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Canadian Intellectual Property Office

CA 2889304 C 2023/03/21

(11)(21) 2 889 304

(12) BREVET CANADIEN
CANADIAN PATENT

(13) C

(86) Date de dépôt PCT/PCT Filing Date: 2013/10/30
(87) Date publication PCT/PCT Publication Date: 2014/05/08
(45) Date de délivrance/Issue Date: 2023/03/21
(85) Entrée phase nationale/National Entry: 2015/04/23
(86) N° demande PCT/PCT Application No.: EP 2013/072712
(87) N° publication PCT/PCT Publication No.: 2014/067996
(30) Priorité/Priority: 2012/10/30 (DE10 2012 110 384.4)

(51) Cl.Int./Int.Cl. *G08G 3/02* (2006.01),
H04B 7/185 (2006.01)

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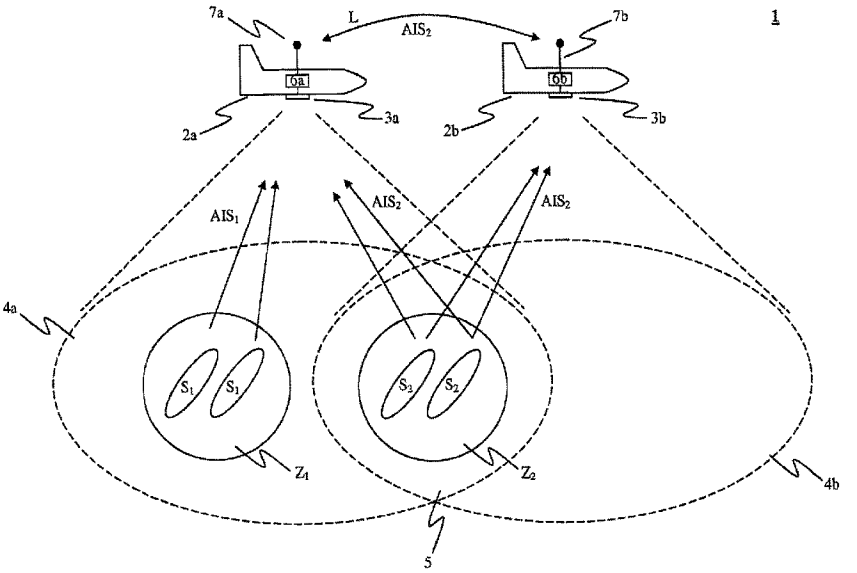
(54) Titre : SYSTEME DE SURVEILLANCE AIS
(54) Title: AIS MONITORING SYSTEM



(57) Abrégé/Abstract:
The invention relates to an AIS monitoring system for monitoring ships which transmit AIS radio signals with the aid of transmission units, said signals being received with the aid of an aerial object. The received AIS radio signals are processed with the help of radio signals received by other receiver units in an overlap region of the receiver region.

ABSTRACT

The invention relates to an AIS monitoring system for monitoring ships which transmit AIS radio signals with the aid of transmission units, said signals being received with the aid of an aerial object. The received AIS radio signals are processed with the help of radio signals received by other receiver units in an overlap region of the receiver region.

AIS MONITORING SYSTEM

Technical Field

The invention relates to a monitoring system for monitoring ships that each have AIS ship transmission units for transmitting AIS radio signals that contain shipping traffic data from the respective sending ship, having a plurality of AIS reception units for receiving the AIS radio signals sent by the ships within a respective reception range of the AIS reception units, wherein at least some of the AIS reception units are arranged on a plurality of flying objects for air monitoring purposes.

Background

Today, monitoring of shipping traffic, which is increasing worldwide, is based predominantly on radar monitoring, radio telephony and the use of AIS (Automatic Identification System). Since the year 2000, the AIS has been stipulated as an obligatory standard by the International Maritime Organization (IMO) in order to increase the safety of international shipping traffic. This locally bounded radio system is used in this case for the interchange of navigation and other shipping data that are meant to allow the ships to obtain a comprehensive overview of the adjacent shipping traffic. The primary aim in this case is to avoid collisions between ships.

The AIS alternately transmits on two channels in the VHF marine radio band, namely first on 168.975 MHz and secondly on 162.025 MHz. In this case, the individual AIS shipping data items are transmitted in fixed timeframes, the use of which is automatically coordinated by the relevant subscribers (what is known as SOTDMA: self-organizing time-division multiple access). Hence, there are just 2250 time slots per minute available to the individual subscribers for transmitting data.

On the basis of the VHF frequency band used, the radio range of AIS from ship to ship corresponds to approximately 40 to 60 km, which corresponds to little more than normal visibility on the high sea. Coastal stations are able to cover a radius of up to 100 km as a result of their relatively high position. On account of the limited range and also the transmission protocol used, ships that are able to see and receive one another form an AIS radio cell within which the subscribers are able to send and receive their data without collision.

Hence, the AIS is merely a local radio system that, although it provides sufficient data for a ship on the high sea, is not suitable for worldwide collection for the increasing shipping traffic. For shipping companies, shipping organizations or environmental ministries, however, realtime collection of the AIS shipping traffic data accruing worldwide would be of great interest in order to counteract particularly also illegal practices on the high sea.

In the very recent past, attempts have been made to arrange AIS reception antennas on satellites so as to allow global reception of the AIS radio signals transmitted worldwide that are regularly transmitted by the ships. Although this would allow worldwide collection of the shipping traffic data transmitted using AIS, it has considerable difficulties and disadvantages in practice, since the AIS has not been developed for satellite reception.

The reason is that the extremely high altitude of a satellite means that a reception range, which is also called an illumination area or footprint, with a diameter of approximately 5000 km is produced. Since

the AIS, as a local radio system, automatically organizes itself into individual radio cells that all send on the same frequency bands, such a large reception diameter results in a multiplicity of radio cells with identical transmission frequencies being received, so that the AIS radio signals from the various AIS radio cells in the reception range of the satellite are superimposed and are no longer able to be evaluated without complex signal processing.

In this regard, DE 10 2011 113 152.7, for example, proposes arranging AIS reception units on commercial aircraft so as to record the AIS radio signals transmitted by the ships during flight. Owing to the relatively low altitude of aircraft (approximately 10 km) in comparison with satellites, the reception range covered, with a diameter of approximately 400 to 600 km, is distinctly smaller, which means that the risk of signal collisions on account of the reception of various different AIS radio signals is lower. However, it has been found that complex signal processing is also necessary in this case, since commercial aircraft usually cover the highly frequented shipping routes and therefore a multiplicity of AIS radio signals are received despite the relatively small reception diameter in comparison with satellites, which means that superimposed AIS radio signals are received in this case too.

Summary

It is therefore an object of certain embodiments to specify a monitoring system for monitoring ships by means of AIS radio signals that is able to be used to pick up the AIS radio signals despite the large reception diameter of flying objects and nevertheless to securely and reliably extract the shipping traffic data from the AIS radio signals.

Certain embodiments achieve this by means of the monitoring system of the type cited at the outset by virtue of at least one signal processing device being provided that is set up to ascertain AIS radio signals from received superimposed AIS radio signals from different AIS radio cells in a reception range of an AIS reception unit arranged on a flying object on the basis of one or more radio signals from the superimposed AIS radio signals from the reception range that have been received by one or more AIS reception units within the reception range that are different than the AIS reception unit of the flying object.

Certain exemplary embodiments can provide a monitoring system for monitoring ships that each have AIS ship transmission units for transmitting AIS radio signals that contain shipping traffic data from the respective sending ship, the system comprising: a plurality of AIS reception units for receiving the AIS radio signals transmitted by the ships within a respective reception range of the AIS reception units, wherein at least some of the AIS reception units are arranged on a plurality of commercial aircraft for air monitoring purposes; at least one signal processing device

for ascertaining the AIS radio signals which are contained in received superimposed AIS radio signals from different AIS radio cells in the reception range of one of the plurality of the AIS reception units arranged on one of the plurality of commercial aircraft based on one or more of the AIS radio signals contained in the superimposed AIS radio signals from the reception range that have been received by one or more of the plurality of AIS reception units within the reception range that are different than the one of the plurality of AIS reception units of the one of the plurality of commercial aircraft; wherein the at least one signal processing device further takes signal propagation times for a same AIS radio signal as has been received by different ones of the plurality of AIS reception units as a basis for determining a location information item for the AIS ship transmission unit that has transmitted the same AIS radio signal and to ascertain the AIS radio signals from the received superimposed AIS radio signals additionally based on the location information item.

Brief Description of Figures

Figure 1 shows a monitoring system in accordance with one embodiment of the invention.

Figure 2 shows a monitoring system in accordance with another embodiment of the invention.

Detailed Description

Accordingly, the invention proposes that the signal processing for the superimposed AIS radio signals that have

been received by a flying object by means of its AIS reception unit is supported by means of AIS radio signals that are part of the received superimposed AIS radio signals and have been received by other AIS reception units. In this way, the reception ranges of the various AIS reception units, particularly those of the flying objects, are superimposed very frequently, as a result of which at least some of the AIS radio signals from a reception range could also be received at least in part (in the overlap region) by adjacent AIS reception units. These AIS radio signals recorded by the other AIS reception units in the overlap region of the reception range of the flying object can then be used for signal processing and signal conditioning for the superimposed AIS radio signals from the reception range, as a result of which the quality of the signal conditioning can be substantially improved.

This achieves cooperative signal processing, in which the same AIS radio signals as have, however, been received by other AIS reception units are used for ascertaining the AIS radio signals from the

superimposed AIS radio signals. With knowledge of an AIS radio signal that is meant to be contained in superimposed AIS radio signals, the signal processing can be substantially simplified, since these radio signals are deducted from the overall signal (superimposed radio signal), for example, and thus this process can be iteratively continued until all signals have been detected.

The term air monitoring is otherwise understood to mean monitoring of the ships by receiving AIS radio signals by means of flying objects. In this case, superimposed AIS radio signals are an AIS overall signal can that can be received by an AIS reception unit of a flying object when the reception range contains a plurality of different AIS radio cells, as a result of which signal collisions and interference occur owing to overlapping of the AIS radio signals from the different AIS radio cells. In this case, the present invention can be used to increase the probability of detection of AIS radio signals within such an overlapping AIS radio signal containing interference.

In an advantageous embodiment, each flying object that has an AIS reception unit has at least one signal processing device, so that the signal processing for the superimposed AIS radio signals can be effected locally by each flying object. So as now to be able to obtain information regarding AIS radio signals from other AIS reception units, the AIS reception units are connected to at least one communication device for signaling purposes, so that the communication device can be used to exchange the AIS radio signals received by an AIS reception unit with other signal processing devices via a communication link. The AIS radio signals exchanged via the communication devices are then provided for the respective signal processing device

for signal processing purposes.

By way of example, it is thus conceivable for an AIS reception unit, a signal processing device and a communication device to be arranged on a flying object. The same arrangement is provided on a further flying object. When AIS radio signals are now received by the first flying object, these AIS radio signals received by the first flying object are transmitted to the second flying object via a communication link between the communication devices, so that the AIS radio signals received by the first flying object can be provided for the signal processing device of the second flying object. If the reception range of the first flying object now overlaps that of the second flying object in a particular region, both flying objects receive the same radio signals by means of their AIS reception units in the shared reception range. These radio signals received in the shared reception range can then be made available to the respective other flying object and its respective signal processing device for signal processing purposes.

In this case, the AIS radio signals that are received in the shared reception range of a flying object and its AIS reception unit can also be received by AIS reception units that are arranged on ships, coastal stations or the like, for example. In this case, the invention is not limited to the exchange of AIS radio signals between flying objects by means of their communication devices.

In a further advantageous embodiment, the signal processing device is part of a ground station, wherein the AIS reception units are each connected to at least one communication device for signaling purposes, so that the AIS radio signals received by the AIS

reception units can be transmitted to the ground station via a communication link and then provided for the signal processing device of the ground station. In the case of the central solution for the signal processing, all of the received AIS radio signals, including the superimposed AIS radio signals, are therefore sent to a central signal processing device of a ground station, which then has all of the data made available to it and can thus decide which radio signals have been received by different AIS reception units in parallel, so as to substantially improve the signal processing and to increase the probability of detection when the AIS radio signals are ascertained from superimposed AIS radio signals.

In this case, the various AIS reception units may be connected by means of their communication device to a direct communication link to the ground station, for example via a satellite communication link or the like.

Advantageously, the received AIS radio signals, including the superimposed AIS radio signals, have a time and/or location information item added, for example by means of a GNSS device that is connected to the respective AIS reception unit. As a result, when the signals are received, a time and/or location information item for the AIS reception unit can be produced, which is then added to the signal. The signal processing device or devices is/are then set up such that it/they ascertain(s) the AIS radio signals from the received superposed AIS radio signals additionally on the basis of the added time and/or location information items of the AIS radio signals. By way of example, the time and/or location information item of a signal can thus be used to establish whether said AIS radio signal has been received at the same time in an overlapping reception range, so that this can be used

to derive whether or not said AIS radio signal is contained in a superimposed AIS radio signal, received by another AIS reception unit. In other words, such a time and/or location information item can be used to establish the parallel reception of an AIS radio signal within a shared reception range and thus to use the AIS radio signal for signal processing for superimposed AIS radio signals.

Furthermore, it is particularly advantageous if at least one of the signal processing devices is set up to take signal propagation times for the same AIS radio signal as has been received by different AIS reception units as a basis for determining a location information item for the AIS ship transmission unit that has transmitted the AIS radio signal (simple or superimposed radio signal). Thus, hyperbolic navigation or even trilateration or also multilateration of the received AIS radio signals can establish the location or the position of the AIS ship transmission unit, which normally essentially matches the ship's position. On the basis of this location or position information item, the AIS radio signals are then ascertained from the received superimposed AIS radio signals, with the location information item acting in the supporting role in this case. The reason is that knowledge of the location information item from the transmitter and inference of the ship's position therefore reveal an information item that must be within the received radio signals, since the ship's position is part of the shipping traffic data that are contained in the AIS radio signals.

It is thus conceivable for each signal processing device to follow reception of an AIS radio signal by performing propagation time determination for the radio signal. In the case of superimposed AIS radio signals,

this can be effected on the basis of a signal peak that is clearly prominent from the superimposed AIS radio signals, for example.

A known information item that must be part of the received signals can therefore substantially simplify the signal processing. By way of example, it is thus particularly advantageous if the signal processing device is set up to retrieve and/or receive shipping traffic data already extracted from AIS radio signals so as to perform the signal processing for the superimposed AIS radio signals with knowledge of the shipping traffic data from a reception range. In this case, the shipping traffic data can be retrieved from a database, for example, to which they are written following extraction from the AIS radio signals. Alternatively, it is conceivable for the shipping traffic data to be interchanged between the signal processing devices or a special extraction unit in the case of the local solution, so that the AIS radio signals are ascertained from the superimposed AIS radio signals on the basis of supplementary information, for example from a previous coarse overview of the situation within the reception range. This can be detected more quickly and more securely on the basis of the statistical ship data, for example, such as IMO number, ship's name, call sign, etc., since these data can now be exactly associated with particular signals.

Advantageously, the signal processing device is therefore provided with an extraction unit that is set up to extract the shipping traffic data contained in the AIS radio signals.

By way of example, the signal processing can be effected such that AIS radio signals that have been received by other AIS reception units are correlated to

the superimposed AIS radio signals, the correlation being taken as a basis for ascertaining the AIS radio signals from the superimposed AIS radio signals. In this case, the signals are correlated to one another such that patterns arise at correlation peaks that record the propagation time differences, as a result of which the signal processing and ascertainment of the AIS radio signals is performed on the basis of these correlation peaks. When a signal is detected, it can then be deducted from the overall signal (superimposed AIS radio signal), with iteration of this process then allowing all of the AIS radio signals to be ascertained.

Within the context of the present invention, a flying object may be a commercial aircraft or a satellite, for example. The AIS reception units can be arranged on ships, coastal reception stations and geostationary flying platforms, for example.

The invention is explained in more detail by way of example with reference to the appended figures, in which:

Figure 1 shows a schematic illustration of a monitoring system with local signal processing;

Figure 2 shows a schematic illustration of a monitoring system with central signal processing.

Figures 1 and 2 show the monitoring system according to the invention in two embodiments, namely local signal processing and central signal processing. In this case, the two exemplary embodiments are an alternative to the other respective exemplary embodiment. However, the two

exemplary embodiments in figure 1 and figure 2 could also be operated together in a monitoring system, i.e. with both central and local signal processing.

Figure 1 shows the monitoring system 1 with local signal processing. Two flying objects 2a and 2b each have an AIS reception unit 3a and 3b onboard, these being able to be used by the flying objects 2a, 2b to receive AIS radio signals AIS_1 and AIS_2.

Thus, the flying object 2a can use its AIS reception unit 3a within its reception range 4a to receive the AIS radio signals AIS_1 and AIS_2. The flying object 2b is at a certain interval from the flying object 2a, with the reception range 4b of the flying object 2b intersecting or overlapping the reception range 4a of the flying object 2a in a subregion 5. The AIS radio signals AIS_2 transmitted in the overlap region 5 are then also received by the AIS reception unit 3b of the flying object 2b.

In this case, the AIS radio signals AIS_1 are AIS radio signals from a first AIS radio cell Z_1, while the AIS radio signals AIS_2 are transmitted by ships that are located in a second cell Z_2. The ships S_1 in the first cell Z_1 cannot see the ships S_2 in the second cell Z_2 in this case, and likewise cannot receive their corresponding transmitted AIS radio signals.

On account of the overlap between the two reception ranges 4a, 4b in the shared reception range 5, the flying object 2a can receive the AIS radio signals AIS_1 and AIS_2 from the first cell Z_1 and from the second cell Z_2, while the flying object 2b can merely receive the AIS radio signals AIS_2 from the second cell Z_2. In this case, the AIS radio signals AIS_1 from the first cell Z_1 are not situated within the reception range 4b of the

second flying object 2b. Only the AIS radio signals AIS_2 from the second cell Z_2, which is located within the shared reception range 5 (overlap region), can be received by both flying objects 2a, 2b together.

Following reception of the AIS radio signals by the respective AIS reception units 3a, 3b, the received signals are then forwarded to a respective signal processing device 6a, 6b connected to the respective reception unit. In this case, the signal processing device 6a is arranged on the first flying object 2a, while the signal processing device 6b is arranged on the second flying object 2b.

Since the flying object 2a receives at least two cells Z_1 and Z_2 in its reception range 4a, the received signal is a superimposed AIS radio signal that needs to be conditioned for signaling purposes. To this end, the first flying object 2a uses a communication device 7a to receive, via a communication link L, the AIS radio signals AIS_2 received by the second flying object 2b. In this case, the second flying object 2b likewise has a communication unit 7b. These communication devices 7a, 7b can thus be used to exchange the received AIS radio signals with one another, the exchange of the radio signals being intended to be understood within the context of the present invention to mean that the radio signals can be transmitted to and received from other communication units via a communication link.

Since the second flying object 2a has now received the AIS radio signals AIS_2 from the second flying object 2b via the communication link L, the signal processing device 6a can extract the AIS radio signals from the received superimposed AIS radio signals, for example by virtue of the signal processing device 6a extracting from the received superimposed AIS radio signal the AIS

radio signal AIS_2 that has been provided by the second flying object 2b. In the exemplary embodiment in figure 1, the AIS radio signal AIS_1 would then remain, as a result of which it has been possible to extract all of the AIS radio signals from the reception range 4a of the second flying object 2a despite the superimposition and interference as a result of the simultaneous transmission.

In the exemplary embodiment in figure 1, a multiplicity of different AIS radio cells have been dispensed with for reasons of clarity, only two radio cells being shown. The invention is not limited to this, however. Rather, provision is made for the flying objects to be able to receive a multiplicity of widely different AIS radio cells, with the radio signals transmitted by other flying objects via the communication link then being used to condition the superimposed radio signal for signaling purposes.

In this case, the signal processing by the signal processing device 6a, 6b can be further improved if additional information is made available, such as a current overview of the situation for the reception range 4a or the like. Knowledge of static ship data allows a substantial improvement in the signal conditioning and the ascertainment of the AIS radio signals from the superimposed AIS radio signals.

In contrast to figure 1, figure 2 shows a central solution for the signal processing, the AIS radio signals received by the flying objects 2a, 2b being forwarded to a ground station 7 via a communication device 6a, 6b. In this case, the transmission can be effected directly, as implemented by the flying object 2a, for example, or via a satellite communication link 8, as shown by means of the example of the second

flying object 2b. The ground station 7 contains a central signal processing device 9 that conditions the received AIS radio signals in a similar manner to the signal processing devices 6a, 6b in figure 1. In this case, the signal processing device 9 can retrieve appropriate supplementary information regarding ship data within the reception ranges 4a, 4b from a database 10 in order thus to improve the signal processing and the detection of the AIS radio signals from the superimposed AIS radio signals.

The flying objects 2a, 2b in figures 1 and 2 may be commercial aircraft, for example. The flying objects may also be satellites, however.

The supplementary information stored in the database 10 allows a substantial improvement in the detection of the individual AIS radio signals within the superimposed AIS radio signals, since at least some of the content of the individual radio signals is now known. Furthermore, it is conceivable not only for such supplementary information to be obtained by extracting the data from the individual radio signals but also for the position of the transmitter to be found by means of propagation time measurements and triangulations, for example. This also allows detection of the radio signals to be improved.

Claims:

1. A monitoring system for monitoring ships that each have AIS ship transmission units for transmitting AIS radio signals that contain shipping traffic data from the respective sending ship, the system comprising:

a plurality of AIS reception units for receiving the AIS radio signals transmitted by the ships within a respective reception range of the AIS reception units, wherein at least some of the AIS reception units are arranged on a plurality of commercial aircraft for air monitoring purposes;

at least one signal processing device for ascertaining the AIS radio signals which are contained in received superimposed AIS radio signals from different AIS radio cells in the reception range of one of the plurality of the AIS reception units arranged on one of the plurality of commercial aircraft based on one or more of the AIS radio signals contained in the superimposed AIS radio signals from the reception range that have been received by one or more of the plurality of AIS reception units within the reception range that are different than the one of the plurality of AIS reception units of the one of the plurality of commercial aircraft;

wherein the at least one signal processing device further takes signal propagation times for a same AIS radio signal as has been received by different ones of the plurality of AIS reception units as a basis for determining a location information item for the AIS ship transmission unit that has transmitted the same AIS radio signal and to ascertain the AIS

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radio signals from the received superimposed AIS radio signals additionally based on the location information item;

wherein each of the plurality of commercial aircraft has at least one signal processing device arranged thereon that is connected to the AIS reception unit of the respective commercial aircraft for signaling purposes, and the AIS reception unit is connected to at least one communication device for signaling purposes, wherein the communication devices each exchange the AIS radio signals received by the connected AIS reception units in the respective reception range with other communication devices via a communication link and provide exchanged AIS radio signals for a signal processing device, connected to the respective communication device, for signal processing purposes; and

a ground station including a signal processing device, wherein the plurality of AIS reception units are each connected to at least one communication device for signaling purposes, wherein the communication devices each forward the AIS radio signals received by the connected AIS reception units in the respective reception range to the ground station via a communication link in order to provide the AIS radio signals for the signal processing device of the ground station.

2. The monitoring system as claimed in claim 1, wherein the plurality of AIS reception units add at least one of a time information item and the location information item to the received AIS radio signals, wherein the at least one signal processing device ascertains the AIS radio signals from the received superimposed AIS radio signals additionally based on

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the added at least one of time information item and location information item of the AIS radio signals.

3. The monitoring system as claimed in any one of claims 1 to 2, further comprising at least one extraction unit for extracting the shipping traffic data contained in the AIS radio signals.

4. The monitoring system as claimed in claim 3, wherein the at least one signal processing device at least one of retrieves and receives the extracted shipping traffic data and ascertains the AIS radio signals from the received superimposed AIS radio signals additionally based on the at least one of retrieved and received shipping traffic data from the reception range in which the superimposed AIS radio signals have been received.

5. The monitoring system as claimed in any one of claims 1 to 4, wherein the at least one signal processing device correlates the superimposed AIS radio signals received by one of the plurality of AIS reception units to the superimposed AIS radio signals that have been received by others of the plurality of AIS reception units and takes the correlation as a basis for ascertaining the AIS radio signals from the superimposed AIS radio signals.

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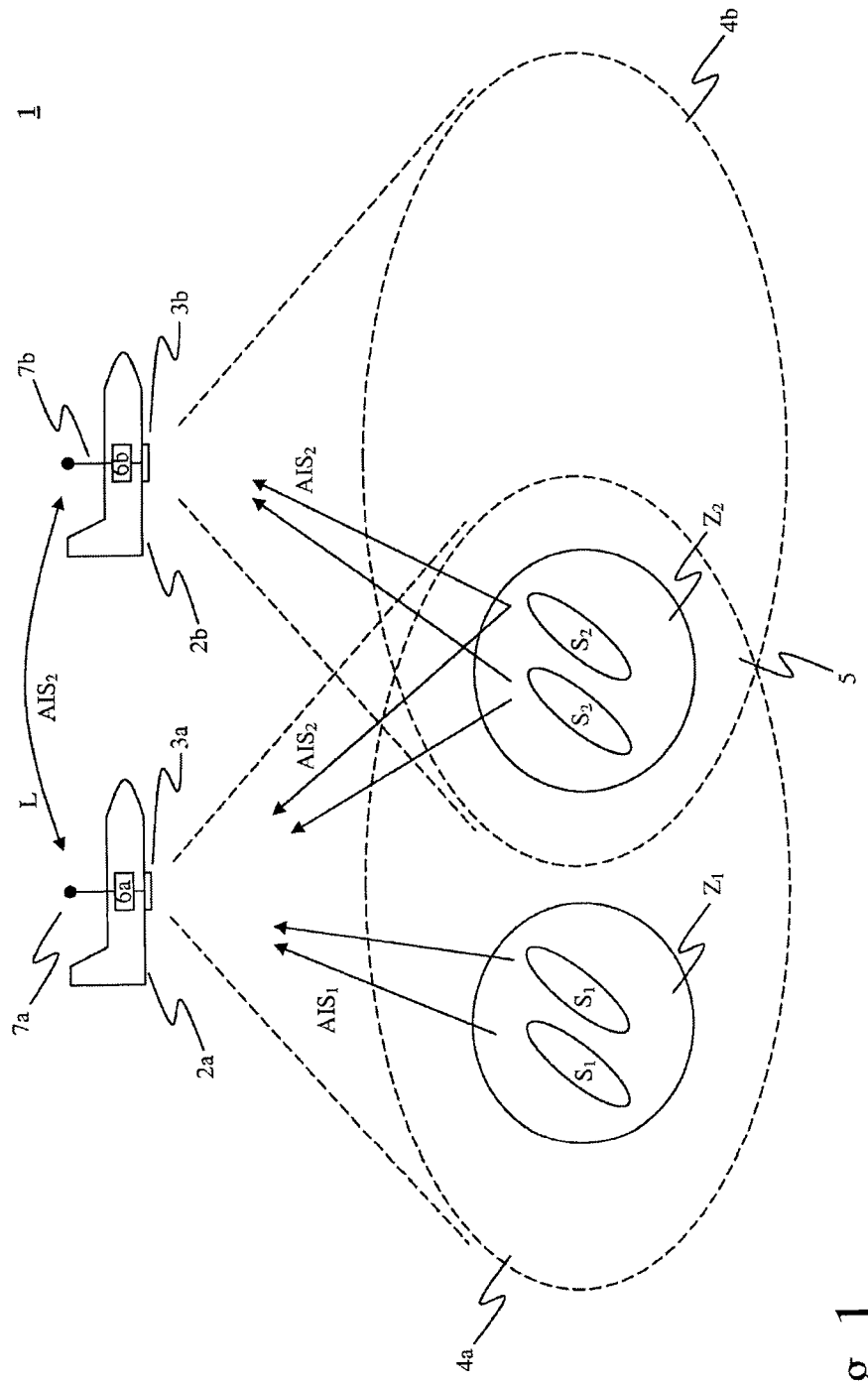
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7b
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Z2
S2
S2
2b
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S1
S1
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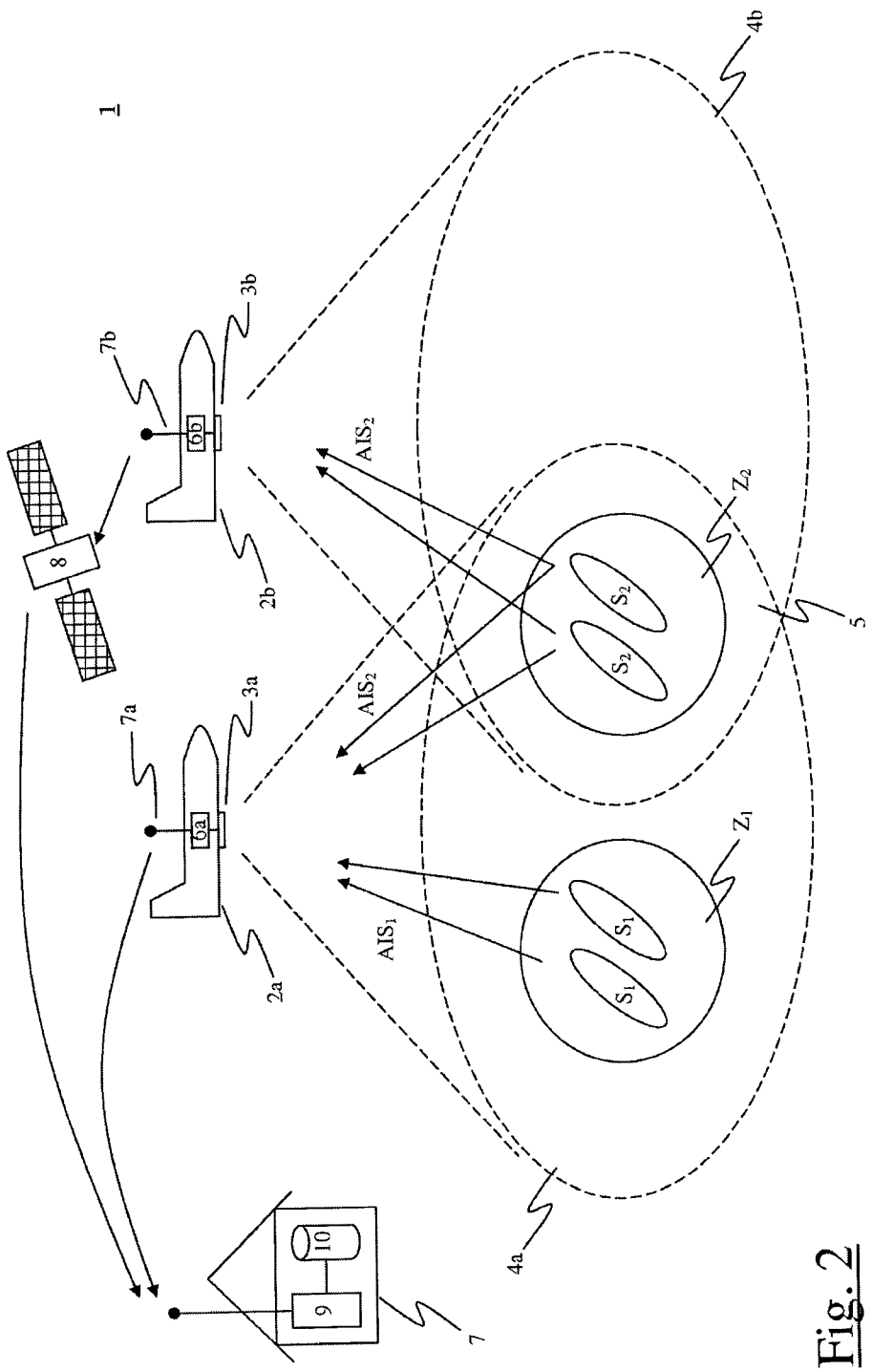
4a

Fig. 1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4a
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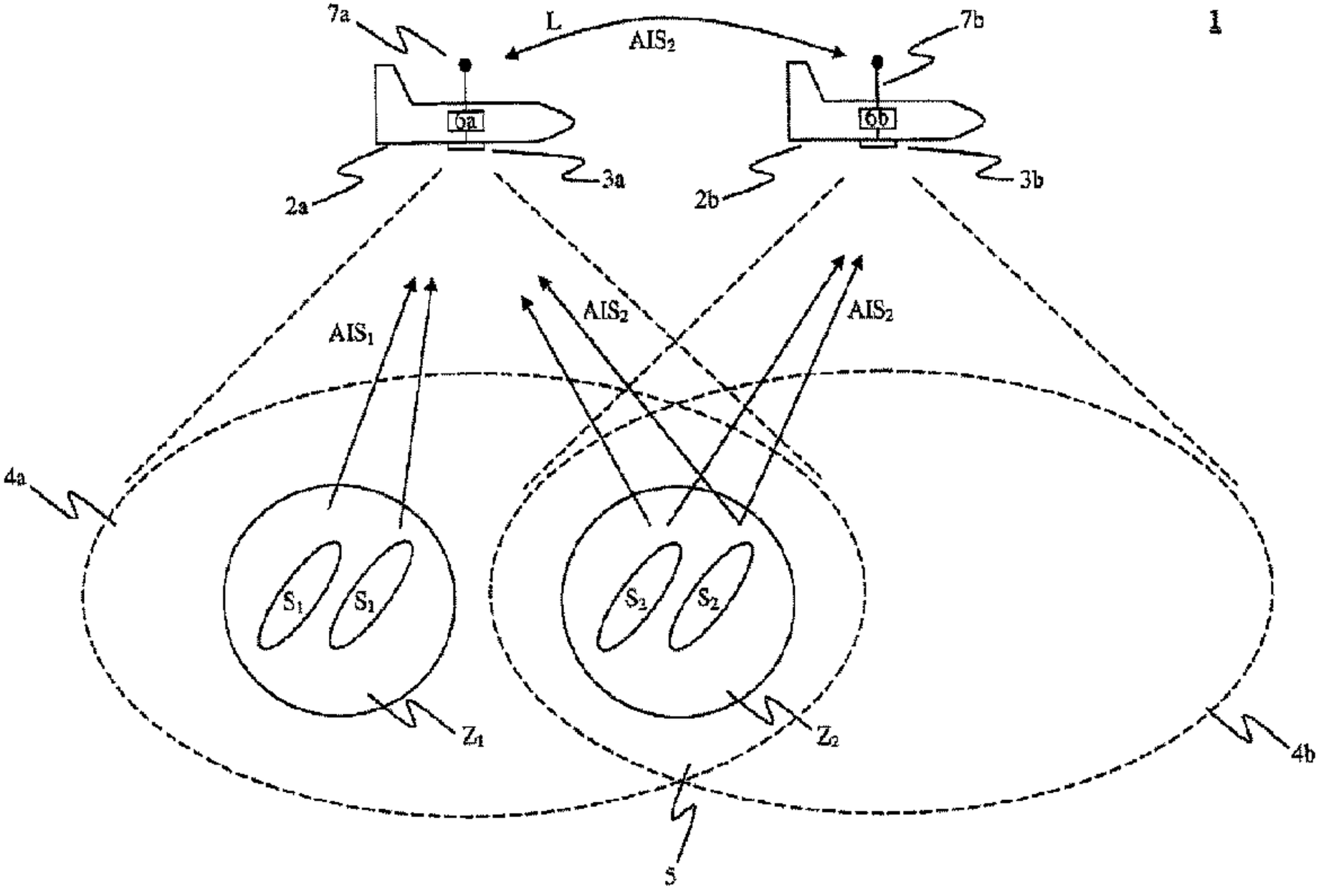
9
7

Fig. 2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Z2
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