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(71) Applicant: **ADB Safegate Sweden AB**
213 76 Malmö (SE)

(72) Inventors:

- **Håkansson, Peter**
213 76 Malmö (SE)
- **Berkmo, Anders**
213 76 Malmö (SE)

(74) Representative: **AWA Sweden AB**
Box 5117
200 71 Malmö (SE)

(54) **METHOD FOR MONITORING BACKWARD MOVEMENT OF AN AIRCRAFT AT AN AIRPORT STAND**

(57) The disclosure relates to a method for monitoring backward movement of a first aircraft (10) at a first airport stand (1), the method comprising: receiving, from a first docking system (100) arranged at the first airport stand (1), first sensor data which pertains to a movement behaviour of the first aircraft (10), receiving, from a second docking system (200) arranged at a second airport stand (2), second sensor data which pertains to a movement behaviour of a second aircraft (20, 30), receiving

aircraft data which pertains to an expected movement behaviour of at least one of: the first aircraft (10) and the second aircraft (20, 30), comparing the first sensor data with at least one of the second sensor data and the aircraft data; and outputting an alarm signal in response to determining that the movement behaviour of the first aircraft fails to meet a predetermined movement behaviour criterion.

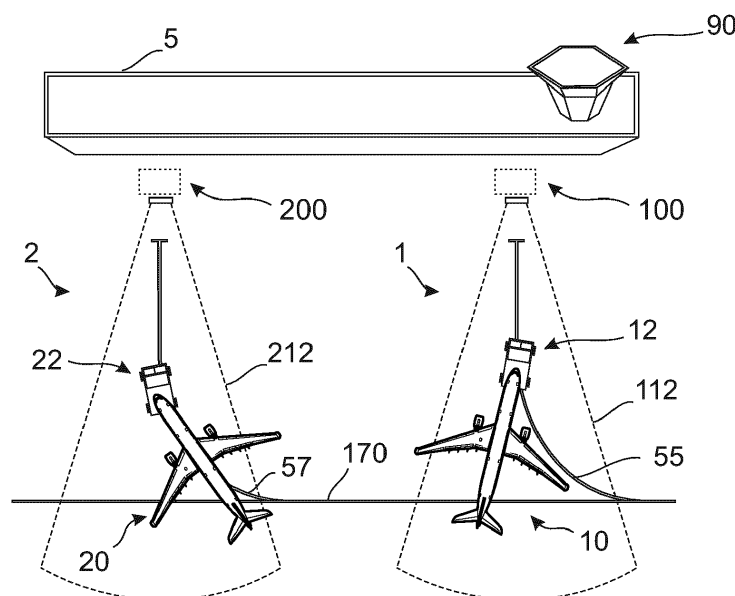


Fig 2

Description

Field of the invention

[0001] The present invention relates to a method for monitoring backward movement of an aircraft at an airport stand.

Background art

[0002] At airports there are commonly a plurality of aircrafts in transit to and from, for example, runways, taxiways and airport stands, as well as parked aircrafts. Additionally, aircrafts parked at an airport stand may be about to move to a runway, or a taxiway. A parked aircraft is usually placed with its tail towards the nearest taxiway. Therefore, when an aircraft is departing from an airport stand, it may need to move backwards towards its nearest taxiway. Such backward, and/or departure, movement of an aircraft is commonly referred to as a push-back or a powerback. Push-back may be performed by a tow truck operated by ground personnel. Powerback may be performed by the pilot of an aircraft to move backwards on the ground using the power of the aircraft engines and the aircraft's thrust reversal system.

[0003] Performing a backward, or departure, movement of an aircraft comes with the risk of, for example, collision with a structure, another aircraft, equipment at the airport, or ground personnel. Further, an aircraft may be backed incorrectly, such that the aircraft is oriented in the wrong direction, or to the wrong taxiway or runway. An incorrectly backed aircraft may pose an increased risk of collision with another aircraft, airport vehicles, equipment at the airport, or even ground personnel. Further, an incorrectly backed aircraft may cause delays due to, for example, having to spend time by being moved into a correct position, and/or by blocking other aircrafts at the airport.

[0004] Thus, there is a need in the art for improved backward movement of aircrafts at airports.

Summary

[0005] It is an object to mitigate, alleviate or eliminate the above-identified deficiency in the art singly or in any combination and solve at least the above-mentioned problem.

[0006] According to a first aspect there is provided a method for monitoring backward movement of a first aircraft at a first airport stand. The method comprises receiving, from a first docking system arranged at the first airport stand, first sensor data which pertains to a movement behaviour of the first aircraft. The method further comprises receiving, from a second docking system arranged at a second airport stand, second sensor data which pertains to a movement behaviour of a second aircraft. The method comprises receiving aircraft data which pertains to an expected movement behaviour of

at least one of: the first aircraft and the second aircraft. The method comprises comparing the first sensor data with at least one of the second sensor data and the aircraft data so as to provide one or more aircraft movement behaviour comparison parameters. The method comprises determining, based on the one or more aircraft movement behaviour comparison parameters, if the movement behaviour of the first aircraft meets one or more predetermined movement behaviour criterions. The method comprises outputting an alarm signal in response to determining that the movement behaviour of the first aircraft fails to meet at least one of the one or more predetermined movement behaviour criterions.

[0007] According to a second aspect there is provided a computer-readable medium comprising computer code instructions which when executed by a device having processing capability are adapted to perform the method according the first aspect.

[0008] According to a third aspect there is provided a docking system for guiding a pilot of an aircraft to a stop position at an airport stand. The aircraft docking system comprises a remote sensing system. The remote sensing system is configured to collect, or capture, sensor data pertaining to a movement behaviour of the aircraft. The aircraft docking system further comprises a display for providing manoeuvring guidance information to the pilot of the aircraft. The docking system is configured to collect, by said remote sensing system, sensor data which pertains to a movement behaviour of the aircraft at the airport stand. The docking system is further configured to receive, from a further docking system arranged at a further airport stand, further sensor data which pertains to a movement behaviour of a further aircraft. The docking system is further configured to receive aircraft data which pertains to an expected movement behaviour of at least one of: the aircraft and the further aircraft. The docking system is further configured to compare the sensor data with at least one of the further sensor data and the aircraft data so as to provide one or more aircraft movement behaviour comparison parameters, to determine, based on said one or more aircraft movement behaviour comparison parameters, if the movement behaviour of the aircraft meets one or more predetermined movement behaviour criterions, and to output an alarm signal in response to determining that the movement behaviour of the aircraft fails to meet at least one of said one or more predetermined movement behaviour criterions.

[0009] According to a fourth aspect, there is provided a system at an airport comprising: a first docking system for guiding a pilot of a first aircraft to a stop position at a first airport stand; a second docking system for guiding a pilot of a second aircraft to a stop position at a second airport stand; said first and second docking systems each comprising a respective remote sensing system configured to collect, or capture, sensor data pertaining to a movement behaviour of the respective aircraft; and a controller operably connected to the first and second

docking systems; wherein said first docking system is configured to collect first sensor data which pertains to a movement behaviour of the first aircraft and transmit said first sensor data to the controller, and wherein said second docking system is configured to collect second sensor data which pertains to a movement behaviour of the second aircraft and transmit said second sensor data to the controller, wherein the controller is configured to: receive aircraft data which pertains to an expected movement behaviour of at least one of: the first aircraft and the second aircraft, compare the first sensor data with at least one of the second sensor data and the aircraft data so as to provide one or more aircraft movement behaviour comparison parameters; determine, based on said one or more aircraft movement behaviour comparison parameters, if the movement behaviour of the first aircraft meets one or more predetermined movement behaviour criteria; and output an alarm signal in response to determining that the movement behaviour of the first aircraft fails to meet at least one of said one or more predetermined movement behaviour criteria.

[0010] The term "backward movement", also referred to as "departure movement", of an aircraft should herein be construed as any backward movement of an aircraft within a stand during the phase of the aircraft leaving the stand, an overall procedure which is herein termed "aircraft stand departure". Backward movement is typically performed either by a push-back or a powerback. Push-back may be performed by a tow truck operated by ground personnel. This implies that the aircraft is towed and not manoeuvred by the pilot. Powerback may be performed by the pilot of an aircraft to move backwards on the ground for example by using the power of the aircraft engines and the aircraft's thrust reversal system. However, the term "backward movement" should not be construed as limited to the examples given above as there may be further ways of achieving an aircraft stand departure.

[0011] The "first aircraft" should be understood as an aircraft which is parked at, is pushed back from, is reversing from, or is docking at a first airport stand. The "second aircraft" should be understood as an aircraft for which a second docking system may collect, and/or capture, sensor data pertaining to a movement behaviour thereof. The second aircraft may, for example, be an aircraft which is parked at, is pushed back from, is reversing from, or is docking at a second airport stand. However, the second aircraft may alternatively be, for example, an aircraft which is parked at, is pushed back from, is reversing from, or is docking at an airport stand different from the second airport stand, but for which the second docking system may collect, or capture, sensor data pertaining to a movement behaviour of the second aircraft. Additionally, the second aircraft may also be, for example, an aircraft which is passing by the second docking system. In other words, the second aircraft may be understood as, for example, an aircraft which is positioned within a capture area of the second docking system. The

capture area of a docking system may be understood as, for example, an area for which the docking system may collect, or capture, sensor data which pertains to a movement behaviour of an aircraft present in the area. The capture area is sometimes referred to as the (sensing) range of the docking system.

[0012] The term "stand departure instructions" should herein be construed as instructions applied at an airport for clearing an aircraft to depart from an airport stand, i.e. perform an aircraft stand departure. Stand departure instructions may comprise a simple Yes/No to depart only, i.e. a clearance to depart from the stand. Alternatively, stand departure instructions may further comprise information pertaining to an expected movement behaviour of the aircraft during departure. This implies that the stand departure instructions may contain for example information indicating a planned route for the aircraft to follow during departure from the stand. Such information could be, for example, instructions to perform backward movement to the left, or backward movement to the right. The stand departure instructions are sometimes referred to as push-back instructions or powerback instructions dependent on the kind of stand departure operation intended. The stand departure instructions may be received from a system of the airport. For example, the stand departure instructions may be received from traffic control at a tower of the airport. The stand departure instructions may be at least partly based on data in a flight plan. It is also conceivable that the stand departure instructions are retrieved from an airport operational database AODB.

[0013] By the term "aircraft data which pertains to an expected movement behaviour of an aircraft", it is meant any data which in any way defines an expected, planned or scheduled position, path, route, orientation etc. of an aircraft either generally, or as function of time. This implies that the aircraft data may comprise spatial coordinates pertaining to an expected position of the aircraft. The spatial coordinates may pertain to a single position, such as a reference position defined at the airport. Alternatively, the spatial coordinates may pertain to a plurality of expected positions of the aircraft. This implies that the aircraft data may comprise spatial coordinates pertaining to an expected path that the aircraft is expected, or cleared, to follow at the airport. Moreover, the aircraft data may comprise orientation data, such as e.g. one or more angles, defining how the aircraft is expected to be oriented with respect to a reference orientation (could be e.g. the stand centre line, or a north direction). The aircraft data may comprise both position data and orientation data but may alternatively contain position data only or orientation data only. The aircraft data may comprise timestamped data. For example, the aircraft data may comprise one or more expected positions, and/or orientations, of an aircraft each defined at a specific position in time. The aircraft data may be received from a system of the airport. For example, the aircraft data may be received from traffic control at a tower of the airport, from an Apron Control system, or from an Apron Management

system. The aircraft data may be at least partly based on data in a flight plan. It is also conceivable that the aircraft data is retrieved from an airport operational database AODB. The aircraft data may be, or may include, stand departure instructions.

[0014] By the phrasing "sensor data which pertains to a movement behaviour of the first/second aircraft" it is meant sensor data which comprises information regarding a movement behaviour of the first/second aircraft. The sensor data may comprise spatial coordinates pertaining to a position of the aircraft. Such spatial coordinates may pertain to a plurality of positions of the aircraft. The plurality of positions may define a tracked path of the aircraft when the aircraft moves within the range of a docking system. Moreover, the sensor data may comprise orientation data, such as e.g. one or more angles, defining how the aircraft is oriented with respect to a reference orientation (could be e.g. the stand centre line, or a north direction). The sensor data may comprise both position data and orientation data but may alternatively contain position data only or orientation data only. The sensor data may comprise timestamped data. For example, the sensor data may comprise one or more sensed positions, and/or orientations, of an aircraft each defined at a specific position in time.

[0015] By the term "aircraft movement behaviour comparison parameter" it is meant, for example, a difference, a quota, and/or a fraction that can be determined based on data which pertains to aircraft movement behaviours or expected aircraft movement behaviours. An aircraft movement behaviour comparison parameter may therefore for example be a determined distance between two positions, a determined ration between two orientations etc.

[0016] By the term "predetermined movement behaviour criterions" is meant any kind of threshold value applicable for the comparison at hand. In the example where the aircraft movement behaviour comparison parameter is a determined distance between two positions, the predetermined movement behaviour criterions may be a minimum distance, such as e.g. 30 meters. For this example, the method may output an alarm signal if the determined distance falls below 30 meters, but not if said determined distance exceeds 30 meters.

[0017] By the term "alarm signal" is here meant any signal which in any way is able to convey that the method indicated the alarm. The alarm signal could thus e.g. be an electrical wired signal, a wireless signal, such as an electromagnetic signal, etc. The alarm signal may be an audio signal, such as a sound alarm. The alarm signal may be a visual signal, such as e.g. information on a display or flashing lights.

[0018] The method according to the first aspect may be advantageous as it allows monitoring the backward movement of an aircraft and predicts the risk of any collision events occurring as a result from said backward movement for a large variety of situations. A collision event may occur for different reasons. One reason is that

the backward movement of the aircraft in question is not made according to regulations e.g. that the backward movement is made without, or in breach of, stand departure instructions. Another reason could be that a further aircraft, such as an aircraft parked in the neighbouring stand, or an aircraft which passes by the stand, are manoeuvred without permission. Yet another reason for a collision is that the stand departure instructions itself are incorrect, for example due to technical and/or human errors in airport traffic control.

[0019] Another advantage with the method is that it allows monitoring the backward movement of aircrafts at airports using existing infrastructure. By utilizing the sensor data already available from existing docking systems, i.e. visual guidance docking systems, VDGS, and the aircraft data already available for example in stand departure instructions, the method may be straight-forward to implement without expensive additions to airport infrastructure.

[0020] The method is based on the concept of receiving data from a plurality of sources, wherein the different data are independent of each other, and comparing the data in order to provide information which would be unobtainable if only one data source was used. Thereby, the method provides an improved monitoring of backward movement of an aircraft at an airport stand in comparison to a method which is only receiving sensor data pertaining to that particular aircraft. In other words, the comparison of the different received data can be used to provide error correction and/or an increased level of redundancy, which increases the security, and/or the efficiency of the backward movement.

[0021] The docking system(s) may be configured to collect, and/or capture, the sensor data. The docking system(s) may comprise a device configured for collecting, and/or capturing, sensor data. For example, the device configured for collecting sensor data may comprise at least one of a laser, a radar, a camera, or a video camera. The docking system may further be configured to process, and/or filter, the sensor data such that the processed, and/or filtered, sensor data is pertaining to a movement behaviour of an aircraft. In other words, the docking system(s) may be configured to determine that at least some of the sensor data is pertaining to a movement behaviour of an aircraft.

[0022] The method according to the first aspect may be configured to be performed continuously. In other words, the docking system may be configured to continuously collect, and/or capture, the sensor data. Thus, the method may be performed as soon as the collected, and/or captured, sensor data pertains to, or indicates that, a backward moment of an aircraft has started an airport stand.

[0023] The method according to the first aspect may be configured to be initiated upon a docking system receiving a signal indicating that a backward movement of an aircraft at an airport stand at which the docking system is arranged is instructed to begin a backward movement.

A transmission of such a signal to the docking system could be triggered by stand departure instructions. If such stand departure instructions include a YES to depart, i. e. a clearance for the aircraft to depart from the stand, this could trigger said signal.

[0024] By comparing the first sensor data with at least one of the second sensor data and the aircraft data so as to provide one or more aircraft movement behaviour comparison parameters, a level of redundancy is provided. In other words, by using data from more than one source, the accuracy of a determination of if the movement behaviour of the first aircraft meets one or more predetermined movement behaviour criterions may be increased. Further, the second sensor data and/or the aircraft data may comprise data which was not obtainable by the first docking system. Thereby, the method may allow for outputting an alarm signal in response to an occurrence which would have been missed if only the first sensor data was used.

[0025] By comparing the first sensor data with at least one of the second sensor data and the aircraft data, the method allows for error correction of the first sensor data. For example, the first sensor data may comprise some error, which may be identified in the comparison with at least one of the second sensor data and the aircraft data.

[0026] The one or more predetermined movement behaviour criterions may be adjusted based on the first sensor data and/or the second sensor data and/or the aircraft data. The one or more predetermined movement behaviour criterions may alternatively be adjusted based on the one or more aircraft movement behaviour comparison parameters. This may be advantageous as it allows automatically adjusting the tolerance of the alarm function of the method based on the situation at hand. As an example, if the second sensor data indicates that the second aircraft is approaching the position of the first aircraft relatively fast, a predetermined movement behaviour comparison criterion in the form of a minimum allowed distance between the two aircrafts may be increased to compensate for the increased risk of collision at the higher speed.

[0027] The first sensor data may inadvertently indicate that the movement behaviour of the first aircraft does not fail to meet at least one of said one or more predetermined movement behaviour criterions, and/or may be unusable, or insufficient, with regards to determining if one or more predetermined movement behaviour criterions are met. For example, the first sensor data may not comprise information regarding a second aircraft, which may be blocked from view of the first docking system or will be in a compromised position in the near future. Thereby, by comparing the first sensor data with at least one of the second sensor data and the aircraft data, the risk of collision between the first aircraft and a second aircraft may be reduced. The first sensor data may not comprise information regarding to which direction or taxiway the first aircraft is supposed to be moved backwards. Thereby, by comparing the first sensor data with at least one

of the second sensor data and the aircraft data, an incorrect backward movement may be avoided.

[0028] The computer-readable medium comprising computer code instructions according to the second aspect may be executed by a device having processing capability, which when executed by the device are adapted to perform the method according the first aspect. The device may, for example, be a docking system, or a controller and/or a processing unit of a docking system. In another example, the device may be a system of the airport, such as a central system, or subsystem of the airport, or a device of the tower of the airport.

[0029] The remote sensing system according to the third aspect may include one or more from: a radar-based system, a laser-based system, and an imaging system. The display according to the third aspect may be configured to output, or display, the alarm signal. This implies that the alarm signal can be a visual signal.

[0030] The aircraft docking system according to the third aspect may comprise a device having processing capability. The docking system may comprise a computer-readable medium comprising computer code instructions according to the second aspect, which when executed by the device having processing capability are adapted to perform the method according to the first aspect.

[0031] The system according to the fourth aspect may comprise a computer-readable medium comprising computer code instructions according to the second aspect. Said computer-readable medium may be operably connected to the controller. The controller and the computer-readable medium may be part of a further system, different from the first and second docking systems. The further system may be a central system at the airport, such as e.g. an Apron Management system or an Apron Control system.

[0032] The first sensor data, the second sensor data and the aircraft data may each comprise aircraft position data. The first sensor data, the second sensor data and the aircraft data may each comprise aircraft orientation data.

[0033] Comparing the first sensor data and the second sensor data may comprise comparing the aircraft position data of the first sensor data with the aircraft position data of the second sensor data and/or the aircraft position data of the aircraft data.

[0034] Comparing the first sensor data and the second sensor data may comprise comparing the aircraft orientation data of the first sensor data with the aircraft orientation data of the second sensor data and/or the aircraft orientation data of the aircraft data.

[0035] Thereby, determining if the movement behaviour of the first aircraft meets one or more predetermined movement behaviour criterions may be based on a comparison of the aircraft position data of the first sensor data with the aircraft position data of the second sensor data and/or the aircraft position data of the aircraft data, and/or a comparison of the aircraft orientation data of the first

sensor data with the aircraft orientation data of the second sensor data and/or the aircraft orientation data of the aircraft data.

[0036] The aircraft data may pertain to the expected movement behaviour of the first aircraft. The one or more aircraft movement behaviour comparison parameters may comprise a first comparison parameter which is based on a comparison between the first sensor data and the aircraft data pertaining to the expected movement behaviour of the first aircraft. The one or more movement behaviour criterions may include a first threshold. The movement behaviour of the first aircraft may fail to meet the at least one of the one or more movement behaviour criterions when the first comparison parameter exceeds the first threshold.

[0037] In other words, the first comparison parameter may comprise a difference between the movement behaviour of the first aircraft, received from the first docking system, and the received expected movement behaviour.

[0038] The aircraft data may, for example, indicate that the aircraft should stay parked for a while longer and depart according to a planned route, while the first sensor data may indicate that the aircraft has already begun stand departure, i.e. backward movement, along the planned route. In such an example, the first comparison parameter may indicate that an incorrect backward movement is being performed, due to it being performed too early. Correspondingly, the first parameter may indicate that a stand departure, i.e. backward movement, should already have been started.

[0039] The first threshold may comprise a maximum difference in position or orientation. For example, the aircraft may be performing a backward movement, which may be acceptable according to the first sensor data, but is incorrect according to the aircraft data, which would be determined by the first comparison parameter exceeding the first threshold.

[0040] Thereby, determining if the first comparison parameter exceeds the first threshold may reduce the risk of an incorrect backward movement.

[0041] The first sensor data may comprise a sensed position of the first aircraft. The aircraft data may comprise an expected position of the first aircraft. The first threshold may comprise a first distance threshold. The movement behaviour of the first aircraft may fail to meet the at least one of the one or more movement behaviour criterions when a difference between the sensed position of the first aircraft and the expected position of the first aircraft exceeds the first distance threshold.

[0042] The first distance threshold may be understood as, for example, a maximum distance for which an aircraft is allowed deviate from an expected position. Determining if a difference between the sensed position of the first aircraft and the expected position of the first aircraft exceeds the first distance threshold, may reduce the risk of incorrect backward movement.

[0043] The first sensor data may comprise a sensed

orientation of the first aircraft. The aircraft data may comprise an expected orientation of the first aircraft. The first threshold may comprise a first orientation threshold. The movement behaviour of the first aircraft may fail to meet the at least one of the one or more movement behaviour criterions when a difference between the sensed orientation of the first aircraft and the expected orientation of the first aircraft exceeds the first orientation threshold.

[0044] The first orientation threshold may be understood as, for example, a maximum orientation for which an aircraft is allowed deviate from an expected orientation. Determining if a difference between the sensed orientation of the first aircraft and the expected orientation of the first aircraft exceeds the first distance threshold, may reduce the risk of incorrect backward movement.

[0045] The one or more aircraft movement behaviour comparison parameters may comprise a second comparison parameter which is based on a comparison between the first sensor data and the second sensor data.

The one or more movement behaviour criterions may include a second threshold. The movement behaviour of the first aircraft may fail to meet the at least one of the one or more predetermined movement behaviour criterions when the second comparison parameter exceeds the second threshold.

[0046] In other words, the second comparison parameter may comprise a difference between first sensor data pertaining to the movement behaviour of the first aircraft, received from the first docking system, and the second sensor data pertaining to the movement behaviour of the second aircraft, received from the second docking system.

[0047] By receiving the first sensor data and the second sensor data from the first docking system and the second docking system, respectively, the method may allow for a comparison of data which was not accessible for a single docking system. For example, the first docking system may be unaware of what the second aircraft is doing. For example, the second comparison parameter may indicate that the first aircraft and the second aircraft are both performing a backward movement, which may increase the risk of a collision.

[0048] Determining if the second comparison parameter exceeds the second threshold may reduce the risk of collision between of the first aircraft and the second aircraft.

[0049] The first sensor data may comprise a sensed position of the first aircraft. The second aircraft data may comprise a sensed position of the second aircraft. The second threshold may comprise a second distance threshold. The movement behaviour of the first aircraft may fail to meet the at least one of the one or more movement behaviour criterions when a difference between the sensed position of the first aircraft and the sensed position of the second aircraft is less than the second distance threshold.

[0050] The second distance threshold may be understood as, for example, a maximum distance which is al-

lowed between the sensed position of the first aircraft and the sensed position of the second aircraft.

[0051] A second aircraft may be positioned, or parked, incorrectly (i.e. at an incorrect position), which the first docking system may be unaware of. If only the first sensor data is used there may be a risk of collision between the first aircraft and the incorrectly positioned, or parked, second aircraft. In other words, by using sensed positions of the first aircraft and the second aircraft, received from the first docking system and the second docking system, respectively, the risk of collision between of the first aircraft and the second aircraft may be reduced.

[0052] Thus, determining if a difference between the sensed position of the first aircraft and the sensed position of the second aircraft exceeds the second distance threshold, may reduce the risk of collision between of the first aircraft and the second aircraft.

[0053] The first sensor data may comprise a sensed orientation of the first aircraft. The second aircraft data may comprise a sensed orientation of the second aircraft. The second threshold may comprise a second orientation threshold. The movement behaviour of the first aircraft may fail to meet the at least one of the one or more movement behaviour criteria when a difference between the sensed orientation of the first aircraft and the sensed orientation of the second aircraft is less than the second orientation threshold.

[0054] The second orientation threshold may be understood as, for example, a maximum orientation difference which is allowed between the sensed orientation of the first aircraft and the sensed orientation of the second aircraft.

[0055] For example, if the first aircraft and the second aircraft are both facing the same direction, the first aircraft and the second aircraft may be understood as having the same orientation. Thus, the difference between the orientations of the first aircraft and the second aircraft having the same orientation may be zero. The second orientation threshold may allow that the difference is up to, for example, 90 degrees, 135 degrees, or higher. For example, the first and the second aircraft being oriented tail-to-tail may be an unallowable orientational relationship. The first and the second aircraft being oriented tail-to-tail would be a difference between the orientations of the first aircraft and the second aircraft equal to 180 degrees, or approximately 180 degrees.

[0056] Thereby, the risk of the first aircraft being moved backwards while the second aircraft is oriented such that the orientational relationship between the first aircraft and the second aircraft is unallowable is reduced. A risk of the first aircraft and the second aircraft being in an unallowable orientation relationship is that personnel performing a stand departure, i.e. backward movement, of the first aircraft or the second aircraft may not be aware of the other aircraft, and/or that backward movement is being performed for the other aircraft. For example, while the first aircraft and the second aircraft are oriented tail-to-tail but on opposite sides of a taxiway, backward move-

ment could be started for the first aircraft, and, while the first aircraft is moving backwards, backward movement could also be started for the second aircraft, which may increase the risk of collision between the first aircraft and the second aircraft.

[0057] However, by determining if a difference between the sensed orientation of the first aircraft and the sensed orientation of the second aircraft exceeds the second orientation threshold, the risk of collision between of the first aircraft and the second aircraft may be reduced.

[0058] The aircraft data may pertain to the expected movement behaviour of the second aircraft. The one or more aircraft movement behaviour comparison parameters may comprise a third comparison parameter which is based on a comparison between the first sensor data and the aircraft data pertaining to the expected movement behaviour of the second aircraft. The movement behaviour of the first aircraft may fail to meet the at least one of the one or more predetermined movement behaviour criteria when the third comparison exceeds the second threshold.

[0059] In other words, the third comparison parameter may comprise a difference between the movement behaviour of the first aircraft, received from the first docking system, and the expected movement behaviour of the second aircraft.

[0060] In other words, the method may allow for a comparison of data which was not accessible for the first docking system with the first sensor data.

[0061] The aircraft data pertaining to the expected movement behaviour of the second aircraft may comprise a planned path, or route, for the second aircraft. Thus, the third comparison parameter may indicate that a collision between the first aircraft and the second aircraft may occur if the first aircraft continues a backward movement, since the first aircraft may be moved, i.e. pushed or reversed, back into the planned path, or route, of the second aircraft indicated by the aircraft data pertaining to the expected movement behaviour of the second aircraft.

[0062] Thereby, determining if the third comparison parameter exceeds the second threshold may reduce the risk of collision between of the first aircraft and the second aircraft.

[0063] The first sensor data may comprise a sensed position of the first aircraft. The aircraft data may comprise an expected position of the second aircraft. The second threshold may comprise a second distance threshold. The movement behaviour of the first aircraft may fail to meet the at least one of the one or more movement behaviour criteria when a difference between the sensed position of the first aircraft and the expected position of the second aircraft is less than the second distance threshold.

[0064] The second distance threshold may be understood as, for example, a maximum distance which is allowed between the sensed position of the first aircraft

and the expected position of the second aircraft.

[0065] By using the sensed position of the first aircraft and the expected position of the second aircraft, the risk of collision between the first aircraft and the second aircraft may be reduced.

[0066] In other words, determining if a difference between the sensed position of the first aircraft and the expected position of the second aircraft exceeds the second distance threshold, may reduce the risk of collision between of the first aircraft and the second aircraft.

[0067] The first sensor data may comprise a sensed orientation of the first aircraft. The aircraft data may comprise an expected orientation of the second aircraft. The second threshold may comprise a second orientation threshold. The movement behaviour of the first aircraft may fail to meet the at least one of the one or more movement behaviour criterions when a difference between the sensed orientation of the first aircraft and the expected orientation of the second aircraft is less than the second orientation threshold.

[0068] The second orientation threshold may be understood as, for example, a maximum orientation difference which is allowed between the sensed orientation of the first aircraft and the expected orientation of the second aircraft.

[0069] Thereby, by determining if a difference between the sensed orientation of the first aircraft and the expected orientation of the second aircraft exceeds the second orientation threshold, the risk of collision between of the first aircraft and the second aircraft may be reduced.

[0070] A further scope of applicability of the present invention will become apparent from the detailed description given below. However, it should be understood that the detailed description and specific examples, while indicating preferred embodiments of the invention, are given by way of illustration only, since various changes and modifications within the scope of the invention will become apparent to those skilled in the art from this detailed description.

[0071] Hence, it is to be understood that this invention is not limited to the particular component parts of the device described or steps of the methods described as such device and method may vary. It is also to be understood that the terminology used herein is for purpose of describing particular embodiments only, and is not intended to be limiting. It must be noted that, as used in the specification and the appended claim, the articles "a", "an", "the", and "said" are intended to mean that there are one or more of the elements unless the context clearly dictates otherwise. Thus, for example, reference to "a unit" or "the unit" may include several devices, and the like. Furthermore, the words "comprising", "including", "containing" and similar wordings does not exclude other elements or steps.

Brief descriptions of the drawings

[0072] The invention will by way of example be de-

scribed in more detail with reference to the appended schematic drawings, which show presently preferred embodiments of the invention.

- 5 Figure 1 shows a top view of an airport stand.
 Figures 2 - 5 show top views of two airport stands, two aircrafts and a taxiway.
 Figure 6 shows a top view of two airport stands, three aircrafts and two taxiways.
 10 Figure 7 shows a top view of airport stands, two aircrafts and three taxiways.
 Figure 8 shows a schematic view of a system according to an example embodiment.

15 Detailed description

[0073] The present invention will now be described more fully hereinafter with reference to the accompanying drawings, in which currently preferred embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided for thoroughness and completeness, and fully convey the scope of the invention to the skilled person.

25 **[0074]** Figure 1 shows a top view of an airport stand 1 and a docking system 100. The docking system 100 comprises a remote sensing system 110 configured to detect an aircraft 10 within a sensing area 112. The aircraft 10 is being push-backed by a tow truck 12 which is operated by ground personnel. The remote sensing system 110 is configured to collect, or capture, sensor data pertaining to a movement behaviour of the aircraft 10. The remote sensing system 110 includes one or more from: a radar-based system, a laser-based system, and an imaging system. The remote sensing system may for example comprise a laser-based remote sensing system configured to scan the sensing area 112.

35 **[0075]** The docking system 100 further comprises a display 130, and the docking system 100 is further configured, based on data from said remote sensing system 110, to detect, track, and guide the aircraft 10 during parking, so that the aircraft 10 is parked at a parking position 160 within a stand area of the airport stand 1. The aircraft stand 1 comprises a lead-in line 55, or centre line, for providing a visible guidance for the pilot of the aircraft 10 and/or ground personnel. The docking system 100 is further configured, based on said detection and tracking of the aircraft 10, to provide pilot manoeuvring guidance information on said display 130 for aiding a pilot of the aircraft 10 in manoeuvring the aircraft 10 towards the parking position 160. The docking system 100 is further configured to detect and track the aircraft 10 during departure of the aircraft 10 from the stand. This departure of the aircraft from the stand is referred to herein as backward movement. The docking system 100 may be configured to monitor the aircraft continuously from the point in time at which the aircraft has first entered within the

range of the remote sensing system 110 to the time at which the aircraft 10 has left the range of the remote sensing system 110. This implies that the docking system 100 may detect the aircraft 10 also during stand-still at the stand. However, it is also conceivable that the docking system 100 is informed of a forthcoming departure and initiates the detection and tracking in response to receiving said information.

[0076] The docking system 100 further comprises a controller 120. The controller 120 is configured to receive, from the remote sensing system 110, sensor data which pertains to a movement behaviour of the aircraft 10. The docking system 100 is configured to output an alarm signal in response to a determination that the aircraft 10 is moving in unwanted manner, based on the received sensor data pertaining to a movement behaviour of the aircraft 10. The manoeuvring guidance information may comprise the alarm signal, for example in the form of a warning message shown on the display 130.

[0077] Figure 2 shows a top view of two airport stands 1, 2, two aircrafts 10, 20 and a taxiway 170. Each of the airport stands 1, 2 comprises a respective docking system 100, 200. Figure 2 further shows airport building 5 which comprises an airport tower 90. The docking systems 100, 200 are configured to communicate with the airport tower 90. The docking systems 100, 200 may be configured to communicate with the airport tower 90 via a central system of the airport.

[0078] The first docking system 100 is configured to collect sensor data pertaining to a movement behaviour of a first aircraft 10 of the two aircrafts, which is positioned within a sensing area 112 of the first docking system 100. The second docking system 100 is configured to collect sensor data pertaining to a movement behaviour of a second aircraft 20 of the two aircrafts, which is positioned within a sensing area 212 of the second docking system 200. The first docking system 100 is unable to collect sensor data pertaining to the movement behaviour of the second aircraft 20, since the second aircraft 20 is positioned outside of the sensing area 112 of the first docking system 100. Correspondingly, the second docking system 200 is unable to collect sensor data pertaining to the movement behaviour of the first aircraft 10, since the first aircraft 10 is positioned outside of the sensing area 212 of the second docking system 200.

[0079] A controller (not shown, see e.g. Figure 1) of the first docking system 100 may be configured to receive the first sensor data, the second sensor data, and aircraft data. The controller may be configured to receive the second sensor data from the second docking system 200 and/or via an intermediate system, such as airport control systems at the airport tower 90. The controller may be configured to receive the aircraft data from the airport tower 90.

[0080] The aircraft data may be, for example, stand departure instructions. Stand departure instructions may comprise a simple Yes/No to depart only, i.e. a clearance to depart from the stand. Alternatively, stand departure

instructions may further comprise information pertaining to an expected movement behaviour of the aircraft during departure. This implies that the stand departure instructions may contain for example information indicating a planned route for the aircraft to follow during departure from the stand. The aircraft data may comprise spatial coordinates pertaining to an expected position of the aircraft. The spatial coordinates may pertain to a single position, such as a reference position defined at the airport. Alternatively, the spatial coordinates may pertain to a plurality of expected positions of the aircraft. This implies that the aircraft data may comprise spatial coordinates pertaining to an expected path that the aircraft is expected, or cleared, to follow at the airport. Moreover, the aircraft data may comprise orientation data, such as e.g. one or more angles, defining how the aircraft is expected to be oriented with respect to a reference orientation (could be e.g. the stand centre line, or a north direction). The aircraft data may comprise both position data and orientation data but may alternatively contain position data only or orientation data only. The aircraft data may comprise timestamped data. For example, the aircraft data may comprise one or more expected positions, and/or orientations, of an aircraft each defined at a specific position in time. The aircraft data may be received from a system of the airport. For example, the aircraft data may be received from traffic control at the tower 90 of the airport. The aircraft data may be at least partly based on data in a flight plan. It is also conceivable that the aircraft data is retrieved from an airport operational database AODB. The aircraft data may be, or may include, stand departure instructions.

[0081] The sensor data may comprise spatial coordinates pertaining to a position of the aircraft. Such spatial coordinates may pertain to a plurality of positions of the aircraft. The plurality of positions may define a tracked path of the aircraft when the aircraft moves within the range of a docking system. Moreover, the sensor data may comprise orientation data, such as e.g. one or more angles, defining how the aircraft is oriented with respect to a reference orientation (could be e.g. the stand centre line, or a north direction). The sensor data may comprise both position data and orientation data but may alternatively contain position data only or orientation data only. The sensor data may comprise timestamped data. For example, the sensor data may comprise one or more sensed positions, and/or orientations, of an aircraft each defined at a specific position in time.

[0082] Referring again to Figure 2, the first aircraft 10 is currently being moved backwards towards the taxiway 170 by a tow truck 12. Thus, the first aircraft 10 is performing a push-back. The backward movement of the first aircraft 10 is not being made along the lead-in line 55. The push-back of the first aircraft 10 is moving the tail-end of the first aircraft 10 backward and toward the second airport stand 2 (i.e. towards the left as shown in Figure 2). The first sensor data, i.e. sensor data pertaining to the push-back of the first aircraft 10, is sensed, or

collected, by the first docking system 100. At the same time as the first aircraft 10 is performing a push-back, the second aircraft 20 is also being moved backwards towards the taxiway 170. The second aircraft 20 is moving backwards without the use of a tow truck. For example, the backward movement of the second aircraft 20 may be a powerback performed by the second aircraft 20. The backward movement of the second aircraft 20 is being made along a second lead-in line 57 of the second airport stand 2. The backward movement of the second aircraft 20 is moving the tail-end of the second aircraft 20 backward and toward the first airport stand 1 (i.e. towards the right as shown in Figure 2). The second sensor data, i.e. sensor data pertaining to the backward movement of the second aircraft 20, is sensed, or collected, by the second docking system 200.

[0083] If neither of the docking systems 100, 200 is aware of what is occurring at the sensing area 112, 212 of the neighbouring docking system, then the backward movements of the first aircraft 10 and the second aircraft 20, as shown in Figure 2, may cause a collision between the first aircraft 10 and the second aircraft 20. However, by receiving, from the first docking system 100, arranged at the first airport stand 1, first sensor data which pertains to the movement behaviour of the first aircraft 10, receiving, from the second docking system 200 arranged at the second airport stand 2, second sensor data which pertains to the movement behaviour of the second aircraft 20, and comparing the first sensor data with the second sensor data, one or more aircraft movement behaviour comparison parameters can be provided. In response to a determination that one or more aircraft movement behaviour comparison parameters fails to meet one or more predetermined movement behaviour criteria, an alarm signal may be output. Thereby, the collision between the first aircraft 10 and the second aircraft 20 may be avoided.

[0084] For example, the first sensor data may comprise a sensed position of the first aircraft 10 and/or a sensed orientation of the first aircraft 10. The second sensor data may comprise a sensed position of the second aircraft 20 and/or a sensed orientation of the second aircraft 20. The one or more aircraft movement behaviour comparison parameters may comprise a second distance parameter which is based on a comparison between the sensed position of the first aircraft 10 and the sensed position of the second aircraft 20, and/or a second orientation parameter which is based on a comparison between the sensed orientation of the first aircraft 10 and the sensed orientation of the second aircraft 20.

[0085] Distance parameters, such as the second distance parameter referred to hereinabove, can be e.g. the shortest distance between the two aircrafts. The distance may be defined as the distance between respective reference positions of the two aircrafts 10, 20, such as e.g. the positions of the respective aircraft noses of the two aircrafts. Orientation parameters, such as the second orientation parameter referred to hereinabove, may be an angular difference in orientation between the two air-

crafts. This may for example be defined as the angular difference between the longitudinal direction of the first aircraft body and the longitudinal direction of the second aircraft body.

[0086] Further, the one or more movement behaviour criteria may include a second distance threshold and/or a second orientation threshold. The movement behaviour of the first aircraft 10 fails to meet the at least one of the one or more predetermined movement behaviour criteria when the second distance parameter exceeds the second distance threshold and/or the second orientation parameter exceeds the second orientation threshold.

[0087] Thus, the alarm signal is output when the second distance parameter exceeds the second distance threshold and/or the second orientation parameter exceeds the second orientation threshold.

[0088] Additionally, the second distance parameter and the second orientation parameter may be taken into consideration. For example, if both of the two aircrafts 10, 20 are facing the same direction, the second distance threshold may be set to a higher level than if the aircrafts were oriented tail-to-tail. Correspondingly, the second orientation parameter and the second distance parameter may be taken into consideration. For example, if the two aircrafts 10, 20 are positioned far away from each other, the second orientation threshold may be set to a higher level than if the aircrafts were positioned in neighbouring airport stands. This implies that the controller may be configured to adjust the thresholds, such as the distance thresholds and/or the orientation thresholds, based on the one or more aircraft movement behaviour comparison parameters.

[0089] The alarm signal could be any kind of signal. Typically, it is an electrical signal transmitted by wire, or a wireless signal, transmitted to relevant receiving parties at the airport, such as e.g. the airport traffic control, i.e. the tower 90, the pilots of the aircrafts 10, 20 and ground crew. It is also conceivable that the docking systems are configured to emit sound- or light-based alarm signals on their own. The alarm signal may also be output on the display 130. As an example, the manoeuvring guidance information may comprise the alarm signal, for example in the form of a warning message shown on the display 130.

[0090] Figure 3 shows another top view of the two airport stands 1, 2, the two aircrafts 10, 20 and the taxiway 170 of Figure 2. A difference between what is shown in Figure 3 and what is shown in Figure 2 is that the second aircraft 20 shown in Figure 3 is not moving backwards, i.e. performing a stand departure. The second aircraft 20 is travelling along the taxiway 170 which passes through the sensing areas 112, 212 of the first and the second docking systems 100, 200. A front portion of the second aircraft 20 is currently positioned within the sensing area 212 of the second docking system 200. Thereby, the second docking system 200 can sense, or collect, second sensor data pertaining to the movement behaviour of the

second aircraft 20. It is to be understood that the second aircraft 20 is not limited to heading for the second airport stand 2 and may only be passing through the sensing area 212 of the second docking system 200 on its way to its destination. Thus, the method of the present disclosure is not limited to sensing aircrafts located within the stand areas. The only requirement is that the docking systems are able to sense the aircrafts, i.e. that the aircrafts are within the sensing range of the docking systems.

[0091] If the first docking system 100 would only be using the first sensor data, it would be unaware of the second aircraft 20. Thereby, the first aircraft 100 could be moving backwards to the taxiway, which would place the first aircraft 100 on the trajectory of the second aircraft 20 travelling along the taxiway 170. In other words, using only the first sensor data may inadvertently result in an incorrect determination that the first aircraft 10 can perform a backward movement. Such an incorrect backward movement may increase the risk of collision, and/or cause delays in the airport traffic.

[0092] However, by receiving the second sensor data from the second docking system 200 a comparison of the first sensor data with the second sensor data can be done so as to provide one or more aircraft movement behaviour comparison parameters. Thereby, in response to a determination that one or more aircraft movement behaviour comparison parameters fails to meet one or more predetermined movement behaviour criteria, an alarm signal may be output. Thereby, the collision between the first aircraft 10 and the second aircraft 20 can be avoided.

[0093] As readily appreciated by the person skilled in the art, the docking systems 100, 200 could be located further apart from each other than in the example where they are arranged at neighbouring stands. Moreover, more than two docking systems may be connected to allow further aircraft sensor data to be used. It is conceivable that all docking systems available at an airport are connected to allow the method to compare the sensor data from the first aircraft 10 with a plurality of further sensor data.

[0094] Figure 4 shows a top view of the two airport stands 1, 2, the two aircrafts 10, 20 and the taxiway 170 of Figures 2 and 3. A difference between what is shown in Figure 4 and what is shown in Figures 2 and 3 is that the second aircraft 20 shown in Figure 4 is currently parked on the taxiway 170 outside of the sensing areas 112, 212 of the first and second docking systems 100, 200. Further, Figure 4 shows a stand departure instruction 66 transmitted from the tower 90 to the first aircraft 10. The stand departure instruction 66 comprises the instruction for the first aircraft to depart from the gate following path 65 indicated in Figure 4 by a thick line extending from the stopping position of the first airport stand 1 towards the taxiway 170 and the second airport stand 2 (i.e. towards the left as shown in Figure 4). The stand departure instructions 66 may be comprised by received

aircraft data.

[0095] In the situation illustrated in Figure 4, the second aircraft 20 has been instructed to stop and wait for the first aircraft 10 to perform a backward movement. Due to the second aircraft 20 being positioned outside of the sensing areas 112, 212 of the first and second docking systems 100, 200, sensor data pertaining to the movement behaviour of the second aircraft 20 is not available. The first aircraft 10 is instructed, by the stand departure instruction 66, to be moved backwards to the taxiway 170 such that the first aircraft 10 and the second aircraft 20 are facing the same direction. In other words, the stand departure instruction 66 provides a path 65 which is deviating from the lead-in line 55. The first aircraft 10 was supposed to travel along the taxiway 170 to the right in Figure 4, thereby making room for the second aircraft 20 to follow the first aircraft 10 along the taxiway 170 along the same direction. However, instead the first aircraft 10 has been incorrectly moved backwards toward the taxiway 170 along the lead-in line 55 instead of the correctly communicated path 65 such that it will end up facing the opposite direction as indicated by the stand departure instruction 66, if the backward movement is followed through. Thus, using only the first sensor data may inadvertently result in an incorrect determination that the first aircraft 10 can safely perform the backward movement. Such a backward movement may increase the risk of collision, and/or cause delays in the airport traffic.

[0096] By receiving aircraft data, comprising the stand departure instruction 66, which pertains to the expected movement behaviour of the first aircraft 10, a first comparison parameter can be obtained by a comparison between the first sensor data and the aircraft data comprising the stand departure instruction 65. Further, the one or more movement behaviour criteria includes a first threshold. Thereby, a determination of if the movement behaviour of the first aircraft meets the first threshold can be made, based on the first comparison parameter.

[0097] In other words, the method allows for a comparison between the movement behaviour of the first aircraft 10 and the expected movement behaviour of the first aircraft 10 as indicated by the stand departure instruction 66, which results in the first comparison parameter. Hence, the first comparison parameter indicates one or more differences between the (real) movement behaviour of the first aircraft 10 and the expected movement behaviour of the first aircraft 10 as indicated by the stand departure instruction 66.

[0098] Thereby, the method allows for outputting an alarm signal when an incorrect backward movement is being performed by receiving the first sensor data and the aircraft data pertaining to the expected movement behaviour of the first aircraft 10 and determining that the first comparison fails to meet the first threshold. Thus, a reduced risk of collision between the first aircraft 10 and the second aircraft 20 can be achieved.

[0099] Figure 5 shows a top view of the two airport stands 1, 2, the two aircrafts 10, 20 and the taxiway 170

of Figures 2 to 4. A difference between what is shown in Figure 5 and what is shown in Figures 2 to 4 is that the second aircraft 20 shown in Figure 5 is currently parked at the second airport stand 2. Further, Figure 5 shows a second stand departure instruction 68 transmitted from the tower 90 to the second aircraft 20. The second stand departure instruction 68 comprises the instruction for the second aircraft 20 to depart from the second airport stand 2 following path 67 as indicated in Figure 5 by a thick line extending from the stopping position of the second airport stand 2 towards the taxiway 170 (i.e. towards the left as shown in Figure 5). The path 67 of the second stand departure instruction 68 is deviating from the lead-in line 57 of the second airport stand 2. It is to be understood that in the situation illustrated in Figure 5, the second aircraft 20 is not moving, while the first aircraft 10 may be understood as performing a backward movement following lead-in line 55.

[0100] The second stand departure instruction 68 may be comprised by the received aircraft data. In other words, the aircraft data, comprising the second stand departure instruction 68, pertains to the expected movement of the second aircraft 20. Thereby, the method allows for a comparison between the sensor data pertaining to the movement behaviour of the first aircraft 10 and the aircraft data pertaining to the expected movement behaviour of the second aircraft 20.

[0101] Since the second aircraft 20 is parked (i.e. standing still), the second sensor data pertaining to the second aircraft 20, which is collected by the second docking system 200, is unusable with regards to estimating a risk of collision. This is an example of where the method is able to predict the risk based on expected rather than real movement at the airport. By receiving the stand departure instruction 68 and the first sensor data, a determination that the first aircraft 10 should not proceed with performing the backward movement (although the first aircraft 10 may indeed have received an instruction to do so) due to the expected movement behaviour of the second aircraft 20, even though the sensor data pertaining to the movement behaviour of the second aircraft 20 does not, at the moment, indicate that the second aircraft 20 will move. This is thus an example of where the stand departure instruction 68 is not correct. The second aircraft 20 should in this case have received an instruction to follow the lead in line 57 during backward movement, not the path 67.

[0102] Figure 6 shows a top view of the two airport stands 1,2, the two aircrafts 10, 20 and the taxiway 170 of Figures 2 to 5. In addition, Figure 6 also illustrates a third aircraft 30 and a second taxiway 171. The third aircraft 30 is travelling along the second taxiway 171 which is parallel to the taxiway 170 and is arranged at a further distance from the two airport stands 1, 2 than the taxiway 170. The second aircraft 20 is parked at the second airport stand 2.

[0103] In the situation illustrated in Figure 6, the first aircraft 10 has been moved backwards past the taxiway

170 towards the second taxiway 171. A portion of the first aircraft 10 is still within the sensing area 112 of the first docking system 100. Thus, the first aircraft 10 is currently positioned between the taxiway 170 and the second taxiway 171. The third aircraft 30 is travelling along the second taxiway 171 in a direction towards the first docking system 100 (i.e. towards the right as shown in Figure 6). If the first aircraft 10 and the third aircraft 30 continue travelling along their current directions, they would risk colliding.

[0104] The first sensor data does not pertain to movement behaviour of the third aircraft 30 since the third aircraft 30 is not within the sensing area 112 of the first docking system 100. Hence, only using the first sensor data is not enough to determine that there is a risk of collision between the first aircraft 10 and the third aircraft 30.

[0105] By receiving aircraft data 69 pertaining to the expected movement behaviour of the third aircraft 30, a comparison between the first sensor data and the aircraft data 69 can be performed so as to provide a third comparison parameter. Thereby, a determination of if the movement behaviour of the first aircraft meets a second threshold, based on the third comparison parameter can be made.

[0106] The third comparison parameter may comprise a difference between a sensed position of the first aircraft 10 and an expected position of the third aircraft 30. The third comparison may comprise a difference between a sensed orientation of the first aircraft 10 and an expected orientation of the third aircraft 30. The second threshold may comprise a second distance threshold and/or a second orientation threshold.

[0107] In Figure 6, the first aircraft 10 has previously received a stand departure instruction 71 which comprises instructions to commence a backward movement following the path 65 which is extending from a stopping position of the first airport stand 1 towards the taxiway 170 (i.e. towards the right as shown in Figure 6). The path 65 is in this example coinciding with lead-in line 55. By receiving aircraft data, comprising said stand departure instruction 71, which pertains to the expected movement behaviour of the first aircraft 10, a first comparison parameter can be obtained by a comparison between the first sensor data and the aircraft data comprising the stand departure instruction 71. Thereby, a determination of if the movement behaviour of the first aircraft 10 meets the first threshold can be made, based on the first comparison parameter, as described in the above with reference to Figure 4.

[0108] Thus, for this example embodiment, the method can use two additional data sources, which are the aircraft data pertaining to the expected movement behaviour of the first aircraft 10 and the aircraft data pertaining to the expected movement behaviour of the third aircraft 30. Each of the data sources allows for a determination that first aircraft 10 fails to meet at least one of the one or more predetermined movement behaviour criterions.

Such a determination would not be possible if only the first sensor data was used. Being able to use two additional, and independent, data sources increases the redundancy of the system, and thereby reduces the risk of a collision.

[0109] Figure 7 shows a top view of airport stands 1, 2, 3, 4, four aircrafts 10, 20, 30, 40 and a taxiway 170. In addition, Figure 7 also shows an airport building 5 and a second airport building 6. It is to be understood that the airport building 5 and the second airport building 6 may be part of a larger airport building, or complex. For example, the two airport buildings 5, 6 may be wings of a larger airport building, or complex.

[0110] Each airport stand 1, 2, 3, 4 comprises a respective docking system 100-400, which have a respective sensing area 112, 212, 312, 412, and a respective lead-in line 55, 57, 59, 61. The first and fourth airport stands 1, 4 are arranged opposite to each other, and the second and third airport stands 2, 3 are arranged opposite to each other. The first and second airport stands 1, 2 are arranged next to each other at the airport building 5, and the third and fourth airport stands 3, 4 are arranged next to each other at the second airport building 6. The sensing areas 112-412 are extending from their respective docking system 100-400 to the taxiway 170. Thereby, the sensing areas 112-412 cover portions of the taxiway 170.

[0111] The first aircraft 10 is performing a backward movement from the first airport stand 1. The first aircraft 10 has been moved backwards to the taxiway 170 by a first tow truck 12. A portion of the first aircraft 10 is within the sensing area 112 of the first docking system 100, and another portion of the first aircraft 10 is within the sensing area 412 of the fourth docking system 400.

[0112] The second and third aircrafts 20, 30 are currently parked at the second and third airport stands 2, 3, respectively.

[0113] The fourth aircraft 40 is performing a backward movement from the fourth airport stand 4 by a fourth tow truck 42. The fourth aircraft 40 is within the sensing area 412 of the fourth aircraft stand 4.

[0114] Thereby, the docking systems 100-400 are able to receive sensor data which pertains to the movement behaviours of the respective four aircrafts 10-40 from the respective docking system 100-400. Additionally, the docking systems 100-40 are able to receive aircraft data which pertains to expected movement behaviours of the four aircrafts 10-40.

[0115] According to another example, the first docking system 100 and/or the fourth docking system 400 may output an alarm signal, to stop the backward movement of the first aircraft 10 and/or the fourth aircraft 40, based on a comparison between the sensor data which pertains to the movement behaviour of the first aircraft 10 and the sensor data which pertains to the movement behaviour of the fourth aircraft 40.

[0116] The alarm signal may be sent by one of the first docking system 100 and the fourth docking system 400,

based on a determination that only one of the first aircraft 10 and the fourth aircraft 40 needs to stop to reduce the risk of a collision. In other words, it may be determined that there is a risk of collision if both of the first aircraft 10 and the fourth aircraft 40 continue performing backward movement. However, due to the first aircraft 10 being positioned at the taxiway 170, which is on the trajectory of the backward movement of the fourth aircraft 40, it may be determined that either only the fourth aircraft 40, or the fourth aircraft 40 and the first aircraft 10, needs to stop in order to reduce the risk of a collision.

[0117] An alarm signal may be sent by the first docking system 100 based on, for example, a comparison between: the first sensor data and the aircraft data pertaining to an expected movement behaviour of the first aircraft 10, which may determine that the backward movement of the first aircraft 10 needs to be stopped before the first aircraft 10 collides with the fourth aircraft 40, or the first sensor data and the fourth sensor data, which may determine that the distance between the first aircraft 10 and the fourth aircraft 40 is below a predetermined distance threshold.

[0118] An alarm signal may be sent by the fourth docking system 400 based on, for example, a comparison between:

the fourth sensor data and the aircraft data pertaining to an expected movement behaviour of the first aircraft 10, which may determine that the fourth aircraft 40 and first aircraft 10 are both performing backward movement, or
the fourth sensor data and the first sensor data, which may determine that the distance between the fourth aircraft 40 and the first aircraft 10 is below a predetermined distance threshold.

[0119] In the described example embodiments, the docking systems are themselves configured to perform the method of the disclosure and output the alarm. This implies that each docking system at the airport may be configured to perform the complete method. As an alternative, the method may be performed by several different systems. For example, two or more docking systems may be operably connected to a central system at the airport. The central system could be e.g. an Apron Management system or an Apron Control system, to which several, or all, docking systems at the airport are operably connected. The central system may comprise a controller configured to carry out parts of the method.

[0120] As an example, a system is illustrated in Fig. 8 which comprises a first docking system 100, a second docking system 200 and a central system 800 which includes a controller 810 and a computer-readable storage medium 820 comprising computer code instructions. The central system 800 is operably connected to the respective controllers 120 of the docking systems 100, 200. The system may operate as follows:

The first docking system 100 first collects first sensor

data which pertains to a movement behaviour of the first aircraft 10 and transmits said first sensor data to the controller 810. The second docking system 200 then collect second sensor data which pertains to a movement behaviour of the second aircraft 20 and transmits said second sensor data to the controller 810.

[0121] Then the controller 810 receives aircraft data which pertains to an expected movement behaviour of at least one of: the first aircraft 10 and the second aircraft 20, compares the first sensor data with at least one of the second sensor data and the aircraft data so as to provide one or more aircraft movement behaviour comparison parameters; determines, based on said one or more aircraft movement behaviour comparison parameters, if the movement behaviour of the first aircraft meets one or more predetermined movement behaviour criteria; and outputs an alarm signal in response to determining that the movement behaviour of the first aircraft fails to meet at least one of said one or more predetermined movement behaviour criteria.

[0122] As readily appreciated by the person skilled in the art, the controller 810 is thereby equally well configured to perform the method on the second aircraft 20, i. e. comparing the second sensor data with at least one of the first sensor data and the aircraft data so as to provide one or more aircraft movement behaviour comparison parameters; determining, based on said one or more aircraft movement behaviour comparison parameters, if the movement behaviour of the second aircraft meets one or more predetermined movement behaviour criteria; and outputting an alarm signal in response to determining that the movement behaviour of the first aircraft fails to meet at least one of said one or more predetermined movement behaviour criteria.

[0123] The alarm signal may be transmitted to the first 100 and/or the second 200 docking system triggering the same to display information on the display(s) 130 of the docking system(s). Alternatively, or additionally, the alarm signal may be transmitted to other entities at the airport, such as traffic control.

[0124] The person skilled in the art realizes that the present invention by no means is limited to the preferred embodiments described above. On the contrary, many modifications and variations are possible within the scope of the appended claims. Additionally, variations to the disclosed embodiments can be understood and effected by the skilled person in practicing the claimed invention, from a study of the drawings, the disclosure, and the appended claims.

Claims

1. A method for monitoring backward movement of a first aircraft (10) at a first airport stand (1), the method comprising:

receiving, from a first docking system (100) ar-

ranged at the first airport stand (1), first sensor data which pertains to a movement behaviour of the first aircraft (10),
receiving, from a second docking system (200) arranged at a second airport stand (2), second sensor data which pertains to a movement behaviour of a second aircraft (20, 30),
receiving aircraft data which pertains to an expected movement behaviour of at least one of: the first aircraft (10) and the second aircraft (20, 30),
comparing the first sensor data with at least one of the second sensor data and the aircraft data so as to provide one or more aircraft movement behaviour comparison parameters;
determining, based on said one or more aircraft movement behaviour comparison parameters, if the movement behaviour of the first aircraft meets one or more predetermined movement behaviour criteria; and
outputting an alarm signal in response to determining that the movement behaviour of the first aircraft fails to meet at least one of said one or more predetermined movement behaviour criteria.

2. A method according to claim 1, wherein said first sensor data, said second sensor data and said aircraft data each comprise aircraft position data, and/or wherein said first sensor data, said second sensor data and said aircraft data each comprise aircraft orientation data.
3. A method according to claim 1 or 2, wherein said aircraft data pertains to the expected movement behaviour of the first aircraft, wherein said one or more aircraft movement behaviour comparison parameters comprises a first comparison parameter which is based on a comparison between said first sensor data and said aircraft data pertaining to the expected movement behaviour of the first aircraft, wherein said one or more movement behaviour criteria include a first threshold; and wherein the movement behaviour of the first aircraft fails to meet said at least one of the one or more movement behaviour criteria when the first comparison parameter exceeds the first threshold.

4. A method according to claim 3,

- wherein said first sensor data comprises a sensed position of the first aircraft,
- wherein said aircraft data comprises an expected position of the first aircraft,
- wherein said first threshold comprises a first distance threshold, and
- wherein the movement behaviour of the first

aircraft fails to meet said at least one of the one or more movement behaviour criteria when a difference between said sensed position of the first aircraft and said expected position of the first aircraft exceeds said first distance threshold.

5. A method according to claim 3 or 4,

- wherein said first sensor data comprises a sensed orientation of the first aircraft,
- wherein said aircraft data comprises an expected orientation of the first aircraft,
- wherein said first threshold comprises a first orientation threshold, and
- wherein the movement behaviour of the first aircraft fails to meet said at least one of the one or more movement behaviour criteria when a difference between said sensed orientation of the first aircraft and said expected orientation of the first aircraft exceeds said first orientation threshold.

6. A method according to any one of the preceding claims, wherein said one or more aircraft movement behaviour comparison parameters comprises a second comparison parameter which is based on a comparison between said first sensor data and said second sensor data, wherein said one or more movement behaviour criteria include a second threshold; and wherein the movement behaviour of the first aircraft fails to meet said at least one of the one or more predetermined movement behaviour criteria when the second comparison parameter exceeds the second threshold.

7. A method according to claim 6,

- wherein said first sensor data comprises a sensed position of the first aircraft,
- wherein said second aircraft data comprises a sensed position of the second aircraft,
- wherein said second threshold comprises a second distance threshold, and
- wherein the movement behaviour of the first aircraft fails to meet said at least one of the one or more movement behaviour criteria when a difference between said sensed position of the first aircraft and said sensed position of the second aircraft is less than said second distance threshold.

8. A method according to claim 6 or 7,

- wherein said first sensor data comprises a sensed orientation of the first aircraft,
- wherein said second aircraft data comprises a

sensed orientation of the second aircraft,

- wherein said second threshold comprises a second orientation threshold, and
- wherein the movement behaviour of the first aircraft fails to meet said at least one of the one or more movement behaviour criteria when a difference between said sensed orientation of the first aircraft and said sensed orientation of the second aircraft is less than said second orientation threshold.

9. A method according to any one of the preceding claims, wherein said aircraft data pertains to the expected movement behaviour of the second aircraft, wherein

said one or more aircraft movement behaviour comparison parameters comprises a third comparison parameter which is based on a comparison between said first sensor data and said aircraft data pertaining to the expected movement behaviour of the second aircraft, and wherein the movement behaviour of the first aircraft fails to meet said at least one of the one or more predetermined movement behaviour criteria when the third comparison exceeds the second threshold.

10. A method according to claim 9,

- wherein said first sensor data comprises a sensed position of the first aircraft,
- wherein said aircraft data comprises an expected position of the second aircraft,
- wherein said second threshold comprises a second distance threshold, and
- wherein the movement behaviour of the first aircraft fails to meet said at least one of the one or more movement behaviour criteria when a difference between said sensed position of the first aircraft and said expected position of the second aircraft is less than said second distance threshold.

11. A method according to claim 9 or 10,

- wherein said first sensor data comprises a sensed orientation of the first aircraft,
- wherein said aircraft data comprises an expected orientation of the second aircraft,
- wherein said second threshold comprises a second orientation threshold, and
- wherein the movement behaviour of the first aircraft fails to meet said at least one of the one or more movement behaviour criteria when a difference between said sensed orientation of the first aircraft and said expected orientation of the second aircraft is less than said second ori-

entation threshold.

12. A method according to any one of the claims 1 to 11, wherein said one or more predetermined movement behaviour criteria are adjusted based on the first sensor data and/or the second sensor data and/or the aircraft data. 5
13. A computer-readable medium comprising computer code instructions which when executed by a device having processing capability are adapted to perform the method according to any one of claim 1 to 12. 10
14. A docking system (100) for guiding a pilot of an aircraft (10) to a stop position at an airport stand (1), the aircraft docking system (100) comprising: 15
a remote sensing system (110) configured to collect, or capture, sensor data pertaining to a movement behaviour of the aircraft (10); 20
a display (130) for providing manoeuvring guidance information to the pilot of the aircraft (10); wherein the docking system is configured to:
collect, by said remote sensing system (110), sensor data which pertains to a movement behaviour of the aircraft (10) at the airport stand (1), 25
receive, from a further docking system (200) arranged at a further airport stand (2), further sensor data which pertains to a movement behaviour of a further aircraft (20, 30), 30
receive aircraft data which pertains to an expected movement behaviour of at least one of: the aircraft (10) and the further aircraft (20, 30), 35
compare the sensor data with at least one of the further sensor data and the aircraft data so as to provide one or more aircraft movement behaviour comparison parameters; 40
determine, based on said one or more aircraft movement behaviour comparison parameters, if the movement behaviour of the aircraft meets one or more predetermined movement behaviour criteria; and 45
output an alarm signal in response to determining that the movement behaviour of the aircraft fails to meet at least one of said one or more predetermined movement behaviour criteria. 50
15. A system at an airport comprising:
a first docking system (100) for guiding a pilot of a first aircraft (10) to a stop position at a first airport stand (1); 55
a second (200) docking system for guiding a pilot

of a second aircraft (20) to a stop position at a second airport stand (2);
said first and second docking systems each comprising a respective remote sensing system (110) configured to collect, or capture, sensor data pertaining to a movement behaviour of the respective aircraft (10,20); and
a controller (810) operably connected to the first and second docking systems;
wherein said first docking system (100) is configured to collect first sensor data which pertains to a movement behaviour of the first aircraft (10) and transmit said first sensor data to the controller (810), and
wherein said second docking system (200) is configured to collect second sensor data which pertains to a movement behaviour of the second aircraft (20) and transmit said second sensor data to the controller (810),
wherein the controller (810) is configured to:

receive aircraft data which pertains to an expected movement behaviour of at least one of: the first aircraft (10) and the second aircraft (20),
compare the first sensor data with at least one of the second sensor data and the aircraft data so as to provide one or more aircraft movement behaviour comparison parameters;
determine, based on said one or more aircraft movement behaviour comparison parameters, if the movement behaviour of the first aircraft meets one or more predetermined movement behaviour criteria; and

output an alarm signal in response to determining that the movement behaviour of the first aircraft fails to meet at least one of said one or more predetermined movement behaviour criteria.

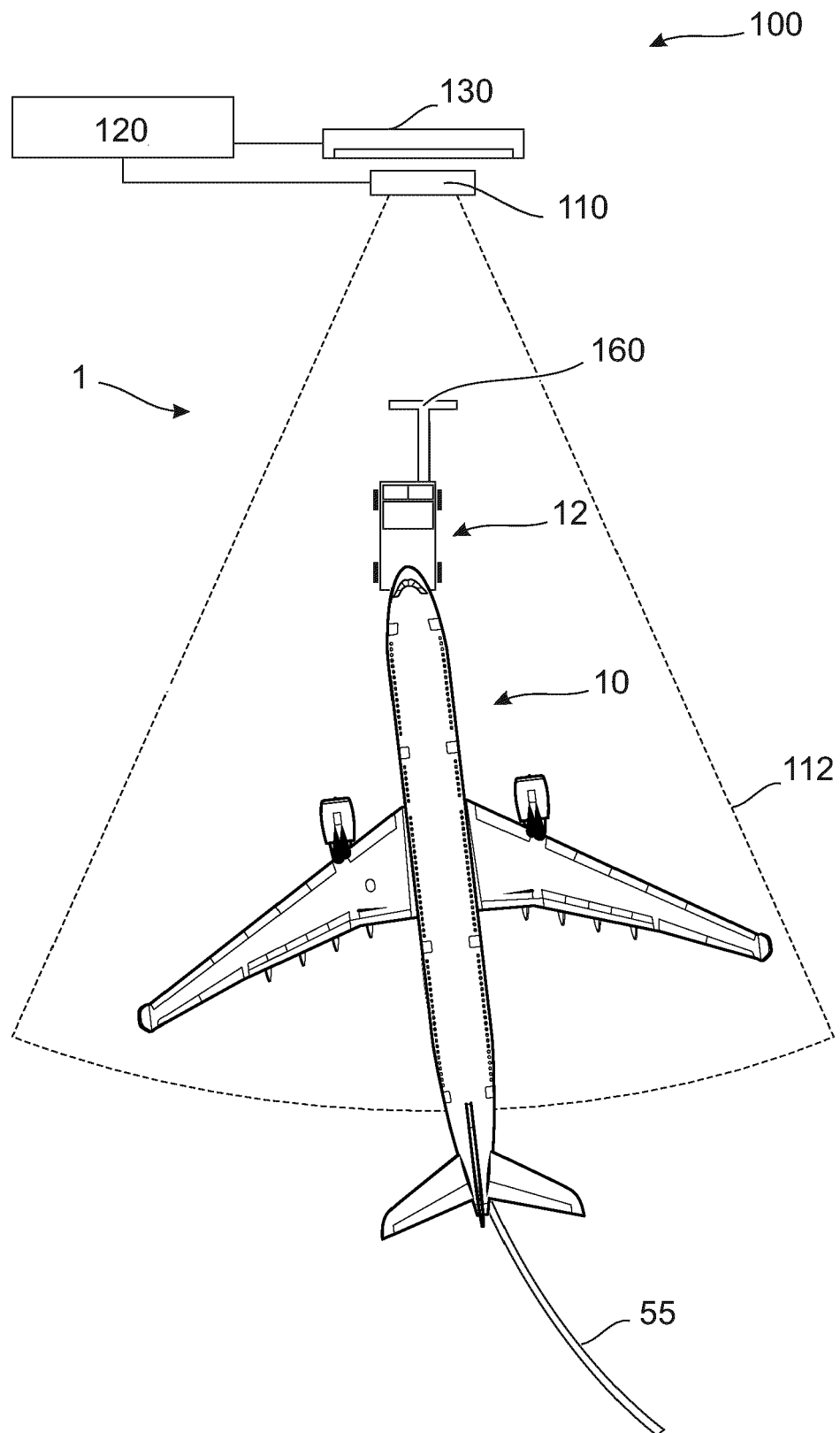
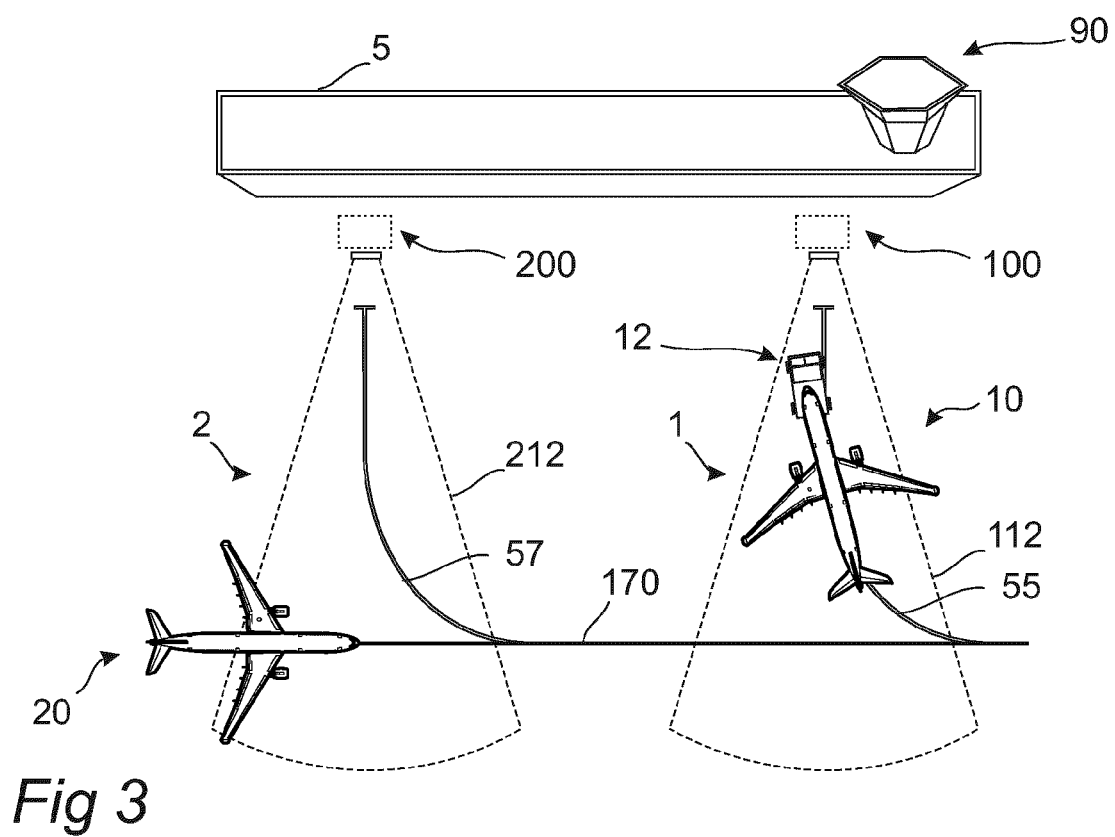
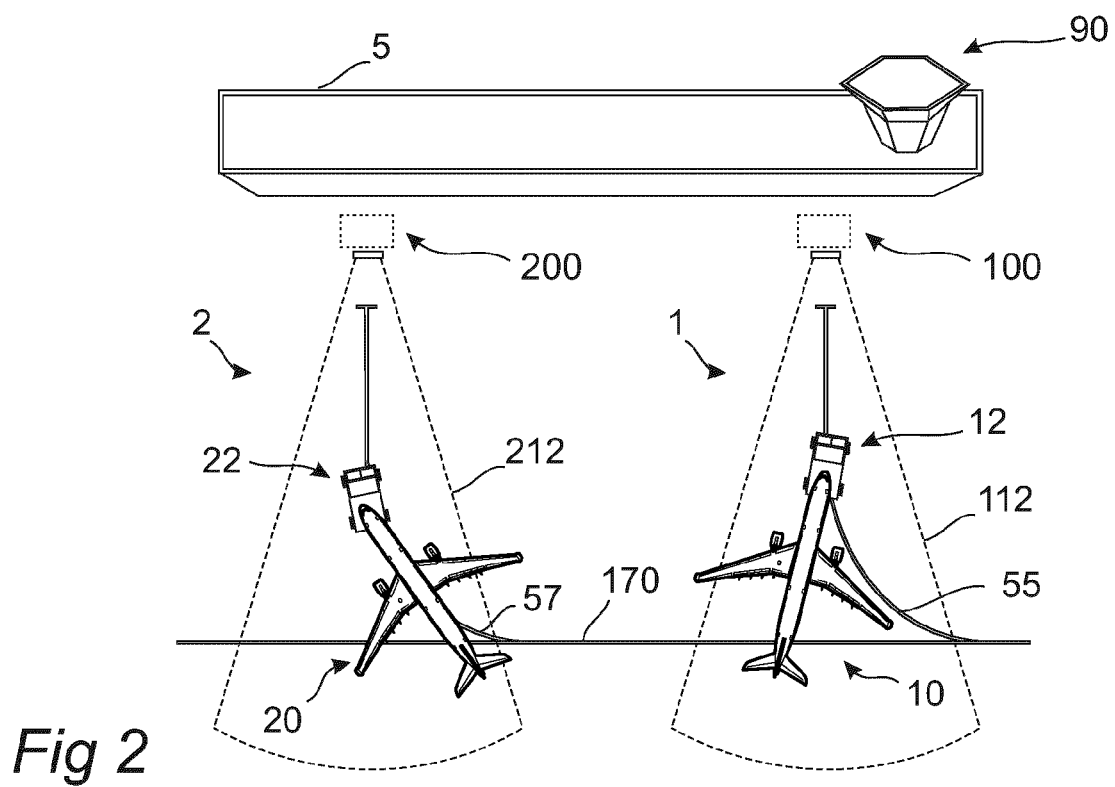
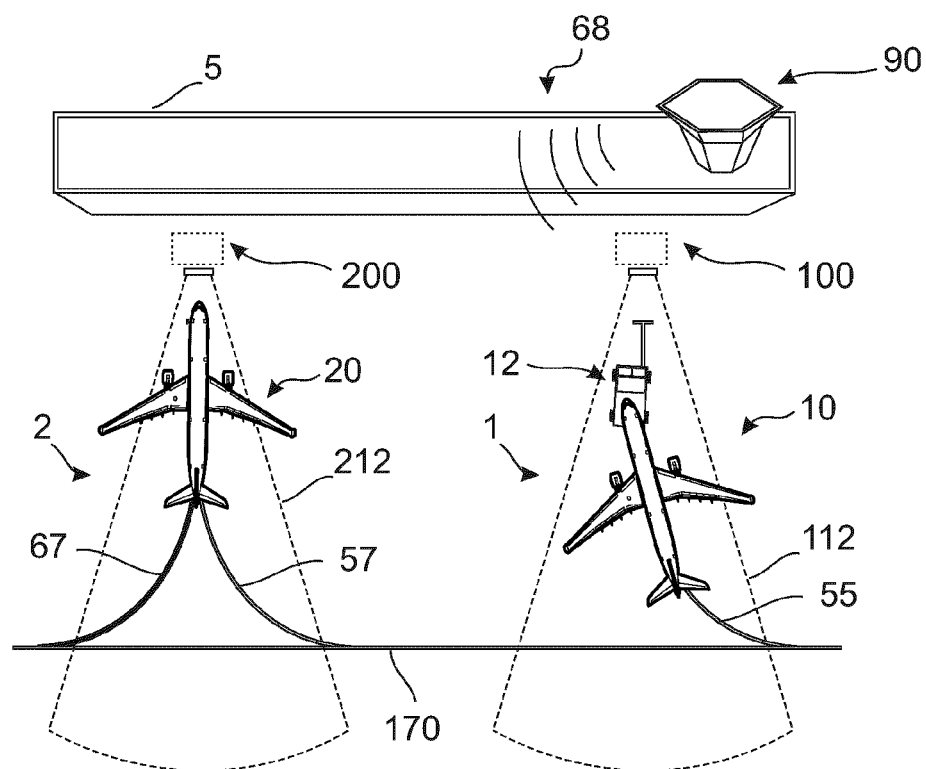
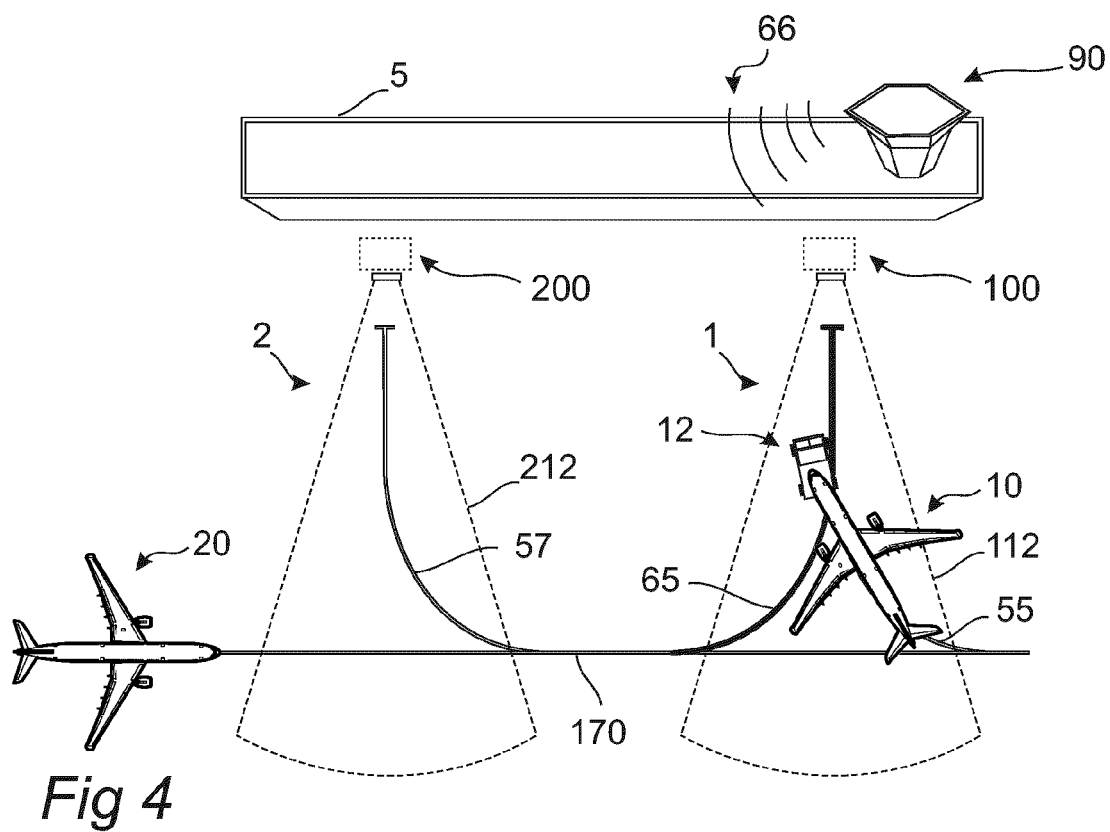


Fig 1





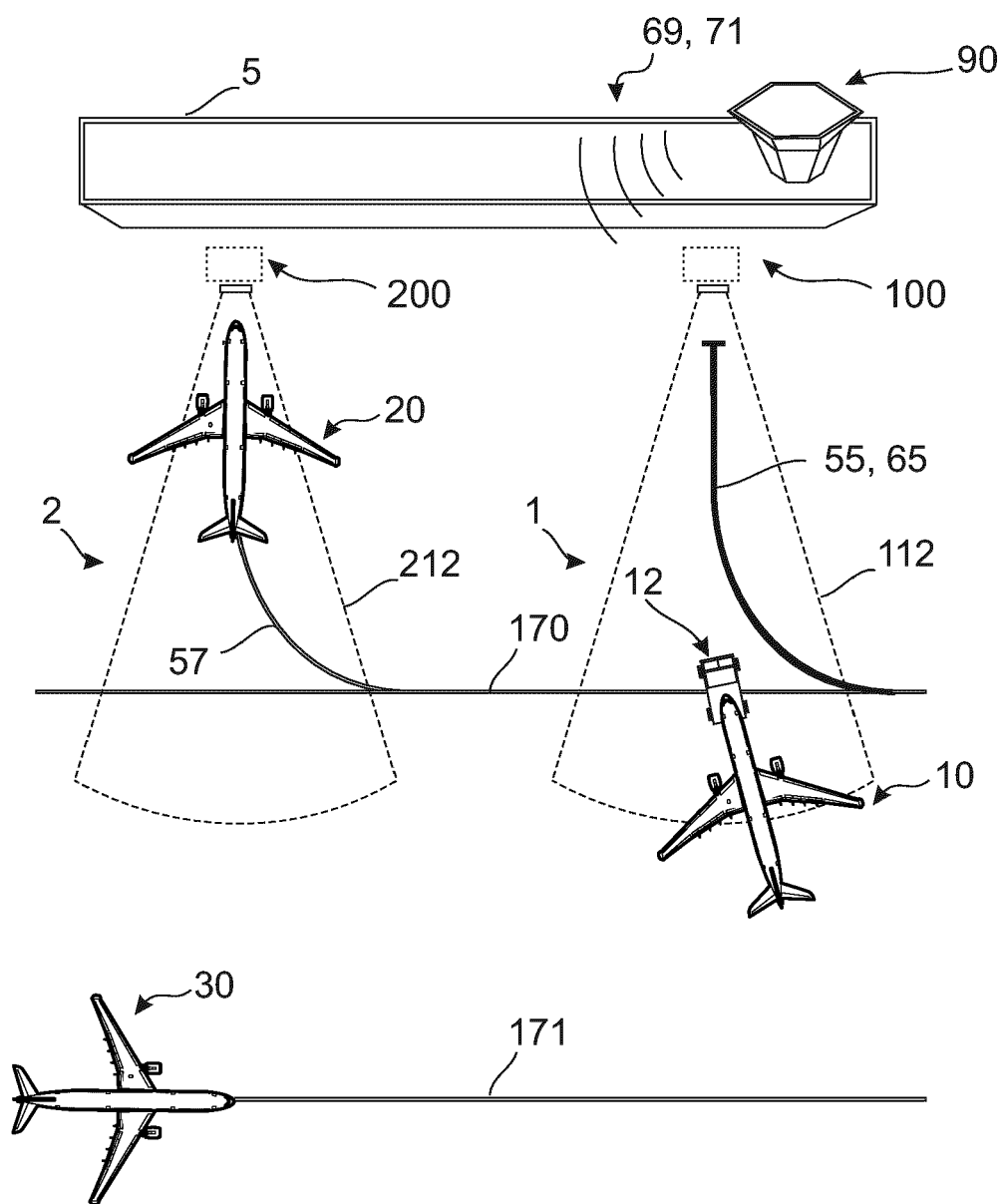


Fig 6

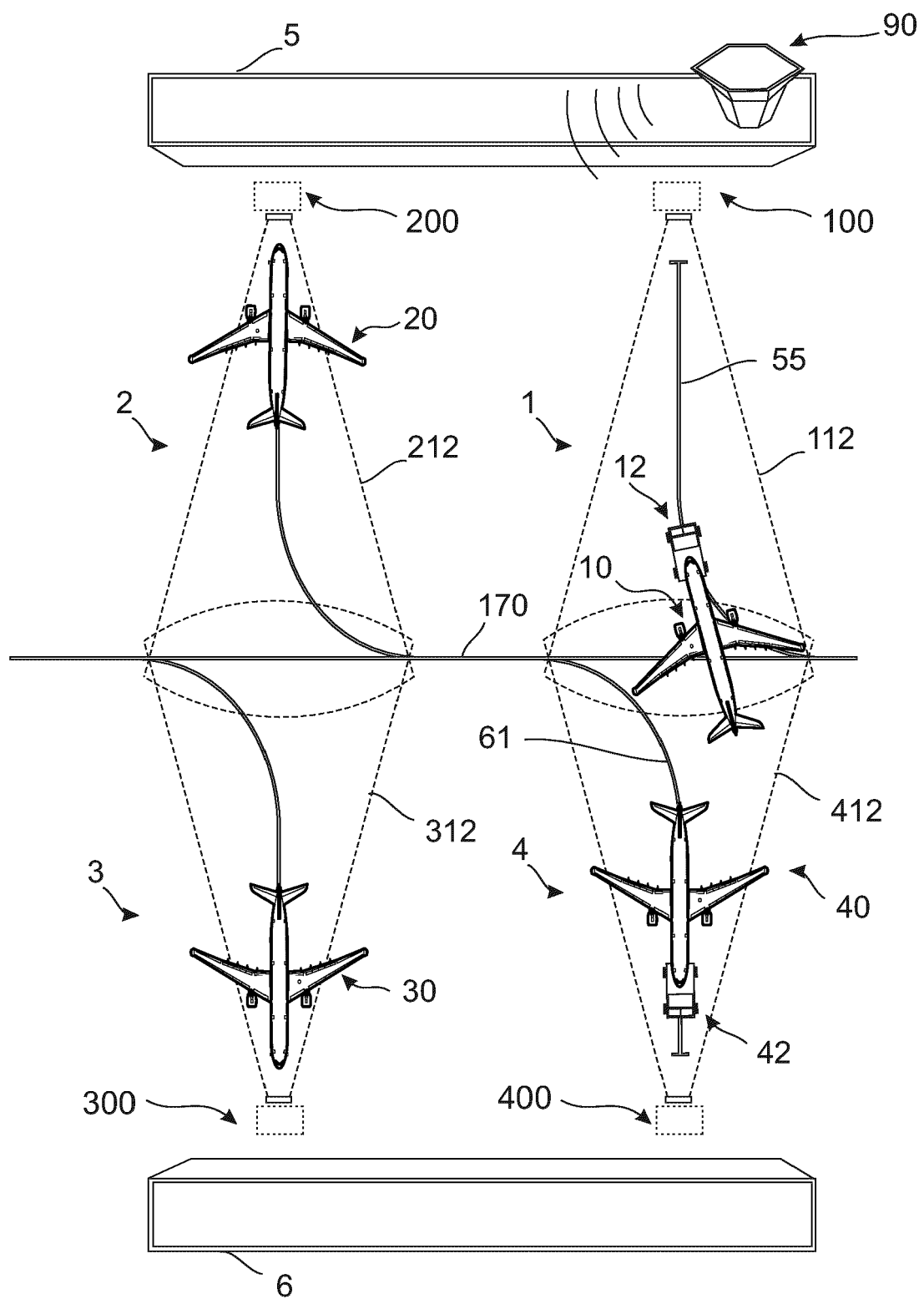


Fig 7

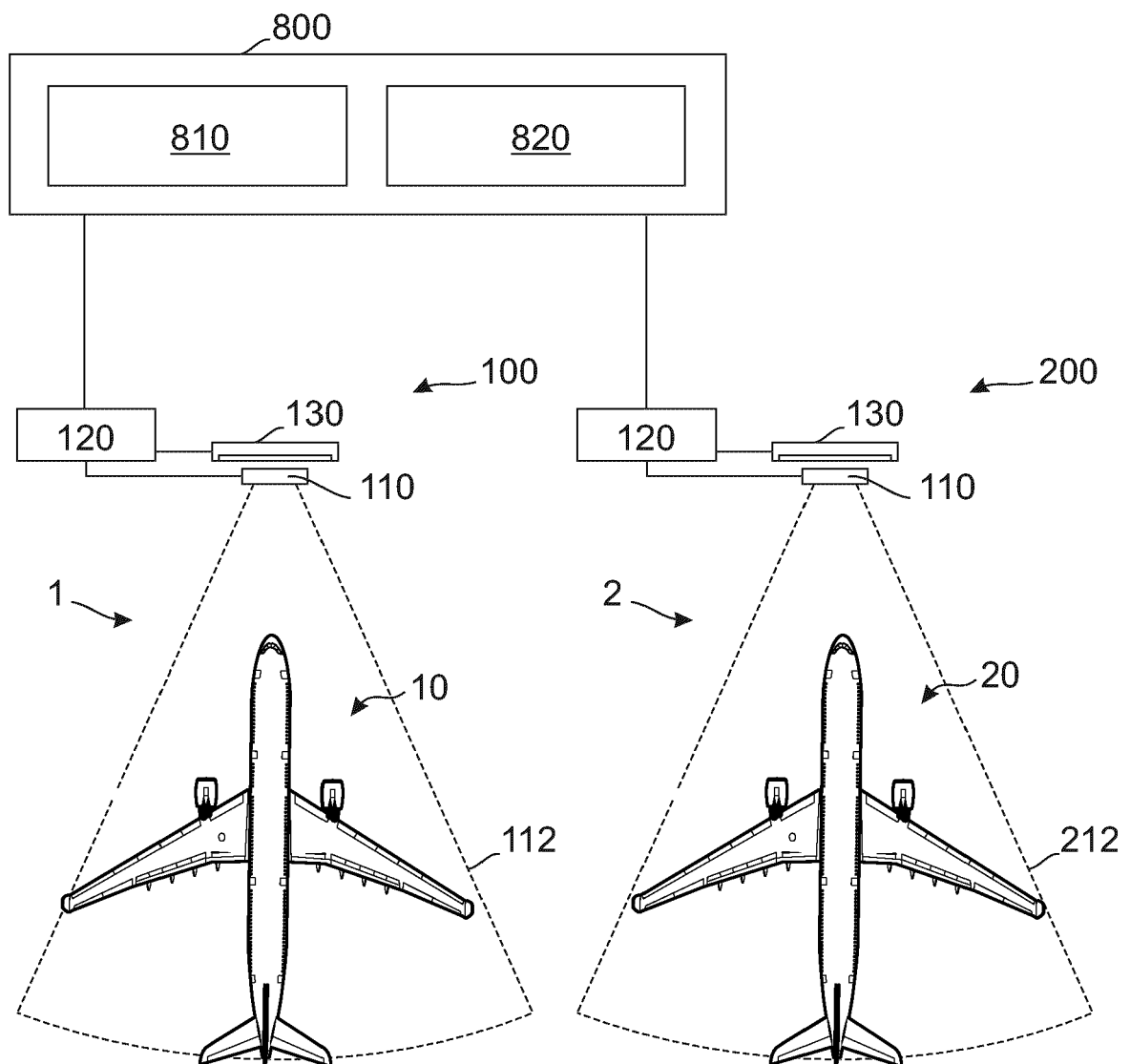


Fig 8



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Application Number

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