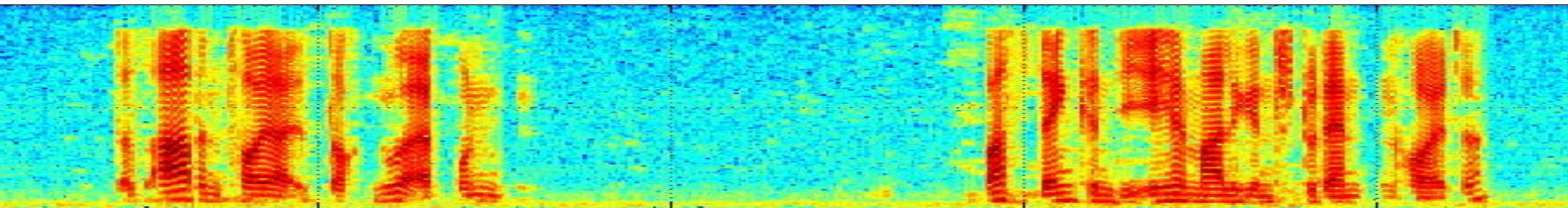# Tim Fingscheidt

Technical University Braunschweig, Germany

Geneva, 5-7 March 2008

On Consistent Improvement
of Speech Quality
by Wideband Speech Technologies

March 7, 2008

1. Overview

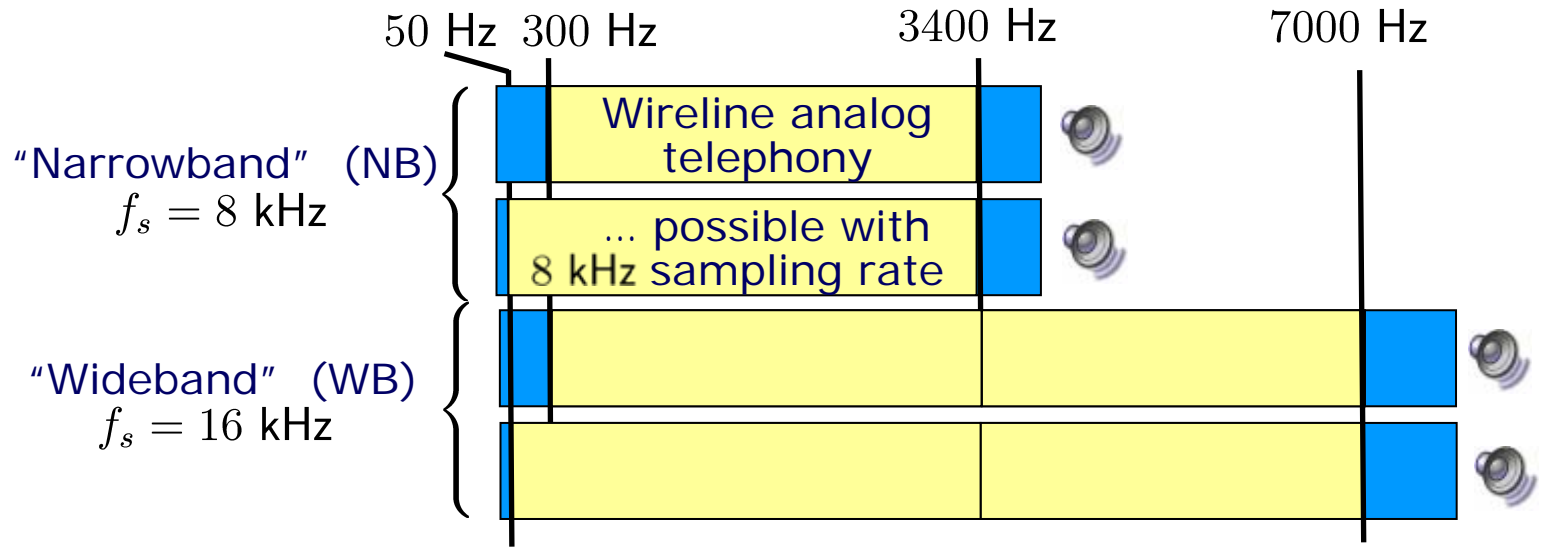2. Wideband Speech – What is it?

3. Wideband Speech Telephony

4. Artificial Bandwidth Extension (ABWE) of Speech

5. Results and Market Implications

2. What is Wideband Speech?
Effect of Speech Bandwidth

Speech characteristics (8 kHz sampling rate, today's mobile telephony):

o   Lower cutoff 300 Hz: - leads to "thin" voice

    Upper cutoff 3400 Hz: - loss of articulateness
                           - loss of intelligibility

o   Both: - loss of speaker-specific characteristics

A speech bandwidth up to 7000 Hz solves these problems to a large extent!

2. What is Wideband Speech?
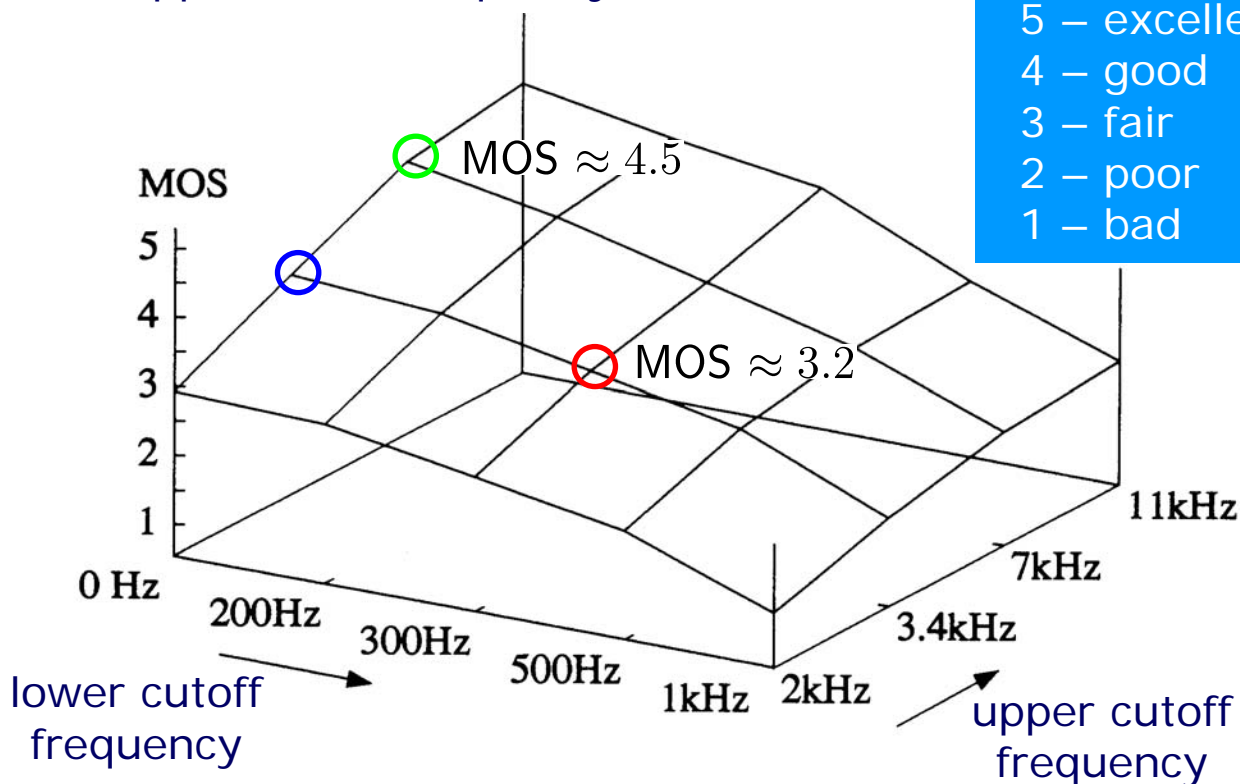## Effect of Speech Bandwidth on Quality

Speech quality experiment:

o Different combinations of lower and upper cutoff frequency

Subjective evaluation of speech quality:

Mean opinion score (MOS):
- 5 – excellent
- 4 – good
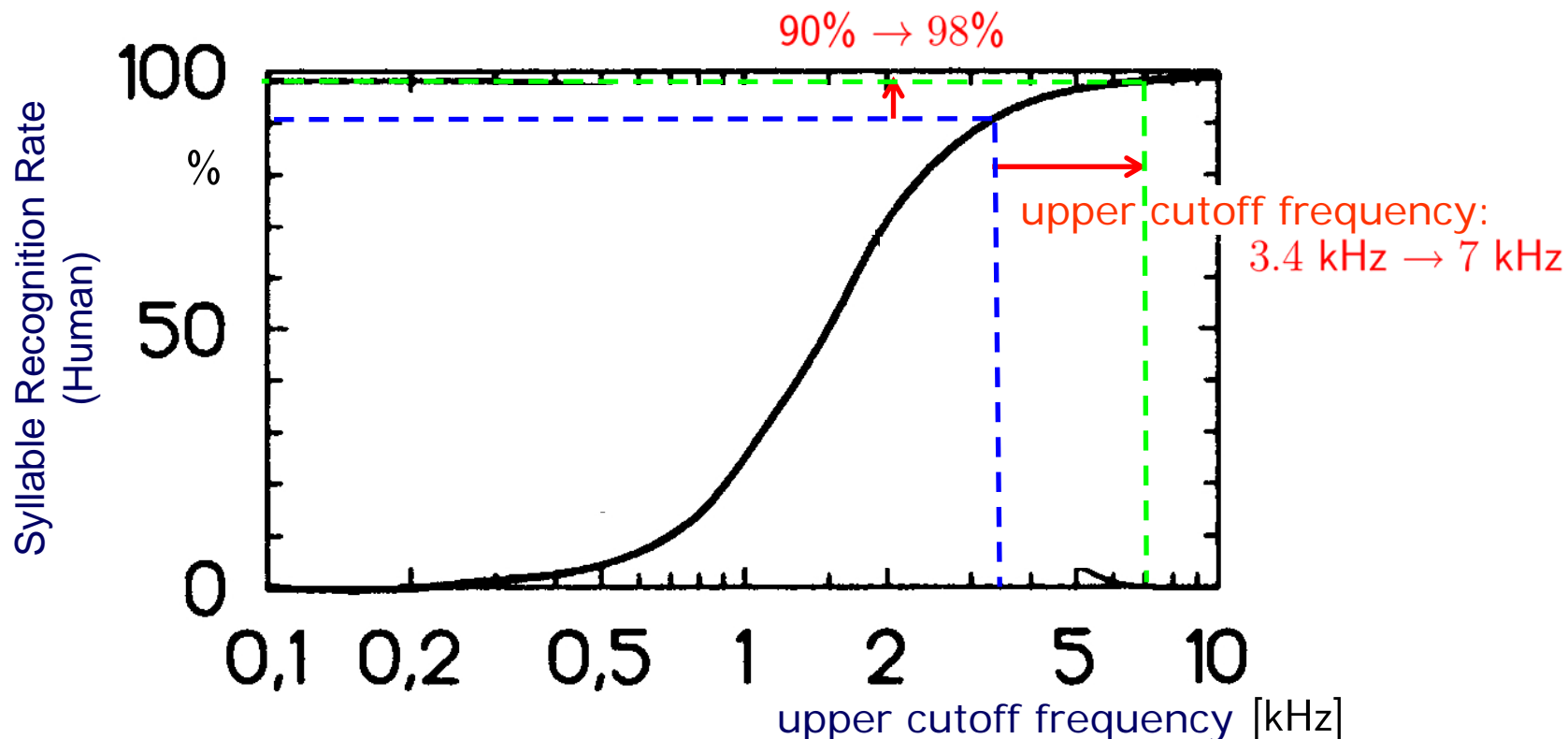- 3 – fair
- 2 – poor
- 1 – bad

MOS ≈ 4.5

MOS ≈ 3.2

MOS

5
4
3
2
1

0 Hz

200Hz   300Hz   500Hz   1kHz   2kHz

11kHz
7kHz
3.4kHz

lower cutoff frequency

upper cutoff frequency

[Data: Krebber, "Sprachübertragungsqualität von Fernsprech-Handapparaten", VDI-Fortschrittsberichte, 1995]

**The Fully Networked Car
Geneva, 5-7 March 2008**

Syllable intelligibility experiment:

o   Application of a low pass with varying upper cutoff frequency

[Terhardt, "Akustische Kommunikation", Springer, 1998]

Adaptive Multirate Wideband (AMR-WB) Speech Codec:

3GPP TS 26.190 (2001), G.722.2 (2001)

GSM — GLOBAL SYSTEM FOR MOBILE COMMUNICATIONS

3GPP

ITU

Sampling rate: $f_s = 16$ kHz   Speech bandwidth: $f_c = 7$ kHz

9 bit rates: 23.85/23.05/19.85/18.25/15.85/14.25/12.65/8.85/6.60 kbps

Applications:

o Circuit-switched speech telephony in GMSK, GERAN/8-PSK, UTRAN

o Packet-switched conversational multimedia applications, streaming, VoIP,

o Multimedia broadcast/multicast serv. (MBMS) speech download, streaming

AMR-WB @ 23.85/23.05/19.85/18.25/15.85/14.25/12.65/8.85/6.60 kbps

ISO   IEC   ITU International Telecommunication Union
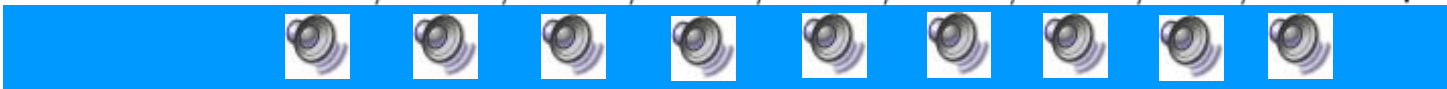
3. Wideband Speech Telephony
Wideband Speech Deployment in Networks

Field Studies:

T··Mobile····

Field study 2006:

- o Longer and more frequent use of mobile phones
- o Market introduction announced for 2008

mobilkom austria

Field study 2007:

- o Significantly increased quality, **particularly in disturbing environments**: Restaurants, bars, shopping malls, **cars**, conference calls, …
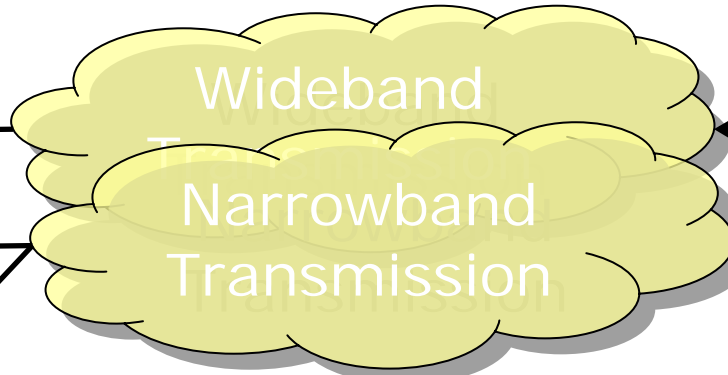
WB capable
carkit & phone

Network

WB capable
phone

WB

Wideband
Transmission

WB
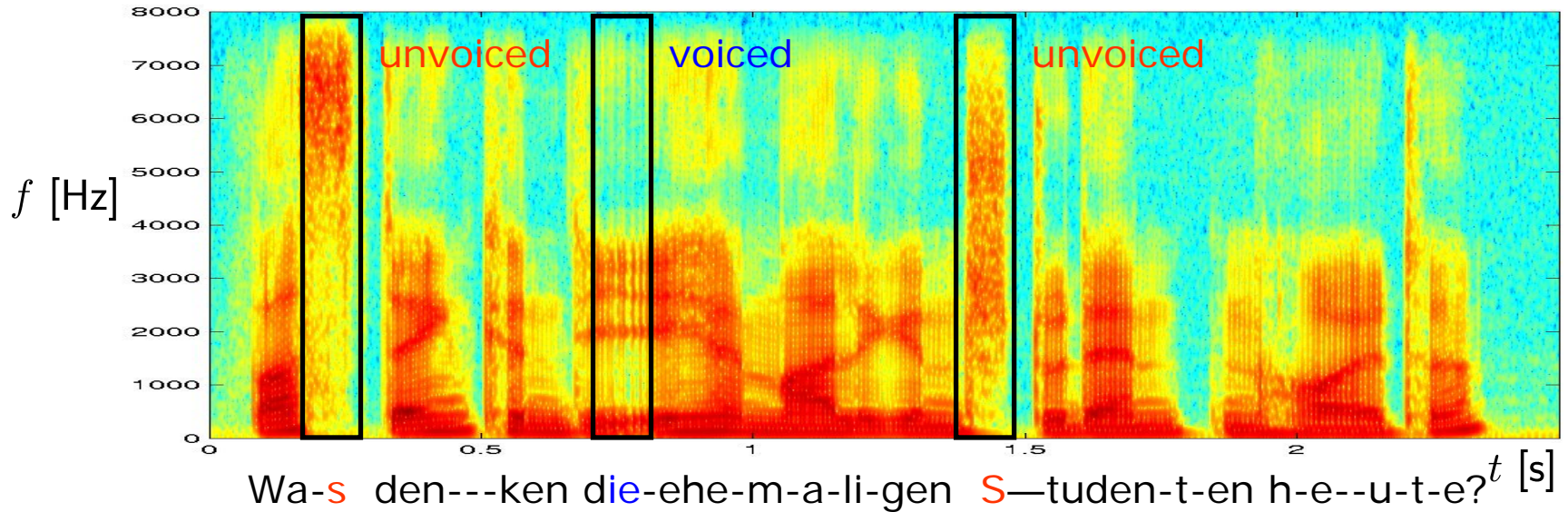
NB Mode

Narrowband
Transmission

ABWE
Mode

NB-only
phone

o „WB starter solution" and "fall-back solution":
Artificial Bandwidth Extension of speech

o Pseudo-wideband speech experience, but:
- No new network components necessary
- No WB-capable phone of communication partner necessary!

ISO   IEC   ITU International Telecommunication Union

Short term spectral analysis (wideband spectrogram):

Wa-s den---ken die-ehe-m-a-li-gen S—tuden-t-en h-e--u-t-e?

Spectral Analysis of Wideband Speech

Challenge of estimation of upper band speech components:

much high frequencies…   little energy…   quite easy to estimate…

f [Hz]

6000
5000
4000
3000
2000
1000
0

0   0.5   1   1.5   2 t [s]

Wa-s den---ken die-ehe-m-a-li-gen S—tuden-t-en h-e--u-t-e?

/s/   /i:/   /S/
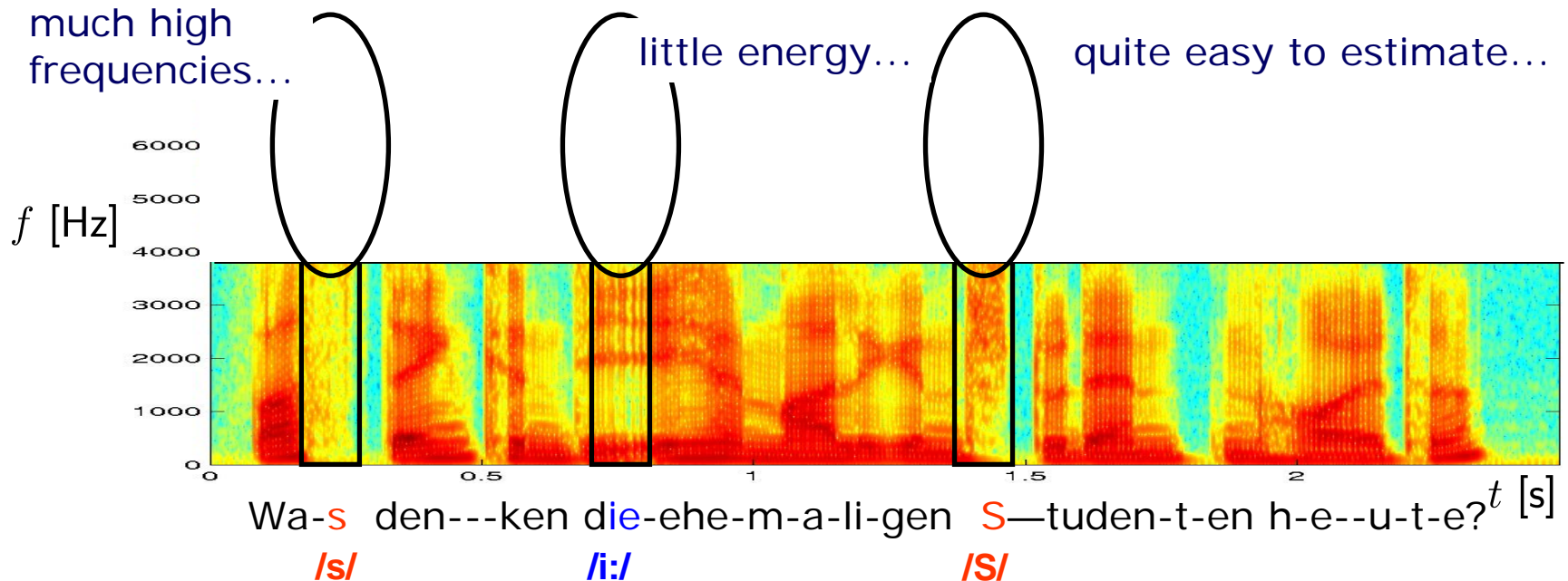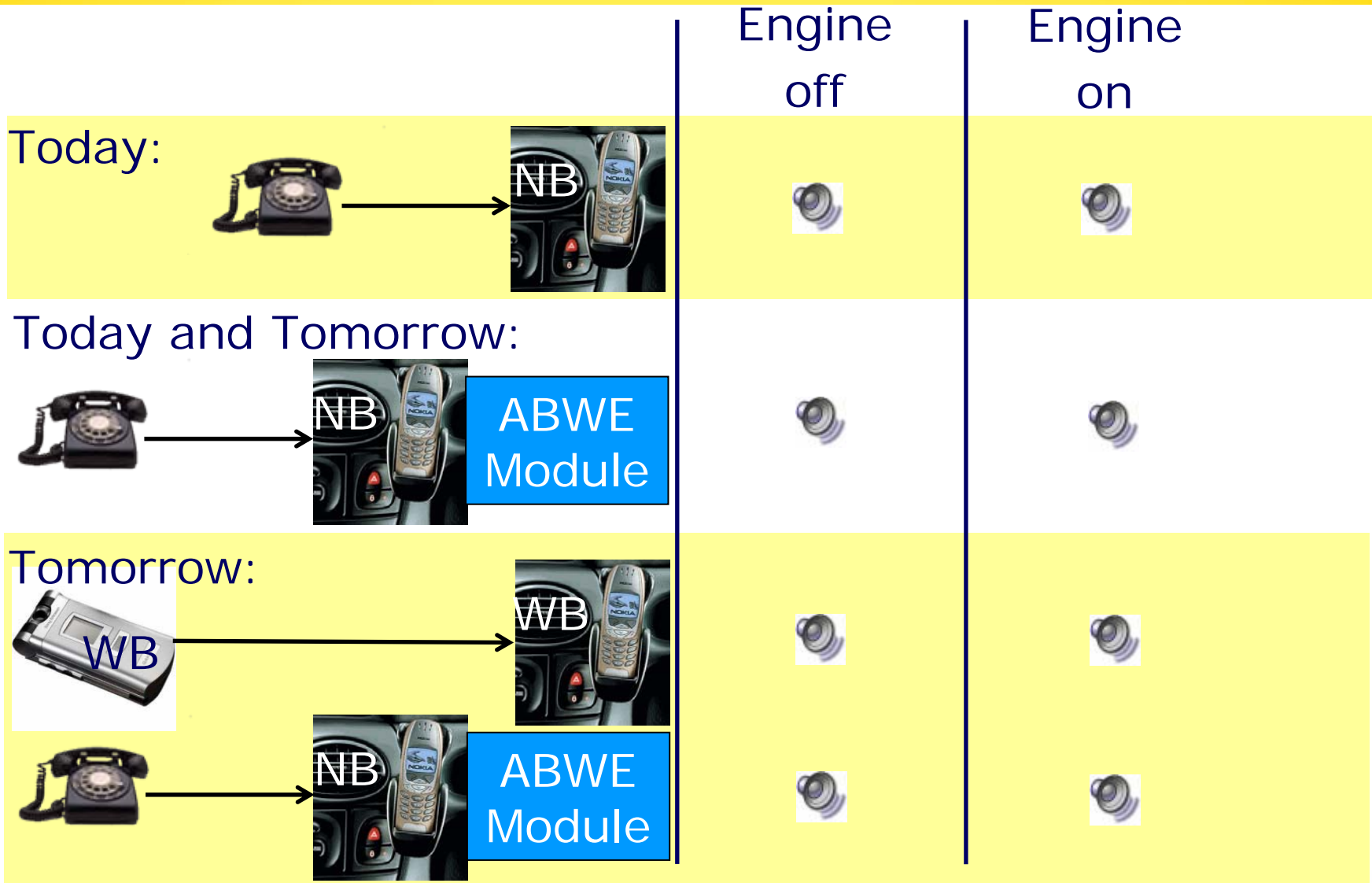
But: Artificial Bandwidth Extension (ABWE) of speech is quite mature today – especially for car deployment!

ISO   IEC   ITU International Telecommunication Union

Loudspeaker

Antenna

WB
or
NB

Carkit
&
phone

Microphone

ABWE
Module

Loudspeaker

5. Results and Market Implications
Audio Demo to Artificial Bandwidth Extension

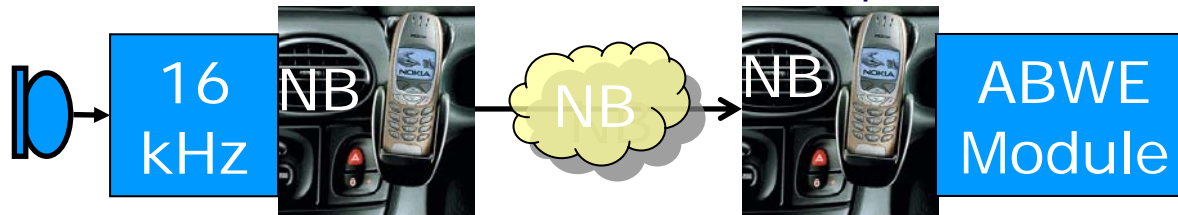|	Engine off	Engine on
Today: NB	🔊	🔊
Today and Tomorrow: NB ABWE Module	🔊	🔊
Tomorrow: WB → WB	🔊	🔊
NB ABWE Module	🔊	🔊

Summary of Pseudo Wideband Systems

Benefit of ABWE in 3 kinds of scenarios / devices:

o NB mobile and carkit:
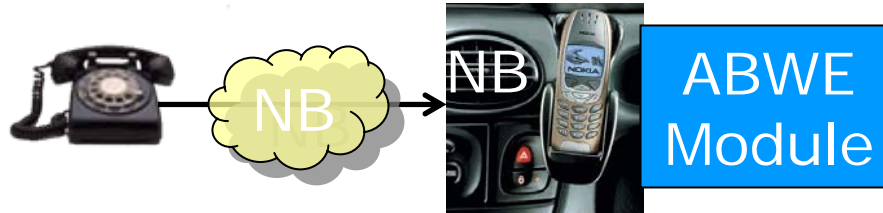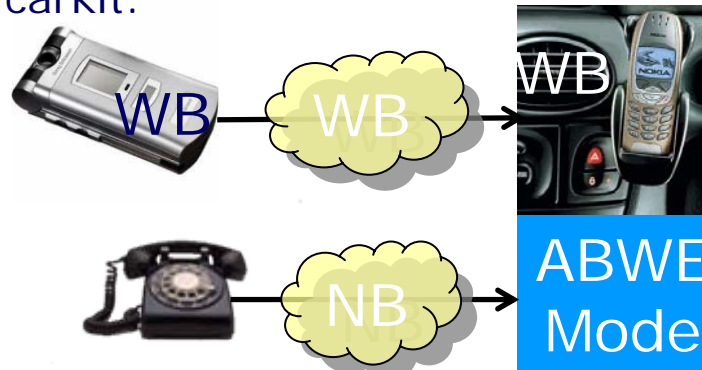

User may be offered already pseudo WB speech quality

o Intelligent NB carkit, NB mobile (car fleet or enterprise solutions):

Both partners' terminals are "intelligent" NB terminals (16 kHz ADC)

User may be offered close-to-WB speech quality

o Full WB mobile and carkit:

User experiences at least pseudo WB speech quality as fallback

Thank you for your attention!

To probe further:

Institute for Communications Technology
Technical University Braunschweig

http://www.ifn.ing.tu-bs.de/en/sp/fingscheidt/