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# Audio technologies for maritime applications

Presented at IALA's 41th Meeting of the Vessel Traffic Services Committee

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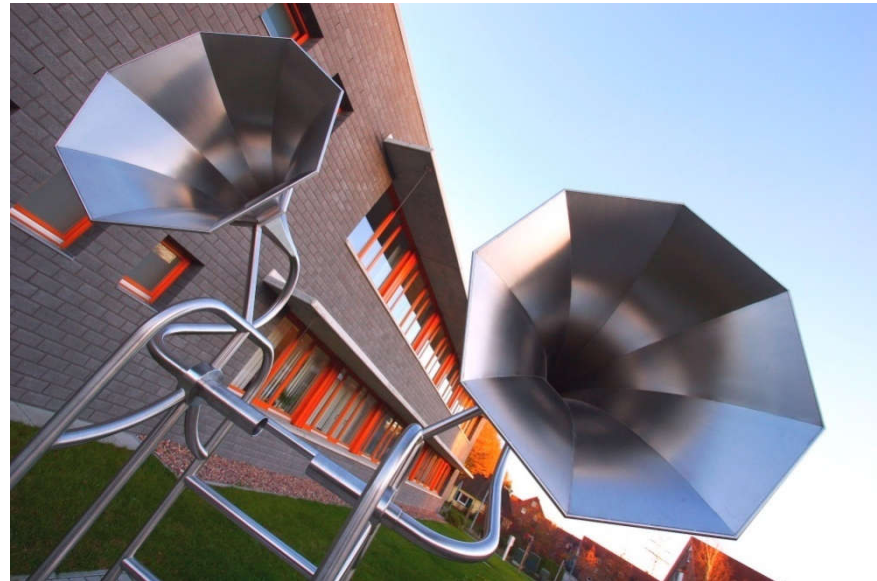
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# Motivation for Hearing Research in Oldenburg, Germany

- Support people with hearing difficulties
- Around 17% of the European population (70 million people) have a hearing impairment, fewer than 25% use a hearing aid
- Speech intelligibility and sound quality gain in importance because of the increasing use of communication and media technologies
- Today, 300 researchers work in basic and applied R&D with the mission

## Hearing for All



# Research at Fraunhofer IDMT's Dept. Hearing, Speech and Audio Technology

- Audio technology for signal enhancement, e.g. multi-channel beamformer, noise reduction, dereverberation, ...
- Sound personalization for normal and hearing impaired listeners
- Modelling of human auditory perception, e.g. prediction of speech intelligibility, audibility of sounds, ...
- Acoustic condition monitoring and event recognition
- Automated speech recognition, applied e.g. in human-machine-interaction to control complex technical systems

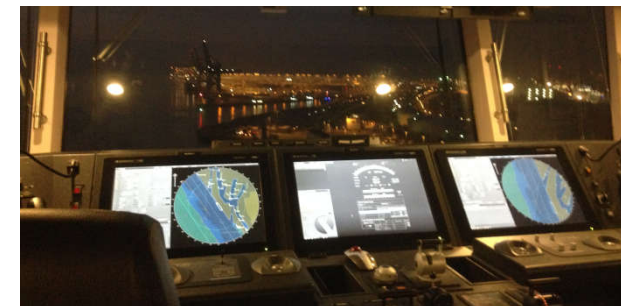
# Research at Fraunhofer IDMT's Dept. Hearing, Speech and Audio Technology

- Audio technology for signal enhancement, e.g. multi-channel beamformer, noise reduction, dereverberation
- Source separation, e.g. for music processing, speech enhancement
- Modelling of speech production and perception, e.g. for speech synthesis, speech recognition
- Acoustic condition monitoring and event recognition
- Automated speech recognition, applied e.g. in human-machine-interaction to control complex technical systems

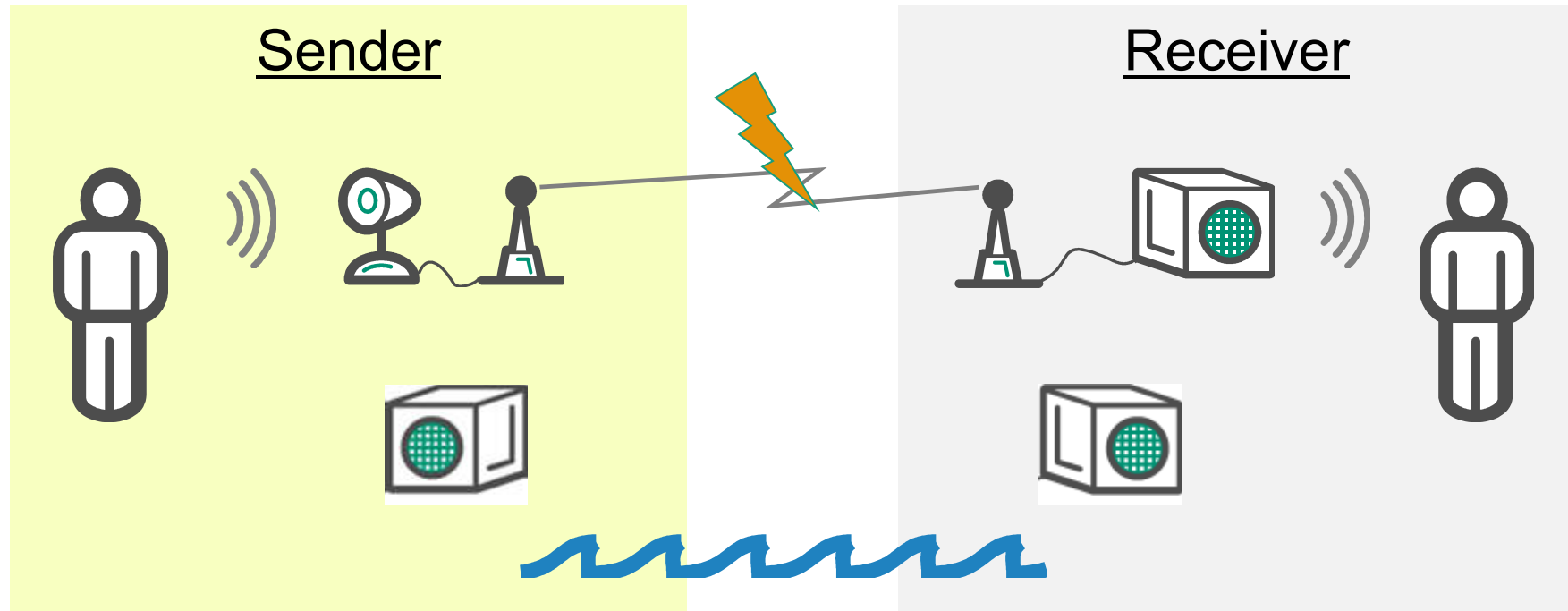
How can this research inspire and improve maritime communication?

# Problems in maritime communication

- Miscommunication is a major trigger for maritime incidents
- Speech-Quality of radio communication and VDR is often insufficient
- Information overload in radio communication (e.g. ship2ship, tugs, VTS, ...)
- Today's ship crews are multi-lingual and multi-cultural
- Standard Marine Communication Phrases (SMCP) not continuously used



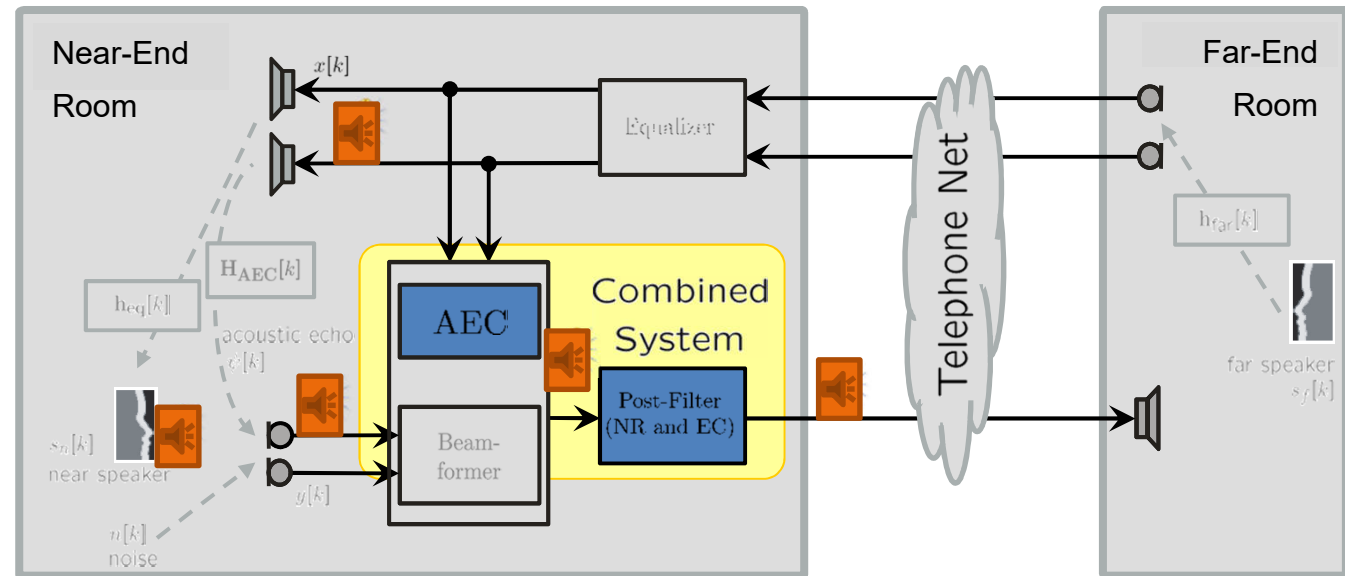
# Challenges in radio communication





- Pick up the speech signal with high quality

# Signal enhancement to improve input signal quality




- Acoustic echo cancellation



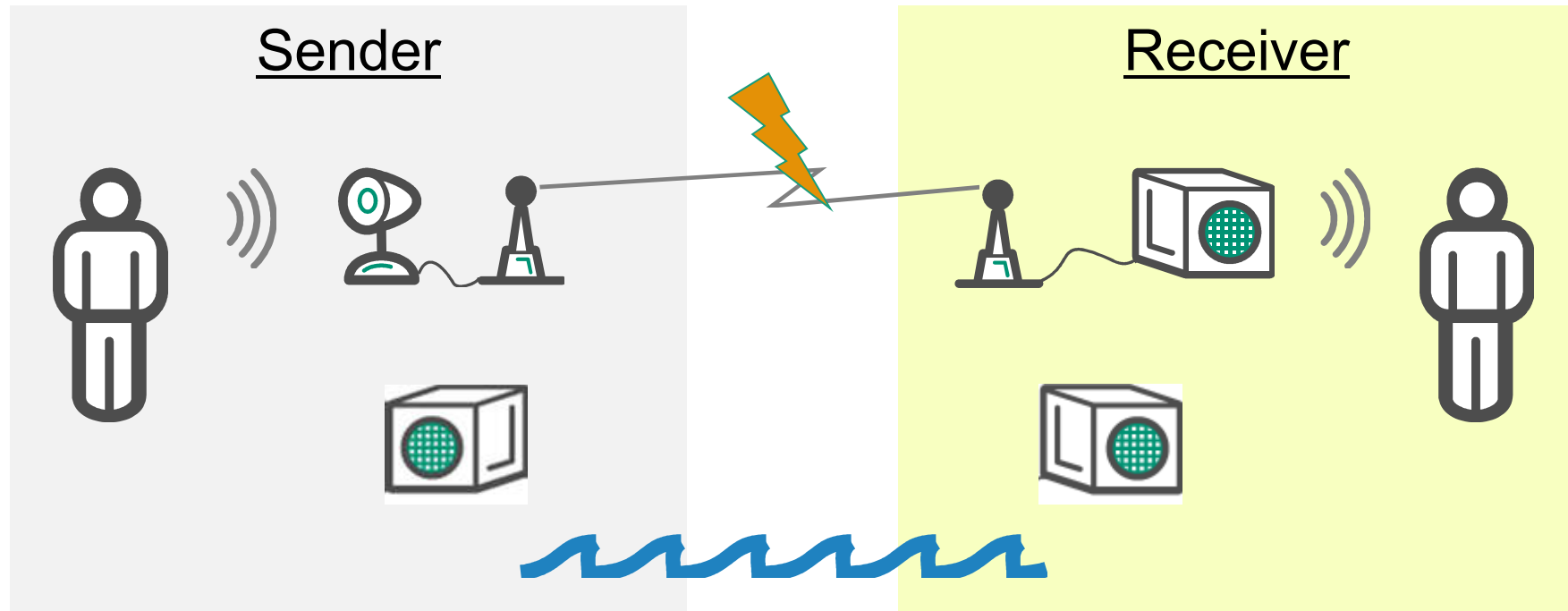
- Dynamic directional filtering to suppress ambient disturbances

 Mixed input signal  
 Filtered / focused signal

- Dereverberation

 Input signal  
 Signal with reverberation  
 De-reverberated signal

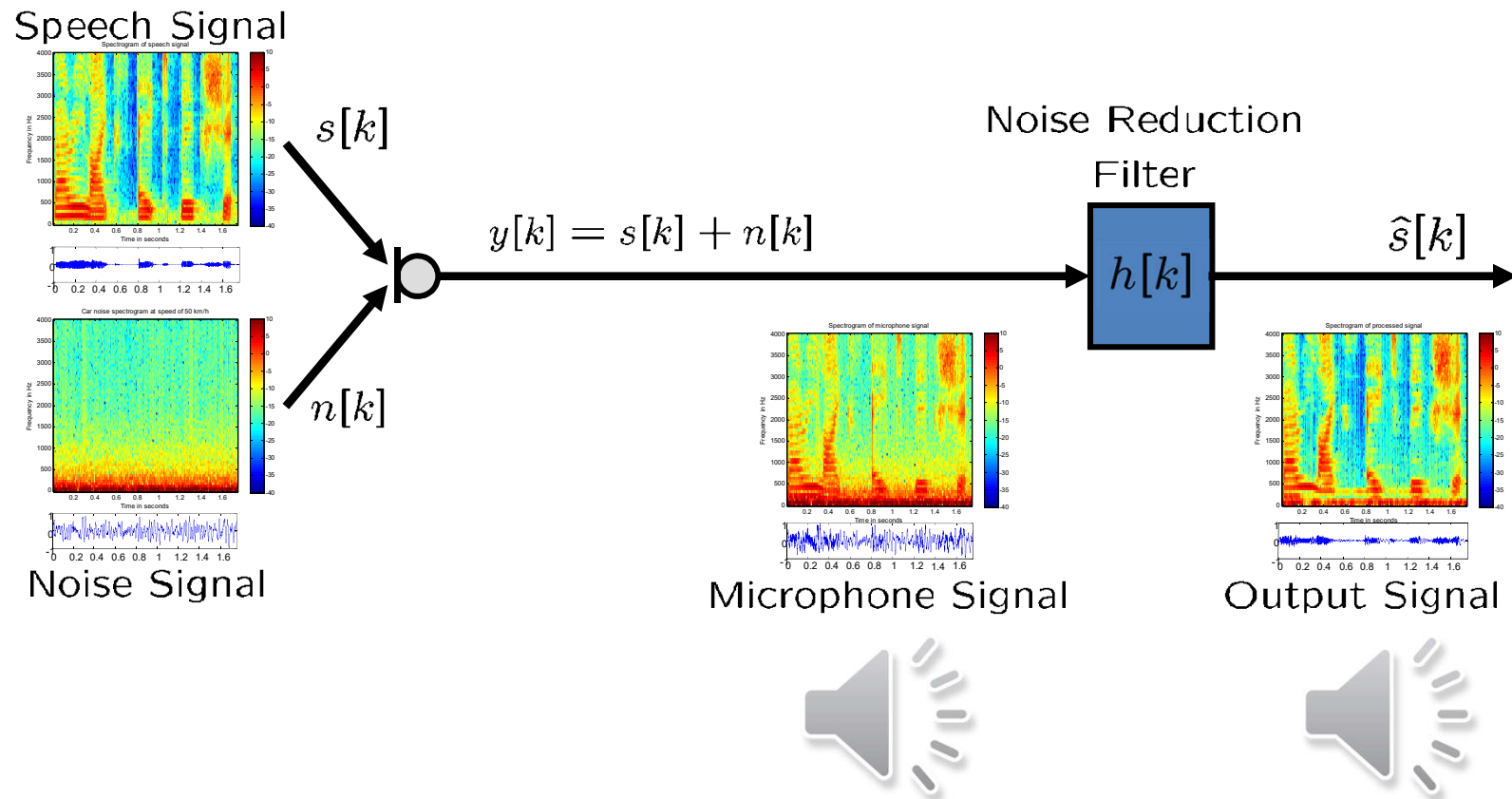
# Challenges in radio communication



- Optimal presentation of the speech signal

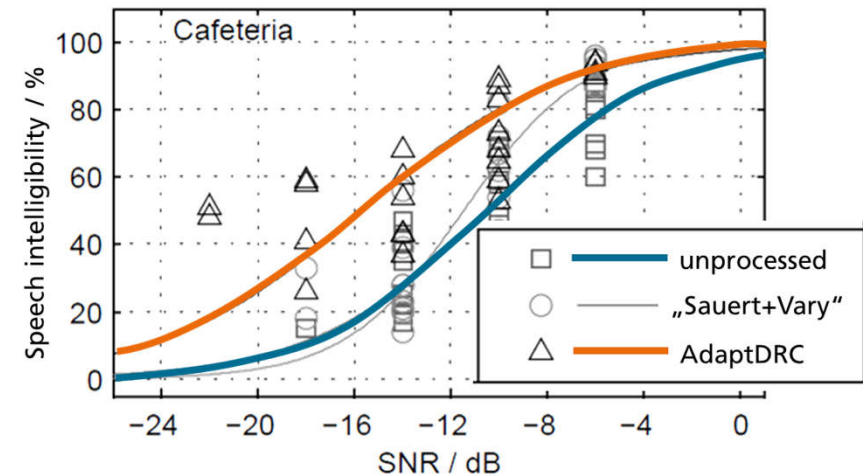
# Signal enhancement to optimize the output signal

## ■ Single channel noise reduction



# Signal enhancement to optimize the output signal

- Optimize speech presentation in a fixed noisy environment



Unprocessed



AdaptDRC

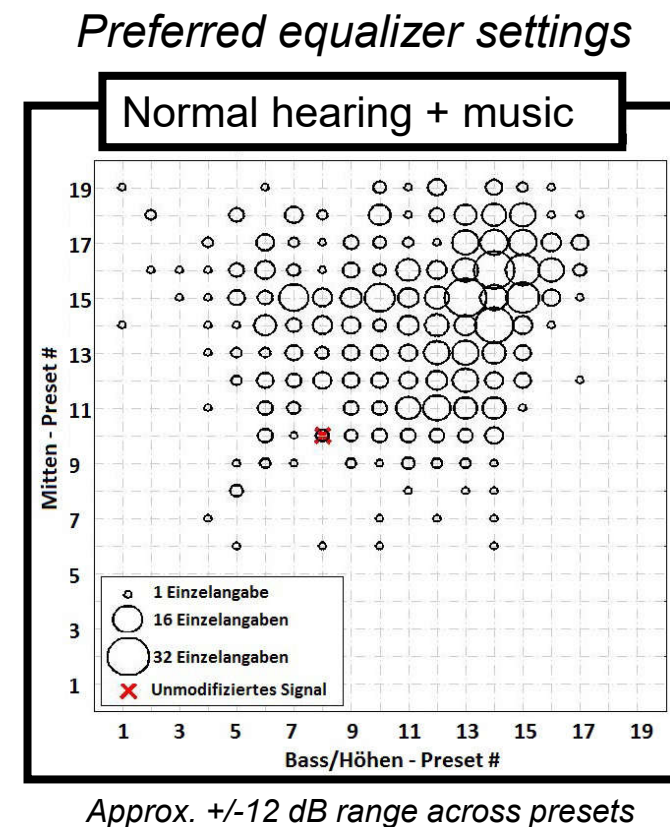


AdaptDRCplus

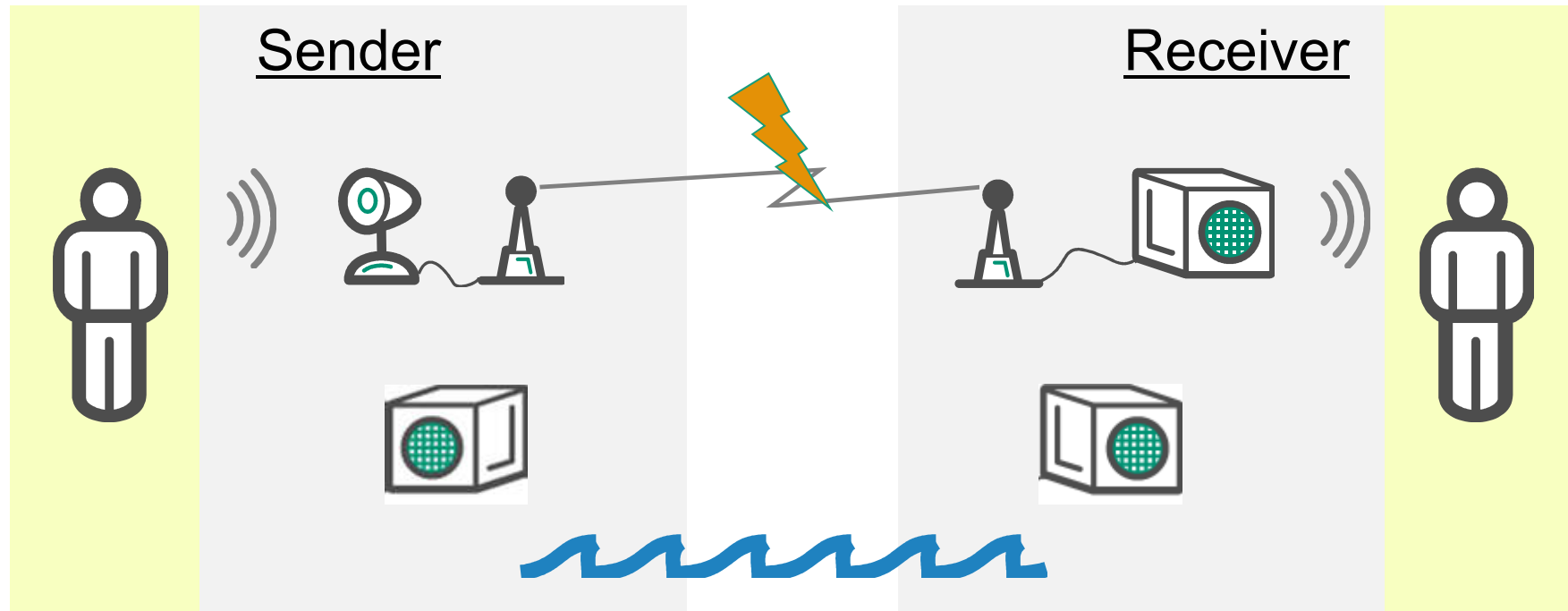
# Signal enhancement to optimize the output signal

## ■ Adopt sound to personal requirements / preference

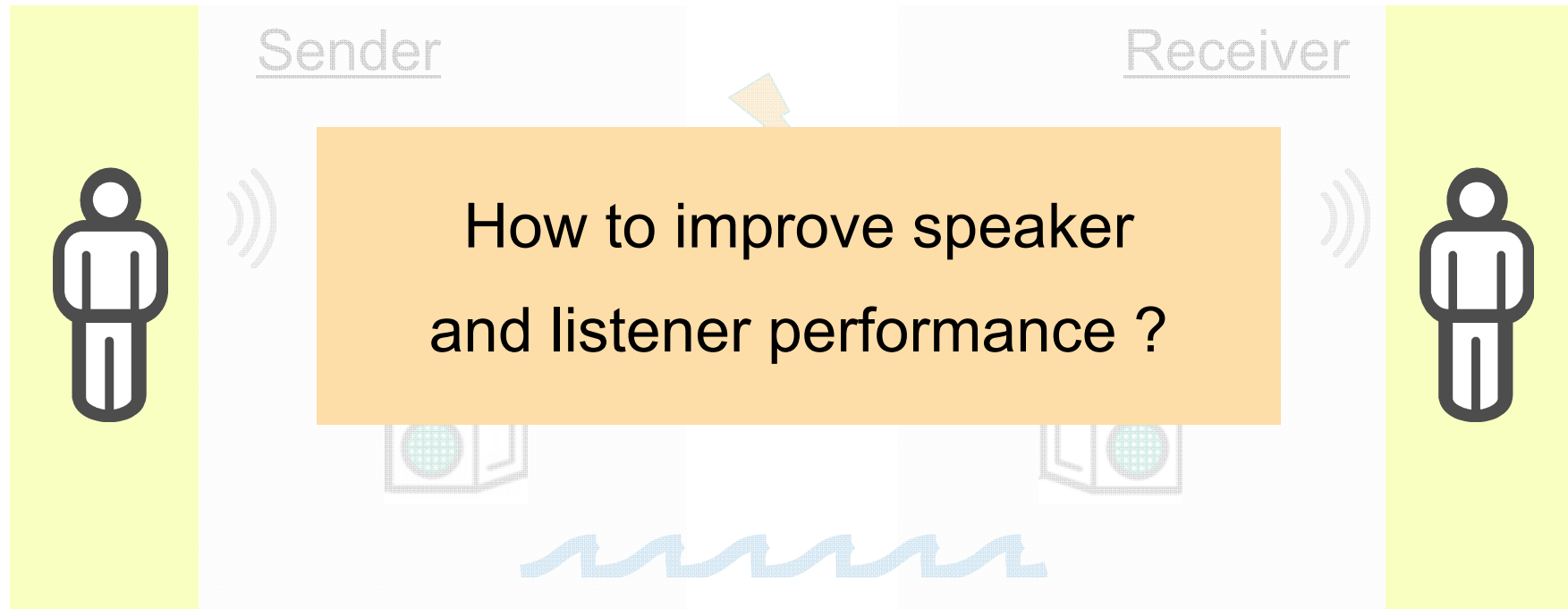
- Sound preferences differ widely with respect to frequency-shaping, volume and dynamic range already within normal-hearing listeners
- Fast and intuitive user interface needed
- Result:
  - better perceived speech intelligibility
  - less stressful communication



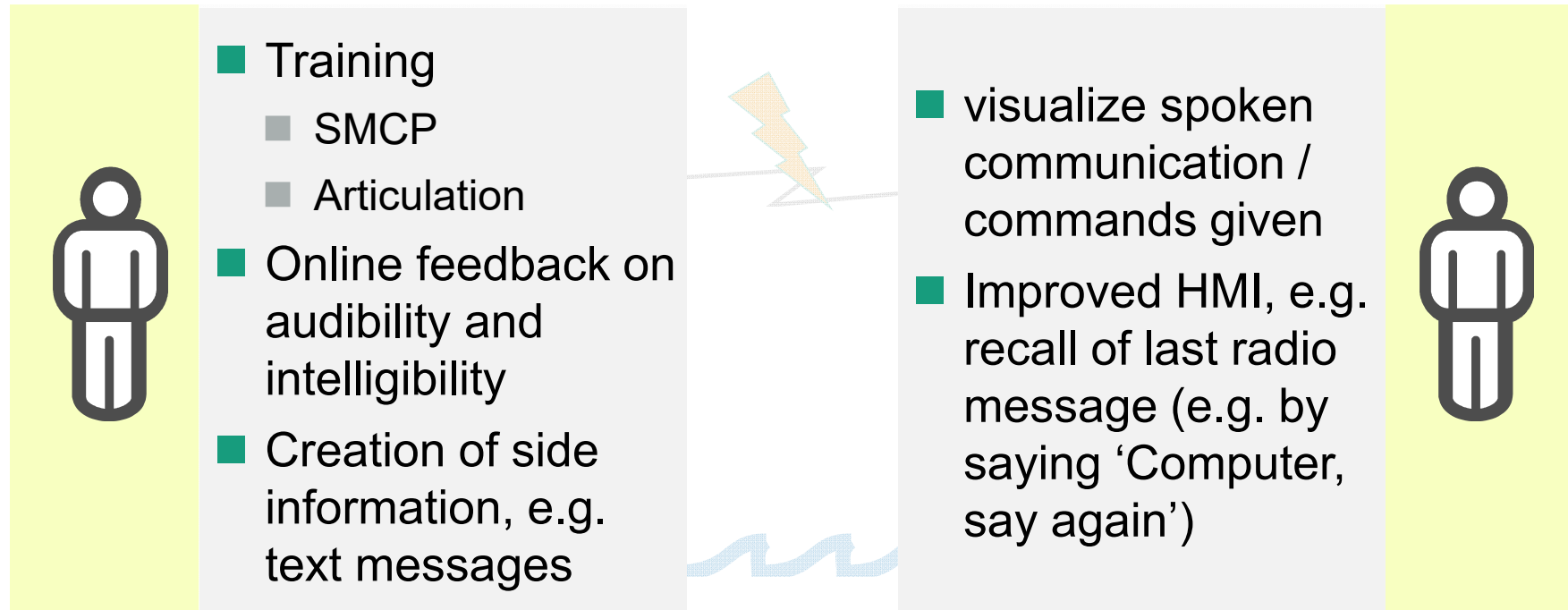
# Challenges in radio communication



# Challenges in radio communication



# Challenges in radio communication



# Automatic speech recognition (ASR)

## Today

No ASR available for recognition of Maritime English without Internet connection.

## Our goal

- Optimization of ASR technology for optimal recognition of Standard Marine Communication Phrases (SMCP)
- Research on ASR based human-machine-interaction
- Stand-alone system to allow decoding on ship

# Monitoring and Feedback on audibility

## Problem

Speaker does not know, how well (s)he will be understood at the receiver's end.

## Ideas

- Monitoring of audibility / speech intelligibility (preferably on receiver's end) and feedback to the speaker's
- Speech-Rate-visualization (optimal number of words per minute)



Bild © Furuno

# ASR-assisted VHF communication

## Challenge

Listener often receives VHF calls of poor audio quality and commands need to be repeated.

## Ideas

- Additional channel to visualize spoken communication as text
- Requires additional digital communication channel (e.g. on side band of VHF, Maritime Broadband or VDES)



Bild © Furuno

# ASR as a Human Machine Interface (HMI)

## Challenge

Repetition of VHF call is time-consuming and puts strain on bandwidth.

## Ideas

- Computer-based replay of speech communication with or without text display of transmitted message: *“computer, say again”*
- Better situational awareness of nautical officers by use of speech interface with on-board systems:
  - *“GPS, what is my position?”*
  - *“ECDIS, what is the depth of water?”*
  - *“What is our present rate of drift?”*

# Computer-assisted radio communication training

## Challenge

Training of verbal communication is time-consuming and costly.

## Ideas

- Use of ASR technology for computer-assisted radio communication training
- Verbal exchange built on Artificial Intelligence (AI) adapts to individual trainee and provides personal feedback on
  - vocalization
  - speech rate
  - general intelligibility
- Computer-based assessment of radio operators (standardized pre-selection process)

# Conclusion

- Audio technologies researched and developed for other domains, like the hearing aid or consumer market, have a high potential to support communication ship to shore and ship to ship.
- In particular Automated Speech Recognition (ASR) developed and optimized for the marine sector can
  - support verbal communication
    - by providing feedback on speech attributes either as a training or within a communication,
    - by presenting speech2text-based textual information
  - simplify human-machine-interaction