



“By extending telephone bandwidth to 7 kHz and beyond, it is clear that one can markedly reduce fatigue, improve concentration and increase intelligibility”¹.

As high definition technology including high definition television (HD TV) and high definition Digital Video Disc (HD DVD) become increasingly accessible and prevalent in society today, everyday consumers are demanding superior quality from all forms of visual and audio media. For some, it may appear that telephony has sat on the periphery of this technological trend while the focus has been on the development of the visual and audio quality of entertainment media specifically. However, this focus has shifted and users of telephony are now expecting more features, better quality and greater intelligibility from their communication devices.

The design of the telephone device has evolved considerably since the first transcontinental call in 1915. Advances over the years in mouthpiece and earpiece designs have seen a significant improvement in frequency while added echo suppression, digital echo cancellation and antisidetone circuits have reduced the far-end echo and allowed the talker to better judge their own loudness². Traditionally a network of fixed-line analogue phone systems, the public switched telephone network (PSTN) is now almost wholly digital at its centre, including mobile as well as fixed telephones. However, “little progress has been made in the amount of audio bandwidth that can be carried by the telephone network”³. For both the general public and regular telephony users such as call centre employees or help-desks who spend much of their work-time on a phone or wearing a headset, the encoding of speech for the PSTN and the resulting narrowband audio that we have become accustomed to has remained largely unchanged for over 60 years.

With the development of the PSTN during the earlier part of the 20th century, the primary arguments for the design of a telephony network based on the concept of limited network bandwidth focused on the “economics of achieving the widest possible deployment while achieving affordable costs and voice quality”⁴. The intrinsic compromises between cost and quality meant that narrowband audio became the generally accepted standard for voice quality. However, with the arrival of converged Internet Protocol (IP) Networks, there has been a dramatic expansion of available bandwidth that has fundamentally challenged the original economical and technical practicalities for narrowband telephony quality, resulting in a drive towards high definition wideband audio. This whitepaper aims to shed light on what wideband audio is, its benefits over narrowband for an improved communications experience and what its increasing deployment in the workplace means for the future of quality voice communications.

What is HD Wideband?

In communications, “bandwidth” refers to the range of frequencies used in the communication channel. The size of the band (in kHz, MHz or GHz) helps determine if it is categorised as *narrowband* or *wideband*. The frequency range that the human voice can produce ranges from ~30 to 18,000 Hz⁵. When designing the traditional telephony system, it was

¹ Rodman, J., *The Effect of Bandwidth on Speech Intelligibility*, Polycom, September 2006, p. 8.

² Ibid, p. 2.

³ Ibid.

⁴ Avaya, *Wideband Audio: Exploring the Potential for Improved Enterprise Communications*, May 2006, p. 3.

⁵ Cisco Systems Inc., *Wideband Audio and IP Telephony: Experience Higher-Quality Media*, December 2007, p. 1.

concluded that listeners did not need to hear all frequencies that make up the human voice to ascertain the words being spoken. Consequently, because most of the “speech energy and voice richness”⁶ are concentrated at the lower frequencies, the voice channel range for traditional voice communications was defined as between 0 and 4000 Hz and the PSTN standard became ~300 – 3400 Hz.

While this solution might have sufficed in the past, the move to a future of high definition technology is prompting telephony users and vendors to demand a better quality audio experience. But why is bandwidth so important in the development of telephony communication quality? Well, “of all the elements that affect intelligibility of speech, bandwidth has been shown to be one of the most critical”⁷ making it a crucial factor in developing call quality and improving the overall communication experience. Because of this, we are seeing narrowband, a concept that ignores that much of human speech intelligibility occurs in the *higher* frequencies, being gradually phased out for a clearer wideband audio experience based on Voice over IP technology (VoIP) which is variously referred to in telephony circles as High Definition Voice, HD Wideband or HD Audio.

So, what is HD Wideband? HD Wideband is a method for improving voice quality and intelligibility within the telephony environment. By expanding the spectrum from the standard PSTN range of ~300 – 3400 Hz to 150 – 7000 Hz or greater, voice communications quality can be improved meaning greater clarity and intelligibility for listeners while reducing miscommunication and user fatigue. The graph below shows the differences between wideband and narrowband frequency ranges, illustrating the amount of extra information the wideband signal can interpret:

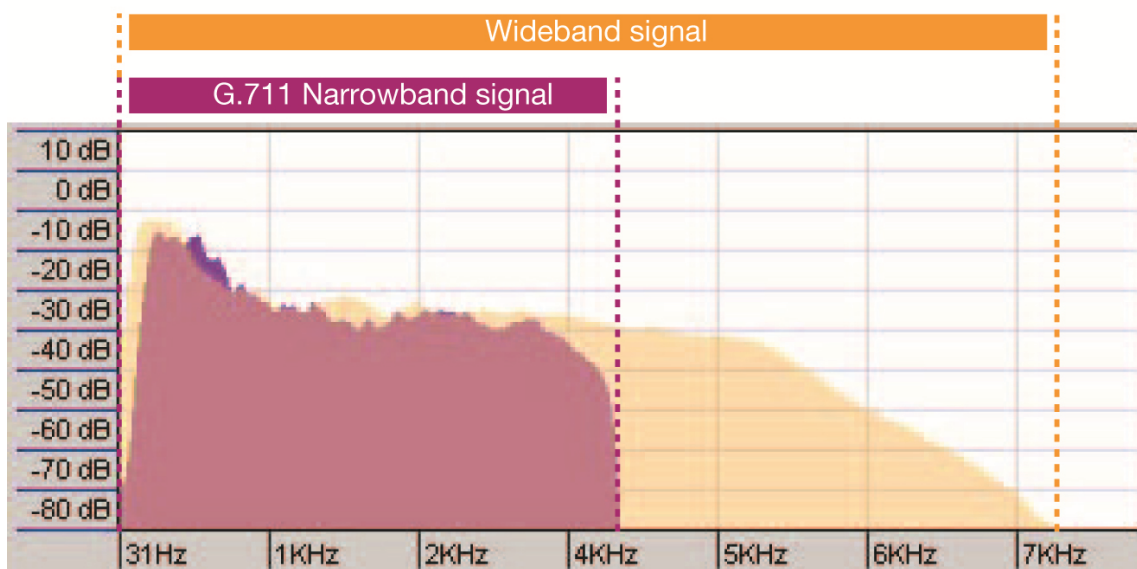


Figure 1. Wideband Audio versus Narrowband Audio⁸

⁶ Ibid.

⁷ Rodman, op.cit., p. 2.

⁸ Dialogic, *SIP Trunking: Enabling Wideband Audio for the Enterprise*, July 2010, p.5.

Research has been conducted in the area of speech recognition to suggest that widening the telephony spectrum to 7 kHz or greater considerably improves the intelligibility of telephone conversations. According to one study, “two-thirds of the frequencies in which the human ear is most sensitive” and over 80% of the frequencies in which human speech occurs are “beyond the capabilities” of the narrowband-based PSTN⁹.

Benefits of HD Wideband vs Narrowband

Narrowband audio quality is mediocre at best when compared to the clarity and intelligibility of wideband audio. Traditional narrowband telephony (~300 – 3400 Hz) removes “significant energy at both ends of the spectrum” while wideband telephony (150 – 7000 Hz) “effectively doubles the narrowband speech signal, providing voice quality significantly better than the best PSTN call”¹⁰. The figure below shows speech waveforms for the statement: “His vicious father has seizures”, recorded by a female voice-over artist:

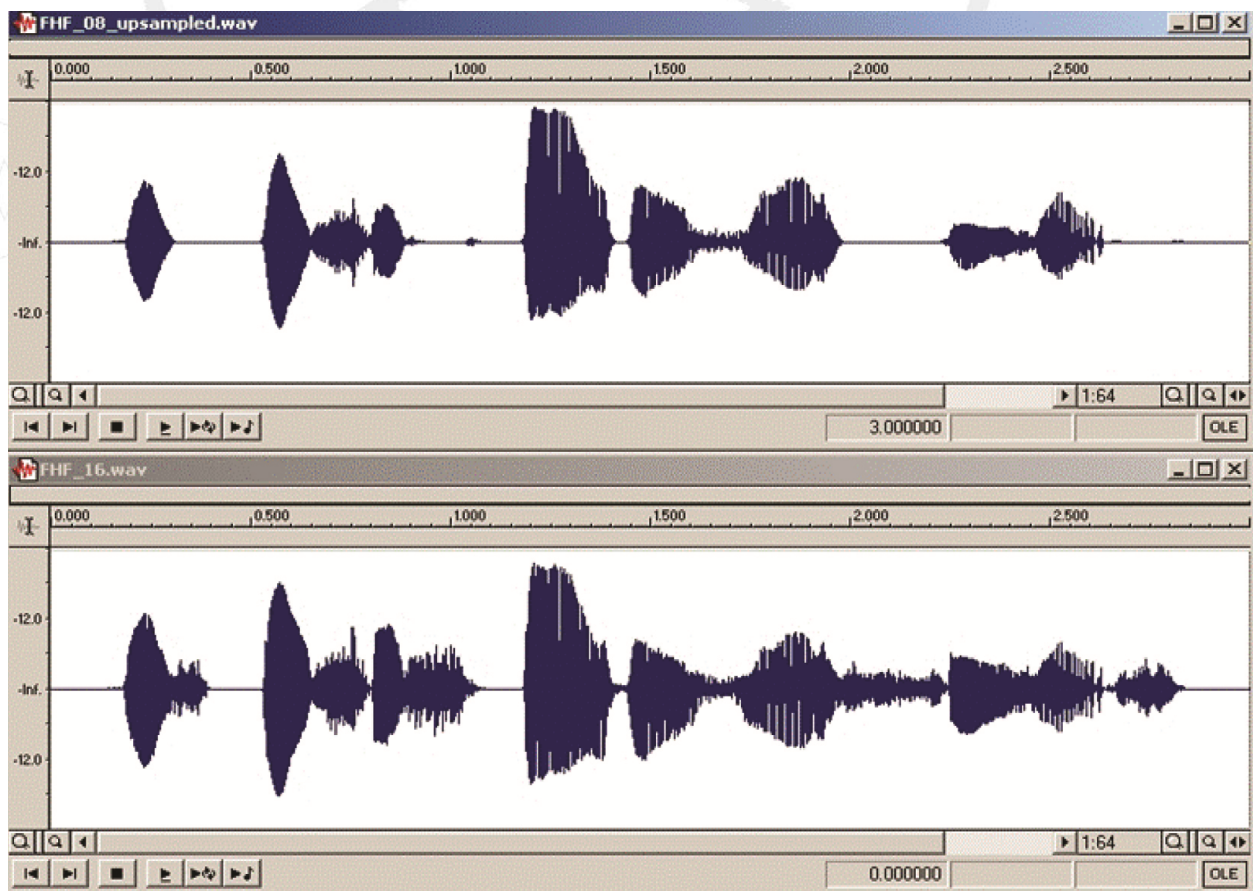


Figure 2. Narrowband (top) and wideband (bottom) speech waveforms for the utterance “His vicious father has seizures.”¹¹

⁹ Rix & Hollier cited in Rodman, op.cit. p. 4.

¹⁰ VoiceAge, *Wideband Telephony: Enhancing VoIP for Full-Service Success*, 2006, p. 1.

¹¹ Avaya, op.cit., p. 4.

The sample at the top of the figure on the previous page illustrates narrowband speech waveforms while the bottom sample illustrates wideband speech waveforms. It is obvious that the wideband waveform contains more audio content and is thus able to provide the listener with greater intelligibility than the narrowband waveform. Further evidence to prove the frequency content disparity between wideband and narrowband is demonstrated in the sonogram figure of the same statement below. Time runs horizontally (left to right) while frequency runs vertically (bottom to top):

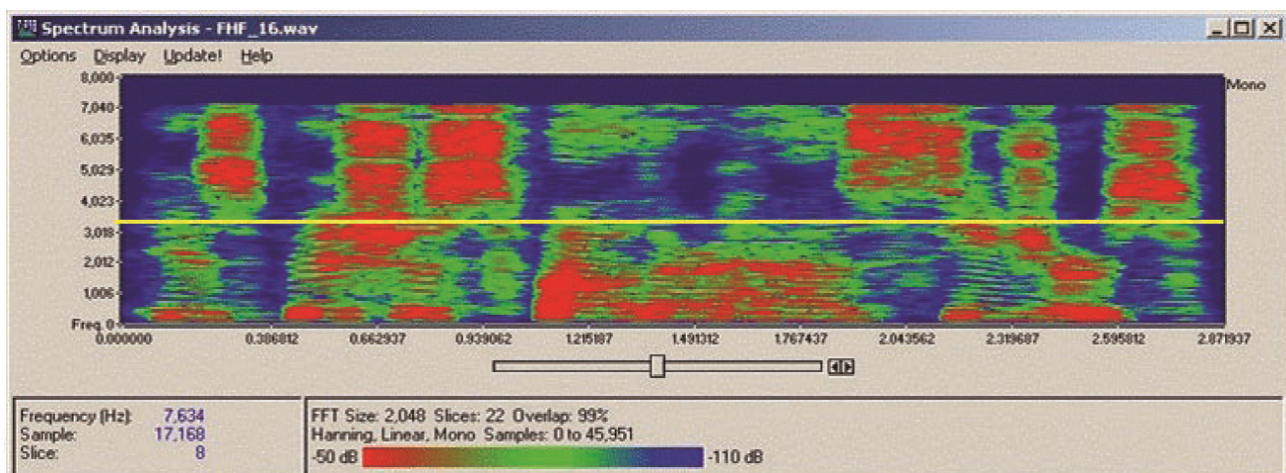


Figure 3. Sonogram of sentence: "His vicious father has seizures." ¹²

The frequency content above the yellow line is not present in the PSTN narrowband waveform, only wideband. This information significantly represents more than half the speech content that is lost on narrowband users. It is interesting to note that differentiating between consonants such as 's' versus 'f' and 'p' versus 't' over the telephone line is dependent upon high-frequency energy (~4 kHz – 14 kHz). This intelligibility is lost when using narrowband because the bandwidth is not wide enough (the content above the yellow line reflects the "lost" impact of these letters for the narrowband user) ¹³.

For the common telephony user, the benefits of wideband compared to the traditional PSTN narrowband standard in their everyday use of communication devices are numerous. People who use narrowband telephony (~300 – 3400 Hz) tend to find it more mentally-demanding and can develop a tendency to close their eyes and tense more muscles. Additionally, narrowband gives the brain fewer perceptual cues and can force speakers to speak louder to ensure the listener on the other end of the phone line can hear them ¹⁴. For those who use conference calls as a regular or primary way to communicate with people interstate or overseas, poor audio quality and a presence of background noise means they often struggle to discern who is talking or to understand whispers, low-talkers or speakers with accents.

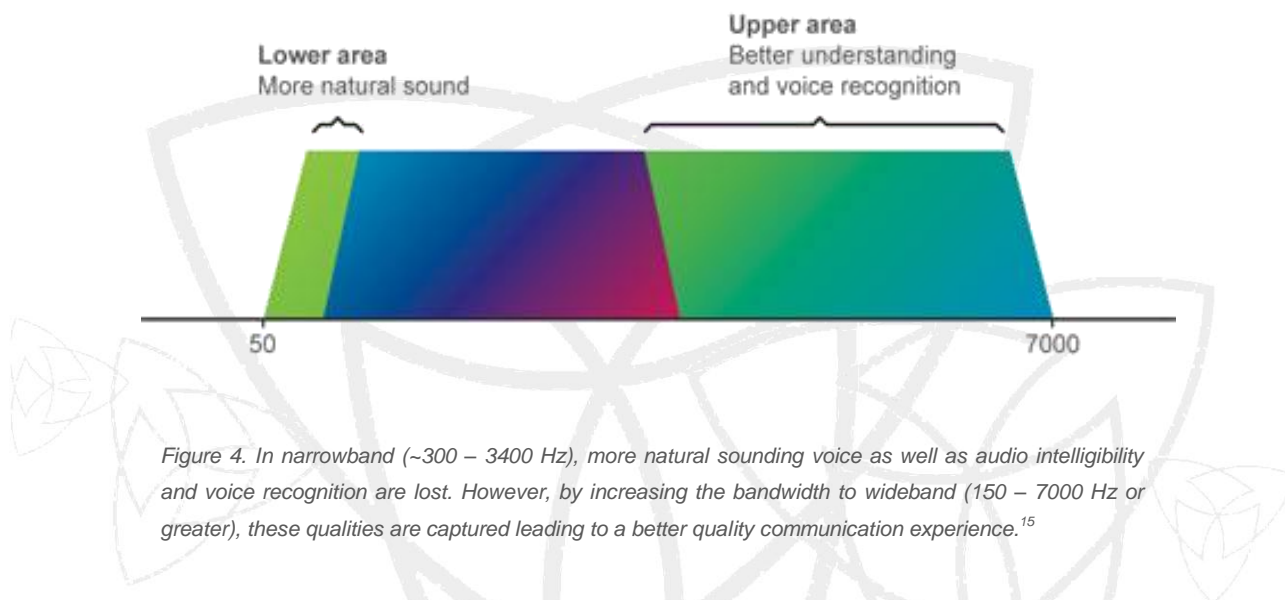
¹² Avaya, op.cit., p. 5. (Research conducted by Joseph Hall of Avaya Labs tested listening responses to recorded speech in two variations, first PSTN telephone bandwidth of 300-3300 Hz and secondly 50-7000 Hz Wideband Audio speech.)

¹³ Ibid.

¹⁴ Roach, D. (Optimal Sound President), *Audio Design for Unified Communications*, WinHEC 2008 Presentation, November 2008, p. 8.

Wideband telephony, on the other hand, greatly increases the audio bandwidth to 150 – 7000 Hz which not only provides clearer, crisper overall sound but helps reduce listener fatigue and makes it easier to understand and distinguish confusing sounds such as ‘P’ versus ‘T’ and ‘F’ versus ‘S’. Users have also reported that wideband audio allows them to better hear and understand low-talkers or if background noise is present.

The figure below simply illustrates the bandwidth eliminated from narrowband and, as a consequence, what factors are lost over the PSTN yet preserved in wideband telephony:



HD Wideband Codecs

“Codec” is a technical name for “compression/decompression” (also, “compressor/decompressor” and “code/decode”) that encodes a data stream or signal for transmission, storage or encryption and then decodes it for playback. To use wideband audio, voice data is coded differently than for narrowband audio, which means a move away from narrowband codecs such as G.711. Many wideband audio codecs are in use today, with most aimed at a different type of connectivity and vying to become the “de-facto standard” codec for specific applications.

Wideband codecs significantly improve voice intelligibility because of the “additional voice data included in the audio stream” and by doubling the “voice signal range while using the same network bandwidth as narrowband codecs”¹⁶. Some wideband codes such as Skype’s SILK are proprietary-owned (albeit, some codecs including SILK have been made available/licensed royalty-free to enable a broader field of application) while others are standards-based.

The original wideband audio codec that is regularly used by handset and headset manufacturers and in high-quality speech applications including wideband VoIP is the G.722 codec. In contrast, the default codec for the narrowband-

¹⁵ Ericsson, *HD Voice – It Speaks for Itself*, October 2011, URL: <http://www.ericsson.com/news/111012_hd_voice_244188808_c>.

¹⁶ Cisco, op.cit., p. 1.

based PSTN is the G.711. When comparing the two, the G.711 codec has an 8 kHz sampling rate and blocks any signal above 3.44 kHz while the G.722 wideband codec sampling rate is increased to 16 kHz, doubling the frequency range to 8 kHz. This increase is demonstrated in the image below comparing samples from the frequency response range of the G.711 codec to the G.722 wideband codec, an increase from almost 3.4 kHz to almost 7 kHz.

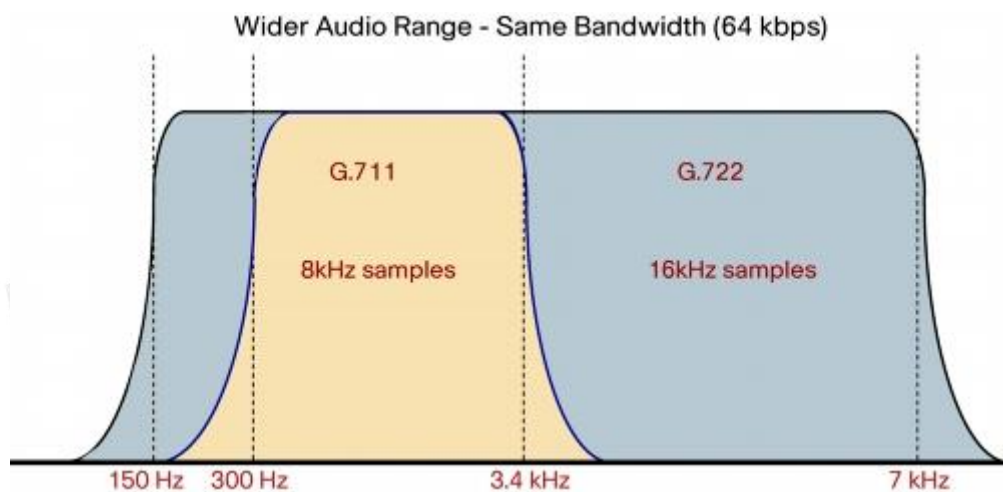


Figure 5. G.711 and G.722 Frequency Response.¹⁷

It is obvious why; as we move forward toward high definition audio in telephony devices, many vendors are now “implementing standards-based wideband codecs”¹⁸ to provide clearer, better quality voice communications for customers.

Growth of HD Wideband

As implementing wideband audio becomes cheaper and more accessible, there has been a growing trend in voice communications to provide voice quality that is better than the PSTN narrowband standard.

Ensuring the right equipment for end users is purchased is a key consideration when deploying wideband audio in the enterprise. To reap the full benefits of HD Wideband the entire system, including hardware and software, must be designed to suit the wideband communication experience so that the resulting call quality is noticeably superior to conventional PSTN calls. Businesses headset or handset equipment must support the relevant codec and have enhanced microphone or speaker acoustic capabilities. As we move into the era of high definition sound, it is no surprise that support for wideband audio is growing rapidly as business telephone systems adopt VoIP technology. Avaya, Cisco, Gigaset, Polycom, Snom and many others now incorporate the G.722 or other wideband codec with additional higher-quality audio components. Headset manufacturers including Polaris, Plantronics, Jabra and Sennheiser are also taking great strides towards offering wideband to customers to enhance their communications experience. Mobile device

¹⁷ Cisco, op.cit., p. 4.

¹⁸ Ibid., p. 1.



manufacturers are increasingly incorporating wideband audio into their mobile phones and audio conferencing service providers are also supporting wideband connections while permitting PSTN users to join the conference in narrowband.

However, we are not all the way there yet. Despite an evident trend amongst the major players in the telephony industry towards complete HD Wideband support, the full benefits of wideband audio are still a while from being realised. Wideband audio is most beneficial for “on-system calls, Session Initiation Protocol (SIP) calls or H.323 trunk calls” but, because the PSTN is still narrowband-based, when the audio stream leaves the IP network the voice is antiquated to an analogue signal or G.711 encoding “thereby losing the full benefit of wideband audio”¹⁹. While IP phone users with wideband audio may still have an improved experience with the enhanced acoustics and hardware on their telephony device, they are not able to properly exploit the full advantages of complete HD Wideband communications.

Conclusion

As we move towards a future of high definition media, traditional telecommunications technology that has been limited to a sound range much narrower than the spectrum of the human voice is being gradually phased out in favour of a richer wideband audio experience based on VoIP technology. By extending telephone bandwidth from ~300 – 3400 Hz to 150 – 7000 Hz or greater, user fatigue and misunderstandings between speakers because of poor audio quality are markedly reduced while improving user concentration and business productivity. Increasing bandwidth on the higher end of the spectrum greatly enhances intelligibility while extending bandwidth below 300 Hz significantly enhances user presence.

We are entering a new generation of sound quality and telephony systems as businesses gradually acclimatise themselves with the now readily available wideband technology and the inherent efficiencies of IP networking. While wideband audio ‘islands’ face the hurdle of connecting on a wideband bandwidth outside of the service provider’s network, this limitation is expected to diminish as HD Voice becomes more mainstream and businesses drive the need for same-type connectivity across line and wireless calls.

¹⁹ Cisco, op.cit., p.4.



Why use Soundshield 4G and Soundpro Wideband?

- Soundshield 4G has 150 – 8000 Hz range
- Polaris Soundpro Wideband Headset range is able to go up to 10000 Hz
- When used together, the Soundshield 4G and Soundpro Wideband provide the ultimate in Acoustic Safety and Comfort as well as superior intelligibility
- Crystal clear sound quality
- More rich, natural sounding speech
- Greater intelligibility: -
 - Easier to decipher confusing sounds such as 'P' versus 'T' and 'F' versus 'S'
 - Able to hear a wider range of emotion and inflections in the human voice
 - Users more readily recognise voices, distinguish confusing sounds and understand accented speakers
 - Users are better able to hear low-talkers
- Increased productivity and reduced listener fatigue because there is less cognitive strain on the user
- Overall, a better communication experience