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(54) Title: DEVICE AND METHOD FOR CLASSIFICATION OF ROAD SEGMENTS BASED ON THEIR SUITABILITY FOR PLATOONING

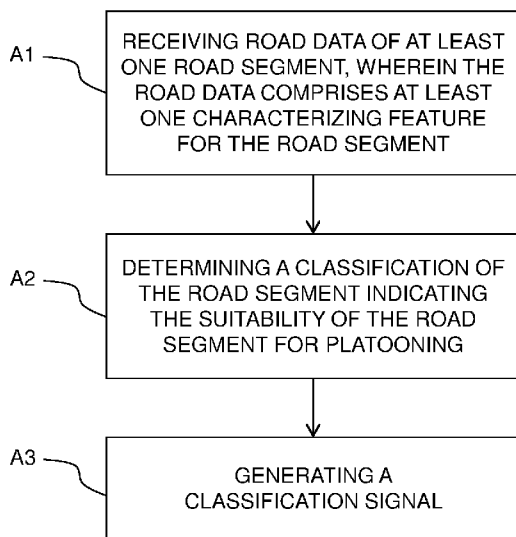


FIG. 3

(57) Abstract: A device and a method for classification of road segments (1) based on their suitability for platooning. The method comprises determining road data α for at least one road segment (1), wherein the road data α comprises at least one characterizing feature for the road segment (1) and identification data identifying the road segment (1). The method further comprises determining a classification of the road segment (1) indicating the suitability of the road segment (1) for platooning, based on a result of an evaluation of the at least one characterizing feature against a decision criterion. The method further comprises generating a classification signal β comprising the classification and the identification data.



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DEVICE AND METHOD FOR CLASSIFICATION OF ROAD SEGMENTS BASED ON THEIR SUITABILITY FOR PLATOONING

Technical field

5 The present disclosure relates to technology for platooning. In particular, the disclosure relates to a device and a method for classification of road segments based on their suitability for platooning. The disclosure also relates to a vehicle comprising the device, a computer program and a computer program product.

Background

10 The European Union has set a goal of reducing greenhouse gases by 20% by 2020, and heavy vehicles currently account for 17% of the total CO₂ emissions in Europe. Thus, focus has been given on reducing fuel consumption of inter alia heavy vehicles to reach the goal and also to save on fuel costs. One way of reducing fuel consumption is to operate several vehicles in a chain formation, also
15 known as platooning or a convoy.

Platooning take advantage of a reduced air drag by operating with small distances between vehicles. Under normal circumstances the air drag of a vehicle is proportional to the square of the vehicle's velocity. This means that a reduction in
20 speed from 90 km/h to 80 km/h reduces air drag by around 20 percent. Also, by staying close to a forward vehicle, an effect of reduced air drag can be obtained.

An adaptive cruise control, ACC, enables both of the above mentioned techniques for reducing air drag and fuel consumption, namely:

- 25
- Allowing a lower cruising speed than the preset speed to reduce air drag when a forward vehicle is present.
 - Staying closer to a forward vehicle may reduce air drag due to the aerodynamic effects.

30 Hence, by operating several vehicles in a chain formation, a substantial fuel reduction can be obtained through automated systems. However, it is difficult to establish or to maintain a vehicle platoon on certain road types. A road with

several highway off- and on-ramps reduces the time a platoon can be maintained. For example, a vehicle might catch up with a preceding vehicle to form a platoon, only to have it turn off the road after a short while. If platoons are hard to establish or are dissolved just after they have been created, drivers may become more
5 reluctant to form platoons.

Summary

It is thus an object of the disclosure to provide a method that supports the formation of platoons. It is a further object of the disclosure to provide a method
10 that increases the likelihood that a platoon will be maintained. These objects and others are at least partly achieved by the method and the device for classification of road segments based on their suitability for platooning according to the independent claims, and by the embodiments according to the dependent claims.

15 According to one aspect, the disclosure comprises a device for classification of road segments based on their suitability for platooning. The device is configured to determine road data α for at least one road segment, wherein the road data α comprises at least one characterizing feature for the road segment and identification data identifying the road segment. The device is further configured to
20 determine a classification of the road segment indicating the suitability of the road segment for platooning, based on a result of an evaluation of the at least one characterizing feature against a decision criterion. The device is further configured to generate a classification signal β comprising the classification and the identification data.

25

According to a second aspect, the disclosure comprises a method for classification of road segments based on their suitability for platooning. The method is comprised of determining road data α for at least one road segment, wherein the road data α comprises at least one characterizing feature for the road
30 segment and identification data identifying the road segment. The method further comprises determining a classification of the road segment indicating the suitability of the road segment for platooning, based on a result of at least one

evaluation of the at least one characterizing feature against a decision criterion, and generating a classification signal β comprising the classification and the identification data.

- 5 The device and/or method may aid fleet managers or operators to plan the transport routes more fuel-efficiently. Furthermore, it also aids in the acceptance of platoons, since by only platooning on the road segments suitable for platooning the traffic will be undisturbed. After positive experiences with platooning, drivers may continue with platooning to a higher extent than if they have negative
10 platooning experiences.

According to one embodiment, the determining of the classification is based on evaluation of a plurality of characterizing features against a decision criterion each.

15

- According to one embodiment, the characterizing feature is any of: a density of off-ramps along the road segment, speed restriction along the road segment, number of lanes along the road segment, road construction, number of previous successful platooning activities along the road segment and current or earlier
20 traffic congestions along the road segment. The decision criterion comprises at least one limit for the characterizing feature, and the evaluation comprises to compare the characterizing feature to the at least one limit.

According to one embodiment, the classification is time-dependent.

25

According to one embodiment, the characterizing features are configured to be continuously updated.

- According to one embodiment, a road segment is any of a road route, a
30 predetermined length of a road, or a length of a road where at least one characterizing feature is not changing or is changing within a predetermined interval.

According to one embodiment, the device is configured to send the classification signal β to a communication device in a vehicle, whereby the classification and the identification data is communicated to the driver of the vehicle.

- 5 According to a third aspect, the disclosure relates to a vehicle comprising the device as disclosed herein.

According to a fourth aspect, the computer program P comprises a computer program code to cause a device, or a computer connected to the device, to
10 perform the method according to any step as disclosed herein.

According to a fifth aspect, the computer program product comprising a computer program code stored on a computer-readable medium to perform the method as disclosed herein, when the computer program code is executed by a device or by
15 a computer connected to the device.

Brief description of the drawings

Fig. 1 illustrates a road network with a plurality of road segments.

Fig. 2 illustrates a device for classification of road segments according to one
20 embodiment of the disclosure.

Fig. 3 illustrates a method for classification of road segments according to one embodiment of the disclosure.

Detailed description

25 Fig. 1 is illustrating part of a road network with a plurality of interconnecting roads
1. When coordinating platoons, it is advantageous if information about the suitability of roads intended for performing platooning is available. If several routes are possible, the route with the most suitable roads for platooning may then be chosen. If there is no route with roads suitable for platooning available, then it
30 may be decided to not platoon on these routes.

- In Fig. 2 a device 2 is shown that has been developed in order to determine data that may be used when coordinating platoons. The device 2 includes a processing unit 3 and a memory unit 4. The processing unit 3 may be made up of one or more Central Processing Units (CPU). The memory unit 4 may be made up of one or more memory units. A memory unit may include a volatile and/or a non-volatile memory, such as a flash memory or Random Access Memory (RAM). The memory unit 4 further includes a computer program P including a computer program code to cause the device 2, or a computer connected to the device 2, to perform any of the method steps that will be described in the following. The device 2 may be an Electronic Control Unit (ECU), and be arranged in a vehicle (not shown). The device 2 may instead be arranged in an off-board system such as a remote computer or a road-side unit (not shown). The method may be performed when the vehicle is on the road, or e.g. on a fleet management portal.
- 15 The device 2 is arranged for classification of road segments based on their suitability for platooning. A road segment may be defined to be a road route, a predetermined length of a road, or a length of a road where at least one characterizing feature is not changing or is changing within a predetermined interval. A road route may be defined by geographical positions from a starting position to a destination position determined e.g. for accomplishing an assignment of a vehicle. A characterizing feature may be any of: a density of off-ramps along the road segment, speed restriction along the road segment, number of lanes along the road segment, road construction, a number of previously successful platooning activities along the road segment and current or earlier traffic congestions along the road segment.
- 25

- In the flowchart shown in Fig. 3 the method for classification of road segments based on their suitability for platooning according to one embodiment is shown. According to one embodiment, only highways are considered for low computational complexity, i.e. fast computation. As previously described, the method may be implemented as program code P and saved in the memory unit 4 (Fig. 2). The method may thus be implemented with the above described
- 30

hardware of the device 2. The method comprises determining road data α for at least one road segment, wherein the road data α comprises at least one characterizing feature for the road segment and identification data identifying the road segment (A1). The road data α may be retrieved from commercial map

5 databases, street maps etc. that may be continuously updated about speed restrictions, traffic conditions such as road works or traffic congestion, number or density of off-ramps, number of lanes etc. Road data α may also be retrieved from a platooning coordinator system, which may keep track of successful and not successful platooning activities, traffic conditions such as road works or traffic
10 congestion, etc. Road data α such as the characterizing features may also be determined by the device 2 based on retrieved data such as time and location of road works, traffic congestions, platooning activities, location of off-ramps, etc. Identification data may include geographical positions of the road segment, route starting position and destination etc.

15

The method further comprises determining a classification of the road segment indicating the suitability of the road segment for platooning, based on a result of at least one evaluation of the at least one characterizing feature against a decision criterion (A2). The determining of the classification may be based on evaluation of
20 a plurality of characterizing features against a decision criterion each. The characterizing feature may be any of: a density of off-ramps along the road segment 1, speed restriction along the road segment 1, number of lanes along the road segment 1, road construction, number of previously successful platooning activities along the road segment 1 and number of current or earlier traffic
25 congestions along the road segment 1. The characterizing features are preferably continuously updated. The decision criterion may comprise at least one limit for the characterizing feature, and the evaluation may comprise comparing the characterizing feature to the at least one limit.

30 The limit for the density of off-ramps may for example be a number of off-ramps per 10 km, e.g. 0, 5, 1, 2, 3 etc. If there are none off-ramps on the road segment, then the road segment is suitable for platooning. If there are 10 off-ramps on the

road segment, and the road segment is 50 km long, then the road segment is not suitable for platooning. Based on the length of the road segment and the number of off-ramps, the density of the road segment may be calculated.

- 5 The speed restriction along the road segment may be compared to a velocity limit, as platooning may be more beneficial, thus more fuel-efficient, during high speed. The speed restriction may be e.g. 70 km/h, or 90 km/h. If the speed restriction is lower than 70 km/h, the road segment is not suitable for platooning. If the speed restriction is lower than 90 km/h, but at least 70 km/h, then the road segment is
- 10 suitable for platooning. If the speed restriction is at least 90 km/h, the road segment is even more suitable for platooning. Moreover, a low speed restriction (e.g. below 70km/h) may be a good indication of the expected traffic density, since more trafficated roads typically have a lower speed restriction. A road segment with high density is thus typically not suitable for platooning.

15

The number of lanes along the road segment 1 may be compared to a lane limit. For example, if the number of lanes in the same direction of the road segment 1 is less than two (2), the road segment 1 is not suitable for platooning. Platooning on a single lane road may cause annoyance to the other vehicles on the road that

20 are not platooning, e.g. passenger vehicles.

- Road data α with a characterizing feature about road construction on the road segment 1 may be considered to determine if the road segment 1 is suitable for platooning or not. For example, if the road segment 1 has an ongoing road
- 25 construction, then the road segment 1 is not suitable for platooning. The characterizing feature about road construction may be indicated as "road construction=yes" in the road data α if there is a road construction along the road segment 1.

- 30 The characterizing feature the number of previous successful platooning activities along the road segment 1 may be compared to a lower limit for previously successful platooning activities along the road segment. For example, the lower

limit may be one (1), and if the number of previous successful platooning activities is less than one (1), then the road segment 1 is not suitable for platooning. The characterizing feature the number of previous not successful platooning activities along the road segment may be compared to an upper limit for previously not
5 successful platooning activities along the road segment. For example, the upper limit may be one (1), and if the number of previously not successful platooning activities is more than one (1), then the road segment 1 is not suitable for platooning. These characterizing features may also be compared against each other. For example, if the number of previously successful platooning activities
10 along the road segment 1 is at least 20, and the number of previously not successful platooning activities along the road segment 1 is two (2), then the road segment 1 may still be determined to be suitable for platooning. The data of successful and not successful platooning activities is preferably continuously updated.

15 The characterizing feature the number of current or earlier traffic congestions along the road segment 1 may be compared to an upper limit for current or earlier traffic congestions along the road segment 1. For example, if the tracked number of earlier traffic congestions is five (5) the last 7 days, then the road segment may
20 be determined to be not suitable for platooning.

The classification of the road segment 1 may according to one embodiment be either “highly suitable for platooning” or “not suitable for platooning”. If any of the available characterizing features of the road segment 1 show that the road
25 segment 1 is not suitable for platooning, then the road segment 1 may according to this embodiment be determined to be “not suitable for platooning”. According to another embodiment, the classification of the road segment 1 may also include “medium suitable for platooning”. This classification may be determined if only some of the available characterizing features of the road segment 1 show that the
30 road segment 1 is not suitable for platooning, and some of the available characterizing features of the road segment 1 show that the road segment 1 is suitable for platooning, or at least is not “not suitable” for platooning. For example,

if there is no road construction along the road segment, but the speed restriction is 65 km/h, then the road segment may get the classification “medium suitable for platooning”.

- 5 The method further comprises generating a classification signal β comprising the classification and the identification data. The classification may thus be any of “highly suitable for platooning”, “medium suitable for platooning” or “not suitable for platooning”. The classifications may however be expressed in another way, e.g. with numbers or other words or letters.

10

The classification signal β may be sent to another entity in the vehicle or remote computer, or be used internally in the same device 2. By having the information of which road segments in a road network that are suitable for platooning, a platooning method may use the information to better choose road segments to
15 platoon on. The platooning method may choose to only use road segments which are highly suitable for platooning.

20

The method may be initiated when information is retrieved, e.g. from a platooning coordination system, that a suitable vehicle for platooning with the own vehicle is
20 located in front of the own vehicle, e.g. further down along the road. The method may also be initiated by the driver. The driver may initiate the method by voice input, via a button or lever, via input to a touch screen etc to a system comprising the device 2. Activation data may then be generated that is sent to the device 2, whereby the method is executed. The road between the own vehicle and the
25 suitable vehicle may then be the road segment, and the method may in real time determine if the road segment is suitable for platooning or not. This information may determine if the own vehicle should platoon with the vehicle in front or not. The device 2 may be configured to send the classification signal to a communication device (not shown) in the own vehicle, whereby the classification
30 and the identification data is communicated to the driver of the own vehicle. The driver is thereby informed about the suitability of the road segment for platooning. The communicated information to the driver may e.g. be that the road segment is

“highly suitable for platooning”, “medium suitable for platooning” or “not suitable for platooning”. If the road segment is suitable for platooning, the driver of the own vehicle may initiate a platooning operation to drive up to the suitable vehicle for platooning. The driver may decide to platoon with the vehicle suitable for

5 platooning further down the road e.g. by giving input to the platooning coordination system. The input to the platooning coordination system may be given as voice input, via a button or lever, via input to a touch screen etc. Platooning between the own vehicle and the vehicle suitable for platooning may then be automatically performed. The driver may instead manually achieve
10 platooning increasing its velocity to catch up with the vehicle suitable for platooning.

The classification may be time-dependent. This may mean that the classification is only valid a certain time of the day. For example may traffic congestion be
15 heavy between 7 and 9 am on the road segment 1 and therefore the road segment 1 may not be suitable for platooning during these hours, meanwhile the traffic conditions during other hours may be better on this road segment 1 such that the road segment 1 during the other hours may be suitable for platooning.

20 The device 2 may be arranged to receive data α via wireless communication such as vehicle-to-vehicle communication (V2V), or via infrastructure communication (V2I), depending on where the device 2 is arranged. The wireless communication may also be conducted via mobile communication servers, via an application in a communication unit or via a server.

25 The present invention is not limited to the above-described preferred embodiments. Various alternatives, modifications and equivalents may be used. Therefore, the above embodiments should not be taken as limiting the scope of the invention, which is defined by the appending claims.

Claims

1. A device (2) for classification of road segments (1) based on their suitability for platooning, characterized in that the device (2) is configured to:
 - 5 - determine road data α for at least one road segment (1), wherein the road data α comprises at least one characterizing feature for the road segment (1) and identification data identifying the road segment (1);
 - determine a classification of the road segment (1) indicating the suitability of the road segment (1) for platooning, based on a result of an evaluation of the at least one characterizing feature against a decision
10 criterion;
 - generate a classification signal β comprising the classification and the identification data.
2. The device (2) according to claim 1, wherein the determining of the
15 classification is based on evaluation of a plurality of characterizing features against a decision criterion each.
3. The device (2) according to claim 1 or 2, wherein the characterizing
20 feature is any of: a density of off-ramps along the road segment (1), speed restriction along the road segment (1), number of lanes along the road segment (1), road construction, number of previously successful platooning activities along the road segment (1) and number of current or earlier traffic congestions along the road segment (1).
4. The device (2) according to claim 3, wherein the decision criterion
25 comprises at least one limit for the characterizing feature, and the evaluation comprises to compare the characterizing feature to the at least one limit.
5. The device (2) according to any of the preceding claims, wherein the classification is time-dependent.
6. The device (2) according to any of the preceding claims, wherein the characterizing features are configured to be continuously updated.
- 30 7. The device (2) according to any of the preceding claims, wherein a road segment is any of a whole road route, a predetermined length of a road,

or a length of a road where at least one characterizing feature is not changing or is changing within a predetermined interval.

8. A device (2) according to any of the preceding claims, wherein the device (2) is configured to send the classification signal β to a communication device in a vehicle, whereby the classification and the identification data is communicated to the driver of the vehicle.
9. A vehicle comprising a device (2) according to any of the preceding claims.
10. A method for classification of road segments (1) based on their suitability for platooning, the method comprising:
 - determining road data α for at least one road segment, wherein the road data α comprises at least one characterizing feature for the road segment (1) and identification data identifying the road segment (1);
 - determining a classification of the road segment (1) indicating the suitability of the road segment (1) for platooning, based on a result of at least one evaluation of the at least one characterizing feature against a decision criterion;
 - generating a classification signal β comprising the classification and the identification data.
11. A computer program P, wherein said computer program P comprises a computer program code to cause a device (1), or a computer connected to said device (1), to perform the method according to claim 10.
12. A computer program product comprising a computer program code stored on a computer-readable medium to perform the method according to claim 10, when said computer program code is executed by a device (1) or by a computer connected to said device (1).

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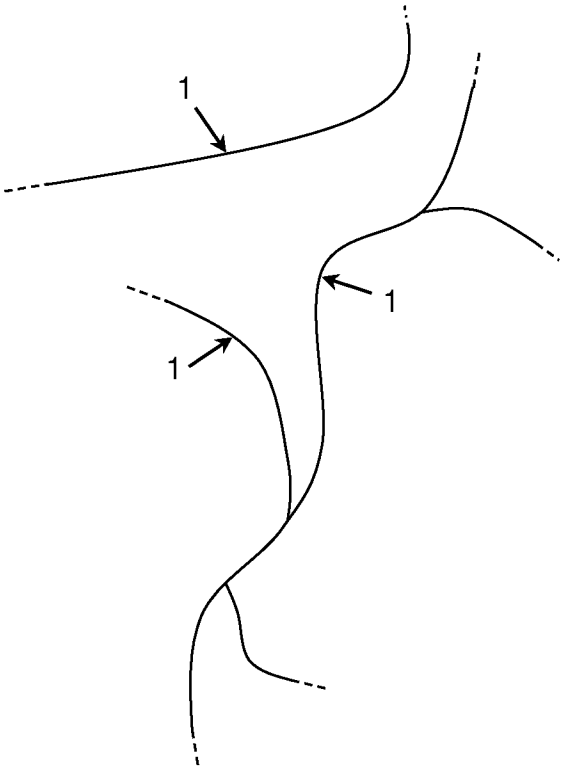


FIG. 1

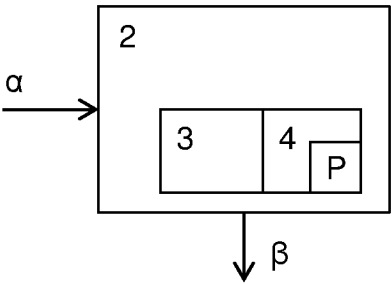


FIG. 2

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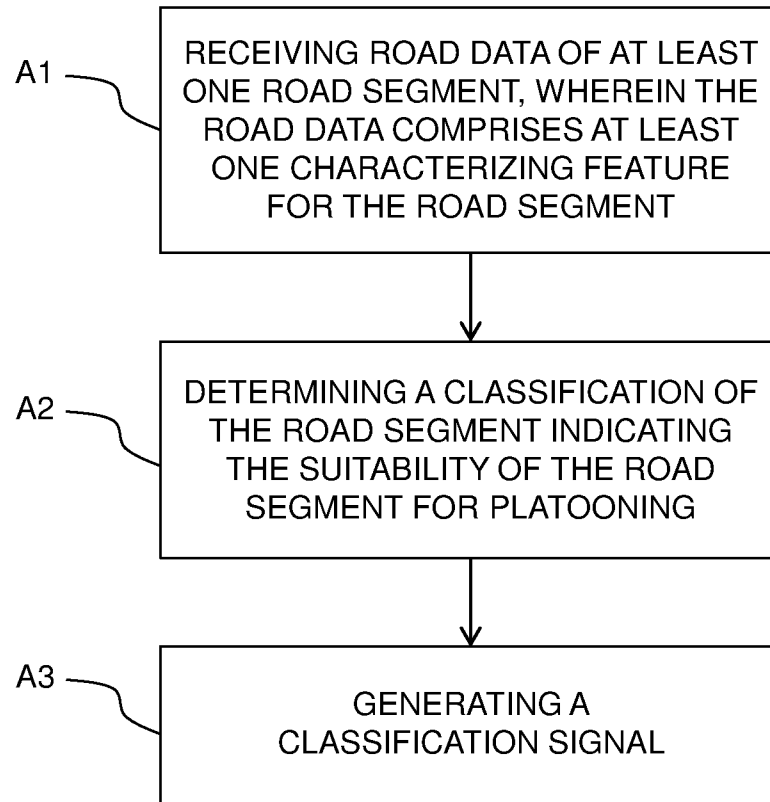


FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2016/050148

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: B60W, G05D, G08G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE, DK, FI, NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, PAJ, WPI data, COMPENDEX, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2014145918 A1 (PELTON TECHNOLOGY INC ET AL), 18 September 2014 (2014-09-18); abstract; paragraphs [0043], [0087]; figures 6B, 18 --	1-12
A	WO 2014062118 A1 (SCANIA CV AB), 24 April 2014 (2014-04-24); abstract --	1-12
A	US 20140278027 A1 (BURKE DENIS R ET AL), 18 September 2014 (2014-09-18); abstract --	1-12
A	US 20100256835 A1 (MUDALIGE UPALI PRIYANTHA), 7 October 2010 (2010-10-07); abstract --	1-12

☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:

“A” document defining the general state of the art which is not considered to be of particular relevance

“E” earlier application or patent but published on or after the international filing date

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“O” document referring to an oral disclosure, use, exhibition or other means

“P” document published prior to the international filing date but later than the priority date claimed

“T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

“X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

“Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

“&” document member of the same patent family

Date of the actual completion of the international search

21-04-2016

Date of mailing of the international search report

21-04-2016

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Patent- och registreringsverket

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2016/050148

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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A	WO 2015047178 A1 (SCANIA CV AB), 2 April 2015 (2015-04-02); abstract -- -----	1-12

Continuation of: second sheet

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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