH-compatible fitting, and measurement modules supplied by hearing instrument and measurement equipment manufacturers.

In addition, calibration of the system will be guided by a procedure and/or software tool provided by manufacturers.

## 2.2 Sound Card

The computer sound card must be capable of playing back signals encoded for the desired speaker configuration in a native format. Sound cards that are advertised to emulate surround sound are not acceptable and are actually stereo devices; therefore, such cards would only be applicable for that speaker distribution, and not for true 5.1 surround sound. To provide the most flexibility in configuration and control, high-quality internal or external sound cards connected via the USB port should be employed. In cases where limited USB ports are available, a USB hub may be used.

## 2.3 Supported Speaker Distribution Configurations

Based on Microsoft Windows Media Format 9 series SDK, the speaker positions supported in the NOAH Sound Equipment Guideline are defined as follows:

| **Configuration Name** | **Full-Range Speakers** | **Sub-Woofers** | **Speaker Abbreviations** |
|---|---|---|---|
| 2-Channel (Front – Back) | 2 | 0 | FC + BC |
| 2-Channel (Left – Right) | 2 | 0 | FL + FR |
| 2-Channel W-2 (Left Back – Right Back) | 2 | 0 | LB+RB |
| Right – Left – Front – Back | 4 | 0 | FC + BC + SL + SR |
| 5.1 Surround Sound | 5 | 1 | FC + FL + FR + LB+ RB + LF |
| 7.1 Surround Sound | 7 | 1 | FC + FL + FR + SL + SR + BL + BR + LF |

Abbreviation Key: FL = Front Left, FR = Front Right, FC = Front Center, SL = Side Left, SR = Side Right, LF = Sub Woofer, LB = Left back, RB = Right Back, BC = Back Center

## 2.4 Speaker Setup

Once a suitable room is chosen, the position of the patient should be selected such that the ear of the average patient is between 0.5 and 2.5 meters (1.65 feet to 8.2 feet) from the speakers (see 6.3.1 – Reference Position below). In addition, all speakers should be approximately the same distance from the patient. Please note that your speaker manufacturer may recommend a minimum distance greater then the minimum distance noted above.

While mounting speakers on walls or room dividers is possible, users are cautioned that reflections from these surfaces may affect the ability of the system to meet the calibration requirements described later in this document.

## 2.4.1 Reference Position

The reference position is the point in the room where sound level measurements are made. The reference position for the purpose of the NOAH Sound Equipment Guideline is defined by elevation and distance. The tolerances of these parameters are shown in figure 2 below.

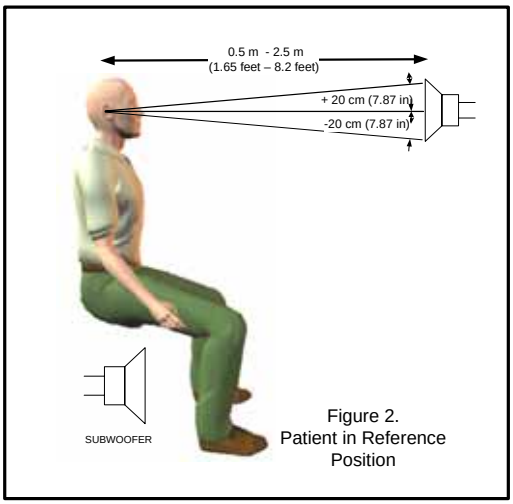



Figure 2.
Patient in Reference Position

## 2.4.2 Positioning The Speakers

1. Beginning from the reference position, arrange the speakers in the positions indicated on the diagram corresponding to the desired speaker configuration..

2. Adjust the height of each speaker so that the center of the speaker is at the approximate height of the average patient's ear, and ensure that all speakers are at the same height.

   Adjust the angle of each speaker so that the front of the speaker grill is pointed to the approximate position of the ear of a patient seated in the reference position as shown in the diagram corresponding to the desired speaker configuration.

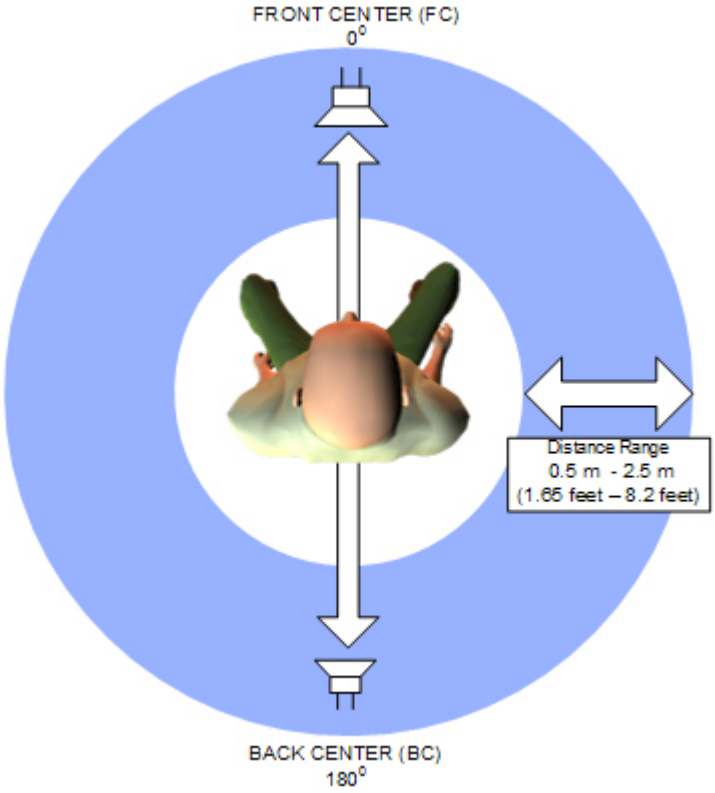
   Speaker cables or stands should remain unsecured at this point, as the distance of each speaker may need to be adjusted during the calibration stage.

3. NOTE: The following speaker configurations are supported by the NOAH Sound Equipment Guideline; however this Guideline does not require all manufacturers supporting the Guideline to support all speaker configurations. Further, each manufacturer is able determine the speaker configurations for which they will provide sound examples. It is advisable for audiologists and hearing instrument specialists to ensure that their desired speaker configuration is supported by the manufacturers with which they do business. It is envisioned that most manufacturers will provide the most complete list of sound files for the 5.1 Surround Sound Configurations.

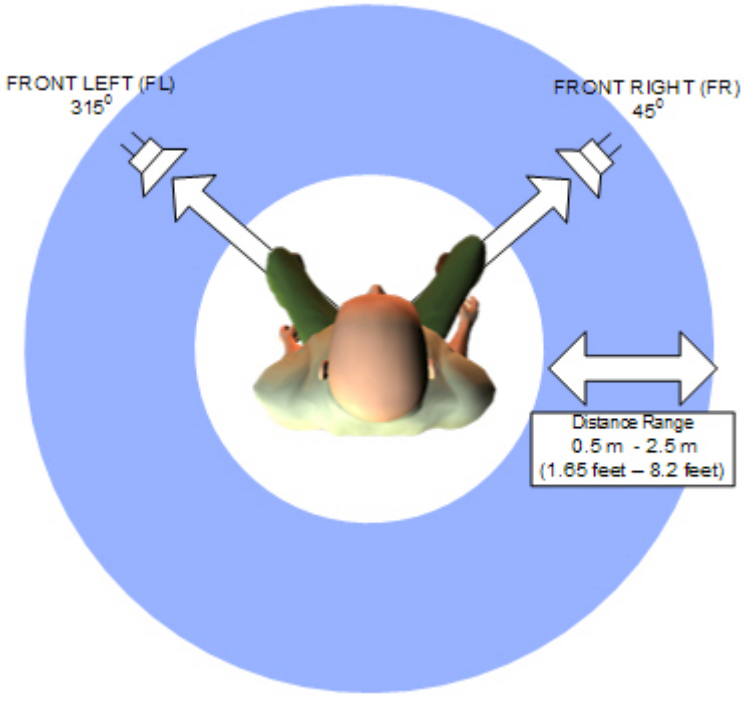
   Larger versions of these diagrams are available at www.himsa.com and in the NOAH Sound Equipment Guideline End-User Calibration Guide

## 2.4.3 Speaker Configurations

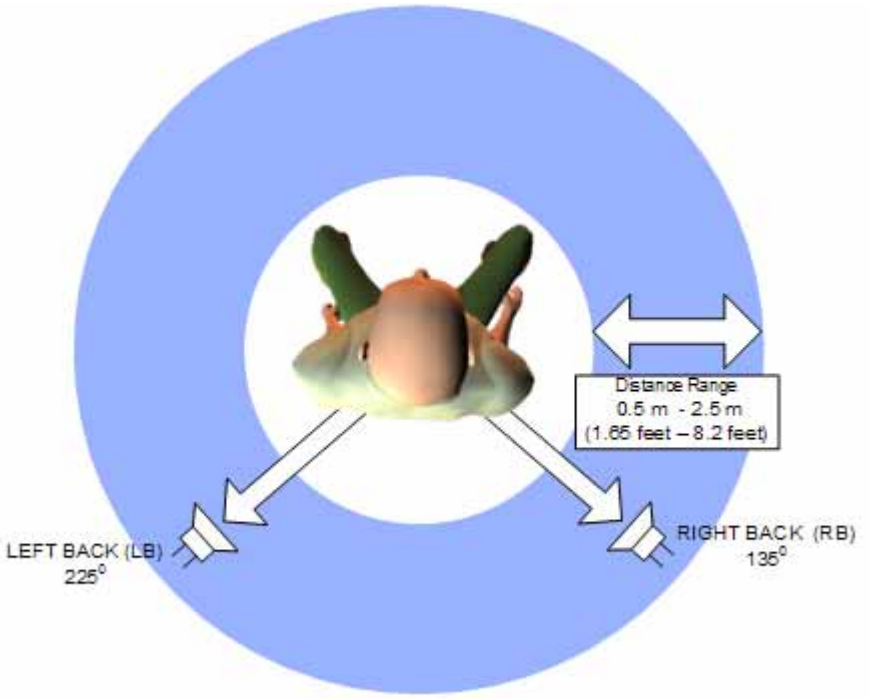
### 2.4.3.1 2-Channel Front-Back Configuration



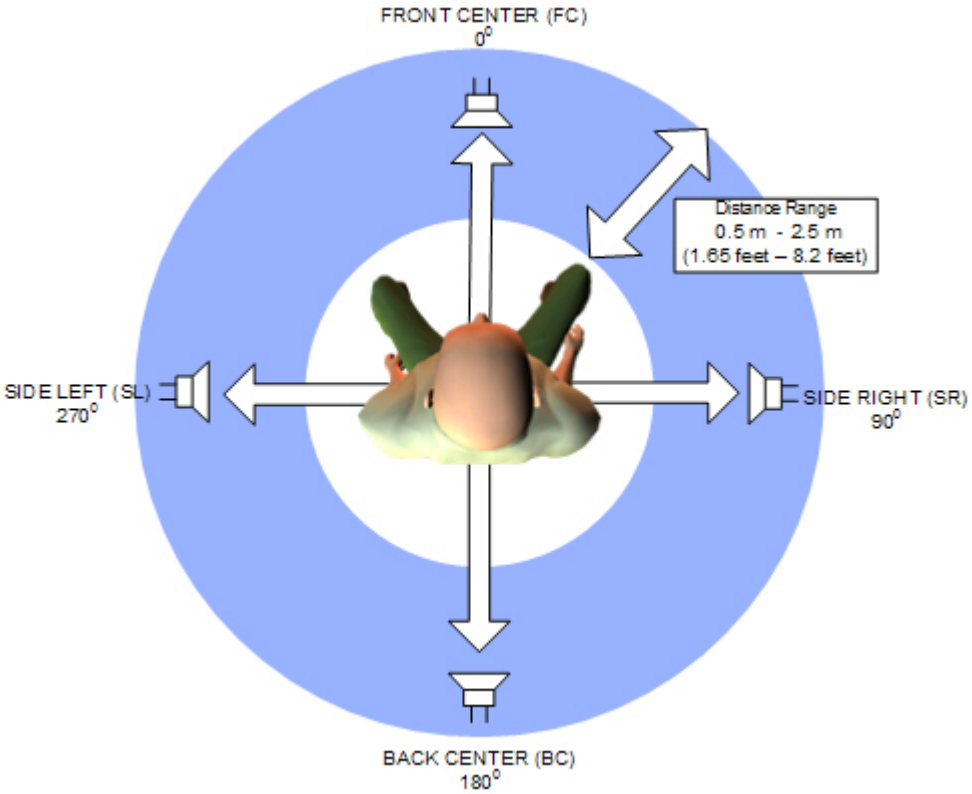

### 2.4.3.2 2-Channel Left-Right Configuration



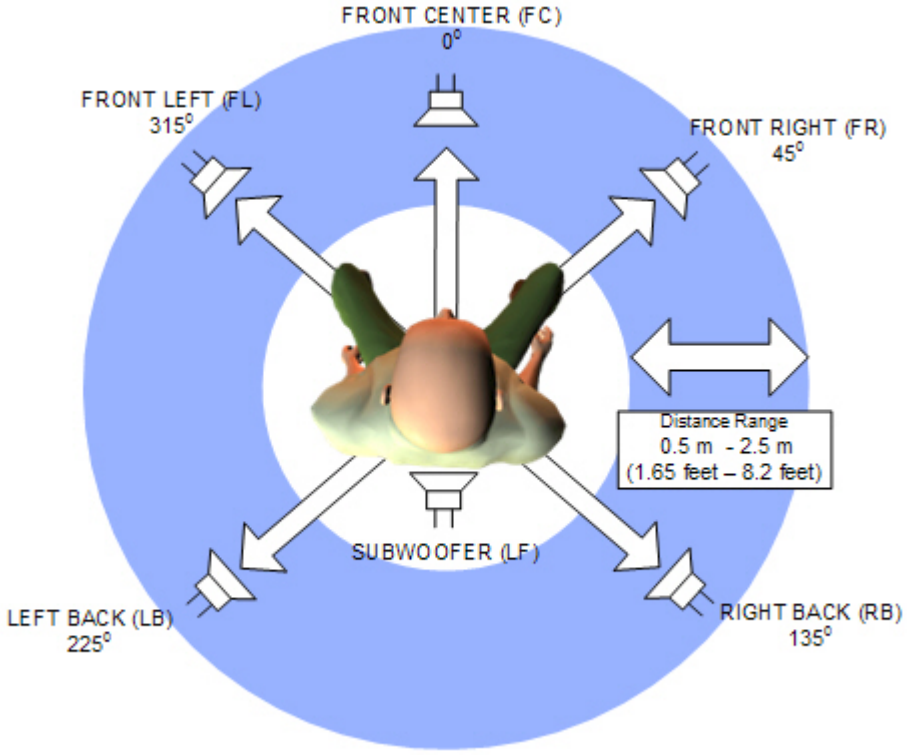
### 2.4.3.3 2-Channel W-2 Configuration




### 2.4.3.4 Front – Back – Left – Right Configuration

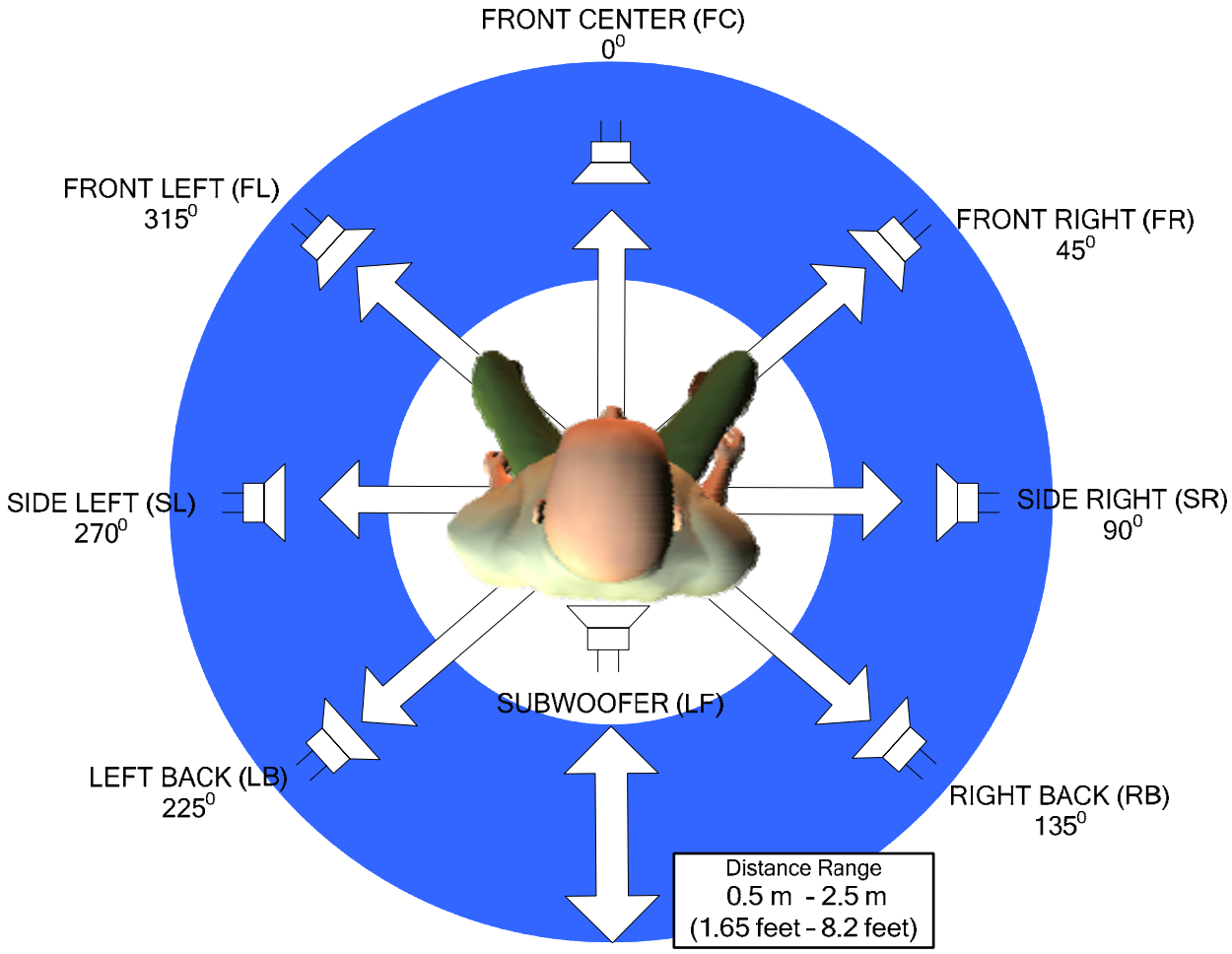


### 2.4.3.5 5.1 Surround Sound Configuration




NOTE: The subwoofer may be placed in locations other than that indicated in this figure. Due to the potential for interactions with room acoustics and specific hearing instrument features, dispensers are advised to verify that their desired subwoofer location is acceptable to the manufacturers with whom they will be working.

### 2.4.3.6 7.1 Surround Sound Configuration




NOTE: The subwoofer may be placed in locations other than that indicated in this figure. Due to the potential for interactions with room acoustics and specific hearing instrument features, dispensers are advised to verify that their desired subwoofer location is acceptable to the manufacturers with whom they will be working.

# 3 Levels of Quality

The NOAH Sound Equipment Guideline describes systems meeting two levels of quality. The primary difference between the two relates to the intended purpose of the system and the accuracy of the calibration of the sound environment.

## 3.2 Level 1 System

### 3.2.1 Intended Purpose

The Level 1 system is intended to be used for the gross demonstration of hearing instrument features and to provide patients with a preview of how the instruments will perform given a variety of sound inputs. Systems meeting this level of quality are not intended to be used for the fine tuning of hearing instruments nor for the verification of the hearing instrument fitting.

More specifically, the Level 1 system is defined as follows:

- **Directionality:** The Level 1 system may be appropriate for demonstrating the subjective benefit of directional microphone systems in understanding speech in background noise.
- **Noise Suppression:** The Level 1 system may be appropriate for demonstrating the subjective benefit of noise suppression/cancellation algorithms in understanding speech in background noise.
- **Aided Benefit:** The Level 1 system may be appropriate for eliciting subjective patient reports of aided benefit in quiet.
- **Maximum Power Output:** The Level 1 system may be appropriate for performing a cursory check to ensure the MPO of a hearing instrument does not exceed the patient's UCL.
- **Annoyance of Sounds:** The Level 1 system may be appropriate for performing cursory checks to ensure that environmental sounds are not annoying to the patient when amplified by hearing instruments or personal assistive listening devices.

## 3.2.2 Calibration

Once the sound field is set up, it must be calibrated. The following steps may be performed manually or may be guided by software tools provided by HIMSA or hearing instrument or diagnostic equipment manufacturers.

### 3.2.2.1 Ambient Room Noise

With the microphone of the measurement device in the reference position, measure the ambient room noise with computers, diagnostic equipment and typical Heat, Ventilation and Air Conditioning (HVAC) units running for 15 seconds. The measurement device should be set to A-weighting, slow response. The ambient room noise shall not exceed 50 dB(A).

### 3.2.2.2 Reverberation Time

As defined above, reverberation time is the time, in seconds, required for a sound's intensity to reduce by 60 dB after the sound source is shut off. Ideally, the reverberation time for rooms used for speech communication is less then 0.6 seconds; however, for the Level 1 system, a subjective assessment is sufficient. To informally assess the reverberation time of the room, dispensers should clap their hands at various points in the room, particularly in the reference position and compare the amount of reverberation (echo) heard to the samples provided. Sample sounds should be listened to under headphones to avoid room effects. If the reverberation of the room approximately matches the "acceptable" sample, then calibration may continue. If not, acoustic damping such as carpets, drapes or cloth-covered office dividers should be introduced into the room. After acoustic treatment, repeat this step until the room's reverberation is acceptable.

### 3.2.2.3 Overall Level

Each speaker in the sound field will be capable of reproducing a calibration signal at 70 dB(A) as measured from the Reference Position. The acceptable variability of level is +/- 3 dB. In order to attain this level, adjustments may be made to the software controls of the computer sound card, the physical attenuators on the speakers, or the position of the speakers as long as they remain within the acceptable distance range of 0.5 to 2.5 meters (1.65 feet to 8.2 feet).

### 3.2.2.4 Frequency Response

All speakers used should have a flat frequency response as reported by the manufacturer's product documentation.

### 3.2.2.5 Distortion

All speakers will be capable of reproducing, without audible distortion, a calibration signal with peak levels at 93 dBSPL at 400 Hz, 1000 Hz and 3000 Hz.

### 3.2.2.6 Frequency of Calibration

The entire calibration procedure detailed above will occur prior to the first use of the room for patient contact. It will be repeated in its entirety whenever any component of the system is replaced or moved (e.g. speakers, sound card, computer), and annually following the initial calibration. The overall level calibration will be repeated every two months following the initial calibration.

## 3.3 Level 2 System

The Level 2 system is configured and calibrated to more exacting specifications and is appropriate for not only the demonstration of hearing instrument features, but may also be used to fine tune the fitting and collect verification data.

### 3.3.1 Intended Purpose

The Level 2 system is intended to be used for not only the gross demonstration of hearing instrument features and to provide patients with a preview of how the instruments will perform given a variety of sound inputs, but also to assist the dispenser in fine tuning and verifying the settings of the hearing instruments.

More specifically, the Level 2 system is defined as follows:

- **Directionality:** The Level 2 system may be used to measure word and/or sentence recognition in noise using tools such as the HINT (Hearing In Noise Test) or the Quick SIN (Speech In Noise) for the purpose of documenting the benefit of directional microphone systems.

- **Noise Suppression:** The Level 2 system may be used to measure word and/or sentence recognition in noise using tools such as the HINT or the Quick SIN for the purpose of documenting the benefit of directional noise reduction/cancellation algorithms.

- **Aided Benefit:** The Level 2 system may be used to measure word and/or sentence recognition in quiet using standard test materials (e.g. NU-6, CID Everyday Sentences).

- **Maximum Power Output:** The Level 2 system may be used to measure frequency-specific LDL/UCL using FM modulated tones or narrow band noise to ensure the MPO of a hearing instrument does not exceed the patient's UCL and also to record frequency-specific LDL thresholds.

- **Annoyance of Sounds:** The Level 2 system may be used to determine which sounds, and at what levels, are judged to be annoying by the patient when amplified by hearing instruments or personal assistive listening devices.

## 3.3.2 Calibration

Once the sound field is set up, it must be calibrated. The following steps may be performed manually or may be guided by software tools provided by HIMSA or hearing instrument or diagnostic equipment manufacturers.

### 3.3.2.1 Ambient Room Noise

With the microphone of the measurement device in the reference position, measure the ambient room noise with computers, diagnostic equipment and typical Heat, Ventilation and Air Conditioning (HVAC) units running for 15 seconds. The measurement device should be set to A-weighting, slow response. The Ambient Room Noise shall not exceed 35 dB(A). Too much ambient room noise may invalidate the result of a test.

### 3.3.2.2 Reverberation Time (RT60)

As defined above, reverberation time is the time, in seconds, required for a sound's intensity to reduce by 60 dB after the sound source is shut off. Ideally, the reverberation time for rooms used for speech communication is less than 0.6 seconds – for a Level 2 system, this value should be calculated following the Sabine Formula using a tool such as the one found at http://www.mcsquared.com/rt60aa.htm).

The RT60 of the room shall not exceed 0.6 seconds at 500, 1000 and 2000 Hz ( re: ANSI S12.60-2002). If the reverberation of the room meets or exceeds this criterion then calibration may continue. If not, acoustic damping such as carpets, drapes or cloth-covered office dividers should be introduced into the room. After acoustic treatment, repeat this step until the room's reverberation is acceptable.

### 3.3.2.3 Overall Level

Each speaker in the room will be capable of reproducing a calibration signal at 70 dB (A) as measured from the reference position. The acceptable variability of level is +/- 3 dB. In order to attain this level, adjustments may be made to the software controls of the computer sound card, the physical attenuators on the speakers, or the position of the speakers as long as they remain within the acceptable distance range of 0.5 and 2.5 meters (1.65 feet to 8.2 feet).

### 3.3.2.4 Frequency Response

This step requires a measurement device capable of measuring sound pressure level using either the C-weighting scale or the linear mode.

- From the reference position, point the measurement device at the first speaker.
- A set of calibration signals supplied by HIMSA or a hearing instrument or diagnostic equipment manufacturer will be delivered through each speaker in turn. This signal will be pre-filtered in 1/3 octave intervals. A narrator will announce the test frequency.
- Tolerances for this step are as follows (re: EN60645-2):
    - +0/- 10 dB for 1/3 octaves from 125 Hz to 250 Hz
    - +/- 3dB for 1/3 octaves from 315 Hz to 4000 Hz.
    - +/- 5 dB for 1/3 octaves from 5000 Hz to 6300 Hz
    - The reference (0 dB) is the average of the measured values from 315 Hz to 4000 Hz

### 3.3.2.5 Distortion

All speakers will be capable of reproducing, without audible distortion, a calibration signal with peak levels at 103 dB SPL at 400 Hz and 93 dB SPL at 1000 Hz and 3000 Hz. The acceptable variability of level is +/- 3 dB SPL. **NOTE: Due to the high sound levels needed for this portion of the calibration, hearing protection should be used by any individuals within the sound field during this procedure.**

### 3.3.2.6 Frequency of Measurement of the System

The entire calibration procedure detailed above will occur prior to the first use of the sound field for patient contact. It will be repeated in its entirety whenever any component of the system is replaced or moved (e.g. speakers, sound card, computer), or on the same schedule as the audiometric equipment in the office, whichever is more frequent. The overall level calibration will be repeated every month following the initial calibration.