

System for testing the accuracy of the automatic positioning means of a signal tracking antenna

Technical field of the invention

5 The present invention relates the testing of directional antennas, such as COTM antennas.

Background of the invention

10 The demand for mobile satellite communication is growing rapidly and with it, the demand for quality and stability.

Establishing communication between a moving vehicle (ship, car, airplane, etc.) and a satellite is done through the implementation of automatic antenna systems that will direct and keep the communication with the satellite either through mechanical (e.g. stabilized antennas) or electronic
15 (e.g. phased array antennas) means. These antenna systems are known in the industry as Communication-On-The-Move (COTM) antennas.

There are several tracking methods used by COTM antennas, e.g. monopulse sensing, sequential amplitude sensing, electronic beam squinting, program tracking, etc. Such antenna systems can be classified
20 as closed-loop or open-loop tracking systems. The closed-loop tracking systems rely on the reception of a continuous beacon signal, used to derive pointing error information, which supplies control signals to the antenna drive servo mechanisms. The antenna is then driven, so as to attempt to minimize the pointing error and hence null the tracking error. The open-loop
25 tracking is using pre-programmed data or is based on algorithmically determined positions from the inertial navigations systems of both the COTM antenna and the source. Antennas can use one or multiple tracking methods, as well as closed loop, open loop, or both.

The mechanical and/or electronic performance of the COTM antenna has a
30 significant impact on the pointing accuracy. Improper tracking due to faulty

mechanisms leads to loss of contact with the transmitting/receiving source and to suffering of the communication link. When an antenna is new, it has probably passed a Factory Acceptance Test and therefore it must function accordingly to the set standards and specific parameters mentioned in the datasheets. However, with age, several issues may impact the antenna function, such as weather impact, harsh conditions, vibrations, and improper use. Hence, there is a need for servicing and upgrade.

COTM antenna systems are highly dependent on the electro-mechanical hardware components inside the antenna to compensate for external movements, meanwhile keeping accurate pointing position for optimal connectivity. Today there are three ways of testing the systems: 1) Factory Acceptance Test (FAT), 2) Sea trial and 3) Inspection by technician. None of these procedures is effective nor efficient. The FAT cannot be used onsite, and inspections by technicians can be hard to guarantee without a sea trial. These procedures may be considered, in some cases, inaccurate and only tests a fraction of the antennas' domain spectrum. Many vessels are mission critical and consider it too much effort, time and/or money to conduct a sea trial. These vessels will then proceed on their mission with a system that could be faulty, operate inaccurately or be vulnerable to failure, which can result in even higher costs.

It is therefore desirable to provide a system, which can stress test, calibrate and ease installation, while the platform, such as a vessel, remains stationary; and preferably regardless of which type of signal tracking mechanism the antenna uses.

Summary of the invention

The inventors of the present invention have provided a system capable of testing the automatic positioning means of a directional antenna, such as a COTM antenna, supported by a mobile platform. The system is intended for

use when the mobile platform, such as a ship, onto which it is mounted is stationary, thereby avoiding expensive sea trials.

5 A first aspect of the present invention relates to the use of an unmanned aerial vehicle and a control station for testing the accuracy of the automatic positioning means of a directional antenna, such as a signal tracking antenna (e.g. a COTM antenna or a phased array antenna), during a satellite signal searching and/or tracking operation; wherein the platform, such as a ship, on which the signal tracking antenna is mounted is kept
10 stationary during the testing operation; wherein the unmanned aerial vehicle is adapted for:

- transmitting, while navigating a flight route, a signal configured for the signal tracking antenna to search for and/or to track;

wherein the control station is adapted for:

- 15 - receiving positioning data from the automatic positioning means during a predefined test period; and
- receiving data, such as signal strength data, from the signal tracking antenna, about the received signal from the unmanned aerial vehicle during said predefined test period.

20 A second aspect relates to a system for testing the accuracy of the automatic positioning means of a directional antenna, such as a signal tracking antenna (e.g. a COTM antenna or a phased array antenna), during a satellite signal searching and/or tracking operation; the system
25 comprising:

- an unmanned aerial vehicle; and
- a control station;

wherein the unmanned aerial vehicle is adapted for:

- transmitting, while navigating a flight route, a signal configured for the
30 directional antenna to search for and/or to track;

wherein the control station is adapted for:

- receiving positioning data from the automatic positioning means during a predefined test period; and
 - receiving data, such as signal strength data, from the directional antenna, about the received signal from the unmanned aerial vehicle during said
- 5 predefined test period.

A third aspect of the present invention relates to the use of an unmanned aerial vehicle and a control station for testing the automatic positioning means of a directional antenna; wherein the unmanned aerial vehicle is

10 adapted for:

- transmitting, while navigating, a tracking signal configured for the directional antenna to lock on; and
 - continuously transmitting its position to the control station;
- wherein the control station is adapted for:
- 15
- receiving positioning data from the unmanned aerial vehicle;
 - calculating simulated positioning data of a directional antenna; and
 - transmitting said calculated simulated positioning data to the control unit of an automatic positioning means of a directional antenna.

20 A fourth aspect relates to a system for testing the automatic positioning means of a directional antenna, the system comprising:

- an unmanned aerial vehicle; and
 - a control station;
- wherein the unmanned aerial vehicle is adapted for:
- 25
- transmitting, while navigating, a tracking signal configured for the directional antenna to lock on; and
 - continuously transmitting its position to the control station;
- wherein the control station is adapted for:
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- receiving positioning data from the unmanned aerial vehicle;
 - calculating simulated positioning data of a directional antenna based on the positioning data of the unmanned aerial vehicle; and

- transmitting said calculated simulated positioning data to the control unit of an automatic positioning means of a directional antenna.

5 A fifth aspect of the present invention relates to the use of an unmanned aerial vehicle and a control station for testing the automatic positioning means of a directional antenna supported by a mobile platform subject to continuous irregular motion; wherein the unmanned aerial vehicle is adapted for:

- 10 - transmitting, while navigating, a tracking signal configured for the directional antenna to lock on; and
 - continuously transmitting its position to the control station;
- wherein the control station is adapted for:
- receiving positioning data from the unmanned aerial vehicle;
 - calculating simulated positioning data of a directional antenna; and
 - 15 - transmitting said calculated simulated positioning data to the control unit of an automatic positioning means of a directional antenna.

20 A sixth aspect relates to a system for testing the automatic positioning means of a directional antenna supported by a mobile platform subject to continuous irregular motion, the system comprising:

- an unmanned aerial vehicle; and
 - a control station;
- wherein the unmanned aerial vehicle is adapted for:
- 25 - transmitting, while navigating, a tracking signal configured for the directional antenna to lock on; and
 - continuously transmitting its position to the control station;
- wherein the control station is adapted for:
- receiving positioning data from the unmanned aerial vehicle;
 - calculating simulated positioning data of a directional antenna based on
 - 30 the positioning data of the unmanned aerial vehicle; and
 - transmitting said calculated simulated positioning data to the control unit

of an automatic positioning means of a directional antenna.

Brief description of the figures

5 Figure 1 shows a system for testing the automatic positioning means of a stabilized satellite communication antenna supported by a mobile platform in accordance with various embodiments of the invention;

10 Figure 2 shows a system for testing the automatic positioning means of a stabilized satellite communication antenna supported by a mobile platform in accordance with various embodiments of the invention;

Figure 3 shows an example of a test route that the quadcopter travels during a test operation;

15 Figure 4 shows a system for testing the automatic positioning means of a directional antenna supported by a mobile platform subject to continuous irregular motion in accordance with various embodiments of the invention;

20 Figure 5 shows selected process steps of the method in accordance with various embodiments of the invention;

Figure 6 shows selected process steps of the method in accordance with various embodiments of the invention; and

25 Figure 7 shows an example of calculating simulated positioning data of a directional antenna based on the positioning data of the unmanned aerial vehicle.

Detailed description of the invention

30 A first aspect of the present invention relates to the use of an unmanned

- aerial vehicle and a control station for testing the accuracy of the automatic positioning means of a directional antenna, such as a signal tracking antenna (e.g. a COTM antenna or a phased array antenna), during a satellite signal searching and/or tracking operation; wherein the platform, such as a ship, on which the signal tracking antenna is mounted is kept stationary during the testing operation; wherein the unmanned aerial vehicle is adapted for:
- transmitting, while navigating a flight route, a signal configured for the signal tracking antenna to search for and/or to track;
- wherein the control station is adapted for:
- receiving positioning data from the automatic positioning means during a predefined test period; and
 - receiving data, such as signal strength data, from the signal tracking antenna, about the received signal from the unmanned aerial vehicle during said predefined test period.

The term “signal” may be used to encompass many forms of content, including, but not limited to, a beacon, video (e.g. Direct Broadcast Satellite (DBS), and Digital Video Broadcasting (DVB)), still images, audio, text, or any other form of intelligence, or data (e.g. identity data). The unmanned aerial vehicle is capable of simulating any type of satellite, and in some embodiments, also capable of distorting and/or fading the signal to simulate different weather conditions, such as heavy rain fall. The signal source will be used to test both the searching and tracking functions of the directional antenna. The functioning of the automatic positioning means is crucial in these functions. Hence, the unmanned aerial vehicle, such as a drone, simulates the satellite and the platform motion. The unmanned aerial vehicle may also simulate multiple spot beam switching, as well as switching between different satellites (e.g. regional or traffic/loading optimization).

Directional antenna systems (e.g. COTM antennas), such as parabolic reflector antennas or yagi type antennas, installed on a moving platform are usually steerable to adequately receive radio waves from remote satellites. To continuously point in the direction of the satellite under platform heading motions, the antenna is commonly steered by automatic positioning means (mechanical or electronic means). A variety of technologies have been developed to steer or direct the antenna to point at the satellite under heading changes. When the directional antenna is mounted aboard a vessel subject to heavy seas, maintaining antenna tracking of e.g. the satellite's RF beacon or an identity signal requires positioning data of the antenna relative to the ship's roll, yaw, and pitch motion; otherwise known as the attitude and heading reference of the antenna relative to the ship's attitude and reference. The ship's attitude and heading information is typically provided by expensive inertial navigation systems mounted to the ship. Inertial navigational systems are not typically suitable, due to weight and size, to mount directly to the antenna pedestal or dish. For this reason, the attitude and heading reference of the antenna is typically derived from the ship's inertial navigation system.

If the directional antenna is not functioning correctly, it will not be able to find and track the signal from the unmanned aerial vehicle. This may be controlled visually, by sensors (e.g. vibration sensors, or camera sensors), or by reading the test output data from the control station configured for recording the performance of the electromechanical and/or electronic components of the automatic positioning means and/or the input signal quality of the tracking signal. The electromechanical components may e.g. be servo amplifiers, and drive dc motors, which adjust the antenna (reflector), azimuth, and elevation. Other electromechanical components may be potentiometers and sensors that provide real time data about the relative azimuth and elevation angles of the antenna reflector. Being a constantly moving system, there are also interconnecting cable assemblies,

bearings, belts, etc. that will wear out over time, or merely be damaged (e.g. during production, shipping, physical installation, calibration) from the first installation of the antenna. Furthermore, power supplies may age/malfunction, e.g. due to the sometimes very high internal temperature within the antenna radome.

In one or more embodiments, the control station is configured to a) output the received positioning data, and data about the received signal and/or b) compare the received positioning data, and data about the received signal with reference values from previous tests and/or with data sheets from the antenna manufacturer.

Global positioning system (GPS) receivers are commonly used in such steering systems to provide a moving platform's track, wherein the track is the vehicle's course over ground or water.

Directional antennas are commonly housed under radomes. A radome is usually necessary to make the antenna resistant to object collisions, wind, moisture, dirt, and corrosive gasses. The radome is usually mounted on a radome base and is removable to facilitate maintenance and repair work.

In one or more embodiments, the control station is configured to receive positioning data from the unmanned aerial vehicle during a test period; and - instructing the automatic positioning means to initiate and/or continue the satellite signal searching and/or tracking operation based on the positioning data from the unmanned aerial vehicle.

In one or more embodiments, the control station is configured to receive positioning data from the unmanned aerial vehicle during a test period;

- calculating simulated positioning data of a directional antenna; and
- transmitting said calculated simulated positioning data to the control unit

of an automatic positioning means of a directional antenna;
wherein the calculation of simulated positioning data of a directional
antenna is based on the positioning data from the unmanned aerial vehicle.
Other parameters used in the calculation of simulated positioning data of a
5 directional antenna may be antenna position during test, and simulated
satellite position.

In one or more embodiments, the control station is further configured to:
- receive positioning data from the unmanned aerial vehicle during a test
10 period; and
- compare the received positioning data from the unmanned aerial vehicle,
the positioning data from the automatic positioning means, and data about
the received signal with reference values from previous tests.

15 In one or more embodiments, the unmanned aerial vehicle is configured for
continuously transmitting its position to the control station.

In one or more embodiments, the control station is integrated into the signal
tracking antenna .

20 In one or more embodiments, the unmanned aerial vehicle is further
adapted for:

- receiving a test flight route from the control station;
- automatically navigating the received test flight route with the aid of a
25 received Global Navigation Satellite System signal; and
wherein the control station is further adapted for:
- transmitting a test flight route signal to the unmanned aerial vehicle.

30 In one or more embodiments, the calculation of simulated positioning data
of a directional antenna is based on the positioning data from the

unmanned aerial vehicle. This will enable the control station to steer the directional antenna towards the unmanned aerial vehicle (e.g. a drone, such as a fixed-wing drone, a tricopter, a quadcopter, a hexacopter, an octocopter, or the like) as it moves around.

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In one or more embodiments, the unmanned aerial vehicle is further adapted for:

- receiving a test flight route from the control station;
 - automatically navigating the received test flight route with the aid of a received Global Navigation Satellite System signal; and
 - 10 - transmitting, while navigating the received flight route, a tracking signal configured for the directional antenna to lock on;
- wherein the control station is further adapted for:
- transmitting a test flight route signal to the unmanned aerial vehicle.

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Global Navigation Satellite Systems (GNSS) is a collective term for a variety of satellite navigation systems, which use orbiting satellites as navigation reference points to determine position fixes on the ground. GNSS includes the Global Positioning System (GPS), the Global

20 Navigation Satellite System (GLONASS), the Compass system, Galileo, and a number of Satellite based augmentation systems (SBAS).

In typical civilian applications, a single GNSS receiver can measure a ground position with a precision of about ten meters. This is, in part, due to

25 various error contributions, which often reduce the precision of determining a position fix. For example, as the GNSS signals pass through the ionosphere and troposphere, propagation delays may occur. Other factors, which may reduce the precision of determining a position fix, may include satellite clock errors, GNSS receiver clock errors, and satellite position

30 errors. One method for improving the precision for determining a position fix is Real-Time Kinematic (RTK) GNSS. Real Time Kinematic (RTK) satellite

navigation is a technique using the phase of the signal's carrier wave, rather than the information content of the signal, and relies on a single reference station or interpolated virtual station to provide real-time corrections.

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In one or more embodiments, the unmanned aerial vehicle comprises a Real Time Kinematic (RTK) GNSS positioning system.

Other methods like PPK (Post-Processed Kinematics), SBAS (satellite-based augmentation systems), PPP (Precise Point Positioning), or Differential GNSS may also be used. In one or more embodiments, the unmanned aerial vehicle comprises a PPK (Post-Processed Kinematics), SBAS (satellite-based augmentation systems), PPP (Precise Point Positioning), or Differential GNSS positioning system.

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In one or more embodiments, the unmanned aerial vehicle is manually navigated.

In one or more embodiments, the control station is configured to bypass the integrated position measuring means of an automatic positioning means of a directional antenna.

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A second aspect relates to a system for testing the accuracy of the automatic positioning means of a directional antenna, such as a signal tracking antenna (e.g. a COTM antenna or a phased array antenna), during a satellite signal searching and/or tracking operation; the system comprising:

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- unmanned aerial vehicle; and
- a control station;

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wherein the unmanned aerial vehicle is adapted for:

- transmitting, while navigating a flight route, a signal configured for the

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signal tracking antenna to search for and/or to track;

wherein the control station is adapted for:

- receiving positioning data from the automatic positioning means during a predefined test period; and
- 5 - receiving data, such as signal strength data, from the signal tracking antenna about the received signal from the unmanned aerial vehicle during said predefined test period.

10 A third aspect of the present invention relates to the use of an unmanned aerial vehicle and a control station for testing the automatic positioning means of a directional antenna; wherein the unmanned aerial vehicle is adapted for:

- transmitting, while navigating, a tracking signal configured for the directional antenna to lock on; and
 - 15 - continuously transmitting its position to the control station;
- wherein the control station is adapted for:
- receiving positioning data from the unmanned aerial vehicle;
 - calculating simulated positioning data of a directional antenna; and
 - transmitting said calculated simulated positioning data to the control unit
 - 20 of an automatic positioning means of a directional antenna.

A fourth aspect relates to a system for testing the automatic positioning means of a directional antenna, the system comprising:

- 25 - unmanned aerial vehicle; and
- a control station;

wherein the unmanned aerial vehicle is adapted for:

- transmitting, while navigating, a tracking signal configured for the directional antenna to lock on; and
 - 30 - continuously transmitting its position to the control station;
- wherein the control station is adapted for:

- receiving positioning data from the unmanned aerial vehicle;
 - calculating simulated positioning data of a directional antenna based on the positioning data of the unmanned aerial vehicle; and
 - transmitting said calculated simulated positioning data to the control unit
- 5 of an automatic positioning means of a directional antenna.

In one or more embodiments, the unmanned aerial vehicle is further adapted for:

- receiving a test flight route from the control station;
 - 10 - automatically navigating the received test flight route with the aid of a received Global Navigation Satellite System signal; and
 - transmitting, while navigating the received flight route, a tracking signal configured for the directional antenna to lock on;
- wherein the control station is further adapted for:
- 15 - transmitting a test flight route signal to the unmanned aerial vehicle.

In one or more embodiments, the calculation of simulated positioning data of a directional antenna is based on the positioning data from the unmanned aerial vehicle.

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As used in the specification and the appended claims, the singular forms "a", "an", and "the" include plural referents unless the context clearly dictates otherwise. Ranges may be expressed herein as from "about" or "approximately" one particular value and/or to "about" or "approximately" another particular value. When such a range is expressed, another

25 embodiment includes from the one particular value and/or to the other particular value. Similarly, when values are expressed as approximations, by use of the antecedent "about", it will be understood that the particular value forms another embodiment.

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It should be noted that embodiments and features described in the context

of one of the aspects of the present invention also apply to the other aspects of the invention.

5 The general aspects of the invention are described in the following with references to the Figures 1-6.

Figure 1 shows a system for testing the automatic positioning means of a stabilized satellite communication antenna 10 supported by a mobile platform (not shown) in accordance with various embodiments of the invention. The system comprises an unmanned aerial vehicle 20, and a control station 30. The unmanned aerial vehicle 20 is here represented as a quadcopter with four rotors 24. The unmanned aerial vehicle 20 is adapted for transmitting, while navigating a flight route, a signal configured for the stabilized satellite communication antenna 10 to search for and/or to track.

10 The signal may e.g. be a simulated satellite signal

The control station 30 is adapted for a) receiving positioning data from the automatic positioning means during a predefined test period; and b) receiving data from the stabilized satellite communication antenna about the received signal from the unmanned aerial vehicle 20 during said

15 predefined test period. During the testing operation, the stabilized satellite communication antenna 10 does not transmit, but only receives.

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Figure 2 shows a system for testing the automatic positioning means of a stabilized satellite communication antenna 10 supported by a mobile platform (not shown) in accordance with various embodiments of the invention. The system comprises an unmanned aerial vehicle 20, and a control station 30. The unmanned aerial vehicle 20 is here represented as a quadcopter with four rotors 24, and a signal transmitter (not shown) adapted for communicating with the UAV remote control 22 and with the control station 30. The unmanned aerial vehicle 20 is adapted for a) transmitting, while navigating, a tracking signal configured for the stabilized

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satellite communication antenna 10 search for and/or to track; and b) continuously transmitting its position to the control station 30. The control station 30 is adapted for a) receiving positioning data from the unmanned aerial vehicle 20, b) calculating simulated positioning data of a stabilized
5 satellite communication antenna 10 based on the positioning data of the unmanned aerial vehicle 20, and c) transmitting said calculated simulated positioning data to the control unit 12 of an automatic positioning means of a stabilized satellite communication antenna 10.

10 Figure 3 shows an example of a test route that the quadcopter travels during a test operation. Minimum antenna elevation limit 51; Test path 52 in Azimuth; Test path 53 in elevation; Test path 54 for simulating waves or other mobile platform motions; Drone in Position A (e.g. start position) (20A); and Drone in Position B (e.g. during test) (20B).

15 Figure 4 shows a system for testing the automatic positioning means of a directional antenna 10 supported by a mobile platform 15 subject to continuous irregular motion in accordance with various embodiments of the invention. The system comprises an unmanned aerial vehicle 20, and a
20 control station 30. The unmanned aerial vehicle 20 is here represented as a quadcopter with four rotors 24, a UAV remote control 22 adapted for manually controlling the quadcopter, and a signal transmitter 26 adapted for communicating with the UAV remote control 22 and with the control station 30. The unmanned aerial vehicle 20 is adapted for a) transmitting, while
25 navigating, a tracking signal configured for the directional antenna 10 to lock on; and b) continuously transmitting its position to the control station 30. The control station 30 is adapted for a) receiving positioning data from the unmanned aerial vehicle 20, b) calculating simulated positioning data of a directional antenna 10 based on the positioning data of the unmanned
30 aerial vehicle 20, and c) transmitting said calculated simulated positioning data to the control unit 12 of an automatic positioning means of a directional

antenna 10.

Figure 5 shows selected process steps of the method in accordance with various embodiments of the invention. The first process step is the

5 “Preparation and system start” step, where a) the UAV is deployed, b) the Control station establish connection to the UAV and the Directional antenna, and c) the Directional antenna receives information on tracking parameters. The second step is the “Test initiation” step, where a) the UAV

10 is navigated to the start position in front of the Directional antenna, and initiates emitting the tracking signal, b) the Control station starts to receive positioning data from the automatic positioning means, and data, such as signal strength, and c) the Directional antenna search for and locks onto the tracking signal from the UAV. The third step is the “Test step”, where a) the

15 UAV starts to navigate the test flight route, and continuously emits the tracking signal, b) the Control station continuously receives positioning data from the automatic positioning means, and data, such as signal strength, and c) the Directional antenna continuously tracks using the tracking signal. The fourth step is the “Test termination” step, where a) the UAV returns to

20 the start position, and stops the emission of the tracking signal, b) the Control station exports the simulation data for analysis, and c) the Directional antenna stops locking onto tracking signal from the UAV.

Figure 6 shows selected process steps of the method in accordance with various embodiments of the invention. The first process step is the

25 “Preparation and system start” step, where a) the UAV is deployed, b) the Control station establishes connection to the UAV and the Directional Antenna, and c) the Directional antenna receives information on tracking parameters. The second step is the “Test initiation” step, where a) the UAV

30 is navigated to the start position in front of the Directional antenna, and initiates emitting the tracking signal and position data, b) the Control station starts to receive position data from the UAV, and c) the Directional antenna

locks onto the tracking signal from the UAV. The third step is the "Test step", where a) the UAV starts to navigate the test flight route, and continuously emits the tracking signal and position data, b) the Control station receives position data from the UAV, and calculates position coordinates for the Directional antenna, and c) the Directional antenna receives position coordinates from the Control station, and adjusts its direction in accordance therewith. The fourth step is the "Test termination" step, where a) the UAV returns to the start position, and stops the emission of the tracking signal and position data, b) the Control station exports the simulation data for analysis, and c) the Directional antenna stops locking onto the tracking signal from the UAV.

Figure 7 shows an example for calculating simulated positioning data of a directional antenna based on the positioning data of the unmanned aerial vehicle.

1. First process is the pre-test input from the operator:
 - a. Satellite coordinates (latitude and longitude of the satellite); and distance to satellite (e.g. typical for geosynchronous orbits satellites is 42164 km), Radius of the Earth; and
 - b. Antenna real position during test (e.g. latitude, longitude, altitude, and platform heading);
 2. 1.b is continuously coupled with the received UAV position (e.g. latitude, longitude, altitude) to compute for simulated Azimuth (Az) and Elevation (El);
 3. 1.a is then coupled with 2 to compute for Simulated platform position (platform latitude, longitude and heading; in this example only latitude and longitude);
 4. The said calculated simulated positioning data is transmitted to the control unit of an automatic positioning means of a directional antenna.
- The Earth ellipsoid model can as well be introduced in the formula for more accurate results (optional). Other variations of this formula are known and

can be used.

References

	10	Directional antenna
	12	Control unit (e.g. ACU)
	15	Mobile platform
5	20	Unmanned aerial vehicle (UAV)
	22	UAV remote control
	24	Rotor
	26	Signal transmitter
	30	Control station
10	51	Minimum antenna elevation limit
	52	Test path in azimuth
	53	Test path in elevation
	54	Test path for simulating mobile platform motion

Claims

1. Use of an unmanned aerial vehicle (20) and a control station (30) for testing the accuracy of the automatic positioning means of a signal tracking antenna (10) during a satellite signal searching and/or tracking operation; wherein a platform on which the signal tracking antenna (10) is mounted is kept stationary during the testing operation; wherein the unmanned aerial vehicle (20) is adapted for:
 - receiving a test flight route from the control station (30), wherein the test flight route is configured for simulating waves or other mobile platform motions;
 - automatically navigating the received test flight route with the aid of a received Global Navigation Satellite System signal;
 - transmitting, while navigating the flight route, a signal configured for the signal tracking antenna (10) to search for and/or to track;
- wherein the control station (30) is adapted for:
 - transmitting the test flight route signal to the unmanned aerial vehicle (20), wherein the test flight route is configured for simulating waves or other mobile platform motions;
 - receiving positioning data from the automatic positioning means during a predefined test period; and
 - receiving data, such as signal strength data, from the signal tracking antenna, about the received signal from the unmanned aerial vehicle (20) during said predefined test period.
2. Use according to claim 1, wherein the control station (30) is configured to a) output the received positioning data, and data about the received signal and/or b) compare the received positioning data, and data about the received signal with reference values from previous tests and/or with data sheets from the antenna manufacturer.

3. Use according to any one of the claims 1-2, wherein the control station (30) is configured to receive positioning data from the unmanned aerial vehicle (20) during a test period; and
 - instructing the automatic positioning means to initiate and/or continue the
- 5 satellite signal searching and/or tracking operation based on the positioning data from the unmanned aerial vehicle (20).
4. Use according to claim 1, wherein the control station (30) is further configured to:
 - receive positioning data from the unmanned aerial vehicle (20) during a test
 - 10 period; and
 - compare the received positioning data from the unmanned aerial vehicle (20), the positioning data from the automatic positioning means, and data about the received signal with reference values from previous tests.
5. Use according to any one of the claims 1-3, wherein the control station (30) is configured to:
 - receive positioning data from the unmanned aerial vehicle (20) during a test
 - 15 period;
 - calculate simulated positioning data of the signal tracking antenna, wherein the signal tracking antenna comprises a directional antenna (10); and
 - 20 - transmit said calculated simulated positioning data to the control unit (12) of an automatic positioning means of the directional antenna (10); wherein the calculation of simulated positioning data of the directional antenna (10) is based on the positioning data from the unmanned aerial vehicle (20).
6. Use according to any one of the claims 3-5, wherein the unmanned aerial
- 25 vehicle (20) is configured for continuously transmitting its position to the control station (30).
7. Use according to any one of the claims 1-6, wherein the control station is integrated into the stabilized satellite communication antenna.

8. Use according to any one of the claims 1-7, wherein the signal tracking antenna is a COTM antenna.

9. A system for testing the accuracy of the automatic positioning means of a stabilized satellite communication antenna (10) during a satellite signal

5 searching and/or tracking operation; the system comprising:

- unmanned aerial vehicle (20); and
- a control station (30);

wherein the unmanned aerial vehicle (20) is adapted for:

10 - receiving a test flight route from the control station (30), wherein the test flight route is configured for simulating waves or other mobile platform motions;

- automatically navigating the received test flight route with the aid of a received Global Navigation Satellite System signal;

15 - transmitting, while navigating a flight route, a signal configured for the signal tracking antenna (10) to search for and/or to track;

wherein the control station (30) is adapted for:

- transmitting the test flight route signal to the unmanned aerial vehicle (20), wherein the test flight route is configured for simulating waves or other mobile platform motions;

20 - receiving positioning data from the automatic positioning means during a predefined test period; and

- receiving data, such as signal strength data, from the signal tracking antenna, about the received signal from the unmanned aerial vehicle (20) during said predefined test period.

25 10. A system according to claim 9, wherein the control station (30) is configured to a) output the received positioning data, and data about the received signal and/or b) compare the received positioning data, and data about the received signal with reference values from previous tests and/or with data sheets from the antenna manufacturer.

11. A system according to any one of the claims 9-10, wherein the control station (30) is configured to receive positioning data from the unmanned aerial vehicle (20) during a test period; and

- instructing the automatic positioning means to initiate and/or continue the satellite signal searching and/or tracking operation based on the positioning data from the unmanned aerial vehicle (20).

12. A system according to any one of the claims 9-11, wherein the control station (30) is configured to:

- receive positioning data from the unmanned aerial vehicle (20) during a test period;
- calculate simulated positioning data of the signal tracking antenna, wherein the signal tracking antenna comprises a directional antenna (10); and
- transmit said calculated simulated positioning data to the control unit (12) of an automatic positioning means of the directional antenna (10); wherein the calculation of simulated positioning data of the directional antenna (10) is based on the positioning data from the unmanned aerial vehicle (20).

13. A system according to claim 9, wherein the control station (30) is further configured to:

- receive positioning data from the unmanned aerial vehicle (20) during a test period; and
- compare the received positioning data from the unmanned aerial vehicle (20), the positioning data from the automatic positioning means, and data about the received signal with reference values from previous tests.

14. A system according to any one of the claims 11-13, wherein the unmanned aerial vehicle (20) is configured for continuously transmitting its position to the control station (30).

15. A system according to any one of the claims 9-14, wherein the control station is integrated into the signal tracking antenna.

16. A system according to any one of the claims 9-15, wherein the signal tracking antenna is a COTM antenna.

17. A method of operating a control station for testing the accuracy of automatic positioning means of a signal tracking antenna (10) during a satellite signal searching and/or tracking operation; wherein a platform on which the signal tracking antenna (10) is mounted is kept stationary during the testing operation; the method, performed by the control station, comprising:
- transmitting a test flight route signal from the control station (30) to an unmanned aerial vehicle (20), wherein the test flight route is configured for simulating waves or other mobile platform motions, and the unmanned aerial vehicle (20) is adapted for:
 - automatically navigating the received test flight route with the aid of a received Global Navigation Satellite System signal, and
 - receiving, while the unmanned aerial vehicle (20) is navigating the flight route, a signal configured for the signal tracking antenna (10) to search for and/or to track;
 - receiving, at the control station (30), positioning data from the automatic positioning means during a predefined test period; and
 - receiving, at the control station (30), data, such as signal strength data, from the signal tracking antenna, about the received signal from the unmanned aerial vehicle (20) during said predefined test period.

18. An apparatus for a control station for testing the accuracy of automatic positioning means of a signal tracking antenna (10) during a satellite signal searching and/or tracking operation; wherein a platform on which the signal tracking antenna (10) is mounted is kept stationary during the testing operation; the apparatus of the control station (30) adapted to:
- transmit a test flight route signal from the control station (30) to an unmanned aerial vehicle (20), wherein the test flight route is configured for simulating waves or other mobile platform motions, and the unmanned aerial vehicle (20) is adapted for:

automatically navigating the received test flight route with the aid of a received Global Navigation Satellite System signal, and

receiving, while the unmanned aerial vehicle (20) is navigating the flight route, a signal configured for the signal tracking antenna (10) to search

5 for and/or to track;

- receive, at the control station (30), positioning data from the automatic positioning means during a predefined test period; and

- receive, at the control station (30), data, such as signal strength data, from the signal tracking antenna, about the received signal from the

10 unmanned aerial vehicle (20) during said predefined test period.

19. A method of operating an unmanned aerial vehicle (20) for testing the accuracy of automatic positioning means of a signal tracking antenna (10)

during a satellite signal searching and/or tracking operation; wherein a

platform on which the signal tracking antenna (10) is mounted is kept

15 stationary during the testing operation; the method, performed by the

unmanned aerial vehicle (20), comprising:

- receiving a test flight route from a control station (30), wherein the test flight route is configured for simulating waves or other mobile platform

motions;

20 - automatically navigating the received test flight route with the aid of a received Global Navigation Satellite System signal; and

- transmitting, while navigating the flight route, a signal configured for the signal tracking antenna (10) to search for and/or to track;

wherein the control station (30) is adapted to:

25 - transmit the test flight route signal to the unmanned aerial vehicle

(20), wherein the test flight route is configured for simulating waves or other mobile platform motions;

- receive positioning data from the automatic positioning means during a predefined test period; and

- receive data, such as signal strength data, from the signal tracking antenna, about the received signal from the unmanned aerial vehicle (20) during said predefined test period.

20. An apparatus for an unmanned aerial vehicle (20) for testing the accuracy
 5 of automatic positioning means of a signal tracking antenna (10) during a satellite signal searching and/or tracking operation; wherein a platform, such as a ship, on which the signal tracking antenna (10) is mounted is kept stationary during the testing operation; the apparatus adapted to:
- receive a test flight route from a control station (30), wherein the test
 10 flight route is configured for simulating waves or other mobile platform motions;
 - automatically navigate the received test flight route with the aid of a received Global Navigation Satellite System signal; and
 - transmit, while navigating the flight route, a signal configured for the
 15 signal tracking antenna (10) to search for and/or to track;
- wherein the control station (30) is adapted to:
- transmit the test flight route signal to the unmanned aerial vehicle
 (20), wherein the test flight route is configured for simulating waves or other
 mobile platform motions;
 - 20 - receive positioning data from the automatic positioning means during a predefined test period; and
 - receive data, such as signal strength data, from the signal tracking antenna, about the received signal from the unmanned aerial vehicle (20) during said predefined test period.