Speech Communication in Emergency Call Scenarios for Motorcycles

Frank Kettler, Silvia Poschen, Marc Lepage, Radi Serafimov

HEAD acoustic GmbH, 52134 Herzogenrath, E-Mail: Frank.Kettler@head-acoustics.de, Silvia.Poschen@head-acoustics.de, Marc.Lepage@head-acoustics.de, Radi.Serafimov@head-acoustics.de,

Motivation

ECall systems are integrated in new car models as they become mandatory from March 2018 on in EU. The Russian market requests this already since 2015. Besides sending a minimum set of data (MSD) including position and vehicle information, voice communication to the nearest public safety answering point (PSAP) for assistance is an additional feature in such systems. Specifications for speech communication are available for eCall systems in cars, such as the Russian MGS/GOST R55531 Specification ([1], currently in the transition phase to GOST 33468 [2]) or ITU-T Recommendation P.1140 [3]. The requirements within the specifications are challenging but feasible, and both specifications are designed with a slightly different focus.

ECall systems for powered-two-wheelers (P2W) are more challenging as the triggers -in cars this is typically the airbag sensor- are not as reliable as in cars. Furthermore, a voice communication is subject to specific challenges due to the acoustic environment, stronger limitations on microphone and loudspeakers and in particular the extreme situations in crash scenarios: bikers may be far away from their motorcycle after a crash [4]. This dramatically increases the problem of speech communication, from the driver to the PSAP and vice versa. However, the advantage of possible speech communication is undisputable. Consequently, reasonable requirements are needed for appropriate system design. The most important test case should be the so called "silent call" scenario which may require a different design and tuning strategy of such implementations. The contribution discusses these challenges and the derivation of potential limits for different tests based on laboratory test results.

Introduction

Besides the general challenge of reliable sensors to trigger eCalls from motorcycles, the design, size, position and orientation of acoustic transducers is crucial. They need to be absolutely robust, waterproof, small and cheap. Furthermore, voice communication in eCall scenarios for motorcycles always need to consider free-field communication. The motorcycle manufacturers clearly state, only to support in-vehicle systems (IVS) instead of rider based equipment, e.g. microphone and speakers mounted in helmets. Only IVS can be maintained and updated by the manufacturers, and such systems would work independently of the rider based equipment.

Another obvious difference between eCall scenarios for motorcycles and cars is the distance between driver and the vehicle, i.e. the motorcycle after a crash. According to [4] the median throwing distance for the rider is approximately 6 m, whereas the throwing distance for the motorcycle itself is around 10 m. This leads to typical "use cases" with IVS and rider in minimum 4 m distance. Consequently, the so called "silent call" test case can be seen as the most important aspect.

Four wheelers versus powered two wheelers

The communication situation between a driver or passenger in a car versus a motorcycle seem to be quite different at a first glance. However, a more detail insight in the different scenarios shows some important conformities (**table 1**).

Table 1: Survey of communication scenarios and requirements for emergency calls

	Cars	Motorcycles
Scenario	manual eCall / conscious passengers	manual eCall / biker uninjured
Requirements	regular hands-free	
Scenario	unconscious passengers in the car	unconscious biker away from bike
Requirements	"Silent Call"	
Scenario	First aiders / passengers outside car	First aiders / biker conscious but away from bike
Requirements	distant communication, specific tests and requirements, "Silent Call"	

A manually triggered eCall with conscious passengers in the vehicle or an uninjured biker close to the motorcycle can follow standards of regular communication and regular requirements for voice communication. Tests and limits need to consider the free-field scenario for motorcycles.

Unconscious passengers in a crashed car or unconscious bikers away from the bike are typical "silent call" scenarios for the public safety answering point (PSAP): The call is established, but no person is actively communicating. The PSAP operator can only judge the severity of the crash by environmental acoustic information transmitted from the place of accident to the PSAP side.

In case first aiders are communicating from (typically) outside the car or from certain distance to a bike with the PSAP side, or the passengers from the crashed car left the car, or the biker is conscious but away from the bike, specific tests and requirements need to be designed. Again the "silent call" scenario can be regarded as the most appropriate scenario; corresponding requirements need to be applied for system design and testing. Note that such a scenario is already covered by tests in ITU-T P.1140 [3].

Testing approach using mobile phones

In order to gain experiences and to reproduce a typical and realistic scenario for testing eCall communication from motorcycles, different waterproofed mobile phones operated in handheld hands-free mode were mounted to a motorcycle (see **figure 1**).

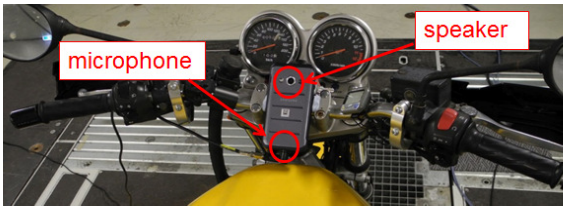

Figure 1: Laboratory test setup (I) with mobile phone operated in handheld hands-free mode

These tests were carried out with three commercial mobile phones designed for outdoor use, with waterproof transducers and housings. The position of an artificial head measurement system relative to the motorcycle is shown in **figure 2**. The distance between artificial mouth and the hands-free microphone was adjusted to approximately 62 cm, reproducing a position as derived with three randomly chosen test persons (realistic position standing beside the motorcycle).

Figure 2: Laboratory test setup (II), HATS position close to motorcycle

An important aspect that needs to be considered for P2W is the influence of helmets. **Figure 3** shows the HATS with mounted helmet in test room to determine transmission characteristics in sending and receiving direction. The tests are carried out first without helmet (as reference), with helmet and open visor and finally with closed visor.

Figure 3: HATS with mounted helmet for tests in sending (left) and receiving direction (right)

The frequency response analysis for the sending direction is shown in **figure 4** on the left-hand side. The analysis highlights the narrowband transmission range up to approximately 4 kHz.

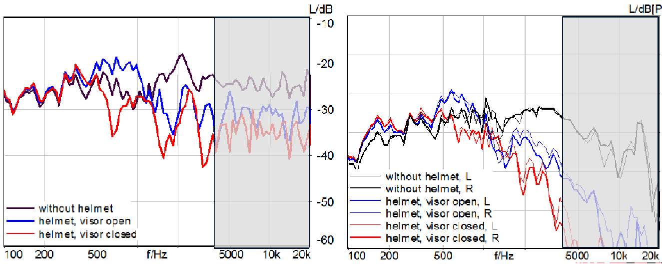

Figure 4: Frequency response in sending direction (left) and receiving direction (right). Grey shadowed frequency range: > 4 kHz.

The sending sensitivity without helmet is given by the black curve. The blue curve is measured with helmet but open visor, the red curve analyses the sending sensitivity with closed visor. Signals played back via the artificial mouth are significantly attenuated for frequencies higher than 1 kHz. The helmet introduces a lowpass characteristic, but the open visor leads to resonances in the mid frequency range (between 500 to 1.2 kHz).

A similar, but more distinct lowpass influence of the helmet can be determined for the receiving direction. The measured binaural curves are shown in the right-hand diagram in **figure 4**. Similar results can be measured with other helmet models.

Sensitivities in hands-free communication are typically expressed by loudness ratings. The Sending Loudness Rating (SLR) and Receiving Loudness Rating (RLR) are given in **table 2** for one device.

Table 2: Influence of helmet on HATS sending and receiving sensitivity of one device (example)

	SLR [dB]	Bin. RLR [dB]
at bike (62 cm)	13.0	9.5
2m, w/o helmet	**24.9**	**17.9**
2m, helmet open	**22.8**	**21.0**
2m, helmet closed	**27.3**	**24.6**

The microphone sensitivity was adjusted to 13 dB SLR for the 62 cm distance, representing a recommended SLR according to [1], [2], [3]. The measured SLR in **table 2** varies between approximately 23 and 27 dB, compared to 25 dB without helmet. Thus, the helmet causes a sensitivity variation in the range of ± 2 dB. The results in receiving direction are less ambiguous: The helmet covers both ears and therefore introduces signal attenuation, independent if the visor is opened or closed. The attenuation is in the range of 3 to 7 dB.

Sensitivity measurements were then carried out using three different mobile phones (outdoor devices with waterproofed transducers), mounted on the motorcycle headset. The HATS is positioned in 62 cm distance and then moved more far away to 1 m, 2 m and 4 m distance as shown in **figure 5**.

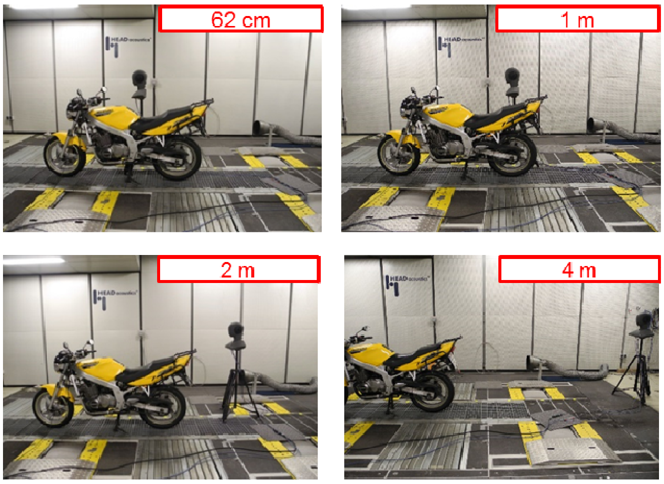

Figure 5: Laboratory test setup (III), HATS position in variable distance

The sending and receiving loudness ratings (SLR, RLR) are then determined for the devices. The SLR results are graphically analyzed in **figure 6**.

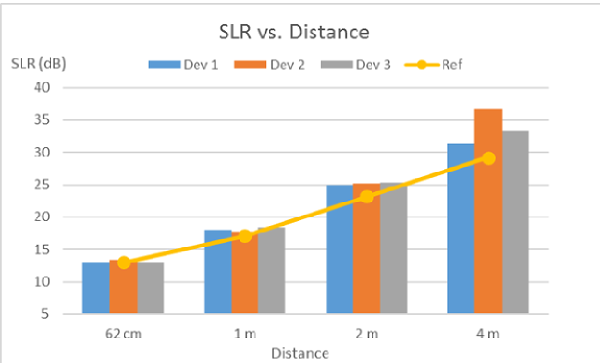

Figure 6: Analysis of SLR results

In addition to the devices (Dev 1 to 3) the sensitivity can also be estimated based on the acoustic distance law. These results are indicated by the yellow line (“Ref”). The results show that the devices in principle follow the theoretical results as calculated by the distance law, a double distance lowers the level by 6 dB, i.e. increasing the SLR accordingly.

The following estimation can be applied: A SLR of 13 dB in a hands-free scenario typically leads to an active speech level of approximately -20 dB_{m0} in mobile networks. The range of speech levels in networks is typically between -5 dB_{m0} and -35 dB_{m0}. It can therefore be estimated, that the SLR may increase up to approximately 28 dB, which would still lead to a reasonable active speech level of approximately -35 dB_{m0} in mobile network.

Considering this assumption, it can be stated, that the communication from a 4 m distance is a limiting case and would lead to a low, but still reasonable speech level in the network. Considering the helmet influence of ± 2 dB does not significantly influence this conclusion.

The corresponding measurements in receiving direction are analyzed in **figure 7**.

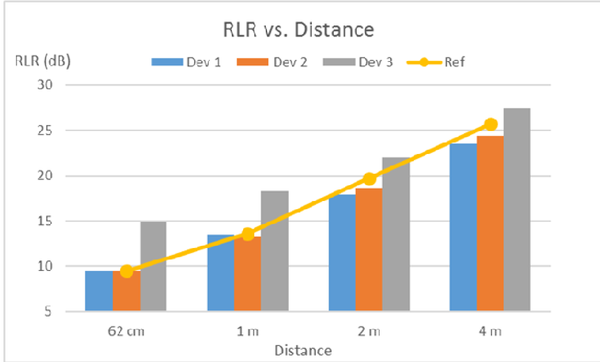

Figure 7: Analysis of RLR results

The reference curve (“Ref”) is again calculated based on the distance law. The RLR results increase with distance as expected. An RLR of around 20 dB corresponds to approximately 55 dB SPL active speech level. This can be regarded as a similar range of perceived speech level in a face to face communication in 2 m distance. This speech level is low but can still be regarded as acceptable. However, considering the additional 3 to 7 dB attenuation introduced by a helmet (see **table 1**), this clearly shows the limitations of a setup as it was realized here using mobile phones. The loudspeaker playback in eCall scenarios for motorcycles can be regarded as the bottleneck in terms of sufficient playback level in realistic distances between motorcycle and the rider after a crash.

Importance of “Silent Calls”

The term ”silent call“ describes an emergency call for the PSAP side without voice communication. This is an important aspect already today since emergency calls can be initiated from mobile phones without necessarily unlocking the device. Silent calls (see also **table 1**) may also appear

- in situations with manual eCalls from vehicles, when driver respectively passengers have left the car to provide assistance as first aider,
- in automatically generated eCalls, when driver and passengers left the vehicle without being seriously injured - as it is recommended by the police, e.g. for accidents on highways,
- or when driver or passengers are unconscious in the car or bikers (or first aiders) are in far distance from the bike after a crash.

The only chance for the PSAP side to judge the severity of a call is to amplify the transmitted signal at the PSAP side as much as possible and gather the information from the transmitted acoustic environment. The transmitted ambient noise carries important information for the PSAP operator in this case.

It can be assumed that the silent call scenario is the most important aspect for voice communication over emergency call systems for motorcycles. Consequently, the specific requirements on implemented signal processing in such IVS devices should be considered, in particular a very moderate or even disabled noise reduction [3].

Conclusion

As IVS emergency call systems for motorcycles are subject to many restrictions, the implementation of voice communication over IVS should not follow the traditional approach, to provide hands-free communication with optimized noise reduction and double talk capability. Other scenarios like the consideration and optimization of environmental noise transmission in silent call scenarios needs to be emphasized. It is reasonable to apply ITU-T P.1140 tests also for P2W eCall tests, but significantly adapt limits and tolerances, emphasizing the silent call test cases in the design and verification of such systems.

References

[1] GOST R55531-2013, Test methods for verification of in-vehicle emergency call system conformity to quality requirements for loudspeaker communication in vehicle cabin, National Standard of the Russian Federation

[2] GOST 33468-2015, Test methods for verification of in-vehicle emergency call device /system conformity to requirements for loudspeaker communication in vehicle cabin, Interstate Standard 2015

[3] ITU-T P.1140, Communications involving vehicles, Speech communication requirements for emergency calls originating from vehicles, 09 2016

[4] Frederik Harnischmacher et al (I_HeERO); State of the art assessment of Powered Two-Wheelers (P2W) eCall, 11th IST European Congress, Glasgow, Scottland June 06-09, 2016