

Latest developments in wireless technology

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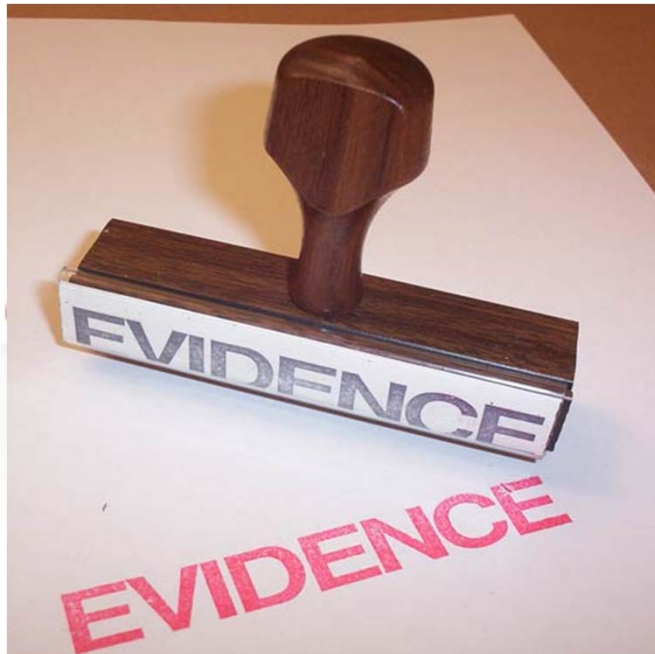
The good news

- Almost all manufacturers offer today some kind of wireless microphone technology; we can expect adoption rate to increase
- Such devices make sense as performance with hearing instruments alone when it comes to speech understanding in noise/reverberation and over distance is limited ; directional microphones in hearing instruments beyond the critical distance do not help a lot
- But choice is sometimes difficult, what is fact and what is fiction?
- What factors decide on the performance of a wireless system or are all the same and is there really no difference and can price and looks decide?

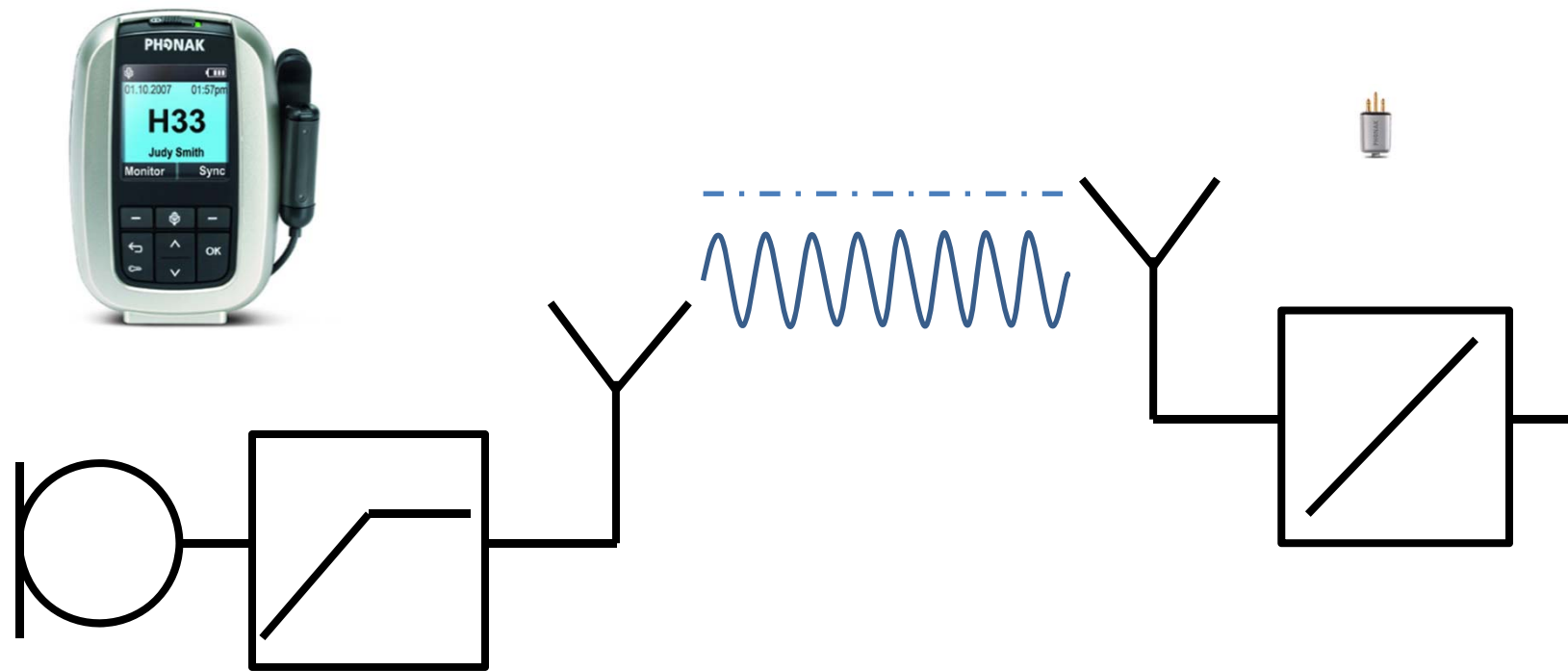


The bad news

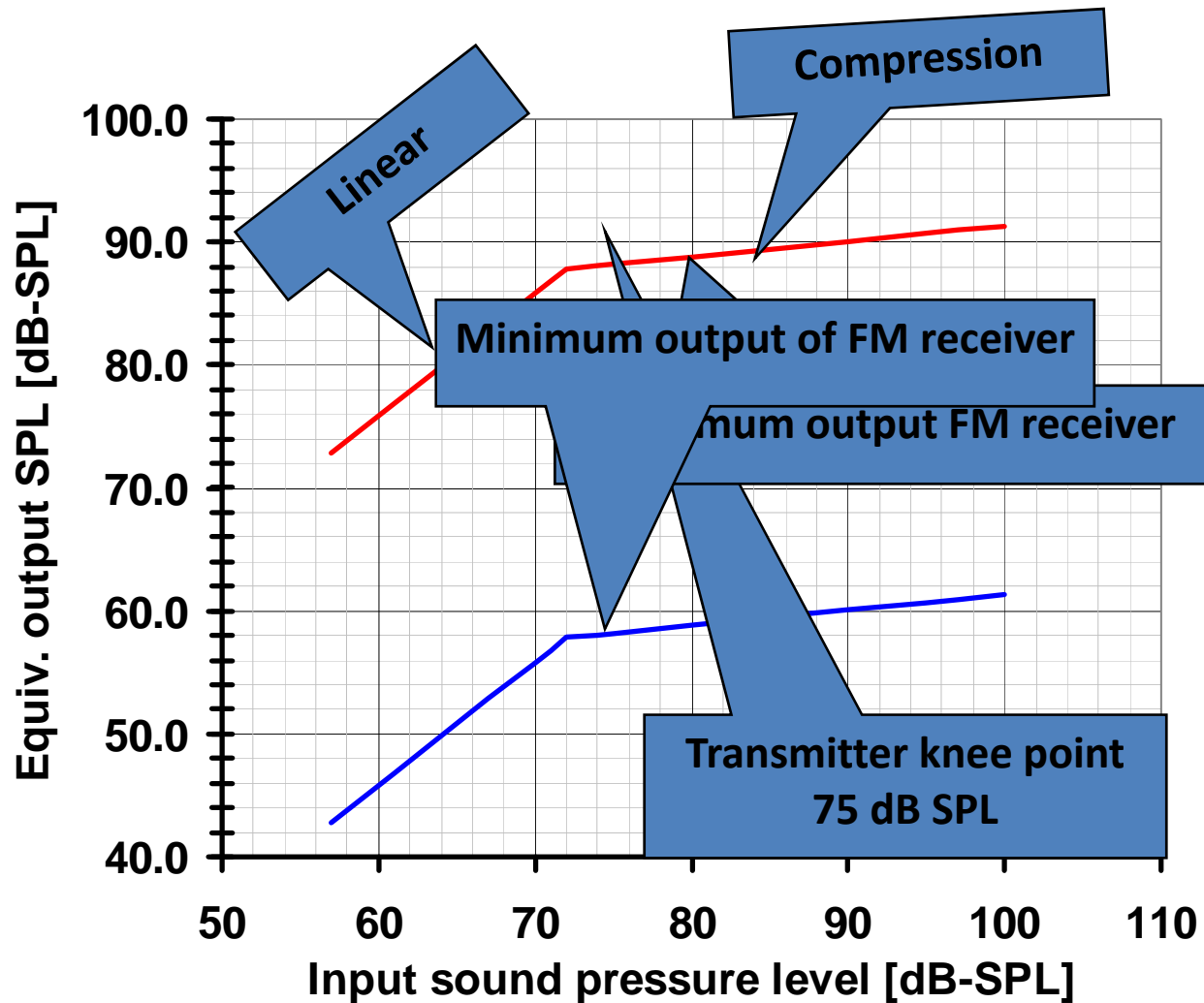
- Scientific evidence on performance of individual products/systems is not yet available
- It is not completely straightforward or feasible to measure speech understanding in noise with an FM system in individual patients



How does an FM system function?



FM System – I/O curves



Compression in the transmitter?

- Gives a stable sound pressure level, independent of level of voice and distance to the FM microphone
- Some systems do not have compression, or at very high knee points → no improvement in performance, fluctuating signal levels
- Experience tells: knee point at around 75 dB SPL for a lapel style microphone is optimal
- Attack and release times have to be set appropriately

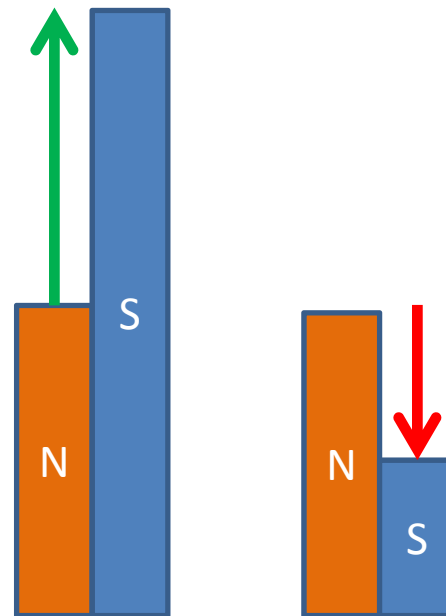


How to set the HI when using FM?

- Depending on use case and on technology FM+M or FM only

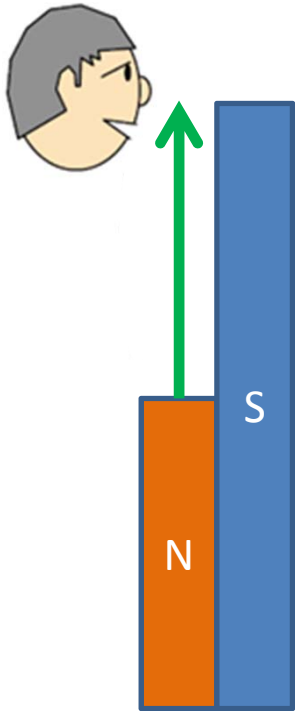
Legend for the following slides

- Noise = brown bars
- Speech = Blue bars
- Arrows = Signal-to-Noise Ratio



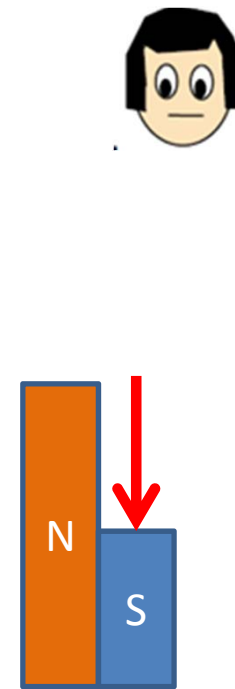
The SNR without FM

Talker



**No FM:
poor SNR**

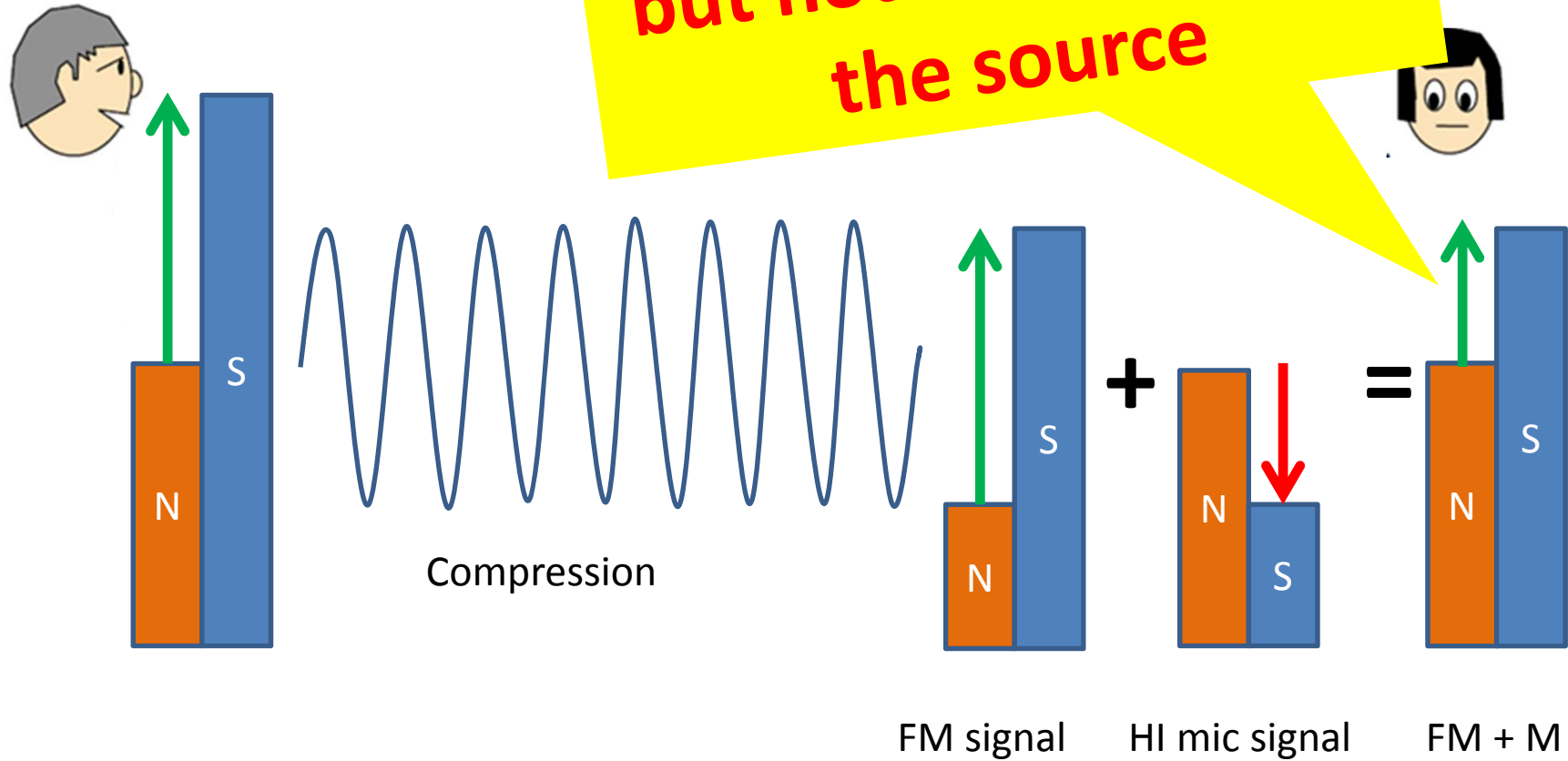
Listener



- Noise is often equally distributed throughout a room
- Speech level drops over distance

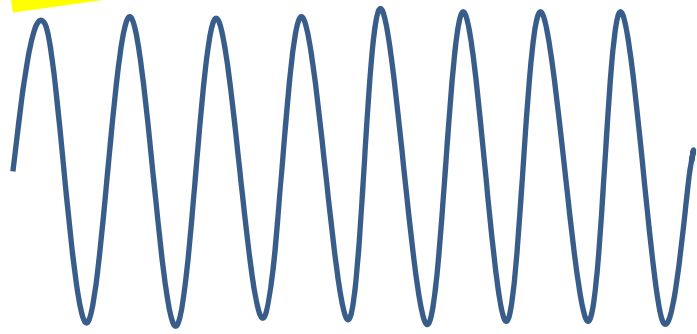
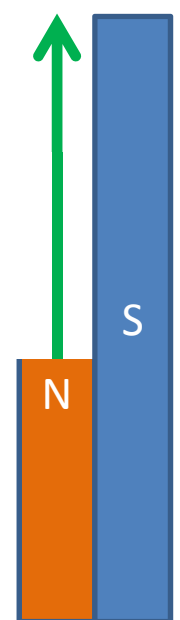
The SNR with FM

With FM: Better SNR, but not as good as at the source

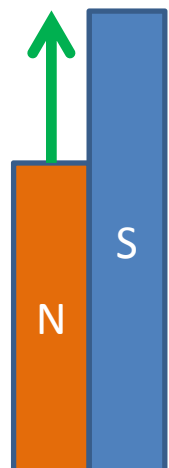


The SNR with FM in high ambient noise levels

**Higher ambient noise:
improvement in SNR stays, but
benefit shrinks**

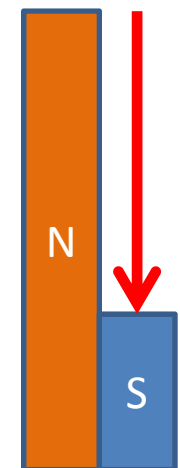


Compression



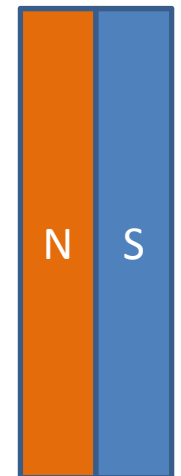
FM signal

+



HI mic signal

=

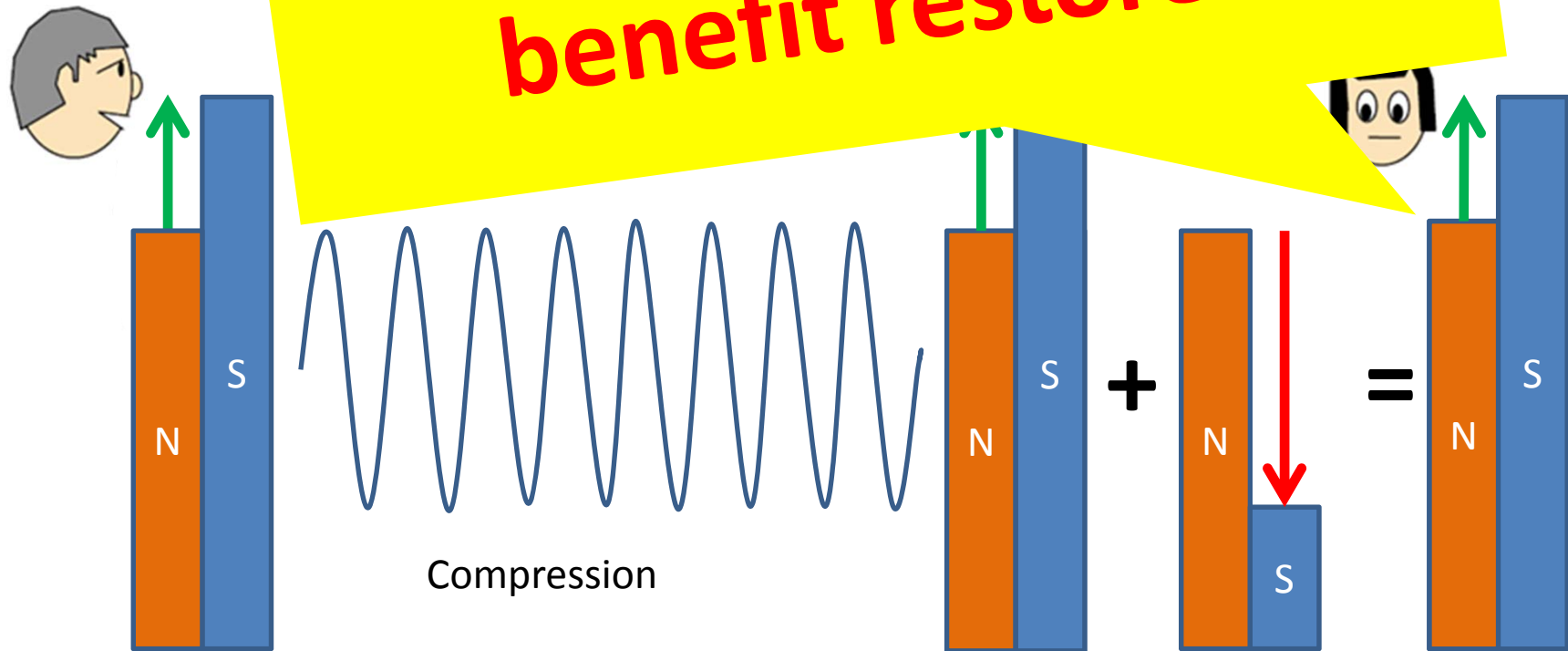


FM + M



Increase the gain of the system

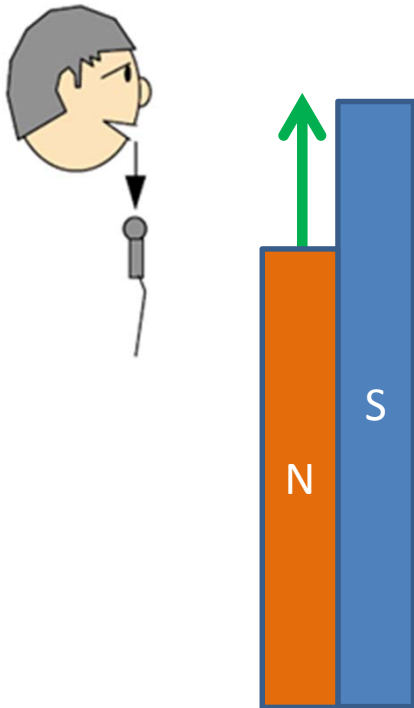
**Adaptive FM gain:
benefit restored**



Dynamic mixing of FM and M

- *Increasing the gain of the receiver at higher noise levels preserves the positive signal-to-noise ratio as captured by the FM microphone*
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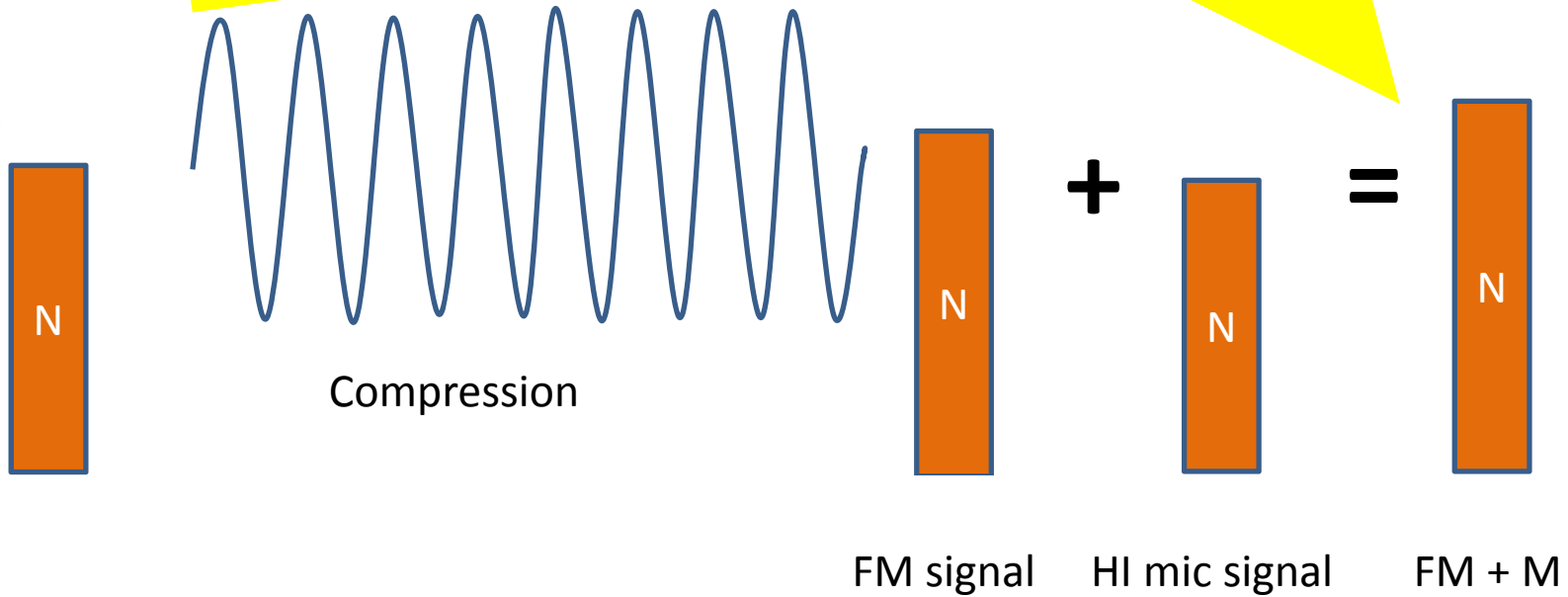
Directional microphones?



- The closer to the source, the more effective a directional microphone is
- Wireless microphones, especially lapel style, that are not directional, miss out on an opportunity for increased performance, especially in noisy conditions
- When in doubt: listen yourself to such systems in noisy conditions and compare with an omni system

What to do when the

Listening comfort and conservation of local SNR



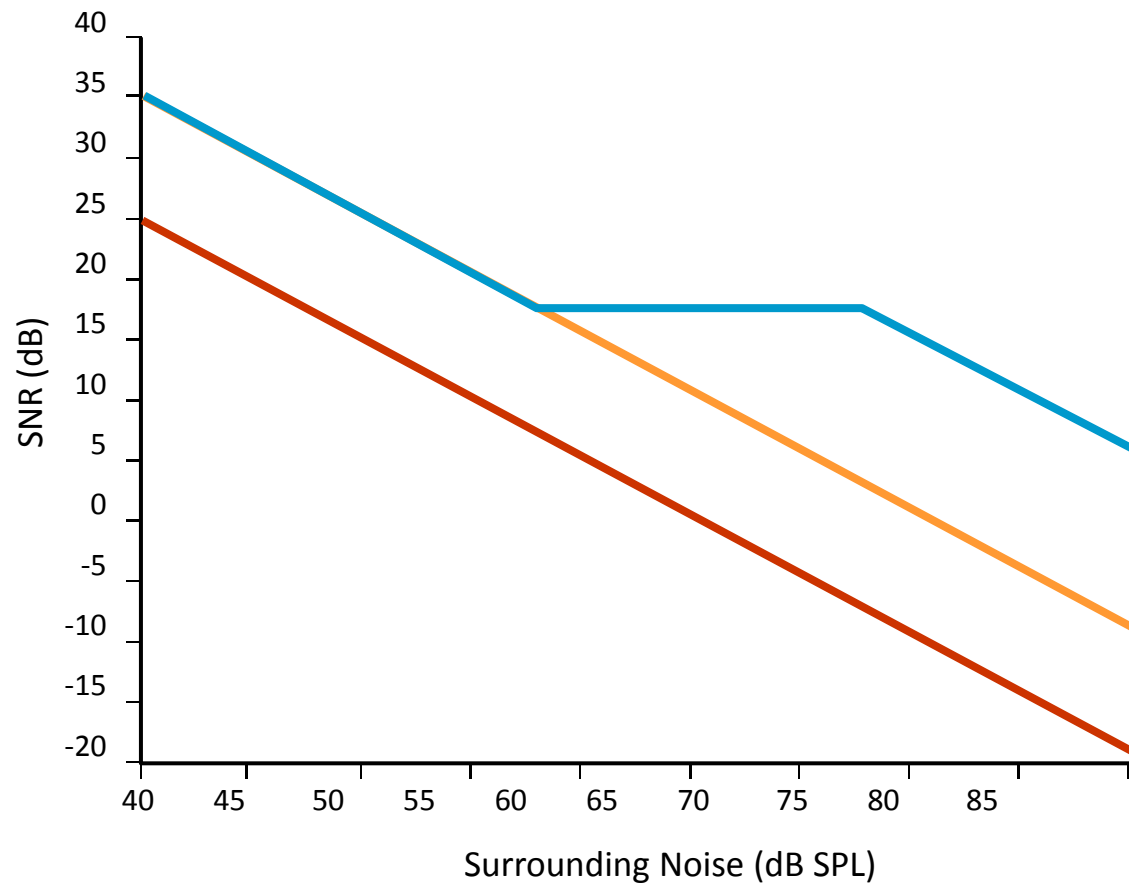
The old compromise

- 10 dB FM Advantage is compromise between different listening objectives
 - remote talker
 - own voice
 - environment close by
- For remote talker a higher FM Advantage is desirable, and this should be higher in higher ambient noise levels
- For own voice and environment close by no FM Advantage is required
- For speech via FM in quiet conditions, 10 dB FM Advantage is still a good starting position and this should be verified
- Not all wireless systems follow the ASHA guidelines

The right strategy

- The key factors for SNR enhancement in high noise conditions:
 1. Bringing the microphone **to the source**, cutting out the distance
 2. Optimize SNR at the source with **beam former** - this very good SNR is the capital to play with
 3. Mix FM with ear level microphone of hearing instrument **dynamically**, by increasing the gain of the receiver in higher ambient noise levels
 4. **Reduce** the FM gain if no voice is present
- Dynamic mixing has been proven to increase performance for both HI users and CI recipients (Thibodeau, 2010; Wolfe et al, 2009) especially at higher noise levels and is currently the de facto global standard

SNR at ear level for different technologies



No FM

Traditional FM

Dynamic FM

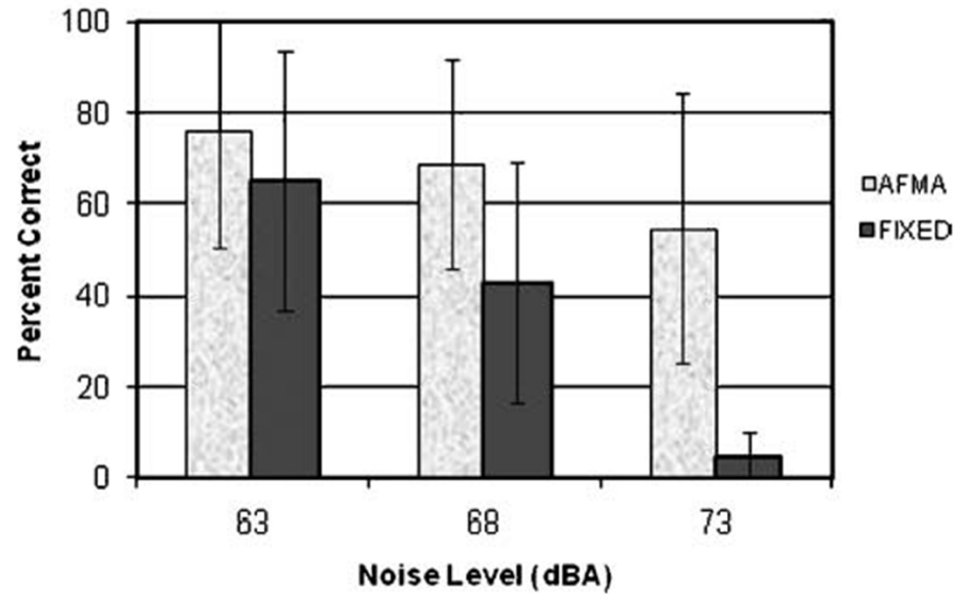
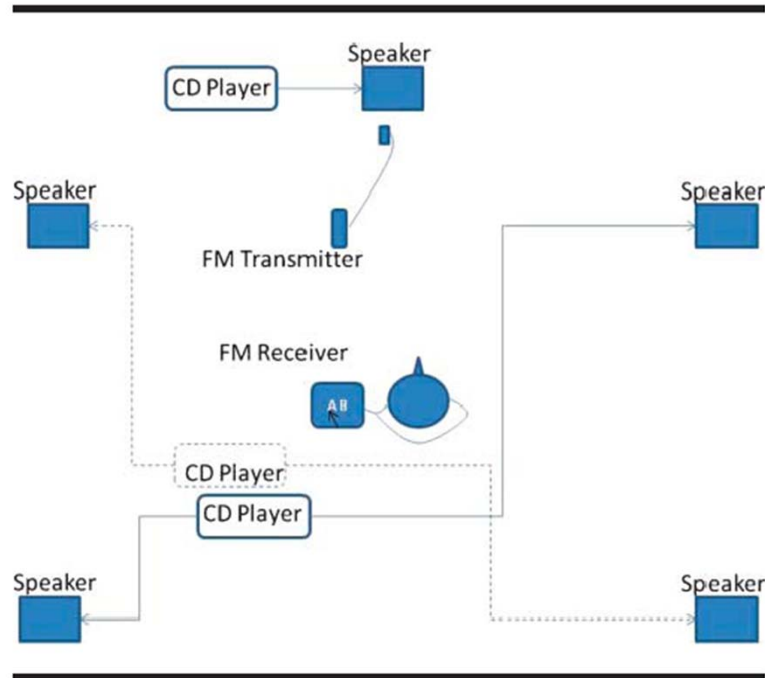
Listening conditions:

distance 2 meters

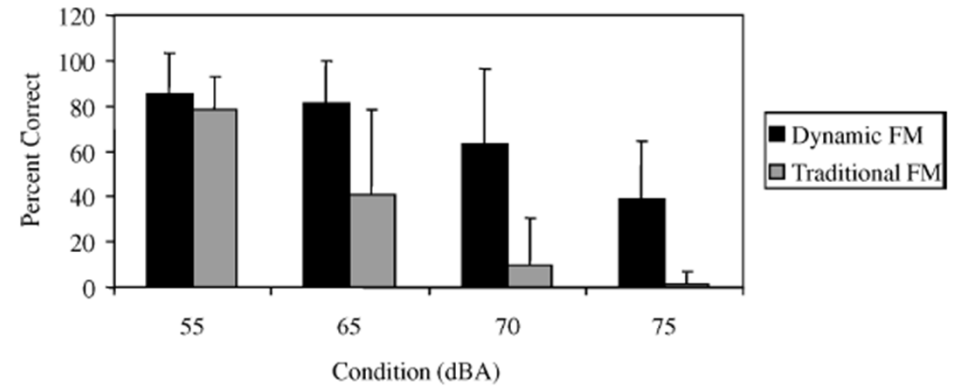
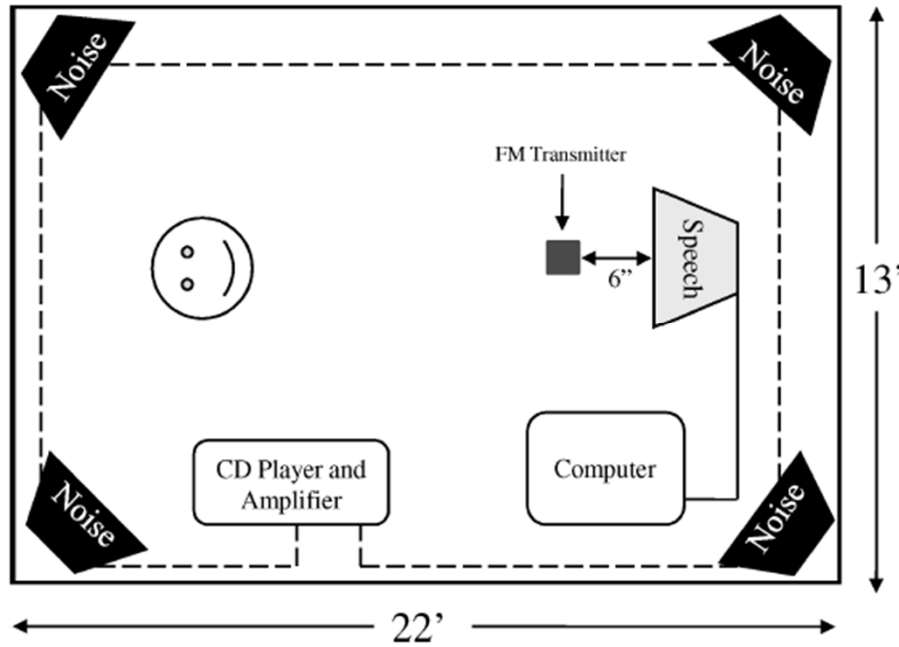
speech level at two
meters 65 dB SPL

Dr. Thibodeau results

Figure 1. Classroom arrangement for speech recognition testing.



Dr. Wolfe results



Verification, FM Advantage and SNR Advantage

- Definitions:
- SNR Advantage is the difference in SNR with and without the FM system
- FM Advantage is difference in level at the output of the HI between HI signal and FM signal

- SNR Advantage: clinically relevant, this is what the listener/patient experiences, but it depends on the FM Advantage, the distance, the noise level and the speech level
- FM Advantage: a technology/system parameter; this is what can be verified

- FM Advantage \neq SNR Advantage
- Verification \neq Validation

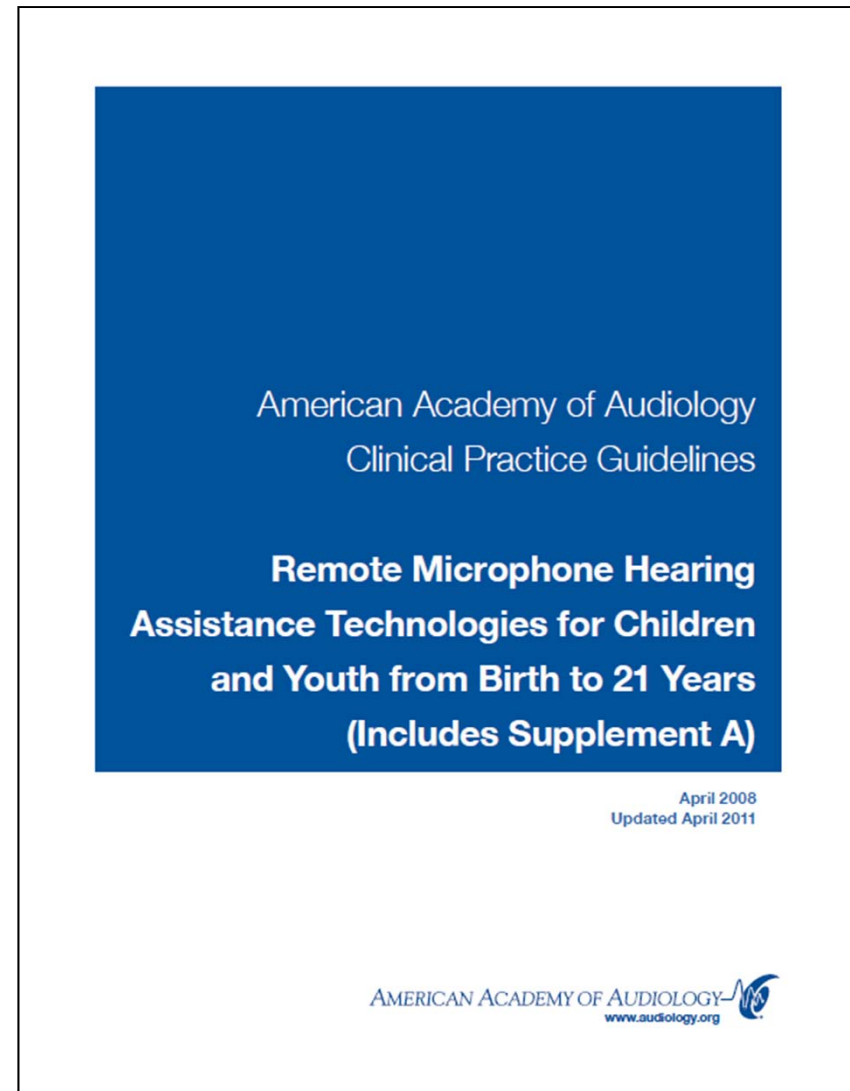
Myth busting

- FM Advantage cannot be verified directly with a standard test box
- Only transparency can be verified:
- If output of HI with 65 dB input to wireless microphone equals output of HI with 65 dB input to HI microphone, then an FM Advantage of 10 dB is there.
- Dynamic FM Advantage: no protocol exists today to verify this directly

- **Myth: Transparency does not mean different systems perform equally well in noise**
- **Myth: listening yourself to a wireless system in quiet does not tell you anything about its performance in noise**

How to verify an FM system?

- HAT guidelines (updated 2011)





Performance enhancement

- There is still room for improvement over Dynamic FM



Frequency Channel Management

- Wouldn't it be great if the notion of frequencies is no longer required, like in cell phones?
- Simple creation of networks and subgroups, like in conference calls
- No more frequency management software
- Infinite number of systems working in parallel without interferences



Transitioning to a new standard?

- Wouldn't it be great if transitioning to a new standard could be done seamless, without schools having to throw out recently purchased equipment?



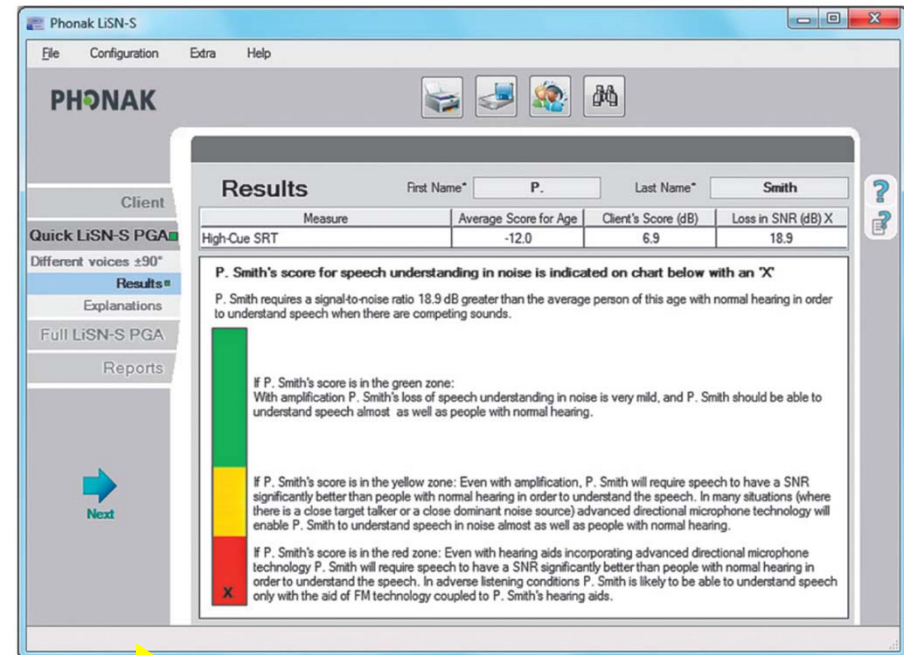
On Networking

- Paired (like BT) or broadcast (like FM)
- 1:1, 1:N, N:N
- Network characteristics: all mics open (Teamteaching), a multitalker network (one mic open at the time) with flat or non-flat hierarchy
- Automatic switching within the network or manual network
- Analogue FM = broadcast
- Bluetooth \neq broadcast, maximum 3 receivers in headset and maximum 1 receiver in A2DP protocol
- Proprietary protocols: depends



Candidacy

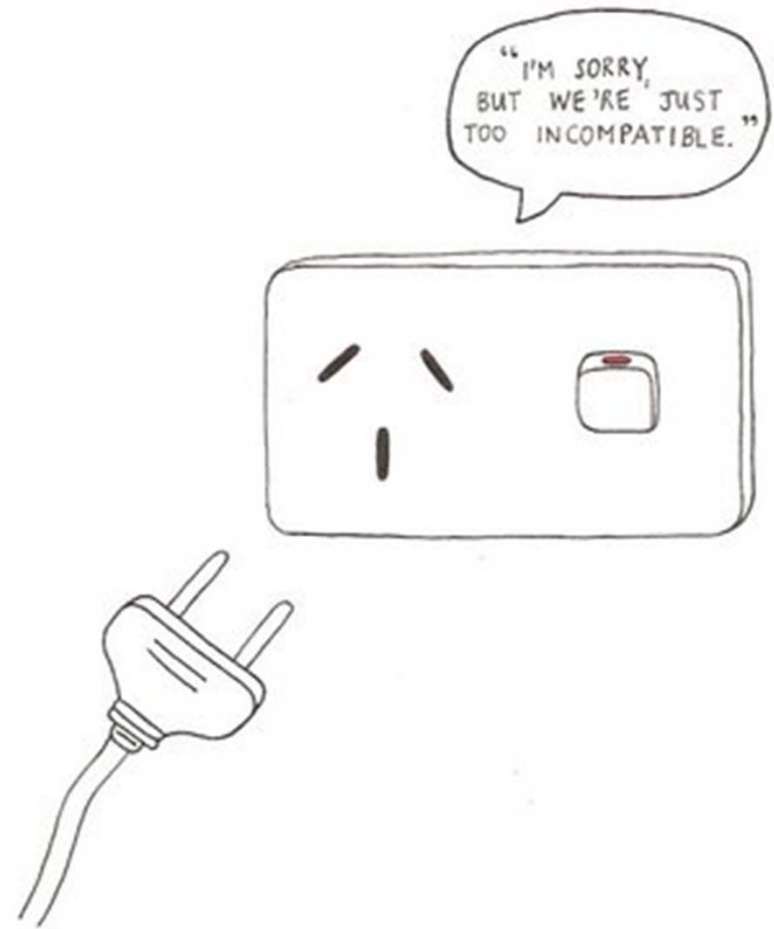
- LiSN-S PGA will help to identify right candidates
- A fourth category to distinguish simple remote microphones from Dynamic FM systems complicates things. Whether a simple remote microphone is enough depends on the actual noise levels a user will encounter in daily live; dynamic mixing starts at 57 dB SPL ambient noise level



**Remember
Dr. Dillon**

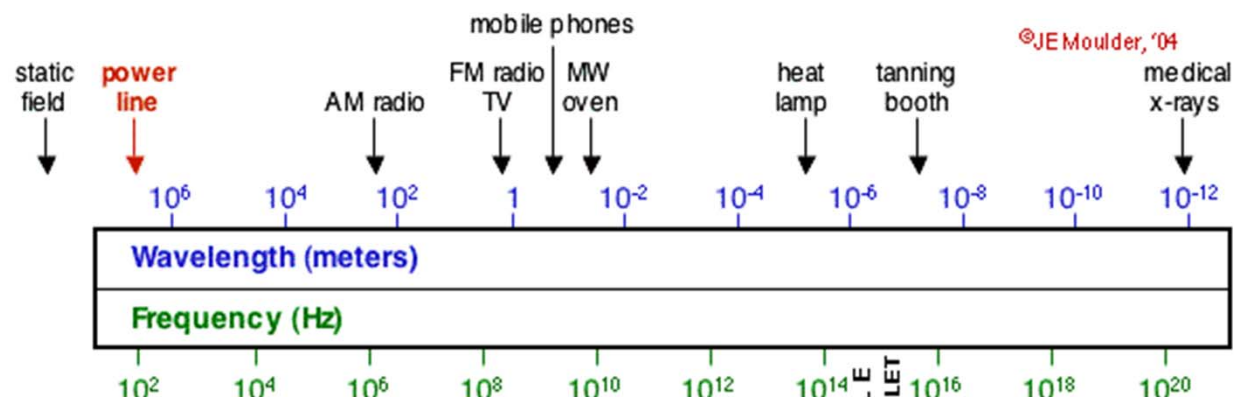
Compatibility is a concern

- Requested: universal compatibility to:
 - all brands of HI's
 - CI's & Baha's
 - ear level solutions for listeners with normal hearing (APD, UHL, Dyslexia, Autism)
 - soundfield (listeners without any pathology)
- Compatibility to future developments and to installed base



Frequency bands used

- FM bands H-Band and N-Band, ~ 200 MHz
- 800-900 MHz
- 2.4 GHz (Wireless LAN, Bluetooth)
- Regulations
- Affects: freedom to travel and use it abroad
- Affects: wavelength and possible size of wireless microphone
- Affects likelihood of interference from different sources, such as Wifi, BT, 4th Gen GSM
- Does not affect performance in noise



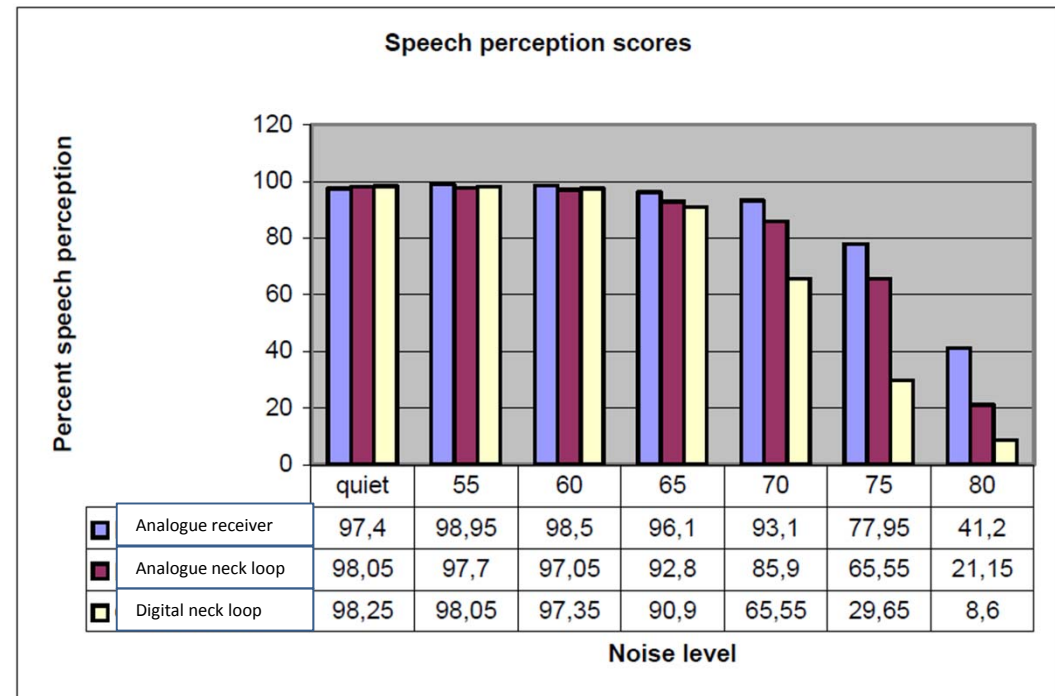
Operating range?

- FM systems are not meant as walkie-talkie
- Legal constraints to maximum emitting output power will limit operating range for all manufacturers
- Most technologies cover normal conversation ranges
- But: beware of head shadows and body absorption, which can interrupt the link



Digital or not?

- Do we talk about digital transmission or digital signal processing (in transmitter and/or receiver) or both?
- Making something digital without adding something new and clever makes things worse: delay, distortion, power consumption
- Digital transmission needs a smart approach to make it better than analogue
- One comparison of analogue FM with digital FM so far showed inferior performance of a digital system (Åslund et al, 2011)
- *Digital is emerging and will eventually bring significant user benefits*



Take home message: make up your mind

	Must have	Nice to have	Not necessary
Dynamic behavior	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Compatibility to XYZ	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
N:N Networking	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ease of use	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Easy to explain	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Electroacoustic verification	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Digital transmission	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Low power receivers	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Stay in touch

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