

POSITIONING USING SATCOM

TECHNICAL FIELD

The presently disclosed subject matter relates to a positioning method and system, and more particularly, to a computerized positioning of an unmanned aerial vehicle (UAV) and a system thereof.

BACKGROUND

Mobile carriers such as aircraft including unmanned aerial vehicle (UAV), land vehicles and maritime vessels, are equipped with GPS systems which enable them to communicate with a GPS satellite to determine the current position of the mobile carriers, and assist them to navigate. While receipt of a GPS signal is not always stable, and it is sometimes lost for a certain duration, or is spoofed or jammed and cannot be used temporarily or permanently, there is a constant, and sometimes crucial, need to have data on the current position of the mobile carrier. Therefore, it is desired to obtain data on the current position of a mobile carrier even when the GPS signal is not available.

Current known systems enable to determine the position of the UAV even where GPS signal is not available, or cannot be used to determine the current position of the UAV. For example, Conte, G., Doherty, P.: *An Integrated UAV Navigation System Based on Aerial Image Matching*, in **2008**: IEEE Aerospace Conference, pp. **1-10** IEEE, March **2008**, <https://www.ida.liu.se/divisions/aics/publications/AEROCONF-2008-Integrated-UAV-Navigation.pdf> describes usage of geo-referenced satellite or aerial images to augment the UAV navigation system in case of GPS failure. US **7,191,056** also describes processing of two-dimensional (**2-D**) sensor images for navigation and determination of position in three-dimensions (**3-D**) for flying vehicles. For example, landmark features, such as roads, rivers, coastlines, and buildings, are extracted from two-dimensional sensor images and correlated to landmark features data stored in a database via pattern recognition techniques to thereby estimate latitude, longitude, and altitude of the vehicle. US **5,208,757** describes an airborne system for determining the

position of an aerial vehicle. A first memory is provided containing the general characteristics of different types of discrete landmarks and a second memory containing the geographic position of such landmarks on the ground to be flown over, a device for extracting, from the signals delivered by sensitive means, the general characteristics of said different types of discrete landmarks located on the ground being flown over, and a device for computing from the signals delivered by said sensitive means the relative positions of said vehicle with respect to said recognized landmarks, which it feeds to Kalman filter means.

However, in order to determine the position of the UAV, the known systems either rely upon known discrete landmarks along the route of the UAV, require the landmarks to comprise devices with sensitive means that emit signals, or uses image processing technology. It is desired to obtain data on the current position of a mobile carrier even when the GPS signal is not available, in a manner that does not rely upon image processing or identification of landmarks.

Alongside the GPS technology, mobile carriers and UAV use communications satellite (SATCOM). SATCOM is used for establishing a communication channel between ground stations, or between a mobile station and a ground station.

Stations are equipped with a satellite antenna that is able to establish communication with the SATCOM, but setting the antenna to aim at the SATCOM. Usually, the SATCOM's spatial position is known in advance, either since it is stationary, or since the spatial position can easily be obtained or calculated by the station, e.g. the UAV, using the SATCOM. Ground stations that use SATCOM technology can set their antenna to permanently aim at the spatial position of the SATCOM to maintain a constant link between the ground station and the SATCOM. Since the ground station position is permanent and the SATCOM's spatial position is either permanent or known at any stage, the antenna of the ground station can be locked and track, if required, the SATCOM, to maintain the constant link.

SATCOM On The Move (SOTM), is used in the context of mobile satellite technology. In SOTM, the UAV must track the SATCOM during its movement to maintain a current optimal receipt of signal emitted from the SATCOM in real time. In order to perform the tracking, the UAV is equipped with a satellite antenna system which can capture, and accurately pointing the target SATCOM by repeatedly moving and setting the angle of the antenna towards the SATCOM's spatial position. Since the UAV is on the move, the antenna's angle repeatedly changes in the tracking process.

In some known systems, the tracking process includes a processor fitted on-board the UAV that operably coupled to the antenna. The processor calculates the strength of the signal (e.g. every given time interval) as received by the antenna, while the antenna is moving, compares it to previous strength of the signal received by the antenna, perhaps in different angle of the antenna, and sets the antenna to be in the angle in which the strength of the signal is currently the optimal. In the next time interval, the UAV's position towards the SATCOM may be different. Hence, a different angle of antenna, in which the signal's receipt is optimal, may be determined and set. Other known systems, may use different processes for tracking the SATCOM's spatial position and determining the angle of the antenna in which the signal's receipt is optimal. The SATCOM technology operates simultaneously and independent of the GPS technology.

GENERAL DESCRIPTION

The presently disclosed subject matter deals with mobile carriers including unmanned aerial vehicle (UAV), land vehicles and maritime vessels. As explained above, UAV are equipped with GPS systems enabling to receive GPS signal and determine the position of the UAV at any moment based on the GPS signal. As explained above obtaining constant data of the position of the UAV may be crucial even when GPS signals are not available.

In addition, mobile carriers, including the UAV, utilizes SATCOM and SOTM technologies, as described above. The SATCOM technology operates simultaneously and independent of the GPS technology.

Bearing this in mind, in some cases of the invention, since the SATCOM spatial position is known to the UAV, and the current altitude of the UAV is also known to the UAV (using known *per se* techniques), the UAV is configured to determine its current position, using the spatial position of the SATCOM, the current altitude of the UAV and the current angle of the antenna towards the SATCOM's spatial position, thereby determining the UAV's position, without the GPS signal.

Calculating the current position of the UAV without using GPS system is advantageous, for example, in cases where a GPS signal is disrupted. Moreover, determining the position in accordance with embodiments of the invention, using SATCOM in the manner described herein does not involve complex computations or, does not rely upon ground landmarks or require image processing technology, and implements, a quick way of calculating and determining the position of the UAV when needed. In vehicles on the move, fast calculation is advantageous and can be crucial for certain type of applications.

It is to be noted that the subject matter described below utilizes known techniques for determining the angle of the antenna in which the signal receipt from the SATCOM, is optimal. These known techniques for determining the angle of the antenna are provided for simplicity of explanation. Accordingly, the invention, as will be described herein, is not bound by any specific technique.

Also, it is to be noted that the subject matter describe below is described with respect to a specific example of a UAV and a SATCOM, and determining the position of the UAV, partially based on data indicative of the spatial position of the SATCOM. However, SATCOM should not be considered as limiting, and any radiation emitting object can be used to implement the invention, if a signal from that object can be received at the UAV, and if the position of the radiation emitting object is known to or can be calculated

by the UAV. One example of such radiation emitting object is a ground station, where the UAV communicates with the ground station using a Line Of Sight directional antenna. One alternative implementation is illustrated in Fig. 4 with respect to ground station **150**.

According to one aspect of the presently disclosed subject matter there is provided, in a mobile carrier, the mobile carrier comprising a processing and memory circuitry (PMC) and a satellite communications on the move (SOTM) antenna system that includes an antenna and being configured to maintain a communications link from a satellite communications (SATCOM) having a spatial position, a method for determining a position of the mobile carrier, the method comprising, by the PMC:

- (a) obtaining data indicative of the spatial position of the SATCOM;
- (b) obtaining data indicative of an estimated altitude of the mobile carrier;
- (c) obtaining data indicative of an angle of the antenna, wherein the angle is representative of a direction of the antenna towards the SATCOM spatial position; and
- (d) determining the position of the mobile carrier, based on the obtained data indicative of the spatial position of the SATCOM, the obtained data indicative of the estimated altitude, and the obtained data indicative of the angle.

In addition to the above features, the method according to this aspect of the presently disclosed subject matter can optionally comprise one or more of features (i) to (vii) below, in any technically possible combination or permutation:

- i. wherein the mobile carrier is an unmanned aerial vehicle (UAV).
- ii. wherein obtaining data indicative of the angle of the antenna includes obtaining the azimuth and elevation of the angle, relative to the horizontal plane of the earth.
- iii. wherein the angle is determined based on a current optimal receipt of a signal emitted from the SATCOM.
- iv. the method further comprising repeatedly performing steps (a) to (d).

- v. the method further comprising repeatedly performing steps (b) to (d).
- vi. wherein the data indicative of the estimated altitude is obtained using at least one of the following: barometric pressure sensors and radar altimeter, fitted on-board the mobile carrier.
- vii. wherein the mobile carrier further comprises a GPS receiver configured for receiving a GPS signal from a GPS satellite, and wherein stage (d) is executed in cases where a GPS signal is disrupted.

According to another aspect of the presently disclosed subject matter there is provided a system implemented in a mobile carrier for determining a position of the mobile carrier, the system comprising:

a processing and memory circuitry (PMC);

a satellite communications on the move (SOTM) antenna system that includes an antenna and being configured to maintain a communications link from a satellite communications (SATCOM) having a spatial position;

the PMC is configured to:

- (a) obtain data indicative of the spatial position of the SATCOM;
- (b) obtain data indicative of an estimated altitude of the mobile carrier;
- (c) obtain data indicative of an angle of the antenna, wherein the angle is representative of a direction of the antenna towards the SATCOM spatial position; and
- (d) determine the position of the mobile carrier, based on the obtained data indicative of the spatial position of the SATCOM, the obtained data indicative of the estimated altitude, and the obtained data indicative of the angle.

In addition to the above features, the system according to this aspect of the presently disclosed subject matter can optionally comprise one or more of features (viii) to (ix) below, in any technically possible combination or permutation:

- viii. a mobile carrier comprising the system.
- ix. a mobile carrier comprising the system, wherein the mobile carrier further comprises a GPS receiver configured for receiving a GPS signal from a GPS satellite, and wherein stage (d) is executed in cases where a GPS signal is disrupted.

According to another aspect of the presently disclosed subject matter there is provided in a mobile carrier, the mobile carrier comprising a processing and memory circuitry (PMC) and a satellite communications on the move (SOTM) antenna system that includes an antenna and being configured to maintain a communications link from a satellite communications (SATCOM) having a spatial position, a non-transitory computer readable storage medium tangibly embodying a program of instructions that, when executed by a computer, cause the computer to perform a method for determining a position of the mobile carrier, the method comprising:

- (a) obtaining data indicative of the spatial position of the SATCOM;
- (b) obtaining data indicative of an estimated altitude of the mobile carrier;
- (c) obtaining data indicative of an angle of the antenna, wherein the angle is representative of a direction of the antenna towards the SATCOM spatial position; and
- (d) determining the position of the mobile carrier, based on the obtained data indicative of the spatial position of the SATCOM, the obtained data indicative of the estimated altitude, and the obtained data indicative of the angle.

According to another aspect of the presently disclosed subject matter there is provided in an unmanned aerial vehicle (UAV), the UAV comprising a processing and memory circuitry (PMC) and an antenna system that includes an antenna and being configured to maintain a communications link from a radiation emitting object having a spatial position, a method for determining a position of the UAV, the method comprising, by the PMC:

- (a) obtaining data indicative of the spatial position of the radiation emitting object;
- (b) obtaining data indicative of an estimated altitude of the UAV;
- (c) obtaining data indicative of an angle of the antenna, wherein the angle is representative of a direction of the antenna towards the radiation emitting object's spatial position; and
- (d) determining the position of the UAV, based on the obtained data indicative of the spatial position of the radiation emitting object, the obtained data indicative of the estimated altitude, and the obtained data indicative of the angle.

In addition to the above features, the method according to this aspect of the presently disclosed subject matter can optionally comprise the feature below:

- x. wherein the radiation emitting object is stationary or mobile.

The system, method and the non-transitory computer readable storage media disclosed herein according to various aspects, can optionally further comprise one or more of features (i) to (vii) listed above, *mutatis mutandis*, in any technically possible combination or permutation.

BRIEF DESCRIPTION OF THE DRAWINGS

In order to understand the invention and to see how it can be carried out in practice, embodiments will be described, by way of non-limiting examples, with reference to the accompanying drawings, in which:

Fig. 1 shows a high-level illustration of an operational scenario in which the position system is utilized in accordance with certain embodiments of the presently disclosed subject matter;

Fig. 2 illustrates a high-level functional block diagram of a position system fitted on a UAV, in accordance with certain embodiments of the presently disclosed subject matter;

Fig. 3 illustrates a generalized flowchart of operations performed by PMC in the UAV, in accordance with certain embodiments of the presently disclosed subject matter; and

Fig. 4 shows a high-level illustration of an alternative operational scenario in which the position system is utilized in accordance with certain embodiments of the presently disclosed subject matter.

DETAILED DESCRIPTION

As apparent from the following discussions, and unless specifically stated otherwise, it is appreciated that throughout the specification discussions utilizing terms such as "obtaining", "determining", "calculating", "estimating", "performing", "providing", "executing", "receiving" or the like, refer to the action(s) and/or process(es) of a computer that manipulate and/or transform data into other data, said data represented as physical, such as electronic, quantities and/or said data representing the physical objects. The term "computer" should be expansively construed to cover any kind of hardware-based electronic device with data processing capabilities including, by way of non-limiting example, the processing and memory circuitry (PMC) disclosed in the present application.

The operations in accordance with the teachings herein may be performed by a computer specially constructed for the desired purposes, or by a general-purpose computer specially configured for the desired purpose by a computer program stored in a non-transitory computer-readable storage medium.

The terms "non-transitory memory" and "non-transitory storage medium" used herein should be expansively construed to cover any volatile or non-volatile computer memory suitable to the presently disclosed subject matter.

Bearing this in mind, attention is drawn to Fig. 1 which shows a high-level illustration of an operational scenario in which the position system is utilized in accordance with certain embodiments of the presently disclosed subject matter.

Fig. 1 illustrates a operational scenario **100** comprising a mobile carrier, e.g. a UAV **110**, a SATCOM **140** having a spatial position, denoted in Fig. 1 as (X, Y, Z) coordinates, and a ground station **150**, communicating with the SATCOM **140**. The UAV **110** may accommodate a satellite communications on the move (SOTM) antenna system **120** that includes an antenna. The antenna included in the SOTM antenna system **120** being configured to maintain a communications link from the SATCOM **140**. The UAV **110** may include a GPS system **130** configured for receiving a GPS signal from a GPS satellite (not shown). According to some examples, the UAV **110** is configured to obtain data indicative of the spatial position of the SATCOM **140**, data indicative of an estimated altitude of the UAV **110** and data indicative of an angle of the antenna, represented in Fig. 1 as θ . θ represents the direction of the antenna towards the SATCOM spatial position. Based on the obtained data, UAV **110** is configured to determine the position of the UAV **110**, all as will be explained in greater details below with reference to Fig. 3.

Attention is now drawn to Fig. 2 illustrating a non-limiting block diagram of a position system **200** fitted on the UAV **110**, in accordance with certain embodiments of the presently disclosed subject matter. The numeral references of elements of operational scenario **100**, as appearing in Fig. 1, are also applicable to Fig. 2.

As also illustrated in Fig. 1, operational scenario **100** includes UAV **110**, SATCOM **140** and ground station **150**. UAV **110** comprises a positioning system **200** and a GPS **130**. Positioning system **200** may include SOTM antenna system **120** that comprises an antenna **220**. Positioning system **200** may further comprise processing and memory circuitry (PMC) **210**.

In some examples, the PMC **210** is configured to obtain data indicative of the spatial position of the SATCOM **140**. For example, the spatial position is stored in a memory comprised in PMC **210**, obtained from the SATCOM **140** itself or is calculated by the PMC **210**, based on data available to the PMC **210**, using known methods. In addition, PMC **210** obtains data indicative of the estimated altitude of the UAV **110**. For example, PMC **210** is configured to obtain the data from sensors fitted on-board the UAV **110** such as barometric pressure sensors or a radar altimeter. PMC **210** is further configured to obtain data

indicative of the current angle of the antenna e.g., from the antenna system **120**. In Fig. **1**, the angle is denoted by θ . The angle θ is representative of a direction of the antenna towards the spatial position of SATCOM **140**. Considering that the antenna tracks the SATCOM **140**, the PMC **140** is capable of determining the angle of the antenna **220** towards the SATCOM, based on optimal receipt signal from the SATCOM **140**, all as explained in details above e.g. with respect to the tracking process. Based on at least the data indicative of the spatial position of the SATCOM **140**, the data indicative of the estimated altitude of the UAV **110** and the data indicative of the angle of the antenna **220**, the PMC **210** is configured to determine the position of the UAV **110** without using GPS, all as will be explained in greater details with reference to Fig. **3**

It is noted that the teachings of the presently disclosed subject matter are not bound by the position system **200** described with reference to Figs. **1** and **2**. Equivalent and/or modified functionality can be consolidated or divided in another manner and can be implemented in any appropriate combination of software with firmware and/or hardware and executed on a suitable device. Those skilled in the art will also readily appreciate that the memory in PMC **210** can be consolidated or divided in other manner. Databases such as the memory in PMC **210** can be shared with other systems or be provided by other systems, including third party equipment.

For purpose of illustration only, the following description is provided for UAV **110**. Those skilled in the art will readily appreciate that the teachings of the presently disclosed subject matter are, likewise, applicable to other mobile carriers using SOTM with an antenna system **120**, as illustrated throughout the description.

Referring to Fig. **3**, there is illustrated a generalized flowchart of operations performed by the PMC **210** comprised in the UAV **110**, in accordance with certain embodiments of the presently disclosed subject matter. Note that the description below refers occasionally also to elements drawn in Figs. **1** and **2**.

As may be recalled, the UAV **110** comprising a positioning system **200**. The positioning system **200** comprising a PMC **210** and a SOTM antenna system **120** that

includes antenna **220**. The antenna **220** being configured to maintain a communications link from a SATCOM **140**. The SATCOM **140** having a spatial position.

In some cases, in order to determine the position of the UAV **110**, the PMC **210** obtains data indicative of the spatial position of the SATCOM **140** (block **310**). In some examples, the SATCOM **140** is stationary, and its spatial position is stored in a memory comprised in PMC **210**. PMC **210** can obtain data indicative of the spatial position of the SATCOM **140** by retrieving the spatial coordinates from the memory. In some examples, PMC **210** communicates with SATCOM **140** and retrieves from the SATCOM **140** itself the spatial position of the SATCOM **140**. In some other examples, the SATCOM **140** spatial position can be calculated by the PMC **210**, based on data available to the PMC **210**, using known methods. For example, when SATCOM **140** is not stationary and the trajectory of SATCOM **140** is known, the spatial position of SATCOM **140** can be calculated using actual time which denotes the spatial position of SATCOM **140** within its trajectory (using known *per se* techniques).

PMC **210** further obtains data indicative of an estimated altitude of the UAV **110** (block **320**). For example, PMC **210** can obtain the UAV **110** current altitude by obtaining data from sensors fitted on-board the UAV **110** such as barometric pressure sensors or a radar altimeter.

As detailed above, in SOTM technology, the SOTM antenna system **120** tracks the spatial position of the SATCOM **140** by directing the antenna **220** towards the SATCOM **140**, to maintain a communications link. Using known methods, PMC **210** determines, in each time interval, the angle of the antenna **220** in which the signal's current receipt is optimal and the antenna's angle is set to be in that angle (denoted in Fig. **1** as θ). In some other known systems, other technology may be used to track the spatial position of the SATCOM's **140** and setting and determining the angle of the antenna **220** in which the signal's current receipt is optimal.

In some cases, PMC **210** obtains data indicative of the angle θ of the antenna **220**, wherein the angle θ is representative of a direction of the antenna **220** towards the spatial

position of SATCOM **140** relative to the horizontal plane of the earth(block **330**). In some examples, the current angle θ is stored in the memory included in PMC **210** and PMC **210** retrieves the azimuth and elevation of angle θ from the memory. In some other examples, PMC **210** calculates the azimuth and elevation of angle θ , relative to the horizontal plane of the earth. For example, PMC **210** retrieves **2** angles: the azimuth and elevation of the antenna relative to UAV **110**, e.g. from the memory. In addition, PMC **210** obtains, e.g. using Inertial Navigation System fitted on-board the UAV **110**, **3** additional angles: the azimuth, elevation and roll of UAV **110** relative to earth. Based on these **5** angles, PMC **210** can calculate, using known per se techniques, the azimuth and elevation of angle θ relative to the horizontal plane of the earth, representative of a direction of the antenna towards the spatial position of SATCOM **140**.

In some cases, once PMC **210** obtains data on the spatial position of the SATCOM **140**, the estimated altitude of the UAV **110** and the angle θ , PMC **210** determines the position of the UAV **110** (block **340**). As illustrated in Fig. **1**, UAV **110**, the spatial position of SATCOM **140** (X, Y, Z) and angle θ create a virtual triangle. The distance of the UAV **110** from SATCOM, or the position of the UAV **110** on the line denoted in Fig. **1** by 'a' from SATCOM **140** through UAV **110**, can be determined by PMC **210** based on the altitude of UAV **110** as obtained by PMC **210**. Considering the obtained data, using known methods, such as geometric calculations, PMC **210** determines the position of the UAV **110**.

For a UAV **110**, which is always on the move, obtaining constant data of the position of the UAV **110** may be advantageous. In some examples, in order to determine a current position of the UAV **110** during its move, the PMC **210** repeatedly obtains updated data on the UAV **110** and determines, based on the updated data, the current position of the UAV **110**. If the spatial position of SATCOM **140** is stationary and known, the PMC **210** does not have to obtain updated data with respect to the spatial position of SATCOM **140**. Hence, in some examples, PMC **210** repeatedly obtains data indicative of an estimated altitude of the UAV **110** in the current position of the UAV **110**, and data indicative of the current angle θ of the antenna **220**. The current angle θ is representative of a direction of the antenna towards the SATCOM **140** spatial position, when the UAV **110**

in its current position. Based on the updated data, and the known spatial position of the SATCOM **140**, PMC **210** determines the current position of the UAV **110**, all by avoiding the use of the GPS.

In examples where the position of the SATCOM **140** is not stationary, but can be calculated by the UAV **110**, as described above with respect to block **310**, the UAV **110** further obtains data indicative of the current spatial position of the SATCOM **140**, in order to determine the current position of the UAV **110**. Hence, in these examples, PMC **210** repeatedly obtains data indicative of the spatial position of the SATCOM **140**, the estimated altitude of the UAV **110** and the angle θ of antenna **220** and then determines, based on the obtained data, the current position of the UAV **110**.

In some examples, the UAV **110** further comprises GPS **130**, including a GPS receiver configured for receiving a GPS signal from a GPS satellite. However, sometimes, the GPS signal is disrupted. For example, there is no reception at all of the signal, the signal may be spoofed or jammed and does not enable to determine the position of the UAV **110** based upon the GPS signal. It is advantageous to determine the position of the UAV **110** constantly, including in times where the GPS signal is disrupted. Hence, in some cases, the PMC **210** determines the position of the UAV **110**, based on the specified obtained data when a GPS signal is disrupted

Moreover, in some cases, determining the position of the UAV **110**, based on the obtained data indicative of the spatial position of the SATCOM, the obtained data indicative of the estimated altitude, and the obtained data indicative of the angle, without usage of GPS signal, may assist in recognizing that a GPS signal that is received at UAV **110** is disrupted. For example, the determined position in accordance with embodiments of the presently disclosed subject matter, as described throughout the description, can be compared to a position of UAV **110** as determined based on a GPS signal using known per se techniques. A discrepancy between the two positions may be indicative of a disrupted GPS signal received at UAV **110**.

It is noted that the teachings of the presently disclosed subject matter are not bound by the flow chart illustrated in Fig.3 the illustrated operations can occur out of the illustrated order. For example, operations **310**, **320** and **330** shown in succession can be executed substantially concurrently, or in the reverse order. It is also noted that whilst the flow chart is described with reference to elements of UAV **110**, such as PMC **210**, this is by no means binding, and the operations can be performed by elements other than those described herein.

It is to be understood that the invention is not limited in its application to the details set forth in the description contained herein or illustrated in the drawings. The invention is capable of other embodiments and of being practised and carried out in various ways, for example: determining the UAV **110** position using a radiation emitting object. As illustrated above, SATCOM is one example of such a radiation emitting object. However, SATCOM **140** should not be considered as limiting, and any radiation emitting object can be used to implement the invention, if a signal from that object can be received at the UAV **110**, and if the spatial position of the radiation emitting object is known to or can be obtained or calculated by the UAV **110**. The radiation emitting object can be stationary or mobile. Some examples of mobile radiation emitting objects are SATCOM **140** illustrated above and a maritime vessel. One example of a stationary radiation emitting object is ground station **150**.

Bearing this in mind, reference is being made to Fig. 4 which shows a high-level illustration of an alternative operational scenario **400** in which the position system is utilized in accordance with certain embodiments of the presently disclosed subject matter.

Fig. 4 includes all elements depicted in Fig. 1, and further includes a line denoted by 'b' from ground station **150** through UAV **110**, and a respective angle θ' . Line 'b' represents communication of UAV **110** with ground station **150**, e.g. using a Line Of Sight directional antenna on-board the UAV **110**, which communicates with a ground communication antenna on ground station **150**. The spatial position of ground station **150** is known to UAV **110**, or can be obtained by UAV **110**.

In such cases, with reference also to Fig. **3**, the PMC **210** obtains data indicative of the spatial position of ground station **150**, in a similar manner to that described above with reference to block **310** in Fig. **3** of obtaining the spatial position of the SATCOM **140**, mutatis mutandis. PMC **210** further obtains data indicative of an estimated altitude of the UAV **110** in a similar manner to that described above with reference to block **320** in Fig. **3**. PMC **210** further obtains data indicative of the angle θ' of the antenna, wherein the angle θ' is representative of a direction of the antenna **220** towards the spatial position of ground station **150**. For example, PMC **210** obtains the data indicative of the angle θ' , in a similar manner to that described above with respect to block **330** in Fig. **3**, mutatis mutandis.

In some cases, once PMC **210** obtains data on the spatial position of ground station **150**, the estimated altitude of the UAV **110** and the angle θ' , PMC **210** determines the position of the UAV **110**, in a similar manner to that described above with respect to block **340**.

A person versed in the art would realise that other radiation emitting objects can be used instead of SATCOM **140** or ground station **150**.

Hence, it is to be understood that the phraseology and terminology employed herein are for the purpose of description and should not be regarded as limiting. As such, those skilled in the art will appreciate that the conception upon which this disclosure is based may readily be utilized as a basis for designing other structures, methods, and systems for carrying out the several purposes of the presently disclosed subject matter.

It will also be understood that the system according to the invention may be, at least partly, implemented on a suitably programmed computer. Likewise, the invention contemplates a computer program being readable by a computer for executing the method of the invention. The invention further contemplates a non-transitory computer-readable memory tangibly embodying a program of instructions executable by the computer for executing the method of the invention.

Those skilled in the art will readily appreciate that various modifications and changes can be applied to the embodiments of the invention as hereinbefore described without departing from its scope, defined in and by the appended claims.

CLAIMS:

1. In a mobile carrier, the mobile carrier comprising a processing and memory circuitry (PMC) and a satellite communications on the move (SOTM) antenna system that includes an antenna and being configured to maintain a communications link from a satellite communications (SATCOM) having a spatial position, a method for determining a position of the mobile carrier, the method comprising, by the PMC:

- (a) obtaining data indicative of the spatial position of the SATCOM;
- (b) obtaining data indicative of an estimated altitude of the mobile carrier;
- (c) obtaining data indicative of an angle of the antenna, wherein the angle is representative of a direction of the antenna towards the SATCOM spatial position; and
- (d) determining the position of the mobile carrier, based on the obtained data indicative of the spatial position of the SATCOM, the obtained data indicative of the estimated altitude, and the obtained data indicative of the angle.

2. The method of claim **1**, wherein the mobile carrier is an unmanned aerial vehicle (UAV).

3. The method of any one of the preceding claims, wherein the angle is determined based on a current optimal receipt of a signal emitted from the SATCOM.

4. The method of any one of the preceding claims, wherein obtaining data indicative of the angle of the antenna includes obtaining the azimuth and elevation of the angle, relative to the horizontal plane of earth.

5. The method of any one of the preceding claims, the method further comprising:

repeatedly performing steps (a) to (d).

6. The method of any one of the preceding claims, the method further comprising:

repeatedly performing steps (b) to (d).

7. The method of any one of the preceding claims, wherein the data indicative of the estimated altitude is obtained using at least one of the following: barometric pressure sensors and radar altimeter, fitted on-board the mobile carrier.

8. The method of any one of the preceding claims, wherein the mobile carrier further comprises a GPS receiver configured for receiving a GPS signal from a GPS satellite, and wherein stage (d) is executed in cases where a GPS signal is disrupted.

9. A system implemented in a mobile carrier for determining a position of the mobile carrier, the system comprising:

a processing and memory circuitry (PMC);

a satellite communications on the move (SOTM) antenna system that includes an antenna and being configured to maintain a communications link from a satellite communications (SATCOM) having a spatial position;

the PMC is configured to:

(a) obtain data indicative of the spatial position of the SATCOM;

(b) obtain data indicative of an estimated altitude of the mobile carrier;

(c) obtain data indicative of an angle of the antenna, wherein the angle is representative of a direction of the antenna towards the SATCOM spatial position; and

(d) determine the position of the mobile carrier, based on the obtained data indicative of the spatial position of the SATCOM, the obtained data indicative of the estimated altitude, and the obtained data indicative of the angle.

10. A mobile carrier comprising the system of claim 9.

11. The mobile carrier of claim 10, wherein the mobile carrier further comprises a GPS receiver configured for receiving a GPS signal from a GPS satellite, and wherein stage (d) is executed in cases where a GPS signal is disrupted.

12. The system of claim **9**, wherein the mobile carrier is an unmanned aerial vehicle (UAV).

13. The mobile carrier of claim **10** or **11**, wherein the mobile carrier is an unmanned aerial vehicle (UAV).

14. In a mobile carrier, the mobile carrier comprising a processing and memory circuitry (PMC) and a satellite communications on the move (SOTM) antenna system that includes an antenna and being configured to maintain a communications link from a satellite communications (SATCOM) having a spatial position, a non-transitory computer readable storage medium tangibly embodying a program of instructions that, when executed by a computer, cause the computer to perform a method for determining a position of the mobile carrier, the method comprising:

- (a) obtaining data indicative of the spatial position of the SATCOM;
- (b) obtaining data indicative of an estimated altitude of the mobile carrier;
- (c) obtaining data indicative of an angle of the antenna, wherein the angle is representative of a direction of the antenna towards the SATCOM spatial position; and
- (d) determining the position of the mobile carrier, based on the obtained data indicative of the spatial position of the SATCOM, the obtained data indicative of the estimated altitude, and the obtained data indicative of the angle.

15. The non-transitory computer readable storage medium of claim **14**, wherein the mobile carrier is an unmanned aerial vehicle (UAV).