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(54) **Method and system for optimizing the speech intelligibility in a passenger compartment of a vehicle**

(57) A method for optimizing the speech intelligibility in a passenger compartment of a vehicle comprises establishing an acoustic room model of the passenger compartment, establishing background noise data inside and outside the compartment, establishing speaker data, determining a speech intelligibility factor on the basis of the acoustic room model, the background noise data and the speaker data at at least one first test point in the compartment; comparing the determined speech intelligibility

factor with a predetermined speech intelligibility factor and modifying at least one of the speaker characteristics, the geometrical layout and acoustically active material of at least one installation in the compartment in case the predetermined speech intelligibility factor exceeds the determined speech intelligibility factor. Thereby, physical tests may be minimized and optimal speech intelligibility can be ensured.

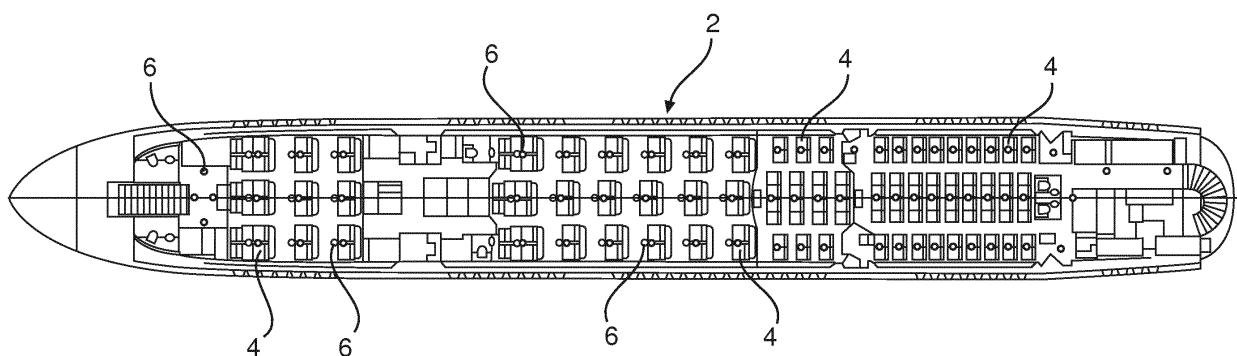


Fig. 1

Description

TECHNICAL FIELD

[0001] The invention relates to a method and a system for optimizing the speech intelligibility in a passenger compartment of a vehicle.

BACKGROUND TO THE INVENTION

[0002] In passenger transport vehicles, e.g. aircraft, public address systems are installed for the purpose of broadcasting safety-related announcements to the passengers. Certification requirements prescribe minimum performance standards and installation requirements for such systems. One requirement is the speech intelligibility at the passenger seats.

[0003] Commonly, each moderate and large modification to a passenger compartment and an aircraft structure may be physically tested in flight for the purpose of certification on speech intelligibility.

[0004] US 20120267476 A1 and EP 2512925 A2 disclose acoustically optimized air conditioning components with sound-dampening walls having a multilayer design with a core layer and cover layers. It is proposed to use one acoustically transparent cover layer, wherein the acoustical transparency relates to the frequency range of speech intelligibility, in order to prevent noise input in this frequency range into the cabin region.

[0005] US 20110147117 A1 discloses a vacuum waste-water system sound-absorber which achieves a broad-band reduction in the arising flow sounds from a vacuum system and/or a vacuum device. The attenuation of the sound absorber system is particularly designed to reduce noise with medium and high frequencies of 1-4 kHz so that the range of highest hearing sensitivity and speech intelligibility is optimally covered.

[0006] DE 10 2007 030 811 A1 discloses a flat speaker for the use in a passenger cabin of an aircraft, while DE 10 2006 049 030 B3 discloses a speaker system for a passenger cabin having exciters attached to functional surface elements in the cabin.

[0007] DE 10 2006 031 433 B4 shows an exciter for surface membrane speakers. DE 10 2006 005 584 B4 shows an audio system for a passenger aircraft and a method for controlling the same.

SUMMARY OF THE INVENTION

[0008] The known prior art does not provide any method or system for optimizing the speech intelligibility on board a vehicle. Only dedicated speech intelligibility increasing solutions for certain noise producing components inside the passenger compartment are known. For optimizing the overall speech intelligibility in the passenger compartment physical tests are necessary, which are cost and labor intensive and time consuming. The question must be raised whether the amount of flight tests

may be reduced for the purpose of cost reduction but maintaining certification.

[0009] It may thus be an object of the invention to propose a method for optimizing the speech intelligibility in a passenger compartment of a vehicle with a least possible amount of physical tests.

[0010] The object is met by a method for optimizing the speech intelligibility in a passenger compartment of a vehicle comprising the features of independent claim 1. Further improvements and embodiments may be gathered from the subclaims and the following description.

[0011] A method for optimizing the speech intelligibility in a passenger compartment of a vehicle is proposed. The method comprises the steps of establishing an acoustic room model of the passenger compartment based on a geometrical layout of the compartment and acoustically active material of installations in the compartment; establishing background noise data inside and outside the compartment; establishing speaker data based on the characteristics and position of at least one speaker in the compartment; determining a speech intelligibility factor on the basis of the acoustic room model, the background noise data and the speaker data at at least one first test point in the compartment; comparing the determined speech intelligibility factor with a predetermined speech intelligibility factor; and modifying at least one of the speaker characteristics, the geometrical layout and acoustically active material of at least one installation in the compartment in case the predetermined speech intelligibility factor exceeds the determined speech intelligibility factor.

[0012] The acoustic room model of the compartment provides the ability to numerically simulate how sound behaves in the compartment by means of a set of physical parameters and a set of algorithms defining physical relationships. The compartment may be defined by using geometrical data, e.g. through a CAD module and may be based on a 2-D layout of the compartment. All installations in the compartment should be considered, such as passenger seats, wall and ceiling cladding or lining elements, floor coverings, partition walls and curtains, luggage compartments and all kinds of monuments useful for a passenger compartment, e.g. toilets and galleys. It goes without saying that the installations depend on the type and use of the vehicle.

[0013] The geometrical data are to be enhanced by material properties, which may be assigned to all surfaces that are "acoustically active", which is to be understood as surfaces facing into the compartment, being impinged by sound waves and being responsible for sound absorption and reverberation. For example, material properties may include absorption coefficients. These may be taken from literature for common materials of building or vehicle acoustics, may be determined by way of physical tests or may be estimated. Hereby, the different physical mechanisms of a plate absorber and a porous absorber have to be taken into account for different materials. The reverberation and absorption characteristics may be de-

terminated by physical tests for a fraction of the present surfaces and remaining surface properties may be estimated. A further important parameter for the determination of speech intelligibility is the scattering coefficient, which may also be assigned to each surface in the compartment to model a diffuse reflection. However, a scattering coefficient only has minor effects on a speech intelligibility and it is hardly possible to measure or determine this parameter for each surface of the passenger compartment. Consequently, a global scattering coefficient may be assumed, which may be in a range of 20-40 % and preferably at about 30 %.

[0014] If it is intended to use acoustic room models for a large variety of different compartment layouts it may be feasible to cross check simulation results of at least one compartment layout with physical tests of the respective compartment layout. In case of unacceptable deviations between simulation results and related physical tests, simulation parameters may be tuned. For example, absorption coefficients may be tuned as long as simulated reverberation times are not congruent with measured reverberation times.

[0015] A certain speech intelligibility is required for different operational phases of the vehicle, which are responsible for the background noise inside and outside the compartment. Background noise data may be established by physical measurement using microphones, while background noise data may always be used for different compartment layouts. As an alternative, background noise may be simulated under consideration of all noise producing installations of the respective vehicle, such as propulsion units, gears, hydraulic and electric motors, etc.. In case different compartment layouts lead to different background noise producing installations, background noise data may be tuned under consideration of the change in background noise producing installations. However, as the spectrum of background noise may be rather broad, background noise measurement should be performed carefully.

[0016] The establishing of speaker data based on the characteristics and position of at least one speaker in the compartment may be performed by simply adding speakers into the acoustic room model as sound sources. Speakers may commonly be located above the passenger seats in a predetermined spacing. The sound produced by the speakers depends on the input signal as well as the dynamic characteristics of the speakers. The input signal may be tuned by at least one filter and a gain.

[0017] A core step of the method according to the invention is the determination of a speech intelligibility factor on the basis of the above described acoustic room model, the background noise data and the speaker data at at least one first test point in the compartment. The speech intelligibility may be described by a so-called "speech transmission index" (STI), which expresses the ability of the transmission channel from the origin of speech to the passengers in the passenger compartment to carry across the characteristics of a speech signal.

The STI predicts a likelihood of syllables, words and sentences being comprehended and being a numerical value in the range from 0 ("bad") to 1 ("excellent"), while a value of at least 0,5 is desirable for most applications. The speech intelligibility depends on a speech level, a frequency response of the above mentioned transmission channel, distortions, the background noise frequency spectrum and levels, characteristics of speakers, reverberation times, echoes and psychoacoustic effects (masking effects). As an alternative to STI, the so-called "rapid speech transmission index" (RASTI) may provide a more practical solution, as it does not take the whole signal-degrading effects of electro-acoustic components into account. Further alternatives to STI and RASTI may be the "articulation index" (AI), the "speech intelligibility index" (SII), the "speech transmission index for public address systems" (STIPA) or similar indices.

[0018] It goes without saying that the determination of speech intelligibility may be conducted for a number of different listening positions (first test points), which may be located in the vicinity of different speakers. Hence, a field or array of speech intelligibility factors may be established for the purpose of further processing.

[0019] After determining the speech intelligibility factor, it is to be compared to a predetermined speech intelligibility factor. If, for example, the speech intelligibility factor STI is used, values in the range of 0,5 and 0,7 may be required on board a passenger compartment, depending on the operating condition of the vehicle. A comparison to such a predetermined speech intelligibility factor results in a conclusion whether it is sufficient or insufficient.

[0020] In order to adjust the setup of the above mentioned transmission channel to achieve sufficient speech intelligibility factors throughout the passenger compartment it is proposed to modify at least one of the speaker characteristics, the geometrical layout and acoustically active material of at least one installation in the compartment in case the predetermined speech intelligibility factor exceeds the determined speech intelligibility factor. Preferably, the method step chain of determining the speech intelligibility, comparing the determined speech intelligibility and modifying the above mentioned parameters constitutes an iterative method. Hence, the modification may be conducted a plurality of times in case the speech intelligibility after a modification does not reach the predetermined speech intelligibility, in order to reach convergence.

[0021] One of the possible parameters to be modified, the speaker characteristics, may include a certain filter setting or an individual gain for the input signal of the respective speaker. In case the individual gains of all speakers in the passenger compartment need to be raised or may be lowered, a central gain may be adjusted as well. For example, in AIRBUS aircraft a cabin intercommunication data system (CIDS) is installed, which is a core system for many cabin related functions in the aircraft and operates and monitors various passenger

and crew functions such as: passenger / cabin announcement, cabin temperature control, water / waste tank level indication, cabin illumination, emergency & evacuation signaling, lavatory smoke warning & indication, aircraft doors & slides Status, IFE system status, and more. A control unit included in the CIDS, the so-called "CIDS director", allows to receive an audio signal, e.g. through a connected handset, and is adapted for adjusting an individual gain and a master gain applied to each speaker signal. The speaker signal is broadcasted to the speakers in the passenger compartment, wherein the frequency settings of the speakers may also be adjusted individually. Hence, in case altering the speaker characteristics is sufficient for improving the speech intelligibility, the individual gains, a master gain or filter settings may be tuned.

[0022] A further parameter to be modified, the geometrical layout, may be helpful if only in certain spots of the passenger compartment the speech intelligibility is insufficient due to excessive reverberation or reflection between parallel walls or the such. In case the iterative process of adjusting individual gains in these spots do not improve the speech intelligibility, a change of the geometrical layout may be considered automatically. It goes without saying that geometrical layout changes should be avoided as much as possible, as the geometrical layout usually is elaborate and optimized.

[0023] A still further parameter to be modified, the material of (acoustically active) surfaces, may be promising, if adjusting individual gains is not helpful in improving the speech intelligibility. Such a change of a material in relevant spots may be considered automatically. For example, in certain spots with increased reverberation or reflection, a material with a higher absorption coefficient may be considered, accompanied by a slight increase of individual gain.

[0024] Concluding, the method according to the invention provides an excellent, time efficient process to optimize the speech intelligibility. By simulating the sound transmission from a sound source to the passengers in a passenger compartment of a vehicle physical tests may be eliminated. By means of a converging iterative process certain parameters may be modified in order to reach a desired speech intelligibility.

[0025] In an advantageous embodiment, at least one of establishing the acoustic room model and of establishing background noise data includes conducting a physical speech intelligibility test for at least one representative layout of the passenger compartment and validating the acoustic room model or the background noise data, respectively. The representative layout includes the geometrical layout, the installation components and the material properties of all acoustically active surfaces. This is especially advantageous in the process of configuring a new cabin configuration and/or vehicle design. An evaluation and certification process for speech intelligibility is extended by validation aspects of the numerical models used for a prediction of speech intelligibility. The rel-

evant steps may usually be handled outside the process but are linked to the general passenger compartment noise prediction process. By conducting a physical test, test data are produced and may be used for adjusting the established acoustic room model. Hereby, the sensitivity to model parameters as well as to vehicle operation parameters may be validated. Vehicle operation parameters may exemplarily be a flight state including flight speed, altitude, angle of attack, high lift system state, etc. Physical tests may be limited to a "head of version", which exemplarily stands for the first customer version of an aircraft, which is extensively tested as a benchmark aircraft for other aircraft of the model type for that customer.

[0026] In another advantageous embodiment establishing the acoustic room model includes establishing a base acoustic room model validated through physical speech intelligibility test and modifying the base acoustic room model to the desired layout of the passenger compartment. Hence, the accuracy of the acoustic room model may be increased by using a validated and very exact base model, which may be tuned or adjusted to the desired layout.

[0027] In a still further advantageous embodiment determining a speech intelligibility factor includes at least one of a robustness analysis of the acoustic room model and a definition of an uncertainty range. For the certification of a vehicle certain speech intelligibility values may be required. As simulation results may still have a certain inaccuracy, it is helpful to define an uncertainty range such that a sufficient probability is given to meet the requirements.

[0028] For the sake of clarifying the process of modifying at least one of the speaker characteristics, the geometrical layout and the acoustically active material, the relevant parameters are further explained in the following. Basically, three groups of parameters to be modified during the optimization are of interest, while the order of mentioning these parameters is completely arbitrary.

a) Geometrical design and environment

[0029] Generally, geometrical design and environment parameters influence the speech intelligibility. The speech intelligibility is not the same at each spot inside the cabin of the vehicle. By modifying the geometrical design the speech intelligibility is influencable.

[0030] For example, the speech intelligibility depends on the speaker distribution. By increasing the number of installed speakers inside the cabin it may be possible to focus the sound propagation of each speaker to a smaller group of passengers in its vicinity and, consequently, the required sound pressure level of the individual speakers may be reduced. This leads to a more equal distribution of the sound pressure level inside the cabin. Instead, by reducing the number of speakers the individual sound pressure levels need to be increased, as a larger group of passengers needs to be addressed by the individual speakers.

[0031] Besides that the speaker positions are of particular relevance. The distance from the passengers to be addressed may impact the perception comfort significantly. For example, a speaker located on a side wall of the cabin, in a region near to a passenger, may suffer a strong level gradient to consecutive passengers or from the nearest ear of the adjacent passenger to the other ear, whereas over head or head-on locations may be preferred. Of course, the relevance of the speaker positions depend on available power, a targeted sound direction and background noise reverberation time / reflexion coefficient, a speaker directivity etc..

[0032] Furthermore it is clear that the number of speakers influences the sound level distribution and the induced power. In general, the sound level distribution may be more even with an increasing number of speakers.

[0033] Still further, the installation type of the individual speakers has an influence on the speech intelligibility. For example, the sound pressure level of a speaker built into a surface increases in a range of 6dB. A free, stand-alone, speaker may provide a more omni-directional radiation but a reduced sound pressure level. Also, a speaker installed in a way that 3 sides are enclosed by other components, such as a channel, a tube or a casing) may cause resonance effects, which is to be carefully considered regarding a change in the signal spectrum, but may cause an increased sound pressure level.

[0034] The boundary characteristics of a room may further influence the speech intelligibility, due to a reflection and absorption coefficient and a scattering coefficient. Exemplarily, an increased absorption may change the spectral content and reduce the background noise level, as well as reduce the reverberation time; both improving speech intelligibility. Besides that, a higher sound scattering generally reduces the level of early reflections which usually worsen speech intelligibility but lead to a higher diffuse field part with lower ability to locate the sound source.

b) Speaker type and characteristics

[0035] The shape and size of a speaker membrane has an effect on the speaker radiation characteristics. For example, oval membranes tend to form slightly focused beams, while circular membranes have more omni-directional characteristics, depending on the frequency and the size of the membrane.

[0036] Also, the speaker type may be chosen to influence the speech intelligibility. Besides common cone speakers also flat panel speakers, distribute mode speakers or hybrids of these speaker types may be used. Generally speakers of these types comprise big differences in how the sound is produced either by radiation of modes or structure vibrations on a "speaker" panel, by con-phase movement of membrane on cone speaker or con-phase movement of flat membranes or foils (e.g. piezo-foil, manger).

[0037] Increasing the efficiency of the speaker has a

positive influence on the speech intelligibility, as increasing the radiated sound power the sound to noise ratio at the same power input is decreased.

[0038] A still further parameter is based on the use of sound lenses, which change the spectral proportion through change in sound resistance. This also impacts the dispersion pattern slightly.

[0039] Furthermore, geometrical components in front of the individual speakers, e.g. a grill or a web, have an influence on the sound and cause a sound deflection by means of reflection or distribution of sound.

c) Signal processing and filtering

[0040] Grouping of speakers through signal conditioning, e.g. through setting signals phase and level correlations, provide directing the sound radiation (e.g. wave field synthesis (sound /wave field conditioning), beam-forming, ...) for influencing the speech intelligibility. By filtering the signal provided to the individual speakers, the amplification of speech relevant frequency bands (also use of "natural hearing" effects like head related transfer function supporting sound location through spectral content / shape) may be caused. Also, (inter) speaker signal group delays provide for the use of psychoacoustics / perception effects to improve and/or change the sound location and thus support the speech intelligibility (e.g. precedence effect, sound envelope).

[0041] The invention further relates to a system for optimizing the speech intelligibility in a passenger compartment of a vehicle. The system comprises a data processing unit having a data processor and a memory unit, wherein the data processing unit is adapted for receiving and storing an acoustic room model, background noise data and speaker data, wherein the data processor is adapted for determining a speech intelligibility factor on the basis of the acoustic room model, the background noise data and the speaker data at at least one first test point in the compartment; for comparing the determined speech intelligibility factor with a predetermined speech intelligibility factor; and for modifying at least one of the speaker characteristics, the geometrical layout and acoustically active material of at least one installation in the acoustic room model in case the predetermined speech intelligibility factor exceeds the determined speech intelligibility factor. The system according to the invention is a means for conducting the above mentioned method for optimizing the speech intelligibility.

[0042] It is preferred that the data processing unit is adapted for validating the acoustic room model and the background noise data, respectively, in relation to data from a physical speech intelligibility test for at least one representative layout of the passenger compartment.

[0043] Further, it is advantageous if the data processing unit is adapted for establishing the acoustic room model by means of modifying a base acoustic room model validated through physical speech intelligibility test to the desired layout of the passenger compartment.

[0044] Still further, the data processing unit is preferably adapted for conducting a robustness analysis of the acoustic room model and a definition of an uncertainty range.

BRIEF DESCRIPTION OF THE DRAWINGS

[0045] Further characteristics, advantages and application options of the present invention are disclosed in the following description of the exemplary embodiments in the figures. All the described and/or illustrated characteristics per se and in any combination form the subject of the invention, even irrespective of their composition in the individual claims or their interrelationships. Furthermore, identical or similar components in the figures have the same reference characters.

Fig. 1 shows an exemplary layout of a passenger compartment.

Fig. 2 shows a transmission channel from a speech source to a test point inside the passenger compartment.

Fig. 3 shows an exemplary embodiment of a method according to the invention.

Fig. 4 shows a result of the optimization of the speech intelligibility in the passenger compartment.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0046] Fig. 1 exemplarily shows an upper deck of a passenger compartment 2 of an Airbus A380 with a plurality of passenger seats 4 and speakers 6 distributed inside the passenger compartment 2 and associated to the passenger seats 4 and other areas such as toilets or galleys in a rear section of the passenger compartment 2. For broadcasting safety related announcements to passengers the passengers need to comprehend the speech information, which means that the speech intelligibility needs to be sufficient. The speech intelligibility may be expressed by a speech intelligibility factor which must equal a predetermined minimum speech intelligibility factor. As the passengers are exposed to background noise originating from outside and inside the passenger compartment 2, speakers need to be adjusted to reproduce a comprehensible sound.

[0047] As shown in Fig. 2 a transmission channel 8 exists that is responsible for the speech intelligibility. A speech source 10, for example the voice from a pilot, acts in a cockpit 12 upon a handset 14. As the cockpit 12 produces and is exposed to noise, additionally to the speech of the pilot background noise acts upon the handset 14. A signal from the handset 14 is transferred to a cabin intercommunication data system (CIDS) and is processed, e.g. through applying a certain gain and/or

by applying certain filters in a sound processing means 16. The amplified and optionally filtered speech signal is then transferred to speakers 6 as indicated in Fig. 1. As the passenger compartment 2 is exposed to and also produces noise, passengers 20 hear background noise and a mixed speech and cockpit background noise signal.

[0048] Due to various installations in the passenger compartment 2 the sound transfer from the speakers 18 to the passengers 20 is subjected to reverberations, echoing, dampening and other sound alterations. The transfer through the passenger compartment 2 may be simulated by an acoustic room model of the passenger compartment 2, which model is an analytic representation for the total sound alterations in the passenger compartment 2.

[0049] For optimizing the speech intelligibility inside the passenger compartment 2 with a least possible amount of physical tests an acoustic room model of the passenger compartment 2 based on a geometrical layout of the compartment 2 and an acoustically active material of insulations in the passenger compartment 2 is to be established 22, as shown in Fig. 3. As background noise is a main influence on the speech intelligibility factor background noise data inside and outside the compartment 2 is to be established 24. This may include both the acquisition of background noise through the use of microphones during a flight test as well as the computer aided simulation of background noise. Furthermore, as the speakers 6 are responsible for the reproduction of speech signals from the speech source 10 speaker data based on the characteristics and position of at least one speaker in the compartment 2 is to be established 26. Afterwards a speech intelligibility factor on the basis of the acoustic room model, the background noise data and the speaker data and at least one first test point in the compartment 2 is to be determined 28. Afterwards, the determined speech intelligibility factor is to be compared 30 with a predetermined speech intelligibility factor. In case the predetermined speech intelligibility factor exceeds the determines speech intelligibility factor at least one of the speaker characteristics, the geometrical layout and an acoustically active material of at least one installation in the compartment is to be modified 32. For optimization purposes the acoustic room model or the speaker data is thereby changed and the speech intelligibility factor is to be determined 28 again.

[0050] It may be preferred to first alter geometrical parameters, in case the design or layout in some sections of the cabin lead to an unduly low speech intelligibility. Additionally or, in case geometrical parameters may not be altered in the respective sections, the speaker type and characteristics may be altered. Additionally, or in case if altering speaker type and characteristics may not be altered, appropriate signal processing and filtering may be established.

[0051] It goes without saying that the method shown in Fig. 3 may also include a dependency on different op-

erating conditions. For example, the speech intelligibility depends on the speed of the vehicle due to different background noises and, if the vehicle is an aircraft, the flight phase, such as start, climb, cruise, descent and landing. Consequently, an optimization may be conducted for different operating conditions. For this purpose a geometrical setup may be investigated which may meet all requirements regarding the speech intelligibility in all operating conditions, such that it is sufficient to adjust electrical parameters need for adjusting the speech intelligibility. By conducting an operating phase depending optimization it may be feasible to create a parameter envelope for the signal processing and filtering, from which a cabin communication system, such as a CIDS in an aircraft, may choose appropriate gain and filter settings depending on the operating phase.

[0052] For example, the passenger compartment 2 shown in Fig. 1 leads to a (fixed) geometrical setup and certain modified and optionally flight phase depending gain values for speakers 6 as depicted in Fig. 4. Exemplarily, four different gain modification regions I to IV are chosen. In outer front and outer rear positions, the highest gain increase (I) is necessary, while in the middle section of the passenger compartment 2 the least gain modification (IV) is required. As the compartment layout should be modified to a least possible extent while optimizing the speech intelligibility, the exclusive modification of gain factors and/or other signal related parameters is preferred.

[0053] In addition, it should be pointed out that "comprising" does not exclude other elements or steps, and "a" or "an" does not exclude a plural number. Furthermore, it should be pointed out that characteristics or steps which have been described with reference to one of the above exemplary embodiments can also be used in combination with other characteristics or steps of other exemplary embodiments described above. Reference characters in the claims are not to be interpreted as limitations.

Claims

1. A method for optimizing the speech intelligibility in a passenger compartment of a vehicle, comprising:
 - establishing (22) an acoustic room model of the passenger compartment (2) based on a geometrical layout of the compartment (2) and acoustically active material of installations in the compartment (2);
 - establishing (24) background noise data inside and outside the compartment (2);
 - establishing (26) speaker data based on the characteristics and position of at least one speaker (6, 18) in the compartment (2);
 - determining (28) a speech intelligibility factor on the basis of the acoustic room model, the

background noise data and the speaker data at at least one first test point in the compartment (2);

- comparing (30) the determined speech intelligibility factor with a predetermined speech intelligibility factor; and
- modifying (32) at least one of the speaker characteristics, the geometrical layout and acoustically active material of at least one installation in the compartment (2) in case the predetermined speech intelligibility factor exceeds the determined speech intelligibility factor.

2. Method of claim 1, wherein at least one of establishing (22) the acoustic room model and of establishing (24) background noise data includes conducting a physical speech intelligibility test for at least one representative layout of the passenger compartment (2) and validating the acoustic room model or the background noise data, respectively.
3. Method of claim 1 or 2, wherein establishing (22) the acoustic room model includes establishing a base acoustic room model validated through physical speech intelligibility test and modifying the base acoustic room model to the desired layout of the passenger compartment (2).
4. Method of claim 1 or 2, wherein determining (28) a speech intelligibility factor includes at least one of a robustness analysis of the acoustic room model and a definition of an uncertainty range.
5. Method of one of the preceding claims, wherein the optimization is conducted depending on at least one operating phase of the vehicle.
6. Method of one of the preceding claims, wherein establishing (24) background noise data inside and outside the compartment (2) comprises a simulation of background noise.
7. Method of one of the preceding claims, wherein modifying (32) the speaker characteristics comprises at least one of adjusting the directional characteristics, changing of the speaker type and changing the installation situation of the speaker.
8. System for optimizing the speech intelligibility in a passenger compartment (2) of a vehicle, comprising a data processing unit having a data processor and a memory unit, wherein the data processing unit is adapted for receiving and storing an acoustic room model, background noise data and speaker data, wherein the data processor is adapted for determining (28) a speech intelligibility factor on the basis of the acoustic room model, the background noise data

and the speaker data at at least one first test point in the compartment (2); for comparing (30) the determined speech intelligibility factor with a predetermined speech intelligibility factor; and for modifying (32) at least one of the speaker characteristics, the geometrical layout and acoustically active material of at least one installation in the acoustic room model in case the predetermined speech intelligibility factor exceeds the determined speech intelligibility factor.

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9. System of claim 8, wherein the data processing unit is adapted for validating the acoustic room model and the background noise data, respectively, in relation to data from a physical speech intelligibility test for at least one representative layout of the passenger compartment (2).

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10. System of claim 8 or 9, wherein the data processing unit is adapted for establishing the acoustic room model by means of modifying a base acoustic room model validated through physical speech intelligibility test to the desired layout of the passenger compartment (2).

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11. System of one of the claims 8 to 10, wherein the data processing unit is adapted for conducting a robustness analysis of the acoustic room model and a definition of an uncertainty range.

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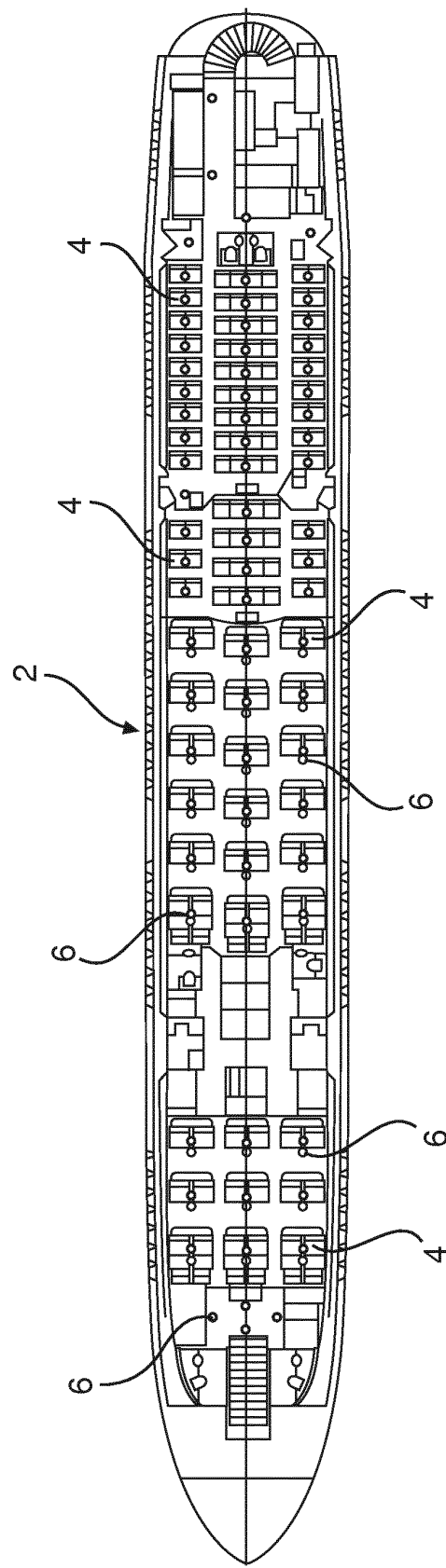


Fig. 1

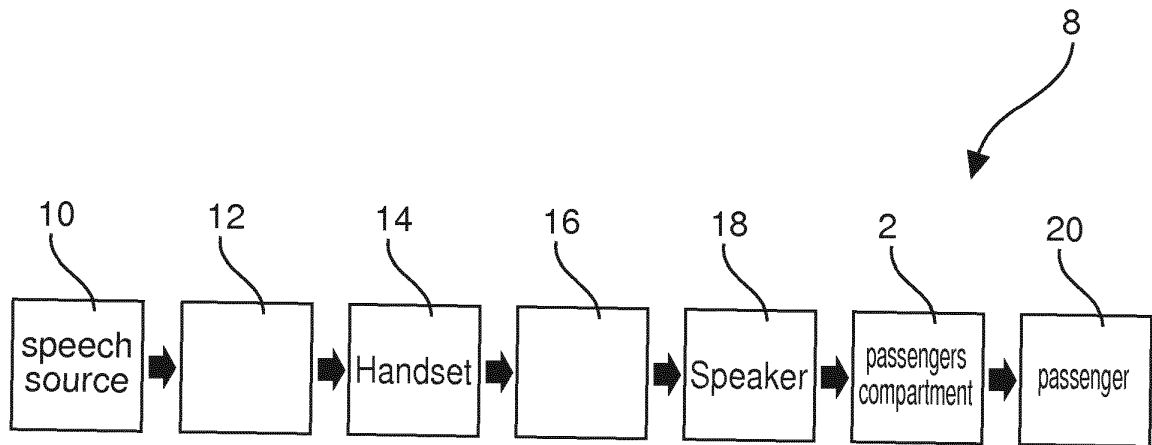


Fig. 2

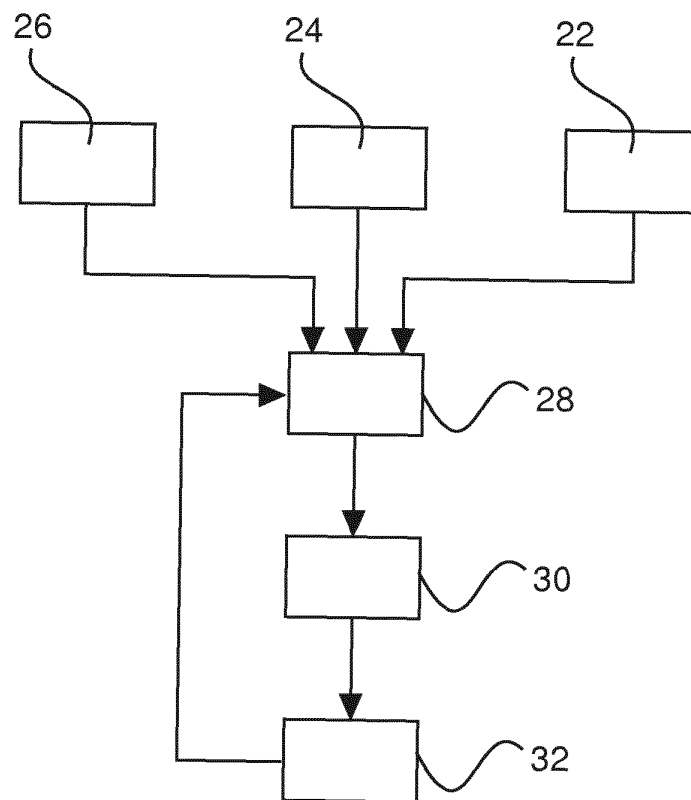


Fig. 3

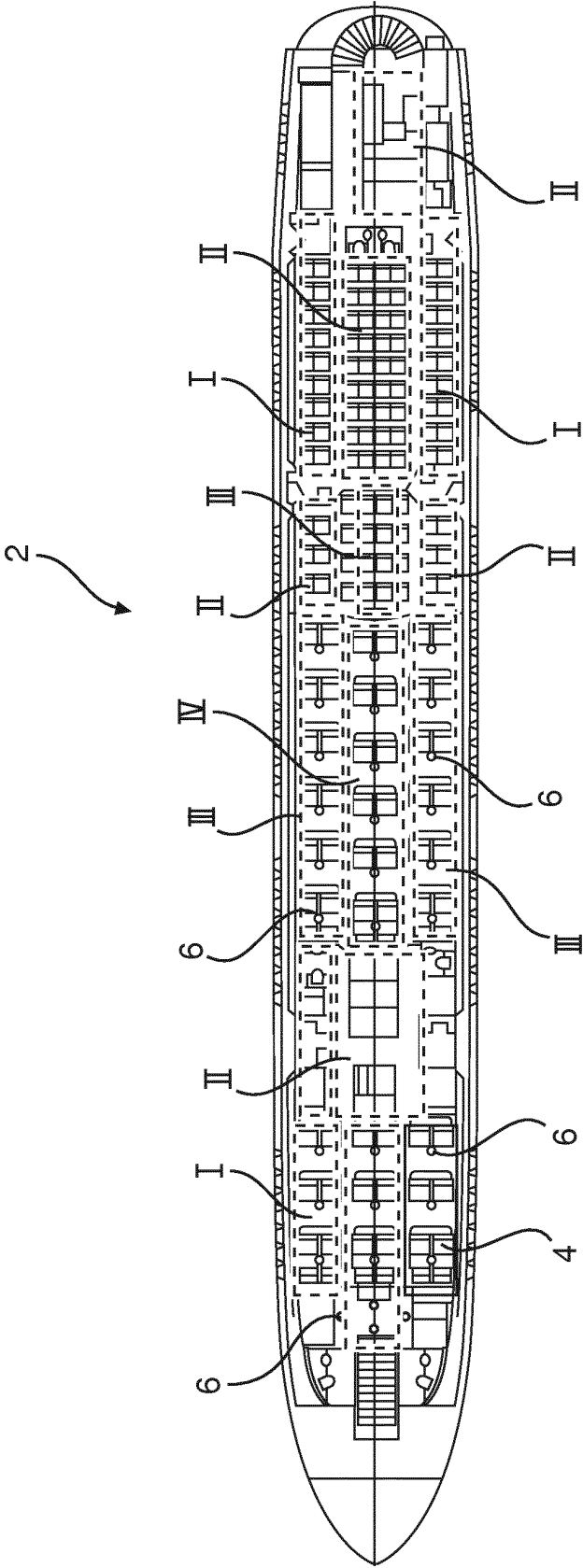


Fig. 4



EUROPEAN SEARCH REPORT

Application Number
EP 13 17 1814

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 14 November 2013	Examiner Bensa, Julien
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