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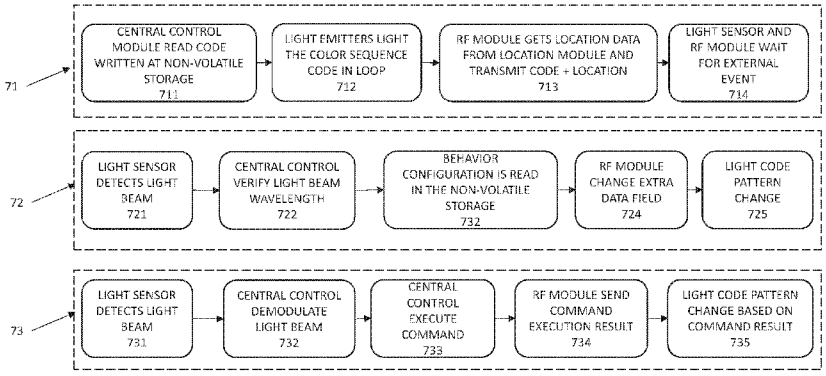

FIG. 7

(57) Abstract: Example implementations associated with the aspects of the present invention include a low altitude aircraft identification system composed by three components: a small aircraft electronic identification box with an embedded logger, a ground identification equipment to automatically identify the aircraft just pointing at it, and an identification code database. The identification code can be transmitted by a visible light color sequence or by a radio frequency signal. The ground identification device is capable of recognizing both kinds of code.

A LOW ALTITUDE AIRCRAFT IDENTIFICATION SYSTEM

BACKGROUND

1. TECHNICAL FIELD

[1] Aspects of the example implementations are directed to methods and systems for identification of airborne objects at a low altitude, and more specifically, to systems and methods for identification of low-altitude aircraft.

2. RELATED ART

[2] Related art unmanned aerial vehicles (UAVs) or unmanned aircraft systems (UASs) markets once belonged to professional companies. However, related art UAVs and UASs now include amateur pilots flying affordable models available for purchase, for example, in an electronic store, and which may be controlled by mobile communication devices such as smartphones. However, these related art flying objects may cause damage and/or injury due to their altitude, speed and weight. Thus, there is a need to manage the related art UAVs and UASs.

[3] In ground-based systems, such as the related art automotive market, one of the bases of the car control system, may include an identification credential issued by a division of motor vehicles (DMV) or others, such as a license plate. However, there is no analogous identification method or system for related art UAVs and/or UASs. For related art small UASs (e.g., aircrafts up to 25 pounds flying up to 500ft of the low altitude airspace), related art tail numbers that are used in commercial aircraft are too large in size (e.g., area) to be provided on these vehicles, or they will be too small to allow the small UAS identification.

[4] An identification solution is needed that permits ground-level identification, as well as identification by other aircrafts of various sizes and altitudes. The identification solution also needs to allow detection in an automated manner using a device.

SUMMARY

[5] Example implementations associated with the aspects of the present invention include a low altitude aircraft identification system composed by three components: a small aircraft electronic identification box with an embedded logger, a ground identification equipment to automatically identify the aircraft just pointing at it, and a central identification code database server.

[6] The identification code can be transmitted by a visible light color sequence or by a radio frequency signal. The ground identification device is capable of recognizing both kinds of code.

Electronic Identification Box

[7] A traffic management system has the function of monitoring the traffic and the ability of notifying the responsible party in case of any non-compliance with a regulation. Therefore, an operation to identify the responsible party is to identify the vehicle. The ground traffic management system requires all vehicles to have a license plate for driving on public roads. This license plate allows the police and other drivers to identify the vehicle.

[8] With respect to UAVs and UASs, there is a need to have a structure that permits identification, as with a traffic management system.

[9] Instead of the related art approach of stamping letters and numbers in the aircraft, the present example implementation is directed to a light array that blinks a defined color pattern sequence for each aircraft. One potential advantage of this identification mechanism is the possibility for a person to visually identify an aircraft from a distance of about 500 feet, without the use of any special equipment. The color sequence, blinking speed and the meaning thereof can be defined by the pilot, the fleet control or even by a regulatory agency. The number of colors used and the number of blinks may define the quantity of codes possible.

[10] Together with the light array, the electronic identification box has a position logger and a transponder. The position logger has a global positioning system (GPS) module to obtain the absolute position where the aircraft is flying by. The logger stores the flight path of each trip made by the aircraft. Together with the positioning information, the speed and heading may also be stored. Telemetry data provided by the aircraft sensors, such as inertial measurement unit (IMU) and power level, and application data provided by the autopilot or any embedded component are also stored. This information is the proof of the aircraft real flight data, and it may perform functions similar to a civil aviation "black box" in case of a crash. In addition, in case of an UAV doing an autonomous flight beyond line-of-sight, the data may show where the UAS flew by.

[11] The transponder may transmit a code similar to the one generated (e.g., blinked) by the light arrays but through the RF frequency, allowing automatic identification by any RF receiver on land, or installed in other aircrafts. In addition to the

code, the transponder may also transmit the last position, including but not limited to heading and speed, thus allowing the implementation of a collision avoidance system. The identification box has also an independent battery to allow the transmitter works even without the external power supply. Accordingly, in case of an aircraft crash, the transponder will continue to transmit the last know position so that the wrecked vehicle may be located or identified.

[12] The identification box has a photo sensor configured to receive external signals. In case the photo sensor is excited with a high luminous beam in a specific wavelength and modulation, such as a laser beam, the identification box may change its operational behavior. The identification box can, for instance, change its light brightness, send commands to the autopilot, increase the data storage frequency, but is not limited thereto.

[13] One of the preset configurations for the photo sensor stimulation is to modify flag data in the RF data sent by the transmitter, and/or the behavior of the blinking pattern. In some scenarios, more than one aircraft may be flying close to each other, in a way that a receiver on the ground is detecting all of the flying aircraft without knowing which UAV is transmitting each identification code. Therefore, it is just a matter of directing a specific wavelength and modulated light beam emitter to one of the aircrafts, and the aircraft will thus modify its behavior and its transmitted data, allowing the data-to-vehicle association. This feature creates a duplex communication, allowing the identification box to send broadcast data by its color light emitters, and receive directional data through the light sensor.

[14] Commands can also be received and executed using the communication channel. Through a physical connection between the identification box and the UAV autopilot, the identification box can, for instance, receive way point change command through a modulated light beam and change the UAV destination coordinates.

Ground Identification Device

[15] A police department may maintain law enforcement agents who are supervising the roads and highways in order to detect drivers disobeying traffic laws. Devices such as the radar allow police officers to detect the vehicle speed. Moreover, the license plate allows for identifying the vehicle owner and accessing the complete history of the vehicle. This kind of control allows for small remote controlled aircraft surveillance and regulation.

[16] The example implementation includes a remote (e.g., ground) device to assist the aircraft identification. Since the electronic identification box relies on visual information, the ground device is equipped with a camera, lens and image processing algorithms to capture the color sequence. In addition, this device has an RF receiver capable of receiving the identification box RF signal to connect both information sources and to verify the authenticity. The device may also have a network connection through Wi-Fi or cellphone network to access the identification server.

[17] The aircraft code and the position where the aircraft was detected at are submitted to the central identification server to identify its owner, the responsible pilot and the flight permission. Hence, if the remote (e.g., ground) user wants to check if one specific vehicle has the flight permission to fly in that area, that user directs the identification device in the vicinity of the aircraft. The identification device automatically handles the identification and crosschecks with the identification database. After the database server verifies the information, the device shows on the screen if the aircraft position and timestamp is according to its permitted flight plan. In one example implementation, the device screen shows a "valid" message. Otherwise, the user will see an "invalid" message. Clicking in the message is possible to see all the information database information associated with the aircraft.

DRAWINGS

[18] FIG 1 shows the external view of the identification box with 4 light arrays, according to an example implementation.

[19] FIG 2 shows the schematic view of the identification box, according to the example implementation.

[20] FIGs. 3A and 3B show the external view of the ground identification device facing forward and backward, according to the example implementation.

[21] FIG 4 shows the schematic view of the ground identification device, according to the example implementation.

[22] FIG 5 shows the user interface of the ground identification device, according to the example implementation.

[23] FIG 6 shows the server process flow, according to the example implementation.

[24] FIG 7 shows the identification box software flow, according to the example implementation.

[25] FIG 8 shows the remote (e.g., ground) device software flow, according to the example implementation.

DETAILED DESCRIPTION

[26] The subject matter described herein is taught by way of example embodiments. Various details have been omitted for the sake of clarity and to avoid obscuring the subject matter. Examples shown below are directed to structures and functions for implementing and enabling control and enforcement of access of user data.

[27] Described herein are example embodiments of systems, devices, and methods that enable identification of airborne objects at a low altitude, and more specifically, to systems and methods for identification of low-altitude aircraft.

[28] FIG. 1 shows the perspective view of one of the two components of the example implementation, FIG. 2 shows its schematic with the internal components, and FIG. 7 shows firmware execution flow.

[29] As shown in FIG. 1, the identification box 1 includes one or more light arrays 2 each including several light color emitters 3. These color emitters 3 are controlled by the light controller module 17 as shown in FIG. 2 as being connected to color emitters 11. More specifically, the color emitters 3 generate (e.g., blink, variable light intensity or color fade) a defined color sequence programmed in the unit firmware executed by the central control unit 18 (shown in FIG. 2), and following the main loop flow 71, shown in FIG. 7 and described below.

[30] The identification box 1 also has a radio antenna 5 connected to a RF module 16 shown in FIG. 2 as being connected to RF antenna 12, that transmits the same code or a modified version of the code through a radio signal. The RF module 16 can receive the RF signal from identification boxes (e.g. nearby) installed in other aircrafts, and save this information in the non-volatile storage module 15 that is connected to the memory card installed in the memory card slot 7.

[31] The example implementation also has one light detection sensor 4 connected to a light receiver module 19 configured to detect external excitation by a light beam with defined wavelength and intensity. In case of external light detection by the light sensor 4, the light beam detection flow 72 of FIG. 7 is executed. Consequently, the behavior of the identification box 1 can change, for instance adding or changing extra data information to the transmitted RF signal or change the light blink pattern or intensity.

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[32] Additionally, the identification box 1 also has a location system antenna 6 (e.g., GPS antenna) connected to a location module 14, shown in FIG. 2 as being connected to system antenna 13, to log the flight path in the storage module 15. This positioning data (e.g. GPS data, camera motion capture, radio triangulation system) is also transmitted by the RF module 16 together with the identification code.

[33] The identification box 1 has also an external power connector 8 used to recharge the internal power storage 20 (e.g., LiPo (Lithium-Polymer) battery or super capacitor) and supply power to all internal and external components.

[34] In case of no power being supplied, the internal power storage 20 can supply power to all the components. In this "no external power" state, the RF module 16 may keep following the main loop flow 71, and transmitting the last location position and the identification code until the battery runs out of power, while the other components will be in a sleep mode.

[35] All the internal components are protected by a housing 9 (e.g., standard weatherproof box) against impact and weather, in order to resist a crash without damaging the internal circuit.

[36] The other component of the example implementation is the ground identification device 21, which is remote from the UAV or UAS, as shown in left and right perspective in FIGs. 3A and 3B respectively, and with its internal schematic in FIG. 4. In addition, the main user interface is shown in FIG. 5, the server process in FIG. 6 and its firmware process flow in FIG 8. The ground identification device 21 may be a custom-made device, specifically for the example implementation. Alternatively, the ground identification device 21 may be a mobile communication device (e.g., smartphone), containing instructions (e.g., software or downloadable and/or online application) as would be known to those skilled in the art. The mobile communication device can also be attached to external components like zoom lens or light beams, but not limited to, to be able to execute other features of the ground device 21.

[37] The ground identification device 21 has a camera with zoom 22 capable of capturing images such as video in real-time. The identification procedure flow 81 as shown in FIG. 8 is executed to process the video and identify the aircraft. This video goes to an image processing module 36, connected to camera 32 in FIG. 4, which analyses the image to detect that the identification box blinks and capture the blink sequence.

[38] In case of a successful detection, the detected code is informed to the touchscreen 24, in the field 51 as shown in FIG. 5. A detection window 54 will be shown

around the detected aircraft. A request to a server will be made to obtain further aircraft data, following the aircraft request data flow 61 as shown in FIG. 6. Other information, associated with the aircraft owner is presented in the field 52, is provided.

[39] A location system antenna 27 (e.g., GPS antenna) is connected to a location module 41 as antenna 40 in FIG. 4, in order to get the position where the aircraft was detected. Both information, including the detected id and the location detection position, are transmitted to a server through a data communication antenna 28 connected to a data communication module 38 as antenna 34 in FIG. 4 (e.g. cellular network or Wi-Fi). The server will follow the aircraft route confirmation process 62 as shown in FIG. 6, and reply an id verification message that is presented in the field 53 of the touchscreen 24.

[40] The ground identification device 21 also can detect aircrafts through the RF signal transmitted from the identification box RF module 16. The signal is received by the RF receiver antenna 26 connected to the RF receiver module 37, shown as antenna 33 in FIG. 4. Since many signals can be received at the substantially same time by the receiver module 37, the detected ids are presented in the field 55 in a list format. If at any time the user decides to use the touchscreen 24 to select (e.g., click) on any id number, a request will be made to a server following the aircraft information flow 61 of FIG. 6, to show more information about that aircraft.

[41] In order to activate (e.g., excite) the identification box light sensor 19, the ground device has a light beam emitter 23 connected to a light beam modulator 35, shown as emitter 31 in FIG. 4. The light beam excitation flow 82 is executed by the ground device 21. This beam, when captured by the light sensor 19 will change the data transmitted by the identification box RF module 16. This difference in the data is detected by the ground device RF module 37, and the light excited aircraft id presented in the field 55 will be shown in a distinguishable form, for example but not by way of limitation, bold-text.

[42] The ground device internal components are protected by a weather proof housing 29. The front screen panel has few general-purpose buttons 25 that can be configured, for instance, to perform commands provided by the user, such as to activate the light beam.

[43] The identification box light emitters 3 and light sensor 4 of the identification box 1 create a two-way communication system. Similarly, the ground device camera 22 and light beam emitter 23 of the ground device 21 also create a two-way communication system. The RF receiver and transmitter 16 and 37 in both the

identification box 1 and the ground device 21 creates a duplex communication. Therefore, the identification box 1 and ground device 21 together can exchange information through light or RF. This feature allows other applications. One example application may be to send data to an UAV through light and RF.

[44] For instance, a delivery drone can receive a message to update its destination coordinate when the delivery drone gets closer to the delivery address as described following. The ground device 21 detects the UAV flying at a long distance from the user address through the RF signal received by the RF module 37. The ground device 21 communicate with the server sending the received ID and the device location capture by the location module 41 (e.g., GPS, AGPS, Wi-Fi mapping or cellphone tower position) to check if the received id belongs to a delivery UAV going to the ground device position.

[45] The server follows the aircraft destination process flow 63 shown in FIG. 6 to return the confirmation to the ground device 21. When the server confirms if the UAV is going to the ground device position, the ground device 21 shows on its screen 24 a message informing the user that his delivery is arriving. The user points the ground device 21 to the UAV (e.g., goes outdoors), and uses one of the general-propose buttons 25 to turn on the light emitter 23.

[46] At this moment, the ground device 21 will start to transmit its position through the RF module 37. The light sensor 4 of the identification box 1 detects the light beam and the RF module 16 receives the ground device 21 position. The identification box central control module 18 sends destination update to the UAV autopilot through the autopilot connector 10. After that, the UAV will update its destination to drop the delivery in the exact location the user is transmitting.

[47] In addition, other applications can be provided if the ground device 21 is attached to an aircraft, and the identification box 1 is attached to a ground object. For instance, an automated landing procedure in a mobile landing pad attached to a vehicle can use these devices in this configuration. The identification device 1 is attached to several landing pads, each one sending a unique identification code through the light emitters 2 and the RF module 16 simultaneously.

[48] The aircraft with the ground device 21 pointing to the ground receives the landing pad id and the location data through the RF module 37. A connection between the aircraft autopilot and the ground device 21 through the data connector 30 allows the ground device to send messages to the aircraft, a destination coordinates update for

instance. After receiving the landing pad id, the ground device 21 search for the landing pad visual position of that specific landing pad color sequence using the camera 22.

[49] This process allows a fine control of the aircraft using real-time optical navigation to approach and land in the moving landing pad. This application can be executed in an outdoor and indoor environment, even without the location data been transmitted by the landing pad identification box.

[50] Further, the ground device 21 can modulate data through the light beam modulator 35. The identification box central control module 18 can demodulate the light beam in order to execute commands. The light beam command transmit flow 83 shown in FIG. 8 is executed by the ground device 21. The user selects the command on the screen 24, and the light beam modulator 35 turns the light beam emitter 23 on and off in a defined frequency and protocol. The identification box light sensor 4 detects the modulated light beam and send the binary data to the central control unit 18 that is execution the light beam command execution flow 73 shown in FIG. 7.

[51] After the command execution, the identification box 1 sends the execution results (e.g. an ACK, or an error status code) to the ground identification unit 21 through the RF module 16 and it can also change the color sequence to show the result visually. For instance, the light controller module 17 can turn the red color on for a while in case of an invalid command, and the green light in case of a successfully executed command.

[52] In FIG. 4 above, the central processing unit 39 receives inputs from the location module 41, the cellular modem 38, the RF module 37, the light beam modulator 35 and the image processing module 36, and performs the processes (e.g., software or instructions) associated with the ground identification unit 21.

[53] FIG 6 shows the server process flow, according to the example implementation. As explained above, and as shown in the flow 61, a server may await the receipt of a request at 611, such as from a ground device, for example. At 612, a ground device may request a database search, as explained above. At 613, the server receives the request from the ground device, and performs a search on the database, for the requested identity information, which was based on the combination of light signals, blanks etc. as explained above. At 614, upon obtaining the requested identification information of the aircraft, the requested information is returned to the ground device. Accordingly, the ground device may obtain identification information of the small and/or low altitude aircraft.

[54] According to another example implementation of the server process flow, as shown in flow 62, at 621, the server waits for one or more requests from the ground device. At 622, the ground device provides a request for a database search. At 623, and as explained above, the server receives the request, and performs a search of the database for the requested identifying information of the aircraft. At 624, the server performs a comparison of the aircraft route data, with the ground device location data. In this operation, the server confirms whether the aircraft is on the correct route or not. At 625, the server provides a confirmation to the ground device as to whether or not the aircraft route is correct. At this point, a ground device or the server may optionally perform an action, such as providing a report of an incorrect aircraft route, or other report that one skilled in the art would understand to provide if an aircraft is not on a correct route.

[55] According to yet another example implementation of the server process flow, as shown in flow 63, a server may await the receipt of a request at 631. As explained above, a ground device may provide a request for database search to the server at 632. At 633, and as explained above, upon receiving the request from the ground device for a server search, the server performs the search for the requested ID, and determines the identification of the aircraft. At 634, the server performs a comparison between the aircraft destination data, and the ground device location data. At this point, the server confirms whether the aircraft is at the correct destination or not. At 625, the server provides a confirmation to the ground device as to whether or not the aircraft is at the correct destination. At this point, and as explained above with respect to operation 625, the ground device or the server may optionally perform an action indicative of the correctness of the aircraft destination.

[56] FIG 7 shows the identification box software flow, according to the example implementation. For example, but not by way of limitation the flows 71, 72, 73 may be implemented on a processor that is present in the identification box as explained above. Alternatively, various operations may be offloaded to other processors in the identification box.

[57] As shown in flow 71, and as explained above, at 711, the central control module reads instructions stored in a non-volatile storage. Based on the reading of those instructions, at 712 the central control module instructs light emitters to light a color sequence instruction in a loop. The color sequence instruction may be determined based on the command received at the central control module. At 713, the RF module receives location data from a location module, and transmits a code and location information

associated with the location data the RF module performs this operation in response to command the central control module. The central control module may provide this command based on the code or instructions stored in the nonvolatile storage. At 714, the light emitters are emitting the instructed color sequence, and the RF module has obtained the necessary location data and prepared the necessary information, and the identification box, including the light sensor and RF module, are waiting an external event, such as the heat of information from the ground device.

[58] As shown in flow 72, and is also explained above, at 721, light sensor detects a light beam. For example, the light beam may be received from the ground device. At 722, the central control module receives the light beam information, and verifies the wavelength of the light beam. Based on the wavelength of light beam, it is determined whether the received light beam is a light beam associated with an instruction for that aircraft associated with the identification box that is attached to the aircraft. At 723, a behavior configuration is read from the nonvolatile storage by the central control module. At 724, the RF module changes in extra data field based on the information provided in operation 725. At 725, a light coat pattern is changed, based on the instruction also provided from central control module, based on the information received in operations 721, 722 and 723. Accordingly, an instruction is provided, either by the ground device, another aircraft or a flight control tower, or other source of instruction as would be understood by those skilled in the art, to instruct the identification box of the aircraft change the light code pattern. Light code pattern changed may be indicative of a certain status of the aircraft, such as being on the correct or incorrect destination, or other information.

[59] As shown in flow 73, the light sensor of the identification box may detect the light beam at 731. At 732, the central control module may demodulate the light beam, thus determining any information instruction associated with light beam. At 733, the central control may execute a command based on the information and instructions received in the demodulated light beam. At 734, the RF module may send from the screen of the user interface of the ground device. At 735, the light code pattern may change based on the command execution result.

[60] FIG 8 shows the remote (e.g., ground) device software flow, according to the example implementation. As shown in flow 81, at 811, the RF module of the ground device may receive identification information, such as the identification should of the aircraft. At 812, imaging processing module may detect a color sequence associated with

the aircraft that is admitted by the identification box. At 813, the central processing unit of the ground device may transmit a request to the server to obtain information associated with color sequence that was received. At this point, one or more of the operations described above in flow 61, 62 and/or 63 may be performed. At 814, the server returns the requested information to the ground device, and the requested information is shown on the screen, as explained above.

[61] As shown in flow 82, at 821, a user may activate an object on a user interface, such as pressing a button on a screen of the ground device. At 822, a light beam modulator may transmit a light beam from the ground device to a target. For example, but not by way of limitation, the target may include the aircraft, and more specifically, the identification box of the aircraft. At the 23, the RF module may detect a change in the extra data might, as explained above. Further, at 824, the target ID may be bolded or otherwise identified in the user interface, so as to highlight to the user the change in that target ID associated with the aircraft.

[62] As shown in flow 83, at 831, the user may select a command in the screen. At 832, a light beam modulator may send a light beam command to the target, such as the identification box of the aircraft as explained above. At 833, the RF module may detect a confirmation message received from the target, such as a message received from the identification box. Further, in response to the light beam, at 834, the image processing module may also detect a confirmation sequence, as shown above. At 835, the screen receives and shows a result of the command execution, as also explained above.

Improvements on Related Art

[63] The related art aircraft identification systems focus on civil or military aviation. None of the related art systems work for a small aircraft in a low altitude. Using a visible light sequence, an aircraft in a low altitude flight may be visually identified.

[64] The other related art identification systems for aircraft need a radar system or special devices to be able to receive the identification signal, which works well for a scenario involving an airport tower and an aircraft, but does not work for a scenario involving a person without such devices and an aircraft.

[65] Using visible light identification, a person can observe at an aircraft and memorize its color sequence. This approach is similar to the way cars are identifiable by their license plate, instead of the way aircrafts are identified in the related art.

Other Uses or Applications for This Invention

[66] This invention is an identification system that can be used to identify any vehicle, ship, aircraft or other static or mobile objects that are located up to about 1 mile from a person.

[67] Although a few example embodiments have been shown and described, these example embodiments are provided to convey the subject matter described herein to people who are familiar with this field. It should be understood that the subject matter described herein may be embodied in various forms without being limited to the described example embodiments. The subject matter described herein can be practiced without those specifically defined or described matters or with other or different elements or matters not described. It will be appreciated by those familiar with this field that changes may be made in these example embodiments without departing from the subject matter described herein as defined in the appended claims and their equivalents.

REFERENCE NUMERALS IN THE DRAWINGS

1 – Identification box	2 – Light arrays
3 – Light emitters	4 – Light sensor
5 – RF antenna	6 – Location system antenna
7 – Memory card slot	8 – Power connector
9 – Housing	10 – Autopilot data connector
11 – Light emitter	12 – RF antenna
13 – Location system antenna	14 – Location module
15 – Non-volatile storage module	16 – RF module
17 – Light controller module	18 – Central control module
19 – Light receiver	20 – Internal power storage
21 – Ground identification device	22 – Camera with zoom
23 – Light beam emitter	24 – Touchscreen
25 – General buttons	26 – RF antenna

27 – Location system antenna

28 – Data communication antenna

29 – Housing

30 – Data connector

31 – Light beam emitter

32 – Camera module

33 – RF antenna

34 – Data communication antenna

35 – Light beam modulator

36 – Image processing module

37 – RF module

38 – Data communication module

39 – Central processing unit

40 – Location system antenna

41 – Location module

51 – Id captured by the camera

52 – Aircraft responsible name

53 – System message

54 – Detection window

55 – RF detected ids

56 – General buttons

61 – Aircraft data request flow

62 – Aircraft route confirmation process

63 – Aircraft destination confirmation process

71 – Main loop flow

72 – Light beam detection flow

73 – Light beam command execution flow

81 – Identification procedure flow

82 – Light beam excitation flow

83 – Light beam command transmit flow

CLAIMS

1. A device configured to communicate identification information associated with low-altitude aircraft, the device comprising:

one or more light arrays each including color emitters that generate a defined color sequence in response to an instruction received from a light controller configured to control the color emitters;

a radio antenna connected to an RF module that transmits information associated with the low-altitude aircraft through a radio signal, and is configured to receive an RF signal and stores the information in a storage;

a light detection sensor connected to a light receiver module configured to detect external excitation of the color emitters based on a light beam with a wavelength and an intensity; and

a location system antenna connected to a location module, configured to log the flight path in the storage, and to transmit positioning data by the RF module together with the information, wherein the device is attached to the low-altitude aircraft.

2. The device of claim 1, further comprising an external power connector configured to recharge an internal power storage and supply power to all internal and external components.
3. The device of claim 1, further comprising a housing that protects the device against impact and weather.
4. The device of claim 1, wherein the color sequence comprises an identification (ID) code using a visible light sequence.
5. The device of claim 1, where the color sequence comprises a sequence of different colors in a loop.
6. The device of claim 1, where the color sequence comprises one or more colors with different blink times.
7. The device of claim 1, wherein the light emitters comprises one or more of LEDs, OLEDs, quantum dots, light bulbs and laser beams.
8. The device of claim 1, further comprising an external light detection sensor.
9. The device of claim 1, where the information is transmitted together with the identification information of the low-altitude aircraft.
10. The device of claim 1, further comprising a location receiver.
11. The device of claim 1, further comprising a GPS receiver.

12. The device of claim 1, further comprising a cellular network modem.
13. The device of claim 1, further comprising a wireless radio data link.
14. The device of claim 1, further comprising a defined light beam emitter.
15. A device configured to communicate with low-altitude aircraft, the device being remote from the low-altitude aircraft, the device comprising:

an image capture device configured to receive one or more images associated with a plurality of colors emitted from the low-altitude aircraft as detected by the image capture device, and an image processing module connected to image capture device, which analyses the one or more images, to detect that the identification box blinks and capture the blink sequence;

a user interface that receives a command from a user and provides information to the user associated with the low-altitude aircraft, wherein a request is provided to a server to obtain information associated with the low-flying aircraft;

an antenna connected to a location module to determine a position of detection of the low-altitude aircraft, including a detected id and a location detection position, and to transmit instructions to a server through a data communication antenna connected to a data communication module;

an RF receiver antenna connected to an RF receiver module 37, and configured to receive RF signals from the low-altitude aircraft; and .

a light beam emitter configured to activate a sensor of the low-altitude aircraft, and to provide at least one of instructions and information to the low-altitude aircraft.

16. The device of claim 15, where a code is received at the RF receiver module by an RF signal transmitted from the low-altitude aircraft.
17. The device of claim 15, where extra data is transmitted together with an ID comprising the information.
18. The device of claim 17, wherein a defined wavelength is detected, and an intensity light beam is generated to change the extra data transmitted.
19. The device of claim 15, wherein the low-altitude aircraft detects a defined light beam generated by the device.

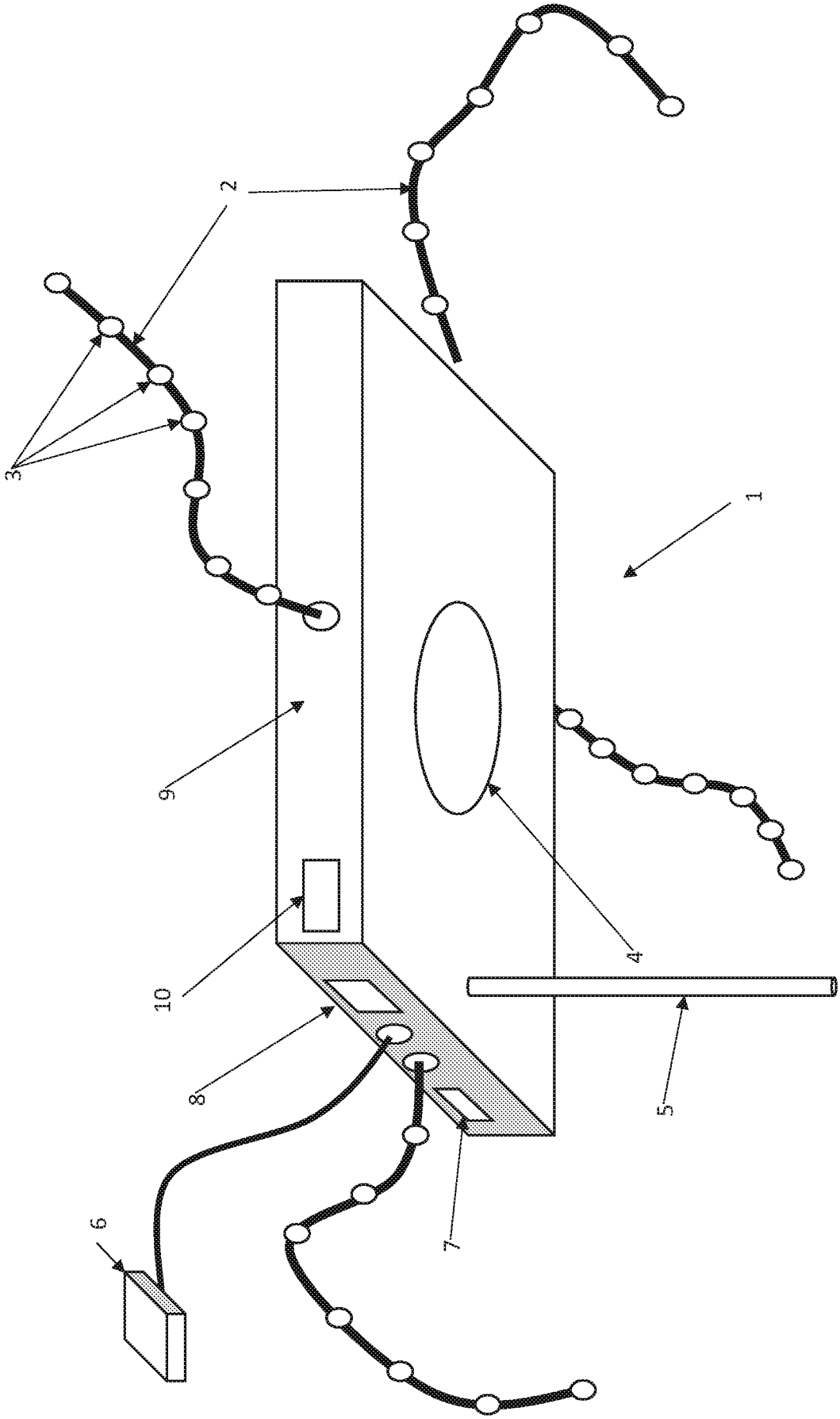
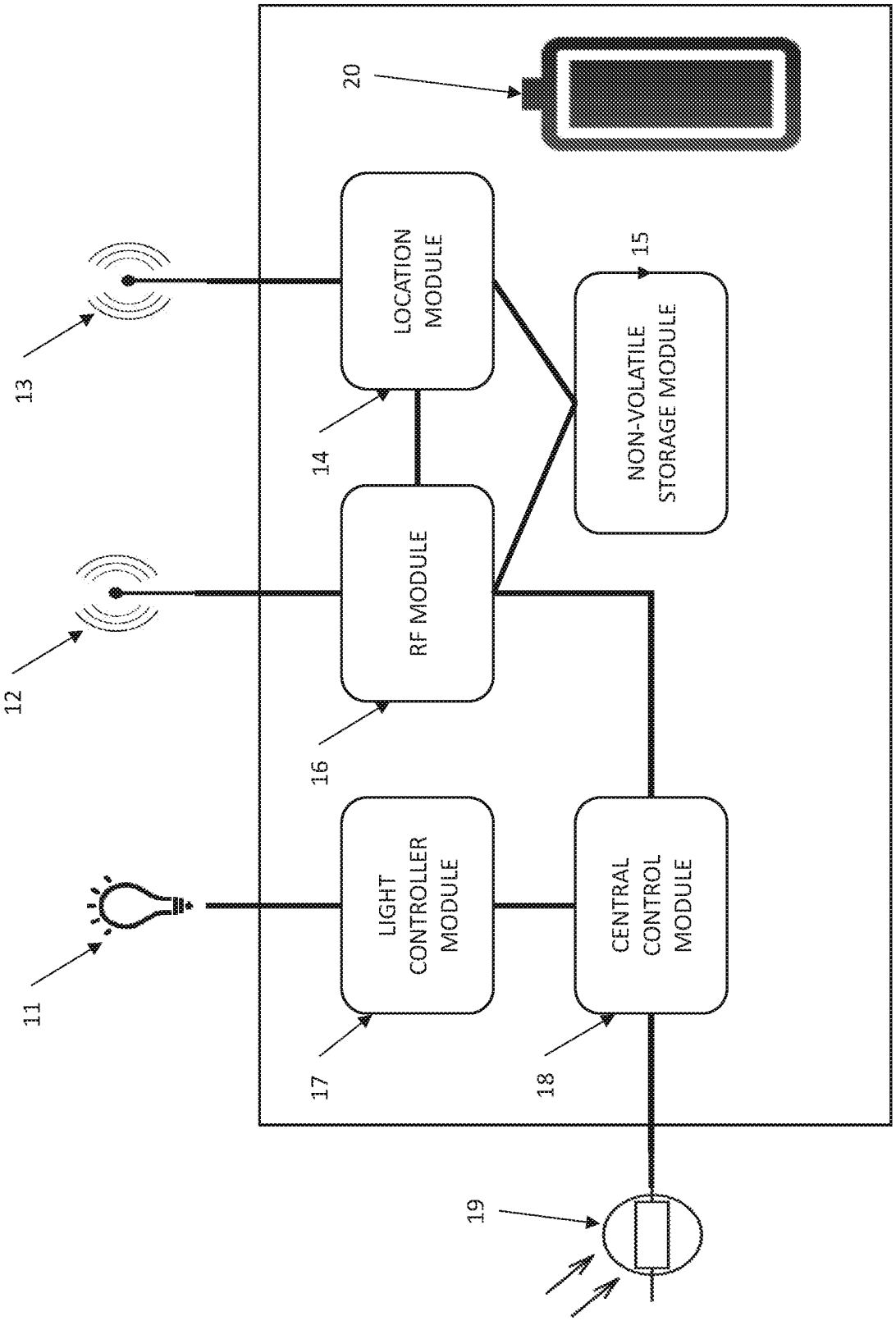


FIG. 1


20
LOCATION MODULE
15
NON-VOLATILE STORAGE MODULE
13
14
RF MODULE
12
16
LIGHT CONTROLLER MODULE
CENTRAL CONTROL MODULE
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17
18
19

FIG. 2

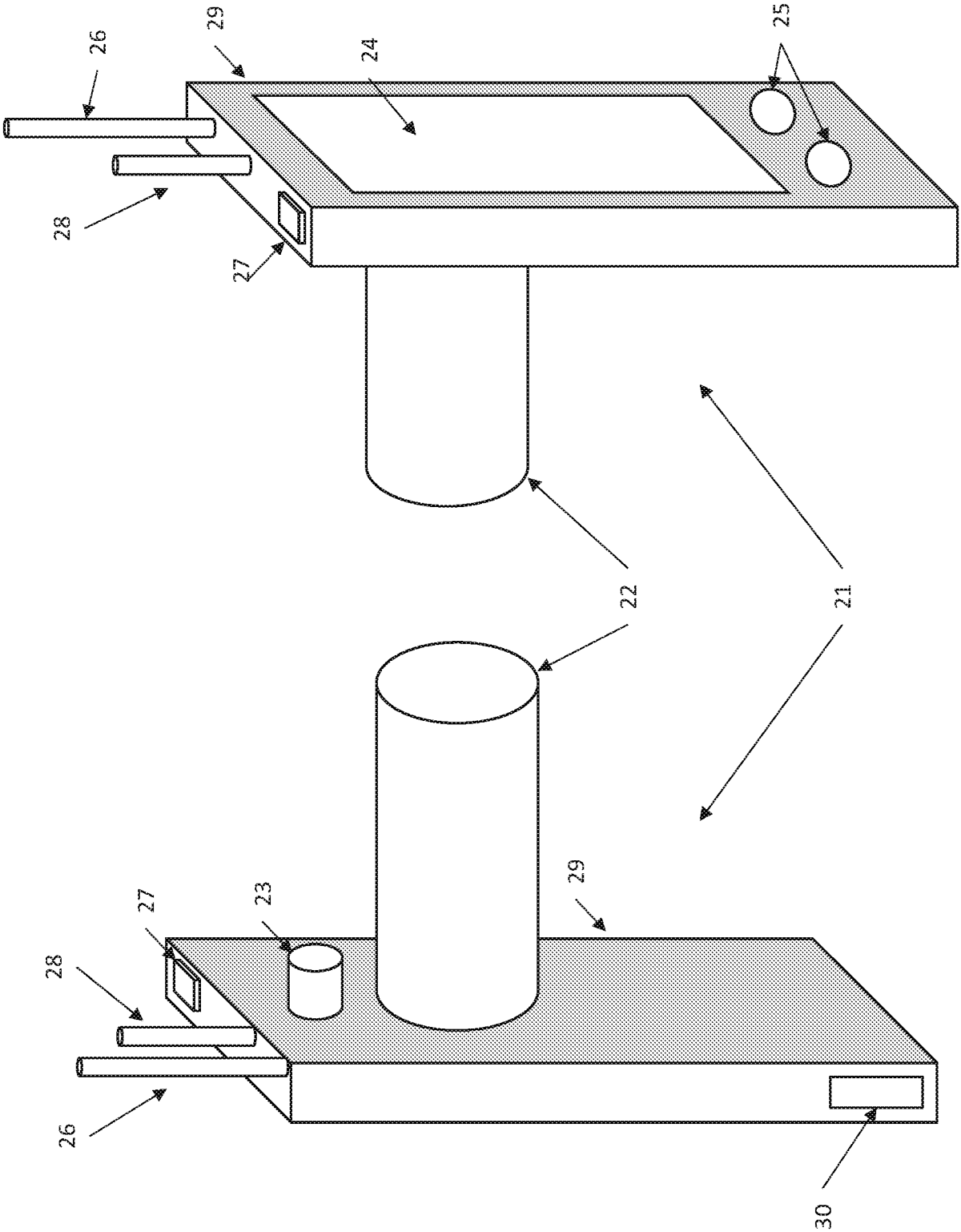
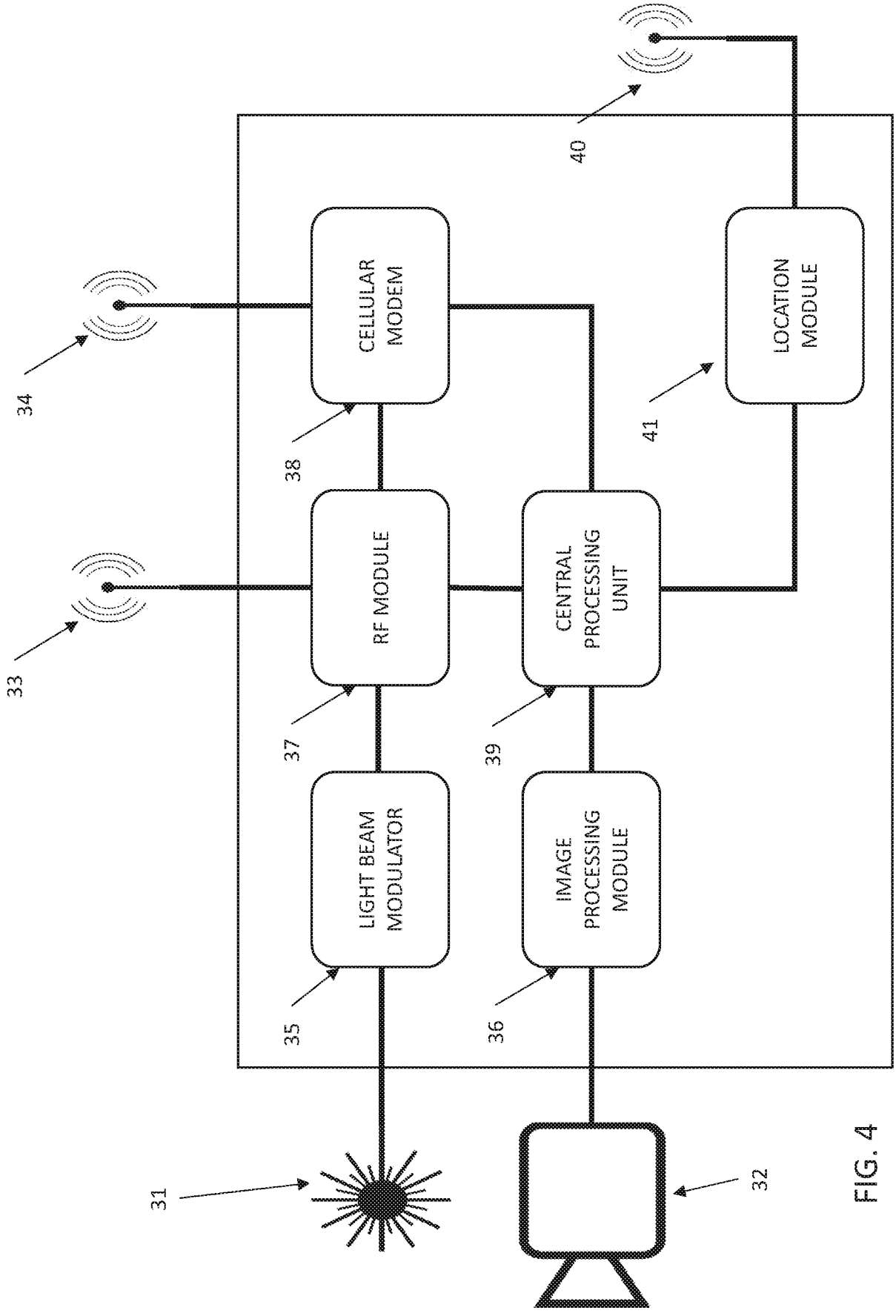


FIG. 3


CELLULAR MODEM
LOCATION MODULE
RF MODULE
CENTRAL PROCESSING UNIT
LIGHT BEAM MODULATOR
IMAGE PROCESSING MODULE
31
32
33
34
35
36
37
38
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40
41

FIG. 4

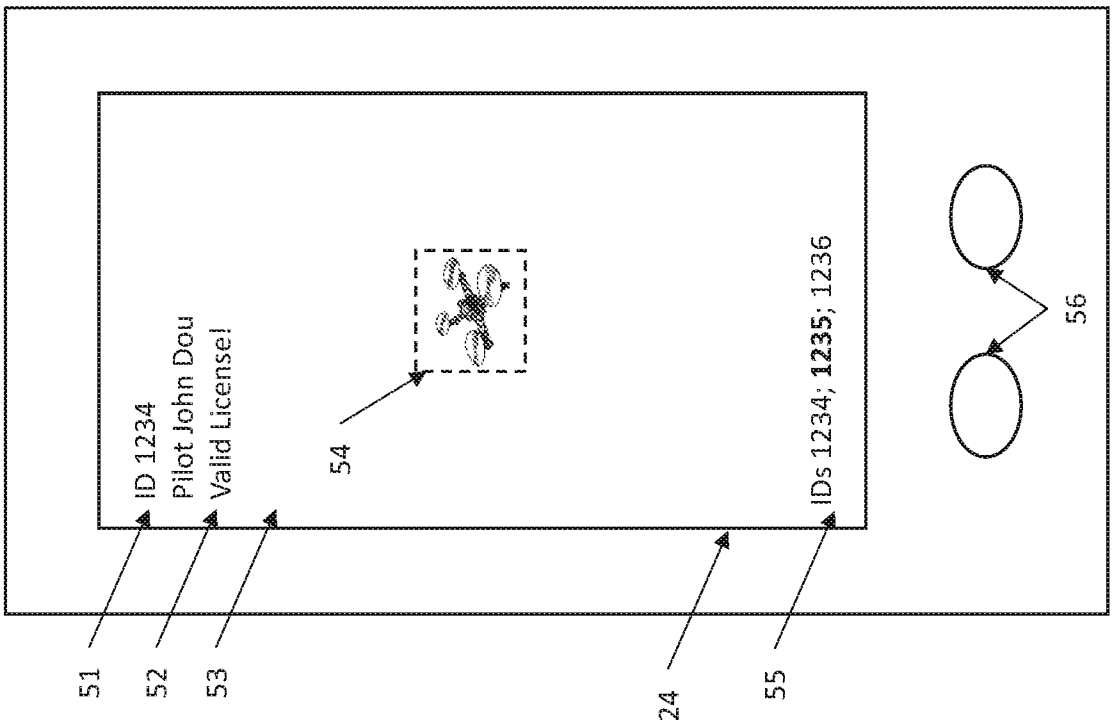

ID 1234
Pilot John Dou
Valid License!
IDs 1234; 1235; 1236
54
56
51
52
53
24
55

FIG. 5

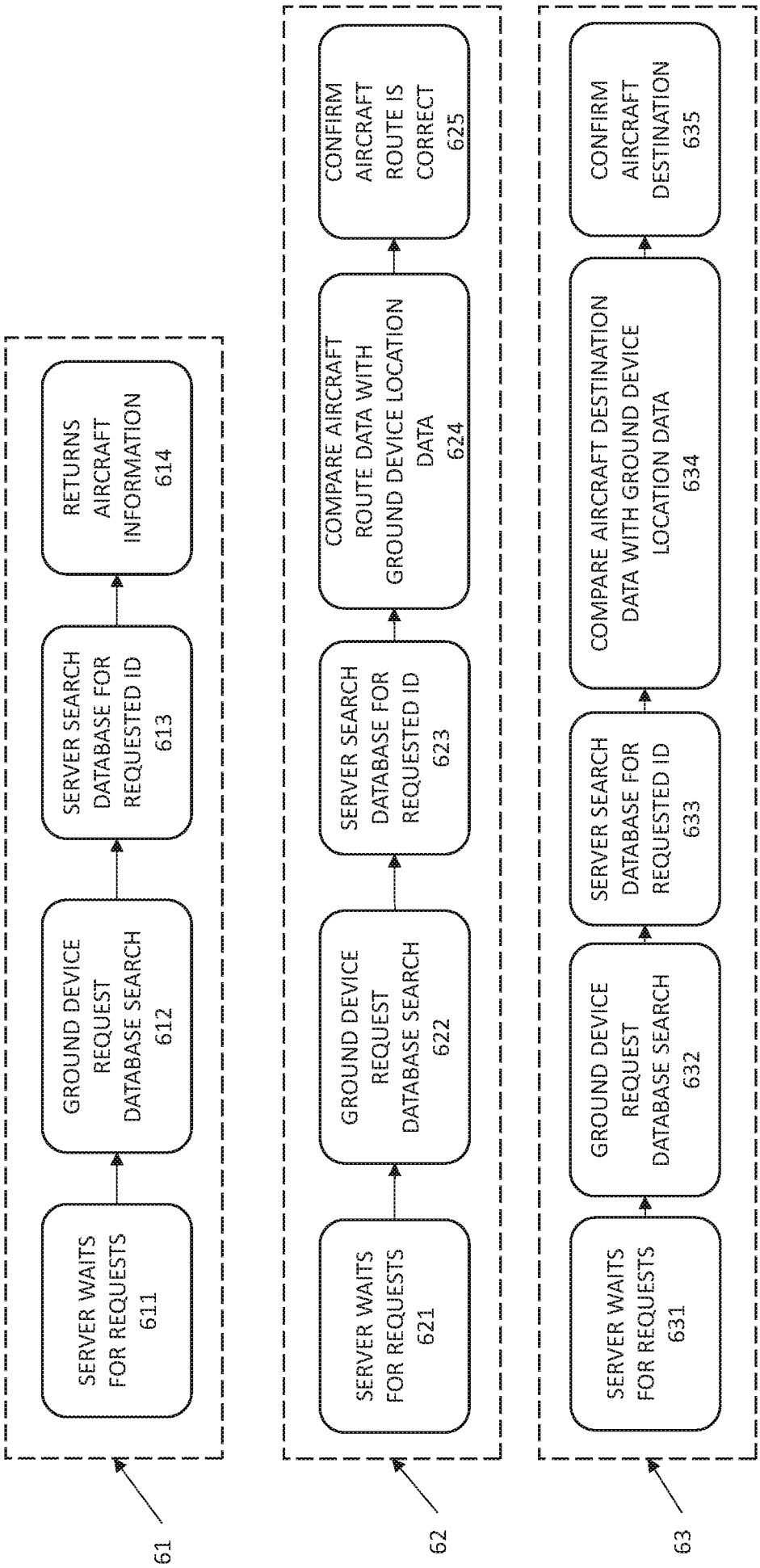

61
SERVER WAITS FOR REQUESTS 611
GROUND DEVICE REQUEST DATABASE SEARCH 612
SERVER SEARCH DATABASE FOR REQUESTED ID 613
RETURNS AIRCRAFT INFORMATION 614
62
SERVER WAITS FOR REQUESTS 621
GROUND DEVICE REQUEST DATABASE SEARCH 622
SERVER SEARCH DATABASE FOR REQUESTED ID 623
COMPARE AIRCRAFT ROUTE DATA WITH GROUND DEVICE LOCATION DATA 624
CONFIRM AIRCRAFT ROUTE IS CORRECT 625
63
SERVER WAITS FOR REQUESTS 631
GROUND DEVICE REQUEST DATABASE SEARCH 632
SERVER SEARCH DATABASE FOR REQUESTED ID 633
COMPARE AIRCRAFT DESTINATION DATA WITH GROUND DEVICE LOCATION DATA 634
CONFIRM AIRCRAFT DESTINATION 635

FIG. 6

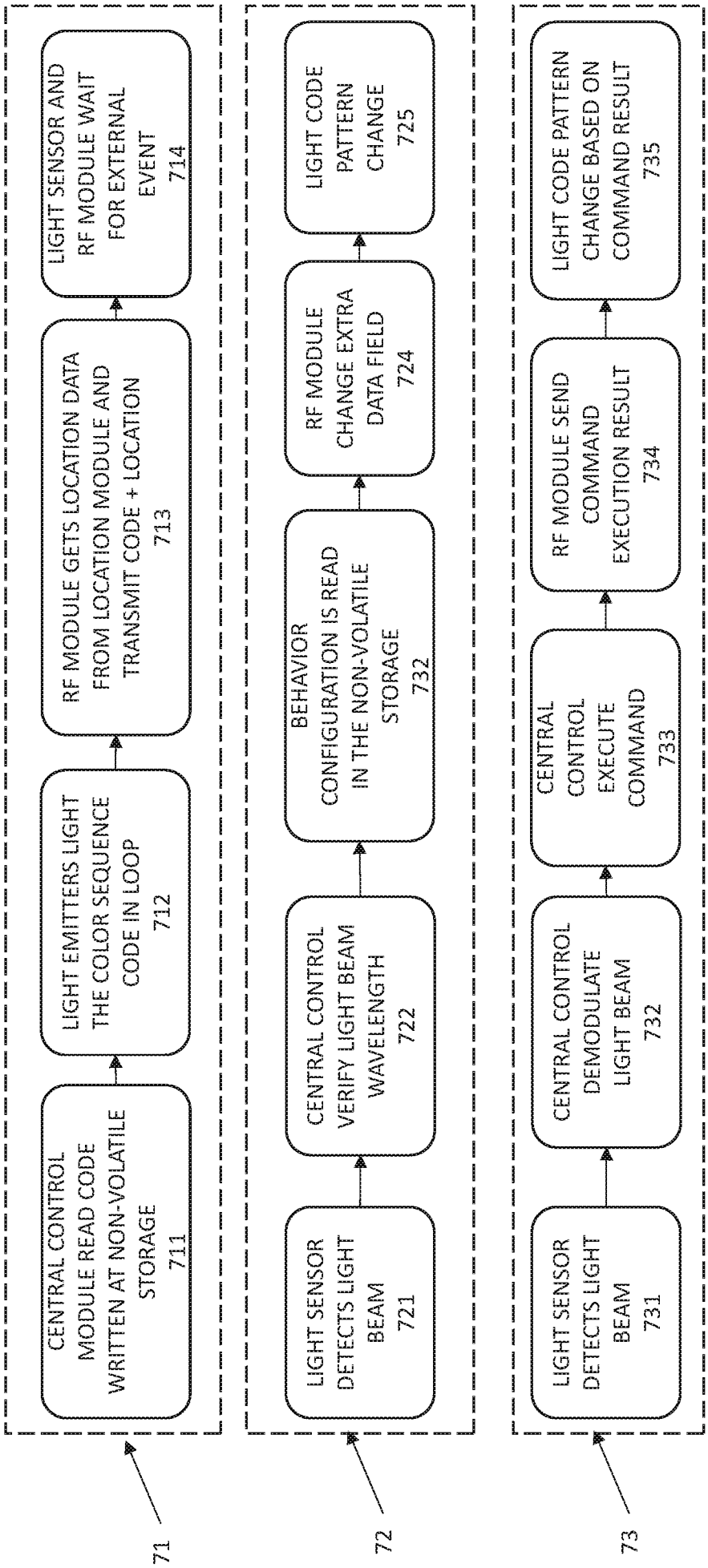
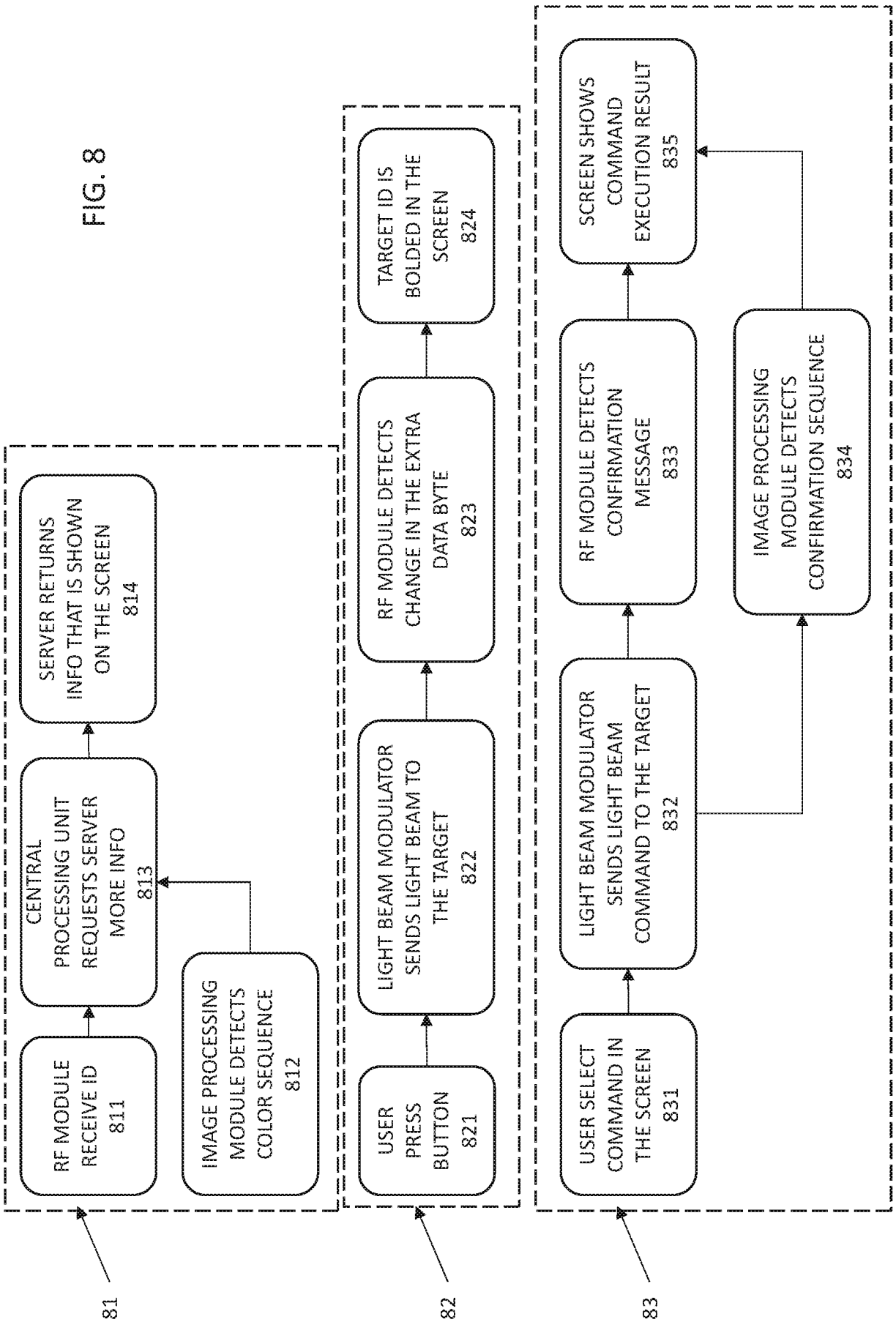

71
CENTRAL CONTROL MODULE READ CODE WRITTEN AT NON-VOLATILE STORAGE 711
LIGHT EMITTERS LIGHT THE COLOR SEQUENCE CODE IN LOOP 712
RF MODULE GETS LOCATION DATA FROM LOCATION MODULE AND TRANSMIT CODE + LOCATION 713
LIGHT SENSOR AND RF MODULE WAIT FOR EXTERNAL EVENT 714
72
LIGHT SENSOR DETECTS LIGHT BEAM 721
CENTRAL CONTROL VERIFY LIGHT BEAM WAVELENGTH 722
BEHAVIOR CONFIGURATION IS READ IN THE NON-VOLATILE STORAGE 732
RF MODULE CHANGE EXTRA DATA FIELD 724
LIGHT CODE PATTERN CHANGE 725
73
LIGHT SENSOR DETECTS LIGHT BEAM 731
CENTRAL CONTROL DEMODULATE LIGHT BEAM 732
CENTRAL CONTROL EXECUTE COMMAND 733
RF MODULE SEND COMMAND EXECUTION RESULT 734
LIGHT CODE PATTERN CHANGE BASED ON COMMAND RESULT 735

FIG. 7

FIG. 8


81
RF MODULE RECEIVE ID 811
CENTRAL PROCESSING UNIT REQUESTS SERVER MORE INFO 813
SERVER RETURNS INFO THAT IS SHOWN ON THE SCREEN 814
IMAGE PROCESSING MODULE DETECTS COLOR SEQUENCE 812
82
USER PRESS BUTTON 821
LIGHT BEAM MODULATOR SENDS LIGHT BEAM TO THE TARGET 822
RF MODULE DETECTS CHANGE IN THE EXTRA DATA BYTE 823
TARGET ID IS BOLDED IN THE SCREEN 824
83
USER SELECT COMMAND IN THE SCREEN 831
LIGHT BEAM MODULATOR SENDS LIGHT BEAM COMMAND TO THE TARGET 832
RF MODULE DETECTS CONFIRMATION MESSAGE 833
IMAGE PROCESSING MODULE DETECTS CONFIRMATION SEQUENCE 834
SCREEN SHOWS COMMAND EXECUTION RESULT 835

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US16/37071

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - G05D 1/00, 1/02, 1/12; G08G 1/017 (2016.01)
CPC - G05D 1/0011, 1/0088, 1/0202, 1/12; G08G 1/017
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8): B64C 39/02; B64D 45/00; G05D 1/00, 1/02, 1/12; G06T 7/00; G08G 1/017 (2016.01)
CPC: B64C 39/024; B64D 45/00; G05D 1/0011, 1/0022, 1/0033, 1/0088, 1/0202, 1/12; G06T 7/0073; G08G 1/017

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PatSeer (US, EP, WO, JP, DE, GB, CN, FR, KR, ES, AU, IN, CA, INPADOC Data); EBSCO; IEEE; Google/Google Scholar; device*, identification*, low-altitude*, aircraft*, light*, array*, color*, emitter* a light*, radio*, antenna*, RF*, frequency*, signal*, storage*, sensor*, beam*, wavelength*, intensity*, location*, flight*, path*, position*

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2014/0277854 A1 (AZURE SKY GROUP, LLC) 18 September 2014, Abstract, Figures 4, 7, Paragraphs [0012], [[0039], [0041], [0069], [0070], [0079].	1-14
Y	US 2015/0054639 A1 (ROSEN, M) 26 February 2015, Paragraphs [0086], [0104]-[0106], [0108], [0220], [0237], [0312], [0324]-[0326], [0328], [0329]-[0331], [0334], Claim 19.	1-19
Y	US 2014/0320667 A1 (CAST GROUP OF COMPANIES, INC.) 30 October 2014, Figure 11, Paragraphs [0100], [0101].	15-19
A	US 7,724,155 B1 (ANDERSON, E et al.) 25 May 2010, entire document.	1-19
A	US 6,173,220 B1 (SCHMITT, J) 09 January 2001, entire document.	1-19
A	CN 103049764 A (SHANGHAI INST MICROSYS & INF) 17 April 2013, See Machine Translation; entire document.	1-19

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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"P" document published prior to the international filing date but later than the priority date claimed
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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 August 2016 (18.08.2016)	02 SEP 2016
Name and mailing address of the ISA/ Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Authorized officer Shane Thomas PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

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