Abstract

Special Needs of Hearing Impaired Broadcast Consumers
(Lecture)

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Modern audio design decisions lead to high dynamic and effectful soundscapes. But sensorineural hearing loss often results in a changed loudness perception and a smaller perceivable dynamic range. To compensate sensorineural hearing loss it is necessary to fit an individually aligned programme signal according to the listener's need, for instance a frequency dependent compressive gain, which may be realised either or both at the studio or the reception side. The contribution firstly focuses on a possible realisation at the reception side: an individual supportive audio signal processing - an easy to use interactive wizard concept, that enables hearing impaired persons to adapt the dynamics of broadcast audio signals frequency dependently to their hearing loss. Accompanying user studies indicate a preference for the fitted signal, an improvement of speech intelligibility and a reduction of disturbing loudness leaps. Secondly, some more measures to improve the audibility of audio programmes for the hearing impaired, well fitted to the international requirements on 'accessibility' (Barrierefreiheit), are discussed.

Special Needs of Hearing Impaired Broadcast Consumers

Overview

- Hearing Loss and Consequences
- **iSASP** (HB) - **i**ndividual **S**upportive **A**udio **S**ignal **P**rocessing
- **iSRAP** (WH) - **i**ntegrated **S**ource and **R**eceiver related **A**udio **P**rocessing
- Conclusions

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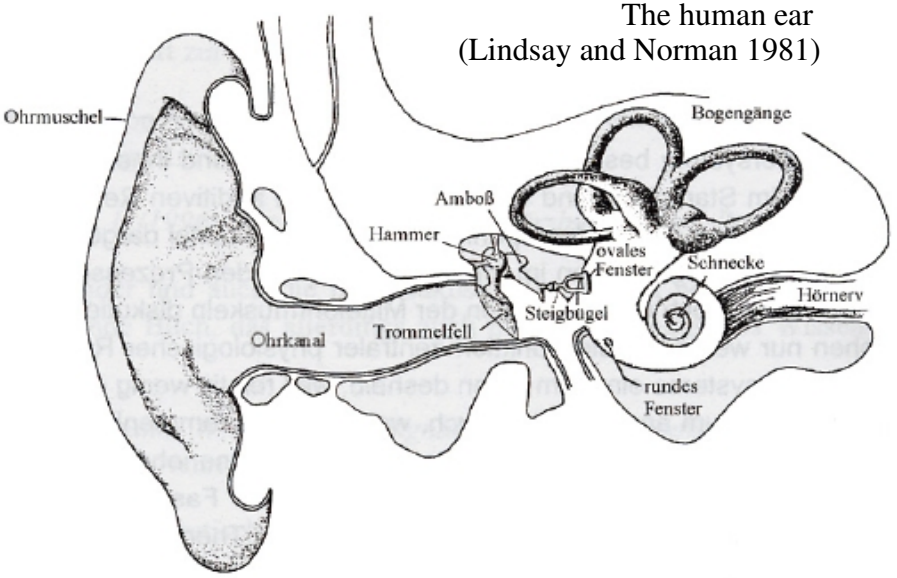
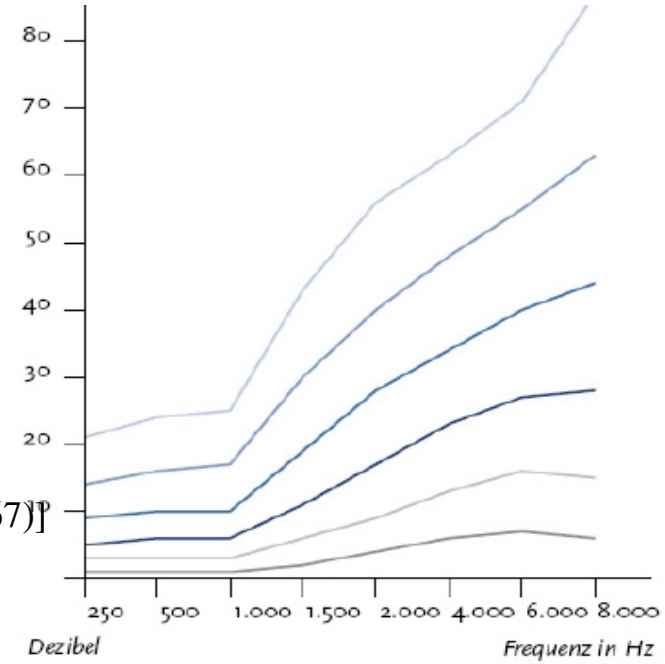
Hearing Loss (HL)

- Outer and middle ear
  - conductive HL
- Inner ear
  - sensorineural HL
    - changed loudness perception
    - reduced frequency resolution
- Presbyakusis
  - Hearing impairment caused by ageing

The human ear
(Lindsay and Norman 1981)

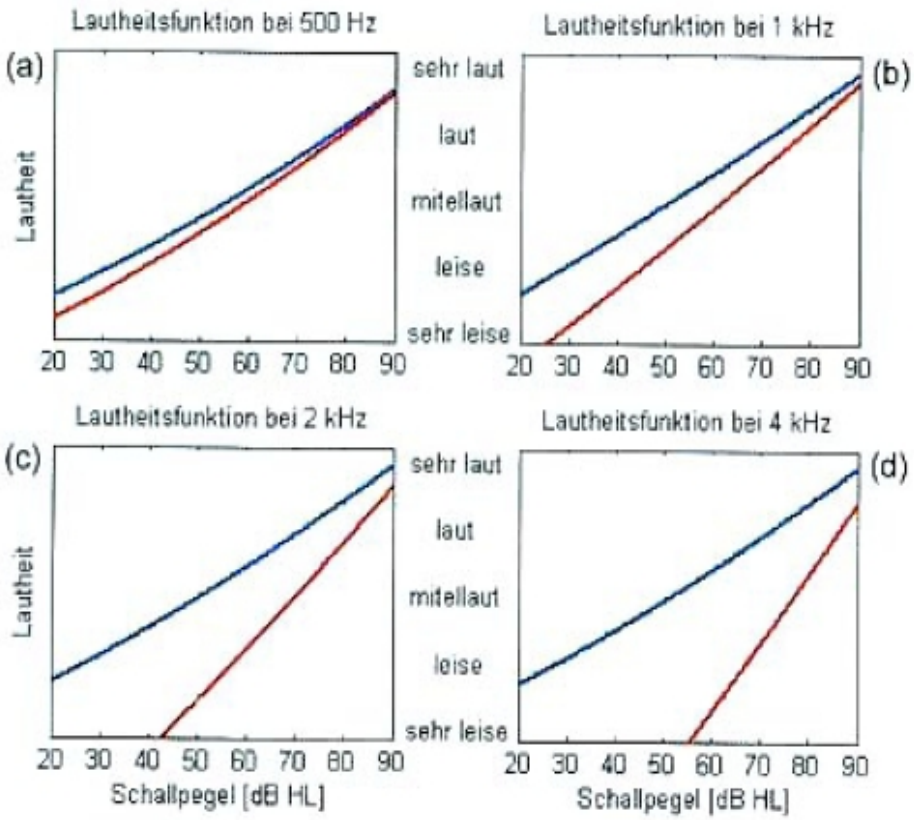


Averaged auditory thresholds as a function of age [Spoor, 1967)]



Loudness and Recruitment

- Loudness – individual sound reception quantity
- Scope of loudness curve
  - subjective loudness as a function of
    - level
    - frequency and bandwidth
    - duration
  - differencies between normal hearing and hearing impaired subjects
    - recruitment = reduced dynamic range
    - changed loudness perception
    - frequency dependent



Percepted loudness as a function of input level for the frequencies 500Hz, and 1, 2 and 4kHz. For reference, the blue lines indicate loudness reception of normal hearing subjects [Schaub, 2005]

Loudness is subjective

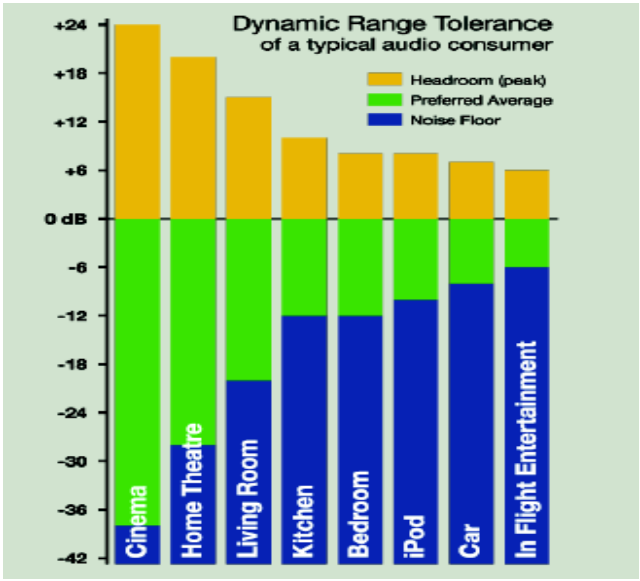
- Between Listeners Tolerance (BLV)
  - subjective loudness reception is dependent on
    - Sound Pressure Level
    - Frequency contents
    - Duration
- Within Listening Variability (WLV)
  - loudness reception of one person is only consistent to some extent and depends on
    - Time of the day and her mood
    - Degree of attention
    - Listening conditions
- Dynamic Range Tolerance (DRT)
  - defined as a preferred average window with a certain peak level headroom above it

From Lund, T.
Inter-Programm Level Jumps in Broadcast,
BroadcastAsia 2008

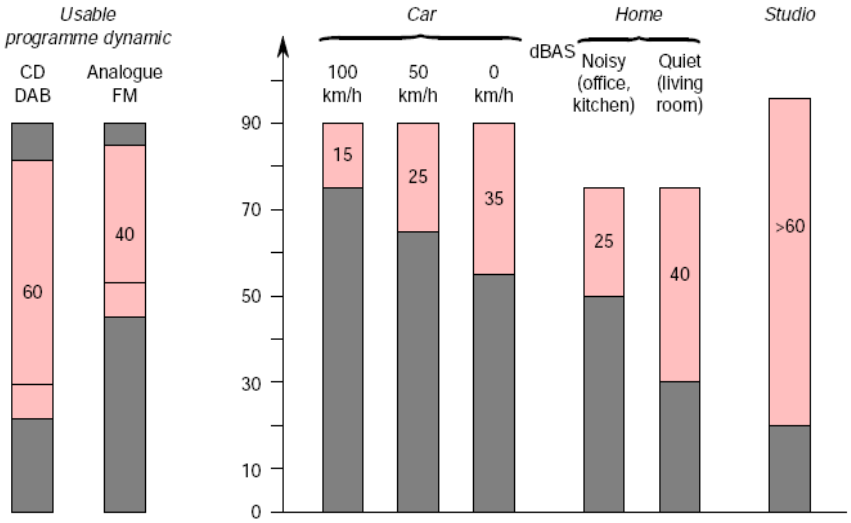
DRT depends on „Where?“

- Consumers prefer low loudness variation under some listening conditions

From Lund, T., *Inter-programm Level Jumps in Broadcast*, BroadcastAsia 2008



- Available dynamic range on the consumer's side depends on acoustic environment



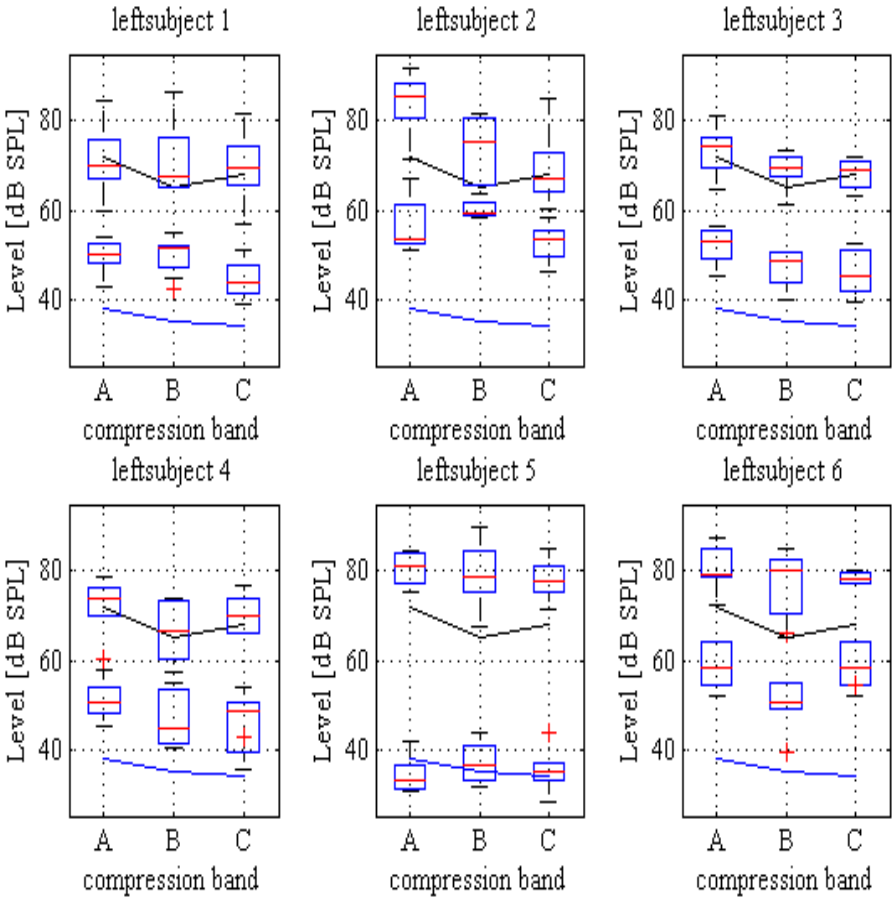
From Hoeg, W. *Dynamic Range Control and Music/Speech Control in DAB*, 1994 (based on Wagner, K.)

15 Available dynamic range (dB, approx.)

Environmental noise floor

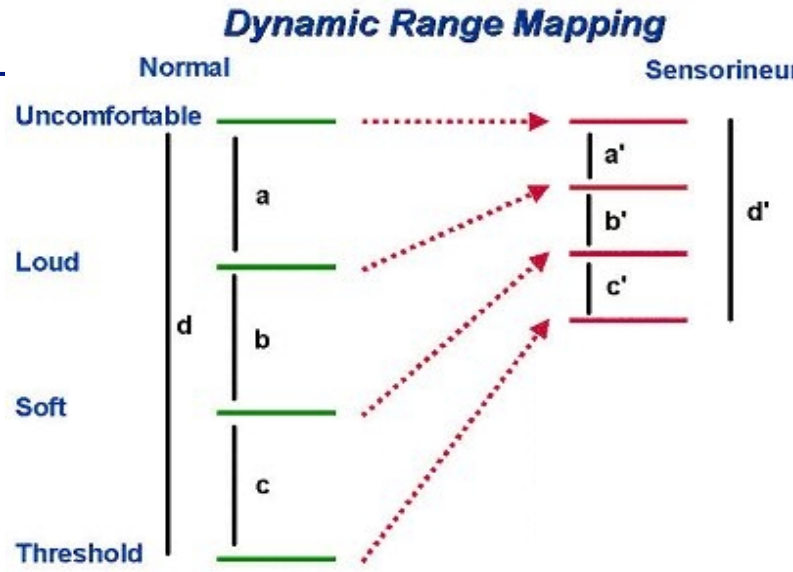
DRT depends on Hearing Loss

- Changed loudness perception
  - **Wanted**: higher listening level, lower dynamics
- Reduced speech intelligibility and extremly reduced speech intelligibilty in noise
  - **Wanted**: Higher SNR
- Lost frequencies (mild, moderate, severe HL)
  - **Wanted**: frequency dependent, individual adaptable dynamic range



Results of Low and High thresholds for 6 hearing impaired subjects, meterd by test and re-test over three following test days. The blue and black lines indicate the reference values of normal hearing subjects.

iSASP: **Scope**



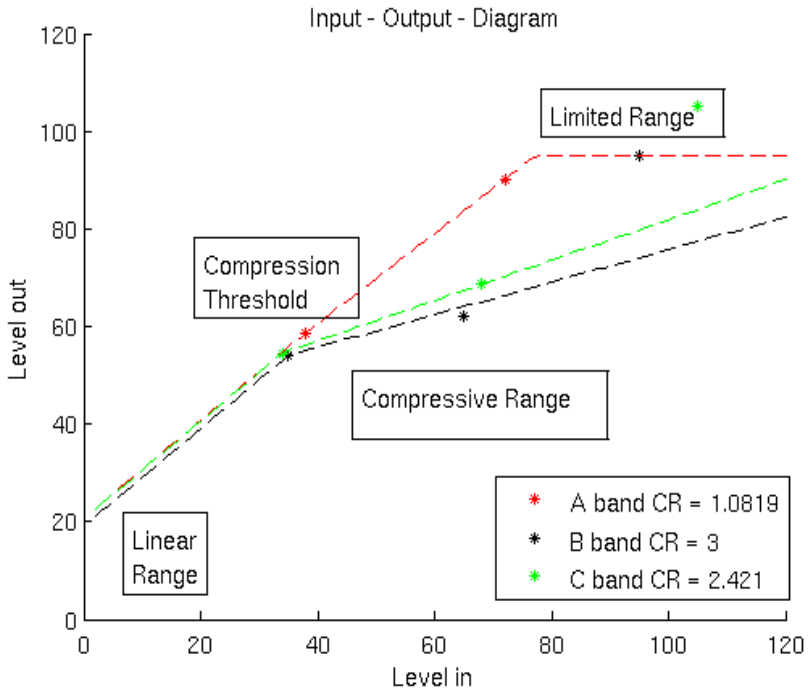
- General:
  Fitting a transfer function to the individual needs of hearing impaired users
  - easily to use
  - intuitive wizard
  - no audiogram
  - realistic broadcast
  - duration below 10 min

- Goal:
  Improving speech intelligibility

- Dynamic Range Mapping
  mapping of the original dynamics to the individually reduced dynamics of the hearing impaired

iSASP: **The Fitted Parameters**

- Compression Threshold CT
- Compression Ratio CR
- Linear Gain

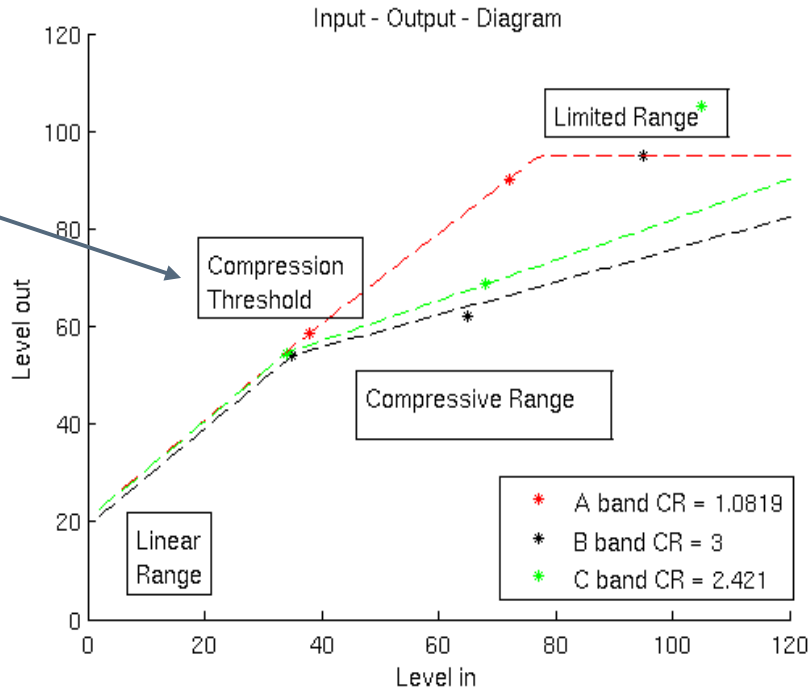


Example of an in-out diagram. For computation of CR, scope m of the straight line within compression range is reciprocal of CR. The Linear Gain is computed by difference between reference Low levels and individual Low levels.

iSASP: **The Fitted Parameters**

- Compression Threshold CT
- Compression Ratio CR
- Linear Gain

CT:
Low(NH) = CompThreshold$_{in}$
Low(HI) = CompThreshold$_{out}$



iSASP: **The Fitted Parameters**

- Compression Threshold CT
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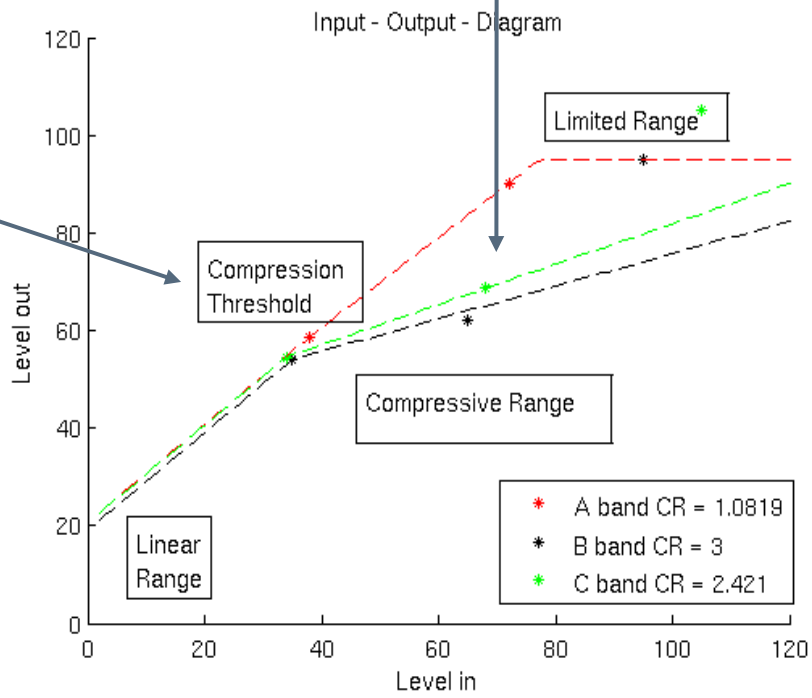
CT:
Low(NH) = CompThreshold$_{in}$
Low(HI) = CompThreshold$_{out}$

CR:
CR = 1/m =
= [High(HI) –Low(HI)] /
(High(NH) – Low(NH)]



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- Compression Threshold CT
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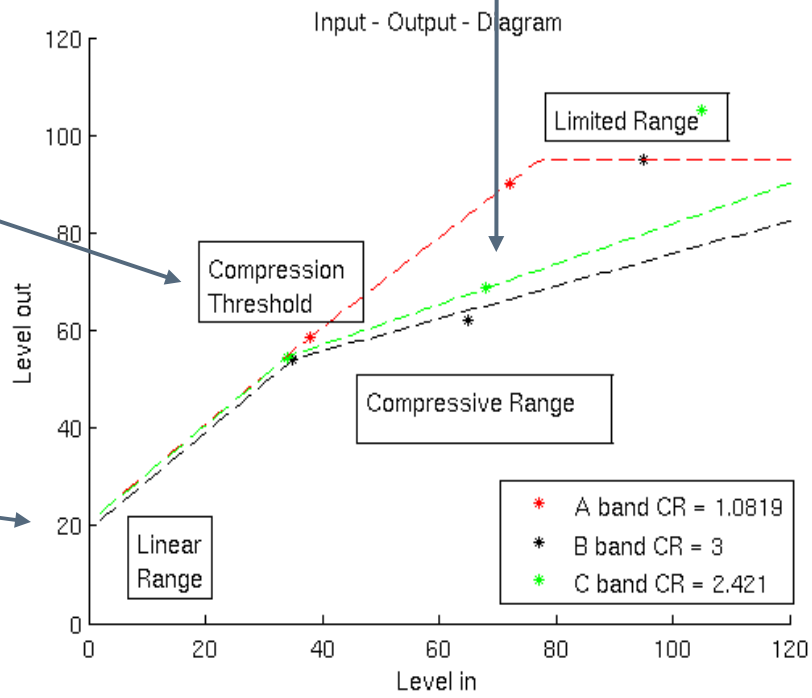
CR:
CR = 1/m =
= [High(HI) –Low(HI)] /
(High(NH) – Low(NH)]

CT:
Low(NH) = CompThreshold$_{in}$
Low(HI) = CompThreshold$_{out}$

Linear Gain:
LinGain = ΔLow =
= Low(HI) – Low(NH)



iSASP: **Pragmatic approach - the Fitting Procedure**

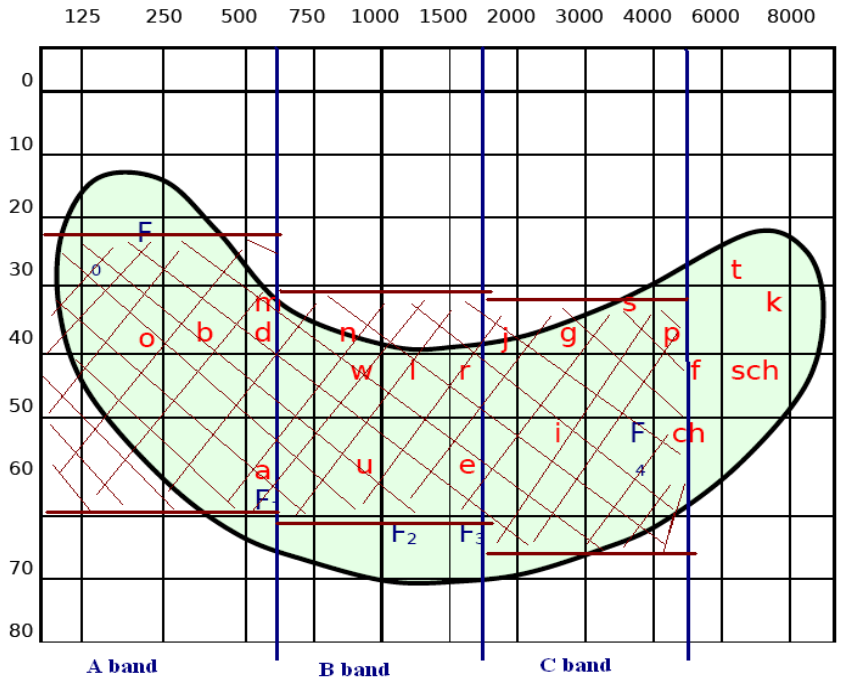
- First fittings performed in the unechoic rooms of *HörTech* laboratories
  - Metering of **LOW** and **HIGH thresholds** in the compression bands
  - Calculation of a **interim compression parameter set**
  - Adjustment of **Panorama** and **Sound Weighting** settings

iSASP: **Reference measurements with normal hearing subjects**

- Fitting with real time broadcast material (news)
- Reference thresholds of normal hearing subjects fits well to “speech banana” [Fant]

band	LOW		HIGH	
A	38	26	72	60
B	35	31	65	61
C	34	32	68	66
	dB SPL	/ HL	dB SPL	/ HL

Reference low and high thresholds, measured with ten normal hearing subjects

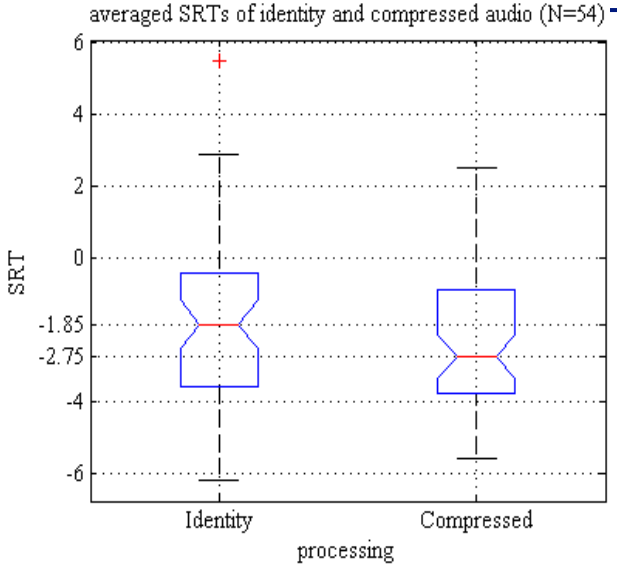


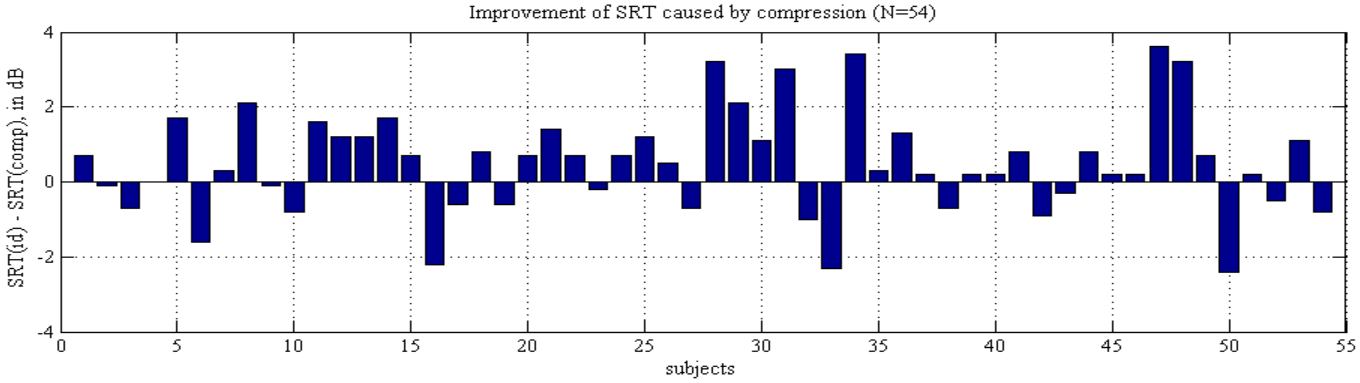
“Speech banana” [Fant)]

iSASP: **Speech Intelligibility Test (N=42)**

Evaluation

- in the whole: 54 parameter sets with 42 hearing impaired subjects
- with mild to moderate hearing loss
- aged between 16 and 73 years
  - July 2008 (N=11)
  - December 2008 (N=15)
  - January 2009 (N=10)
  - June 2009 (three appointments with N=6)

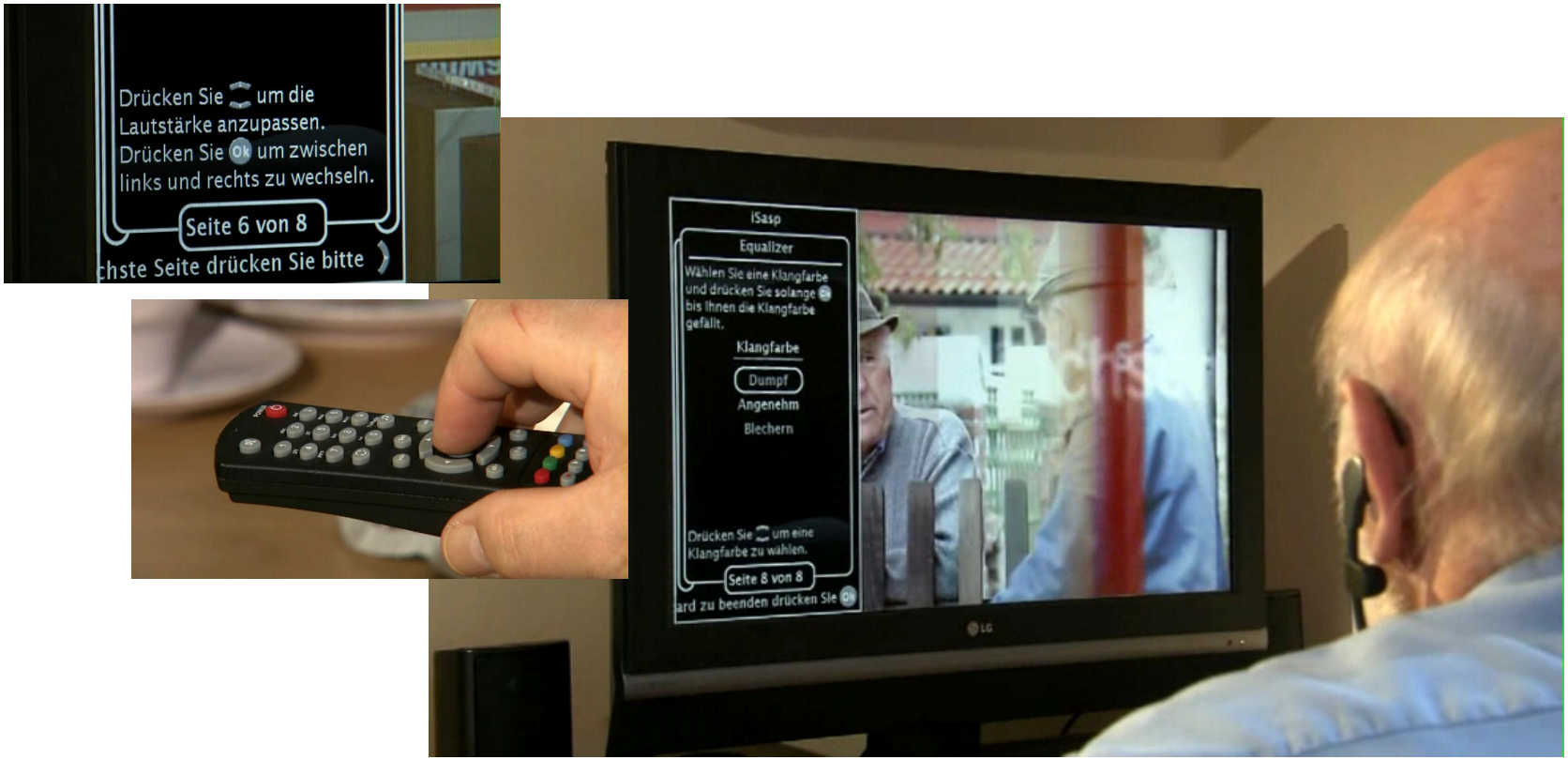




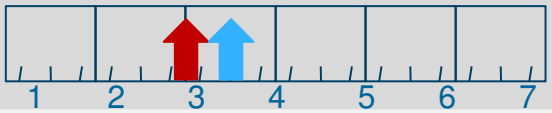
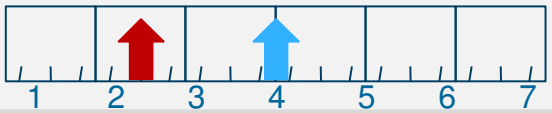
Distribution of Speech Recognition Threshold (SRT), measured with *Oldenburger Satztest*. Fig above, left: metered for identity uncompressed signal; right: SRT for speech, compressed with the self-fitted parameters.

Fig. left: Improvement caused by compression for single subjects.

iSASP: **Final Evaluation (N=20) in the IDEAAL Showroom**

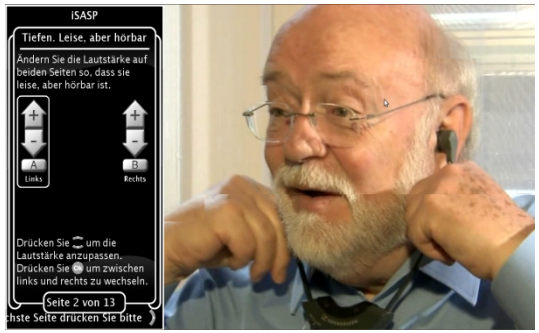


iSASP: **Final Evaluation (N=15) in the IDEAAL Showroom**

	Strongly agree … strongly disagree	Mild HL	Mod/Sev HL
When using iSASP, I immediately noticed that the TV sound changed		1,0	2,0
When using iSASP, I understood people who were speaking better		2,0	2,0
When using iSASP, I liked the TV sound better		3,5	3,0
When using iSASP, watching the TV program was less tiring		4,0	2,5
Overall, I found the iSASP useful		2,0	2,0
It would be nice to have iSASP at home		2,0	2,0

iSASP: **First Conclusion**

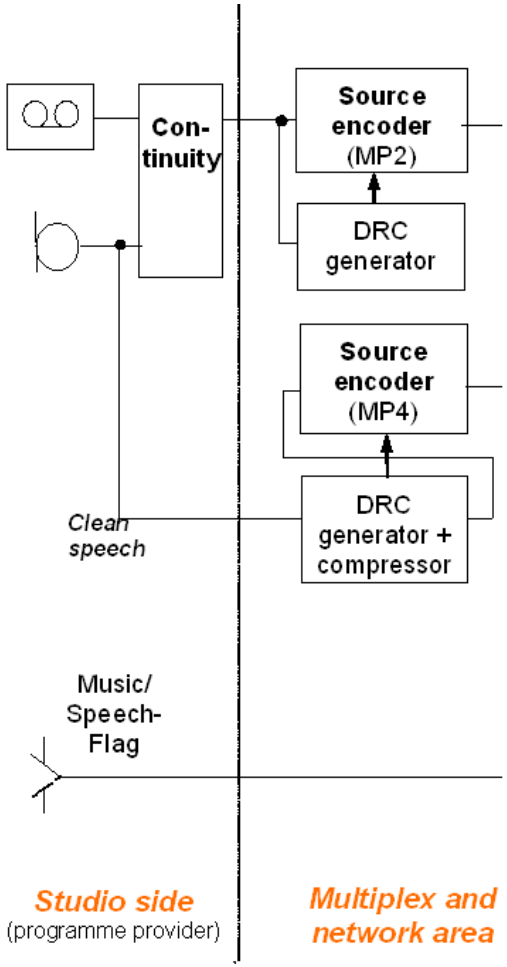
- First Fit works
  - easy to use and intuitiv wizard
  - improving speech intelligibility
- Good acceptance of sound quality and fitting procedure
- Research on further possibilities on the producer's side
  - Metadata
  - Frequency dependent loudness normalisation
- WANTED: Influence of hearing impaired's interests on loudness discussion



iSRAP: **integrated Source and Receiver related Audio Processing**

- Combines measures at the studio side (realised by the programme provider), at the multiplex and network area (operated by the service provider), and at the receiving side (individual settings by the hearing impaired customer)
- Target: to improve the audibility of radio and tv programmes, in particular the speech part
- Uses existing features as standardised with the MPEG-2 or MPEG-4 audio coding systems
- Can be used with DAB, DAB+, DVB or IT transmission

iSRAP: **The studio side**

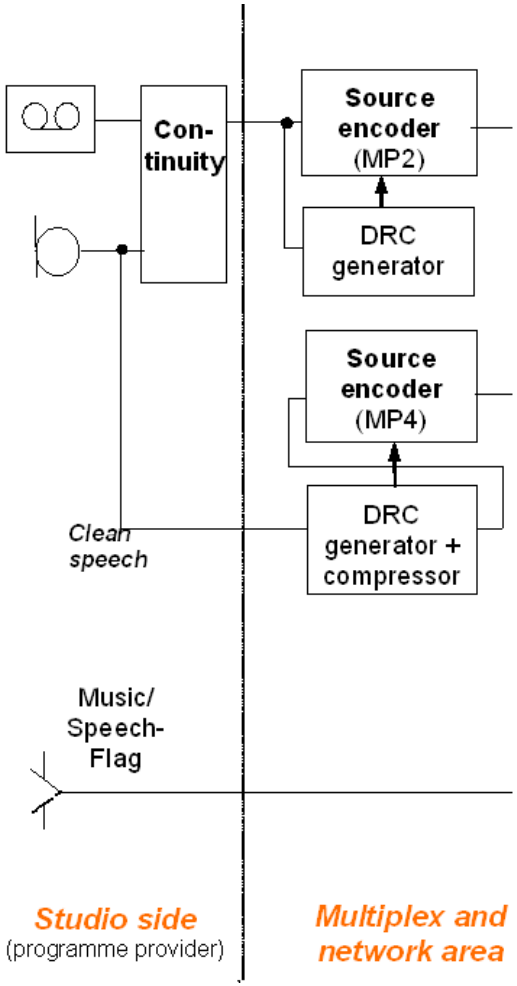


Some smaller additional tasks of the programme provider will be necessary, such as …

- Use of existing or generate new metadata to identify programme content and its dynamics, e.g. Dynamic Range Control (DRC) data and Music/Speech flag
- To extract or to separately produce of a „clean speech“ track, with appropriate SNR and related filtering measures and dynamic compression

From
Hoeg/Lauterbach (Eds.): Digital Audio BroadcastingPrinciples & Applications of DAB, DAB+ and DMB. Chapt. 3.7 John Wiley & Sons, Ltd., Third Edition (2009)

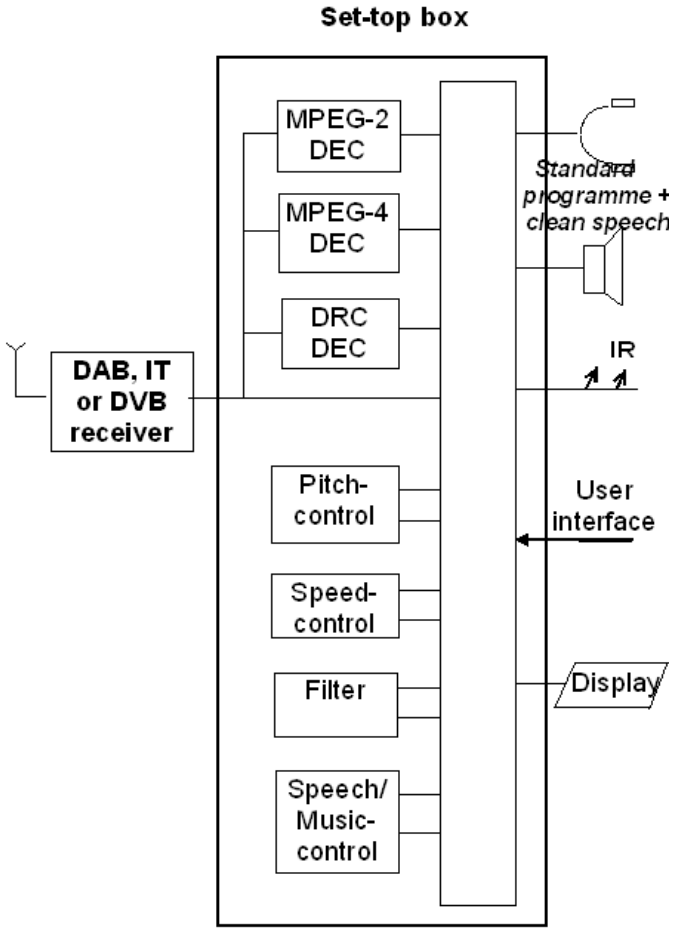
iSRAP: **The multiplex and network area**



- To transmit the mentioned multiplex via the existing DAB, DAB+, DMB, DVB or IP (Internet) channels
- To indicate the availability of such service to the customer, i.e. the hearing impaired listeners
- To insert and to transmit those metadata and/or additional audio bit-streams in parallel to the main audio service, with less additional bit-rate (probably by using the so-called MPEG multi-lingual channels)

iSRAP: **The receiving end**

- Need of a special equipped receiver or set-top box (DAB, DVB) or Media player plug-in (IP-TV/Radio) to match the received programme signal to the individual needs of the customer, such as dynamic range (use of DRC), frequency range etc.
- Use of additional MPEG-4 features, like Pitch-control or Speed-control
- Create an appropriate mix of the processed clean speech with the common programme signal
- Probably to align those measures to the characteristics of the hearing aids used by the customer



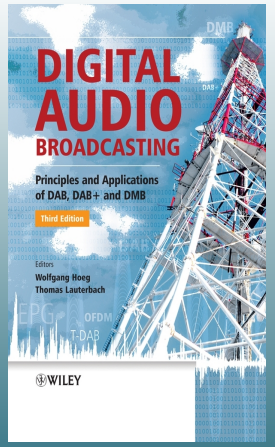
Receiving side

Conclusions

- Hearing Impairness is growing in wide ranges of human population, not only with elder people
- Therefor it is strongly needed for the future to provide comfortable solutions to support audibility and speech intelligibility of radio and tv programmes
- iSASP and iSRAP systems meet the requirements on e-Accessible Information Society (Barrierefreie Informationsgesellschaft)
- Further investigations / developments are needed as concerted actions of research and development, receiver industry, programm providers and involvement by parties affected.

Key features of the book:

- Contents were significantly updated from earlier editions
- Covers latest standards of the DAB system family (DAB, DAB+ & DMB)
- Section included on *Broadcasting for the Hearing Impaired* featuring the **ISRAP** system facilities
- "Must-have" handbook for engineers, developers and other professionals in digital broadcast systems



Thank you for listening!

http://www.hearing-at-home.eu

http://www.audiotechnologie.eu

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