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(54) SYSTEMS AND METHODS FOR ALERTING WHEN AN INTRUDER TREND VECTOR IS PREDICTED TO INTERCEPT WITH AN AIRCRAFT TAXI PATH

(57) A system and method for alerting when a trend vector associated with a traffic aircraft is predicted to intercept a travel route of an ownship aircraft. A control module receives real-time aircraft state data, flight plan data, and traffic data associated with the traffic aircraft. The control module processes these data and constructs the travel route of the ownship aircraft from the current location to the intended destination The control module generates the trend vector associated with the traffic aircraft, predicts a location of an intersection of the trend vector and the travel route, determines an amount of time it will take for the ownship aircraft to reach the location of the intersection, and generates display commands that cause the display device to generate an alert that visually distinguishes the location on the image based at least in part on the amount of time.

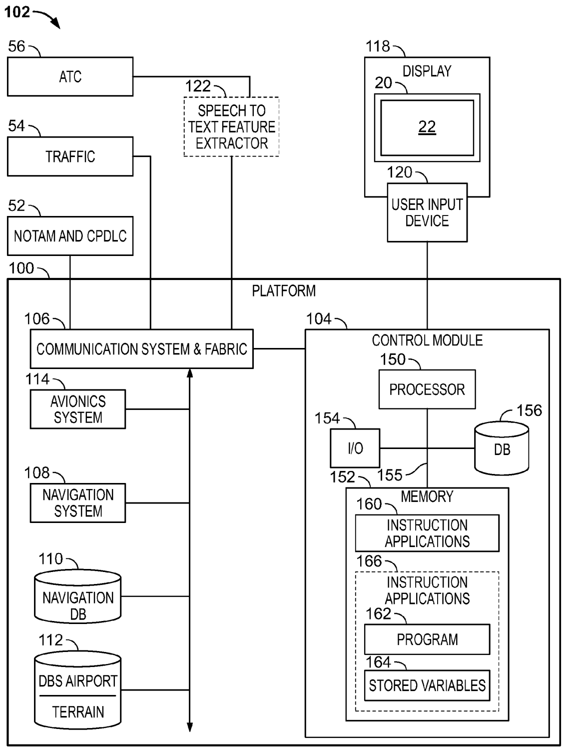

FIG. 1

Description

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application claims benefit of prior filed India Provisional Patent Application No. 202111044413, filed September 30, 2021, which is hereby incorporated by reference herein in its entirety.

TECHNICAL FIELD

[0002] The technical field generally relates to navigational aids, and more particularly relates to systems and methods for alerting when an intruder trend vector is predicted to intercept with an aircraft taxi path.

BACKGROUND

[0003] Runway incursions are undesirable events that have the potential to occur during ground operations. While some potential incursions can be viewed within a field of view of the pilot, not all can. An undesirable runway incursion can occur when an intruder traffic is not within the field of view of the aircraft; this threat can be compounded when there is only a short amount of time to correct for it.

[0004] Accordingly, improved systems and methods that alert when an intruder trend vector is predicted to intercept with an ownship taxi path are desirable. The following disclosure provides these technological enhancements, in addition to addressing related issues.

BRIEF SUMMARY

[0005] This summary is provided to describe select concepts in a simplified form that are further described in the Detailed Description. This summary is not intended to identify key or essential features of the claimed subject matter, nor is it intended to be used as an aid in determining the scope of the claimed subject matter.

[0006] In one embodiment, a system for alerting, in an ownship aircraft, when a trend vector associated with a traffic aircraft that is external to the ownship aircraft is predicted to intercept a travel route of the ownship aircraft, includes a control module. The control module is operationally coupled to receive real-time aircraft state data, flight plan data, and traffic data associated with the traffic aircraft. The real-time aircraft state data includes a current location, a current heading, and a current speed of the ownship aircraft, and the flight plan data includes an intended destination of the ownship aircraft. The control module is configured to: process the real-time aircraft state data, the flight plan data, and the traffic data; construct the travel route of the ownship aircraft from the current location to the intended destination; generate display commands that cause a display device to render an image showing the ownship aircraft at the current location and at the current heading; generate the trend vector associated with the traffic aircraft; predict a location of an intersection of the trend vector and the travel route; determine an amount of time it will take for the ownship aircraft, at the current location, the current heading, and the current speed, to reach the location of the intersection; and generate display commands that cause the display device to generate an alert that visually distinguishes the location on the image based at least in part on the amount of time.

[0007] In another embodiment, a system for alerting, in an ownship aircraft, when a trend vector associated with a traffic aircraft that is external to the ownship aircraft is predicted to intercept a travel route of the ownship aircraft, includes a real-time aircraft state data source, a flight plan data source, a traffic data source, an airport feature data source, and a control moduled. The real-time aircraft data source is configured to supply real-time aircraft state data, where the real-time aircraft state data includes a current location, a current heading, and a current speed of the ownship aircraft. The flight plan data source is configured to supply flight plan data, where the flight plan data includes an intended destination of the ownship aircraft. The traffic data source is configured to supply traffic data associated with the traffic aircraft. The airport feature data source is configured to supply airport feature data, where the airport feature data is representative of an airport field. The control module is operationally coupled to receive the real-time aircraft state data, the flight plan data, and the traffic data, and is configured to: process the real-time aircraft state data, the flight plan data, the traffic data, and the airport field data; construct the travel route of the ownship aircraft from the current location to the intended destination; generate display commands that cause a display device to render an image showing the ownship aircraft at the current location and at the current heading on the airport field; generate the trend vector associated with the traffic aircraft; predict a location of an intersection of the trend vector and the travel route; determine if the traffic aircraft is out of a field of view of the image; determine an amount of time it will take for the ownship aircraft, at the current location, the current heading, and the current speed, to reach the location of the intersection; generate display commands that cause the display device to generate an alert that visually distinguishes the location on the image based at least in part on the amount of time; and when the traffic aircraft is out of the field of view of the image, generate display commands that cause the display device to render the trend vector as a dotted line that extends from the location of the intersection toward the traffic aircraft.

[0008] In yet another embodiment. a method for alerting, in an ownship aircraft, when a trend vector associated with a traffic aircraft that is external to the ownship aircraft is predicted to intercept a travel route of the ownship aircraft, includes the steps of: receiving, in a control module, real-time aircraft state data, flight plan data, and traffic data associated with the traffic aircraft, the real-time aircraft state data including a current location, a current heading, and a current speed of the ownship aircraft, the flight plan data including an intended destination of the ownship aircraft; processing, in the control module, the real-time aircraft state data, the flight plan data, and the traffic data; constructing, in the control module, the travel route of the ownship aircraft from the current location to the intended destination; generating display commands, in the control module, that cause a display device to render an image showing the ownship aircraft at the current location and at the current heading; generating, in the control module, the trend vector associated with the traffic aircraft; predicting, in the control module, a location of an intersection of the trend vector and the travel route; determining, in the control module, an amount of time it will take for the ownship aircraft, at the current location, the current heading, and the current speed, to reach the location of the intersection; and generating display commands, in the control module, that cause the display device to generate an alert that visually distinguishes the location on the image based at least in part on the amount of time.

[0009] Furthermore, other desirable features and characteristics of the system and method will become apparent from the subsequent detailed description and the appended claims, taken in conjunction with the accompanying drawings and the preceding background.

BRIEF DESCRIPTION OF THE DRAWING FIGURES

[0010] At least one example of the present invention will hereinafter be described in conjunction with the following figures, wherein like numerals denote like elements, and:

FIG. 1 is a block diagram of a system for alerting when an intruder trend vector is predicted to intercept with an ownship taxi path, in accordance with an exemplary embodiment;

FIG. 2 is a flow chart for a method for alerting when an intruder trend vector is predicted to intercept with an ownship taxi path, in accordance with an exemplary embodiment; and

FIG. 3 is an illustration of an avionic display showing an alert when an intruder trend vector is predicted to intercept with an ownship taxi path, in accordance with an exemplary embodiment.

DETAILED DESCRIPTION

[0011] The following detailed description is merely illustrative in nature and is not intended to limit the embodiments of the subject matter or the application and uses of such embodiments. As used herein, the word "exemplary" means "serving as an example, instance, or illustration." Thus, any embodiment described herein as "exemplary" is not necessarily to be construed as preferred or advantageous over other embodiments. The embodiments described herein are exemplary embodiments provided to enable persons skilled in the art to make or use the invention and not to limit the scope of the invention that is defined by the claims. Furthermore, there is no intention to be bound by any expressed or implied theory presented in the preceding technical field, background, summary, or the following detailed description.

[0012] As mentioned, it is desirable to update and improve upon navigation systems to add alerting when an intruder trend vector is predicted to intercept with an ownship taxi path.

[0013] Exemplary embodiments provide a technical solution to this problem in the form of a control module (FIG. 1, **104).** The disclosed control module operates on available input and evaluates trend vectors transmitted from traffic that is nearby the ownship to predict whether the traffic will intercept with the ownship taxi path. The figures and descriptions below provide more detail.

[0014] Turning now to FIG. 1, in an embodiment, the system for alerting when an intruder trend vector is predicted to intercept with an ownship taxi path **102** (also referred to herein as "system" **102)** is generally associated with a mobile platform **100.** In various embodiments, the mobile platform **100** is an aircraft, and is referred to as aircraft **100.** The system **102** embodies a control module **104.** In some embodiments, the control module **104** may be integrated within a preexisting mobile platform management system, avionics system, cockpit display system (CDS), flight controls system (FCS), or aircraft flight management system (FMS). Although the control module **104** is shown as an independent functional block, onboard the aircraft **100,** in other embodiments, it may exist in an electronic flight bag (EFB) or portable electronic device (PED), such as a tablet, cellular phone, or the like. In embodiments in which the control module is within an EFB or a PED, the display system **118** and user input device **120** may also be part of the EFB or PED.

[0015] The control module **104** may be operationally coupled to any combination of the following aircraft systems: a communication system and fabric **106;** a source of real-time aircraft state data, such as a navigation system **108;** a source of prescribed flight plan data, such as a navigation database (NavDB **110);** one or more databases **112;** a display system **118;** and a user input device **120.** The control module **104** is communicatively coupled to a source of notice to airmen (NOTAM 52) data, air traffic control 56, and a source of traffic data **54,** such as automatic dependent surveillance broadcast (ADS-B) and traffic information service broadcast (TIS-B). In various embodiments, the control module **104** is additionally operationally coupled to one or more avionics systems **114,** and a speech to text converter/features extractor **122.** The functions of these aircraft systems, and their interaction, are described in more detail below.

[0016] Real-time aircraft state data may include any of: an instantaneous location (e.g., the latitude, longitude, orientation), an instantaneous heading (i.e., the direction the aircraft is traveling in relative to some reference), a flight path angle, a vertical speed, a ground speed, an instantaneous altitude (or height above ground level), and a current phase of flight of the aircraft **100.** As used herein, "real-time" is interchangeable with current and instantaneous. In some embodiments, the real-time aircraft state data is generated by the navigation system **108.** The navigation system **108** may be realized as including a global positioning system (GPS), inertial reference system (IRS), or a radio-based navigation system (e.g., VHF omnidirectional radio range (VOR) or long-range aid to navigation (LORAN)), and may include one or more navigational radios or other sensors suitably configured to support operation of the FMS, as will be appreciated in the art. The data provided by the navigation system **108** is referred to as navigation data (also referred to herein as the real-time aircraft state data). The real-time aircraft state data is made available, generally by way of the communication system and fabric **106,** so other components, such as the control module **104** and the display system **118,** may further process and/or handle the aircraft state data.

[0017] Prescribed flight plan (FP) data may include a series of intended geospatial midpoints between a departure and an arrival, as well as performance data associated with each of the geospatial midpoints (non-limiting examples of the performance data include intended navigation data, such as: intended airspeed, intended altitude, intended acceleration, intended flight path angle, and the like). A source of a prescribed flight plan data may be a storage location or a user input device. In various embodiments, the navigation database, NavDB **110,** is the source of a prescribed flight plan. The navigation database (NavDB **110)** is a storage location that may also maintain a database of flight plans, and/or information regarding terrain and airports and/or other potential landing locations (or destinations) for the aircraft **100.**

[0018] In various embodiments, the avionics systems **114** provide aircraft performance data and sensed data for a variety of aircraft **100** subsystems. Examples of the aircraft performance data include: engine thrust level, fuel level, flap configuration, braking status, temperature control system status, and the like. As may be appreciated, the avionics systems **114** may therefore include a variety of on-board detection sensors and may be operationally coupled to the control module **104,** central management computer, or FMS.

[0019] The communications system and fabric **106** is configured to support instantaneous (i.e., real time or current) communications between onboard systems (i.e., the navigation system **108,** the navigation database **110,** the database **112,** and the avionics systems **114),** the control module **104,** and the one or more external data source(s). As a functional block, the communications system and fabric **106** represents one or more transmitters, receivers, and the supporting communications hardware and software required for components of the system **102** to communicate as described herein. In various embodiments, the communications system and fabric **106** may have additional communications not directly relied upon herein, such as bidirectional pilot-to-ATC (air traffic control) communications via a datalink; support for an automatic dependent surveillance broadcast system (ADS-B); a communication management function (CMF) uplink; a terminal wireless local area network (LAN) unit (TWLU); an instrument landing system (ILS); and, any other suitable radio communication system that supports communications between the aircraft **100** and the various external source(s). In various embodiments, the control module **104** and communications system and fabric **106** also support controller pilot data link communications (CPDLC) with CPDLC **52,** such as through an aircraft communication addressing and reporting system (ACARS) router; in various embodiments, this feature may be referred to as a communications management unit (CMU) or communications management function (CMF). In summary, the communications system and fabric **106** may allow the aircraft **100** and the control module **104** to receive information that would otherwise be unavailable to the pilot and/or co-pilot using only the onboard systems.

[0020] External sources communicate with the aircraft **100** and the control module **104,** generally, by way of the communication system and fabric **106.** External sources include: NOTAM **52** (which includes CPDLC **52),** traffic data system(s) **54;** air traffic control (ATC) **56;** and a variety of other radio inputs, such as source(s) of the radio signals used by the an instrument landing system (ILS), and weather and surface data sources, such as a source for meteorological terminal aviation weather reports (METARS), automatic terminal information service (ATIS), datalink ATIS (D-ATIS), automatic surface observing system (ASOS). The traffic data system(s) **54** include numerous systems for providing real-time neighbor/relevant traffic data and information. For example, traffic data sources **54** may include any combination of: traffic collision avoidance system (TCAS), automatic dependent surveillance broadcast (ADS-B), traffic information system (TIS), crowd sourced traffic data and/or another suitable avionics system. Flight traffic information that is received from the traffic data system may include, for each neighbor aircraft of a plurality of neighbor aircraft, one or more of a respective instantaneous location and heading, vertical speed, ground speed, instantaneous altitude, and aircraft identification.

[0021] The user input device **120** and the control module **104** are cooperatively configured to allow a user (e.g., a pilot, co-pilot, or crew member) to interact with display devices in the display system **118** and/or other elements of the system **102,** as described in greater detail below. Depending on the embodiment, the user input device **120** may be realized as a cursor control device (CCD), keypad, touchpad, keyboard, mouse, touch panel (or touchscreen), joystick, knob, line select key, voice controller, gesture controller, or another suitable device adapted to receive input from a user. When the user input device **120** is configured as a touchpad or touchscreen, it may be integrated with the display system **118.** As used herein, the user input device **120** may be used by a pilot to communicate with ATC **56,** to modify or upload the program product **166,** etc. In various embodiments, the display system **118** and user input device **120** are onboard the aircraft **100** and are also operationally coupled to the communication system and fabric **106.** In some embodiments, the control module **104,** user input device **120,** and display system **118** are configured as a control display unit(CDU).

[0022] In various embodiments, the control module **104,** alone, or as part of a central management computer (CMS) or a flight management system (FMS), draws upon data and information from the navigation system **108** and the NavDB **110** to provide real-time flight guidance for aircraft **100.** The real time flight guidance may be provided to a user by way of commands for the display system **118,** an audio system, or the like. For example, the control module **104** may compare an instantaneous position and heading of the aircraft **100** with the prescribed flight plan data for the aircraft **100** and generate display commands to render images **22** showing these features. The control module **104** may further associate a respective airport, its geographic location, runways (and their respective orientations and/or directions), instrument procedures (e.g., approach procedures, arrival routes and procedures, takeoff procedures, and the like), airspace restrictions, and/or other information or attributes associated with the respective airport (e.g., widths and/or weight limits of taxi paths, the type of surface of the runways or taxi path, and the like) with the instantaneous position and heading of the aircraft **100** and/or with the navigation plan for the aircraft **100.**

[0023] The control module **104** generates display commands for the display system **118** to cause the display device **20** to render thereon the image **22,** comprising various graphical user interface elements, tables, icons, alerts, menus, buttons, and pictorial images, as described herein. The display system **118** is configured to continuously receive and process the display commands from the control module **104.** The display system **118** includes a display device **20** for presenting an image **22.** In various embodiments described herein, the display system **118** includes a synthetic vision system (SVS), and the image **22** is a SVS image. In exemplary embodiments, the display device **20** is realized on one or more electronic display devices configured as any combination of: a head up display (HUD), an alphanumeric display, a vertical situation display (VSD) and a lateral navigation display (ND).

[0024] Renderings on the display system **118** may be processed by a graphics system, components of which may be integrated into the display system **118** and/or be integrated within the control module **104.** Display methods include various types of computer generated symbols, text, and graphic information representing, for example, pitch, heading, flight path, airspeed, altitude, runway information, waypoints, targets, obstacles, terrain, and required navigation performance (RNP) data in an integrated, multi-color or monochrome form. Display methods also include various formatting techniques for visually distinguishing objects and routes from among other similar objects and routes. In an embodiment, the Bokeh effect is used for emphasizing relevant signage with respect to remaining signage. The control module **104** may be said to display various images and selectable options described herein. In practice, this may mean that the control module **104** generates display commands, and, responsive to receiving the display commands from the control module **104,** the display system **118** displays, renders, or otherwise visually conveys on the display device **20,** the graphical images associated with operation of the aircraft **100,** and specifically, the graphical images as directed by the control module **104.**

[0025] In addition to providing flight guidance, in various embodiments, any combination of the control module **104,** user input device **120,** avionics systems **114,** and communication system and fabric **106,** may be coupled to the display system **118** such that the display system **118** may additionally generate or render, on the display device **20,** real-time avionics systems information associated with respective aircraft **100** systems and components.

[0026] In various embodiments, the control module **104** is additionally operationally coupled to one or more databases **112.** The databases **112** may include one or more of: a runway awareness and advisory system (RAAS) database and an Aerodrome Mapping Database (AMDB). In various embodiments, each of these may include an airport features database, having therein maps and geometries, including runway records with corresponding runway threshold locations. The AMDB may also include airport status data for the runways and/or taxi paths at the airport; the airport status data indicating operational status and directional information for the taxi paths (or portions thereof). In some embodiments, the databases **112** may include a terrain database, having therein topographical information for the airport and surrounding environment.

[0027] The control module **104** performs the functions of the system **102.** As used herein, the term "module" refers to any means for facilitating communications and/or interaction between the elements of the system **102** and performing additional processes, tasks and/or functions to support operation of the system **102,** as described herein. In various embodiments, the control module **104** may be any hardware, software, firmware, electronic control component, processing logic, and/or processor device, individually or in any combination. Depending on the embodiment, the control module **104** may be implemented or realized with a general purpose processor (shared, dedicated, or group) controller, microprocessor, or microcontroller, and memory that executes one or more software or firmware programs; a content addressable memory; a digital signal processor; an application specific integrated circuit (ASIC), a field programmable gate array (FPGA); any suitable programmable logic device; combinational logic circuit including discrete gates or transistor logic; discrete hardware components and memory devices; and/or any combination thereof, designed to perform the functions described herein.

[0028] Accordingly, in FIG. 1, an embodiment of the control module **104** is depicted as a computer system including a processor **150** and a memory **152.** The processor **150** may comprise any type of processor or multiple processors, single integrated circuits such as a microprocessor, or any suitable number of integrated circuit devices and/or circuit boards working in cooperation to carry out the described operations, tasks, and functions by manipulating electrical signals representing data bits at memory locations in the system memory, as well as other processing of signals. The memory **152** may comprise RAM memory, ROM memory, flash memory, registers, a hard disk, or another suitable non-transitory short or long-term storage media capable of storing computer-executable programming instructions or other data for execution. The memory **152** may be located on and/or co-located on the same computer chip as the processor **150.** Generally, the memory **152** maintains data bits and may be utilized by the processor **150** as storage and/or a scratch pad during operation. Specifically, the memory **152** stores instructions and applications **160.** Information in the memory **152** may be organized and/or imported from an external data source **50** during an initialization step of a process; it may also be programmed via a user input device **120.** During operation, the processor **150** loads and executes one or more programs, algorithms and rules embodied as instructions and applications **160** contained within the memory **152** and, as such, controls the general operation of the control module **104** as well as the system **102.**

[0029] The novel program **162** includes rules and instructions which, when executed, convert the processor **150**/memory **152**/database **156** configuration into the control module **104,** which is a novel "contextual alerts" control module that performs the functions, techniques, and processing tasks associated with the operation of the system **102.** Novel program **162** and associated stored variables **164** may be stored in a functional form on computer readable media, for example, as depicted, in memory **152.** While the depicted exemplary embodiment is described in the context of a fully functioning computer system, those skilled in the art will recognize that the mechanisms of the present disclosure are capable of being distributed as a program product **166.** As a program product **166,** one or more types of non-transitory computer-readable signal bearing media may be used to store and distribute the program **162,** such as a non-transitory computer readable medium bearing the program **162** and containing therein additional computer instructions for causing a computer processor (such as the processor **150)** to load and execute the program **162.** Such a program product **166** may take a variety of forms, and the present disclosure applies equally regardless of the type of computer-readable signal bearing media used to carry out the distribution. Examples of signal bearing media include: recordable media such as floppy disks, hard drives, memory cards and optical disks, and transmission media such as digital and analog communication links. It will be appreciated that cloud-based storage and/or other techniques may also be utilized in certain embodiments.

[0030] In executing the process described herein, the processor **150** specifically loads the instructions embodied in the program **162,** thereby being programmed with program **162.** During execution of program **162,** the processor **150,** the memory **152,** and a database DB **156** form a novel dynamic processing engine that performs the processing activities of the system **102.**

[0031] In various embodiments, the processor/memory unit of the control module **104** may be communicatively coupled (via a bus **155)** to an input/output (I/O) interface **154,** and a database **156.** The bus **155** serves to transmit programs, data, status and other information or signals between the various components of the control module **104.** The bus 155 can be any suitable physical or logical means of connecting computer systems and components. This includes, but is not limited to, direct hard-wired connections, fiber optics, infrared and wireless bus technologies.

[0032] The I/O interface **154** enables intra control module **104** communication, as well as communications between the control module **104** and other system **102** components, and between the control module **104** and the external data sources via the communication system and fabric **106.** The I/O interface **154** may include one or more network interfaces and can be implemented using any suitable method and apparatus. In various embodiments, the I/O interface **154** is configured to support communication from an external system driver and/or another computer system. In one embodiment, the I/O interface **154** is integrated with the communication system and fabric **106** and obtains data from external data source(s) directly. Also, in various embodiments, the I/O interface **154** may support communication with technicians, and/or one or more storage interfaces for direct connection to storage apparatuses, such as the database **156.**

[0033] In some embodiments, the database **156** is part of the memory **152.** In various embodiments, the database **156** and the database **112** are integrated, either within the control module **104** or external to it. Accordingly, in some embodiments, the airport features data and terrain features are pre-loaded and internal to the control module **104.**

[0034] The system **102** may make its determinations and selections in accordance with a method such as method **200** of FIG. 2. With continued reference to FIG. 1, a flow chart is provided for a method **200** for providing a system **102,** in accordance with various exemplary embodiments. Method **200** represents various embodiments of a method for selecting an accurate runway record. For illustrative purposes, the following description of method **200** may refer to elements mentioned above in connection with FIG. 1. In practice, portions of method **200** may be performed by different components of the described system. It should be appreciated that method **200** may include any number of additional or alternative tasks, the tasks shown in FIG. 2 need not be performed in the illustrated order, and method **200** may be incorporated into a more comprehensive procedure or method having additional functionality not described in detail herein. Moreover, one or more of the tasks shown in FIG. 2 could be omitted from an embodiment of the method **200** if the intended overall functionality remains intact.

[0035] At **202,** the method receives navigation data. At **204,** the intended destination or runway for the ownship aircraft is received. With reference to FIG. 3, and with continued reference to FIG. 2, at **206,** the system **102** constructs a route (i.e., the taxi path **302)** for the aircraft **100** and displays it on an avionic display **300.** It is assumed that the control module **104** has already received the destination or the assigned runway; constructed, using airport feature data, a route for the aircraft **100** to travel from its current location to its destination or its assigned runway (the route including a travel direction); and generated display commands for rendering an image showing the aircraft **100** at the current location and heading on the airport field. The images **22** generated by the display system **118,** responsive to display commands, and are understood to be based on current aircraft state data and to be dynamically modified responsive to continuously obtaining and processing the current aircraft state data. The images **22** may also be continuously updated to reflect real-time changes with respect to terrain, airport features, weather, and neighbor traffic/relevant traffic.

[0036] The avionic display **300** also displays intersection **304,** at which the aircraft **100** is currently entering, and intersection **306,** which is further down the path of the aircraft **100.** At **208,** traffic data is received from external sources such as traffic source **52.** At **210,** the system **102** projects the trend vector **308** of a traffic that is off screen (off screen to the right in this example) and on trend to intercept with the aircraft **100** in the intersection **306.** The system **102** predicts an intersection of the traffic with the taxi path **302.**

[0037] At **212,** the system converts the projected intersection at intersection **306** into an amount of time (time delay) until the intersection at intersection **306** will occur, barring further action, and compares the time delay to predefined thresholds. A first predefined threshold may represent a caution alert and a second predefined threshold (a smaller amount of time than that of the first predefined threshold) may define a critical alert. In an example, the first time delay is in the range of 7-10 seconds and the second time delay is in the range of 5-6 seconds.

[0038] At **214,** the system **102** visually distinguishes the predicted intersection on the avionic display **22.** The system **102** may reference predefined display rules to determine a rendering technique to perform step **214.** For example, the color yellow or amber may be used for the cautionary alert and the color red may be used for the critical alert. In addition, the predefined display rules may specify the size and shape of the visual alert. In an example, as shown in FIG. 3, the size of the visual alert **310** includes an area with a width equal to a width of the displayed the taxi path **302,** and a length that is equal to an entire length **312** of the intersection. In an embodiment, upon determining that the traffic is out of a field of view of the image, the system 102 renders the trend vector associated with the traffic with a dotted or dashed line.

[0039] The avionic display **300** of FIG. 3 of provides a non-limiting example of the provided technological enhancement over other alert systems. As used herein, the intended/assigned destination may also be an assigned taxiway, and the assigned runway may include information for the runway or taxi way, such as an assigned gate and an exit for the runway or taxiway.

[0040] In some embodiments, the system **102** includes a speech-to-text converter **122,** each operationally coupled to the control module **104.** In these embodiments, the control module **104** is further configured to: receive the intended destination or the assigned runway as speech, embedded within a speech command from air traffic control (ATC) or from a CPDLC command; convert the speech command into text; and extract the intended destination or assigned runway from the text.

[0041] Although an exemplary embodiment of the present disclosure has been described above in the context of a fully-functioning computer system (e.g., system **102** described above in conjunction with FIG. 1), those skilled in the art will recognize that the mechanisms of the present disclosure are capable of being distributed as a program product (e.g., an Internet-disseminated program **9** or software application) and, further, that the present teachings apply to the program product regardless of the particular type of computer-readable media (e.g., hard drive, memory card, optical disc, etc.) employed to carry-out its distribution.

[0042] Terms such as "comprise," "include," "have," and variations thereof are utilized herein to denote non-exclusive inclusions. Such terms may thus be utilized in describing processes, articles, apparatuses, and the like that include one or more named steps or elements but may further include additional unnamed steps or elements.

[0043] While at least one exemplary embodiment has been presented in the foregoing detailed description, it should be appreciated that a vast number of variations exist. It should also be appreciated that the exemplary embodiment or exemplary embodiments are only examples, and are not intended to limit the scope, applicability, or configuration of the disclosure in any way. Rather, the foregoing detailed description will provide those skilled in the art with a convenient road map for implementing the exemplary embodiment or exemplary embodiments.

It should be understood that various changes can be made in the function and arrangement of elements without departing from the scope of the disclosure as set forth in the appended claims and the legal equivalents thereof.

Claims

1. A system for alerting, in an ownship aircraft, when a trend vector associated with a traffic aircraft that is external to the ownship aircraft is predicted to intercept a travel route of the ownship aircraft, the system comprising:
   a control module operationally coupled to receive real-time aircraft state data, flight plan data, and traffic data associated with the traffic aircraft, the real-time aircraft state data including a current location, a current heading, and a current speed of the ownship aircraft, the flight plan data including an intended destination of the ownship aircraft, the control module configured to:

      process the real-time aircraft state data, the flight plan data, and the traffic data;
      construct the travel route of the ownship aircraft from the current location to the intended destination;
      generate display commands that cause a display device to render an image showing the ownship aircraft at the current location and at the current heading;
      generate the trend vector associated with the traffic aircraft;
      predict a location of an intersection of the trend vector and the travel route;
      determine an amount of time it will take for the ownship aircraft, at the current location, the current heading, and the current speed, to reach the location of the intersection; and
      generate display commands that cause the display device to generate an alert that visually distinguishes the location on the image based at least in part on the amount of time.

2. The system of claim 1, wherein the control module is further configured to:

      process the traffic data to determine if the traffic aircraft is out of a field of view of the image; and
      when the traffic aircraft is out of the field of view of the image, generate display commands that cause the display device to render the trend vector as a dotted line that extends from the location of the intersection toward the traffic aircraft.

3. The system according to any one of the preceding claims, wherein the control module is further configured to:

      conduct comparisons of the amount of time to a plurality of threshold time values; and
      generate display commands that cause the display device to visually distinguish the alert based on the comparisons.

4. The system according to any one of the preceding claims 3, wherein the control module is further configured to:
   generate display commands that cause the display device to render the alert using different colors based on the comparisons.

5. The system according to any one of the preceding claims, wherein the plurality of threshold time values include a first threshold time value and a second threshold time value, the first threshold time value greater than the second threshold time value.

6. The system according to any one of the preceding claims, wherein the control module is further configured to:

      generate display commands that cause the display device to render the alert using a first color when the amount of time is less than the first threshold time value and greater than the second threshold time value; and
      generate display commands that cause the display device to render the alert using a second color when the amount of time is less than the second threshold time value.

7. The system according to any one of the preceding claims, wherein the control module is further configured to generate display commands that cause the display device to render the alert as a predefined size and shaped.

8. The system according to any one of the preceding claims 1, further comprising:

      a real-time aircraft state data source configured to supply the real-time aircraft state data;
      a flight plan data source configured to supply the flight plan data; and
      a traffic data source configured to supply the traffic data.

9. The system according to any one of the preceding claims, wherein:

      the control module is further operationally coupled to receive airport feature data, the airport feature data representative of an airport field; and
      the control module is further configured to process the airport feature data and generate display

commands that cause the display device to render the image showing the ownship aircraft at the current location and heading on the airport field.

10. The system according to any one of the preceding claims, further comprising:

a real-time aircraft state data source configured to supply the real-time aircraft state data;
a flight plan data source configured to supply the flight plan data;
a traffic data source configured to supply the traffic data; and
an airport feature data source configured to supply the airport feature data.

11. A method for alerting, in an ownship aircraft, when a trend vector associated with a traffic aircraft that is external to the ownship aircraft is predicted to intercept a travel route of the ownship aircraft, the method comprising the steps of:

receiving, in a control module, real-time aircraft state data, flight plan data, and traffic data associated with the traffic aircraft, the real-time aircraft state data including a current location, a current heading, and a current speed of the ownship aircraft, the flight plan data including an intended destination of the ownship aircraft;
processing, in the control module, the real-time aircraft state data, the flight plan data, and the traffic data;
constructing, in the control module, the travel route of the ownship aircraft from the current location to the intended destination;
generating display commands, in the control module, that cause a display device to render an image showing the ownship aircraft at the current location and at the current heading;
generating, in the control module, the trend vector associated with the traffic aircraft;
predicting, in the control module, a location of an intersection of the trend vector and the travel route;
determining, in the control module, an amount of time it will take for the ownship aircraft, at the current location, the current heading, and the current speed, to reach the location of the intersection; and
generating display commands, in the control module, that cause the display device to generate an alert that visually distinguishes the location on the image based at least in part on the amount of time.

12. The method of claim 11, further comprising:

processing the traffic data, in the control module, to determine if the traffic aircraft is out of a field of view of the image; and
when the traffic aircraft is out of the field of view of the image, generating display commands, in the control module, that cause the display device to render the trend vector as a dotted line that extends from the location of the intersection toward the traffic aircraft.

13. The method according to any one of the preceding claims, further comprising:

conducting comparisons, in the control module, of the amount of time to a plurality of threshold time values; and
generating display commands, in the control module, that cause the display device to visually distinguish the alert based on the comparisons.

14. The method according to any one of the preceding claims, further comprising:
generating display commands, in the control module, that cause the display device to render the alert using different colors based on the comparisons.

15. The method according to any one of the preceding claims, wherein the plurality of threshold time values include a first threshold time value and a second threshold time value, the first threshold time value greater than the second threshold time value.

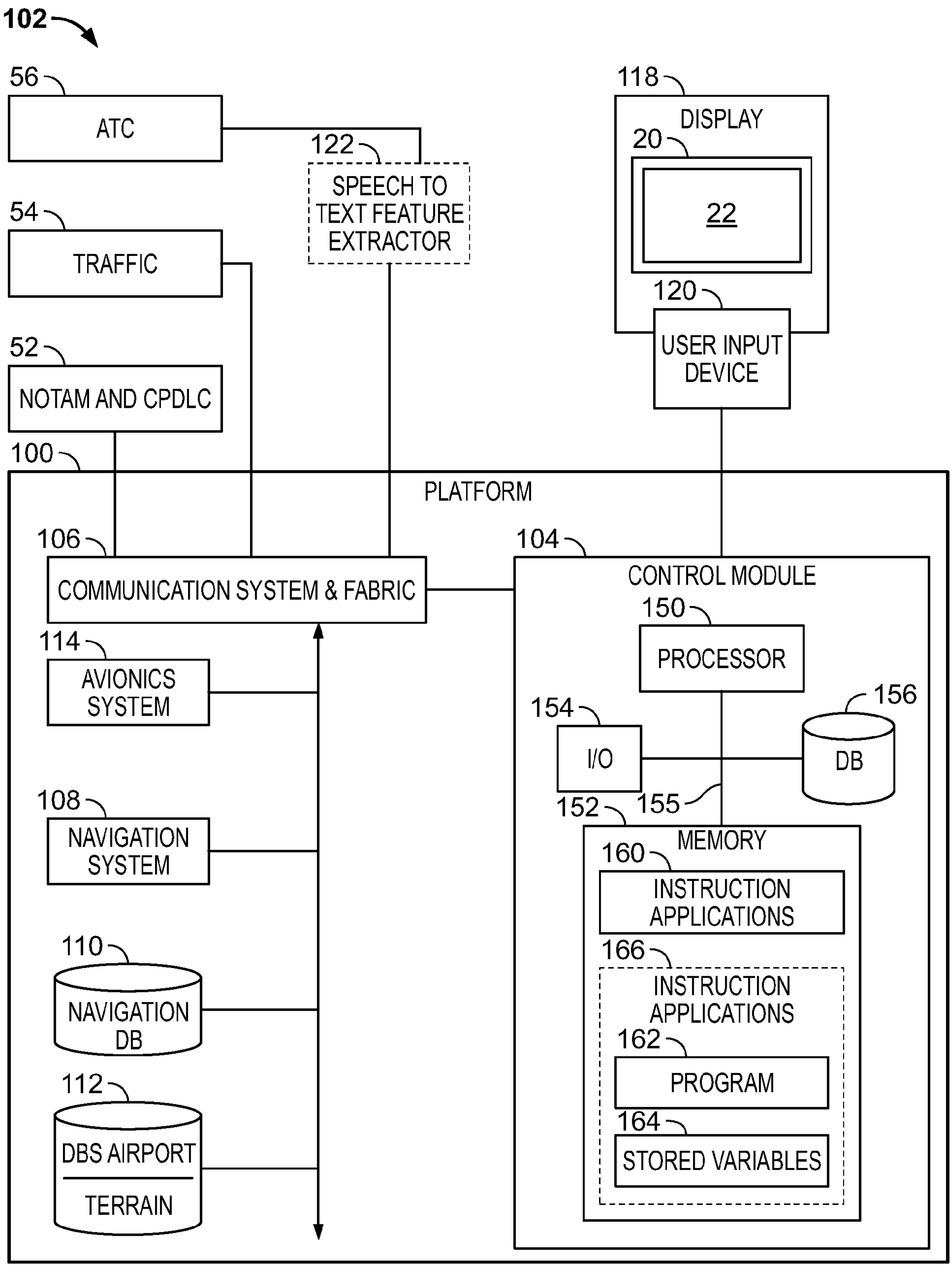
102
56
ATC
122
SPEECH TO TEXT FEATURE EXTRACTOR
54
TRAFFIC
52
NOTAM AND CPDLC
118
DISPLAY
20
22
120
USER INPUT DEVICE
100
PLATFORM
106
COMMUNICATION SYSTEM & FABRIC
104
CONTROL MODULE
150
PROCESSOR
114
AVIONICS SYSTEM
154
I/O
156
DB
152
155
MEMORY
108
NAVIGATION SYSTEM
160
INSTRUCTION APPLICATIONS
166
INSTRUCTION APPLICATIONS
110
NAVIGATION DB
162
PROGRAM
112
DBS AIRPORT
TERRAIN
164
STORED VARIABLES

FIG. 1

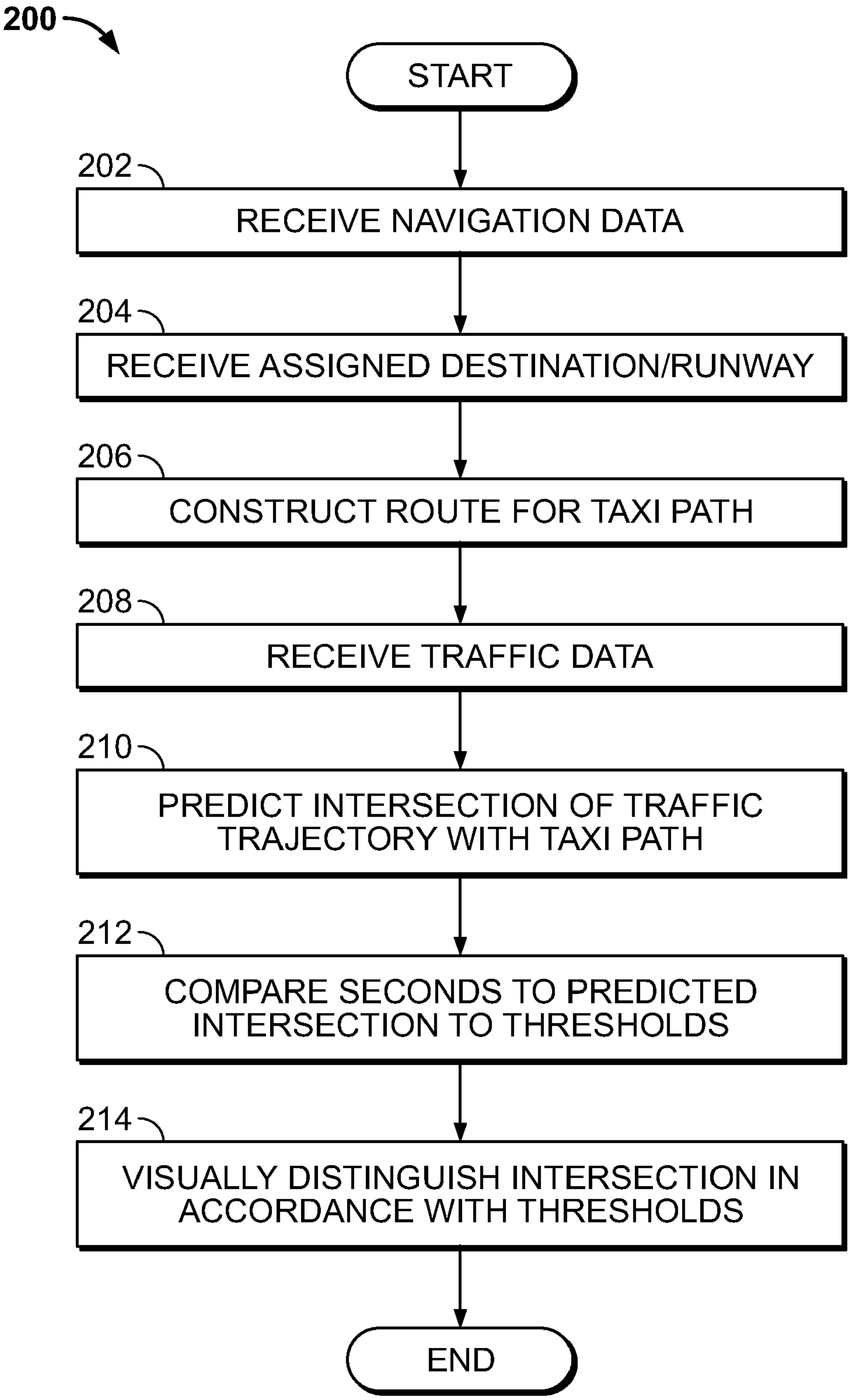
200
START
202
RECEIVE NAVIGATION DATA
204
RECEIVE ASSIGNED DESTINATION/RUNWAY
206
CONSTRUCT ROUTE FOR TAXI PATH
208
RECEIVE TRAFFIC DATA
210
PREDICT INTERSECTION OF TRAFFIC TRAJECTORY WITH TAXI PATH
212
COMPARE SECONDS TO PREDICTED INTERSECTION TO THRESHOLDS
214
VISUALLY DISTINGUISH INTERSECTION IN ACCORDANCE WITH THRESHOLDS
END

FIG. 2

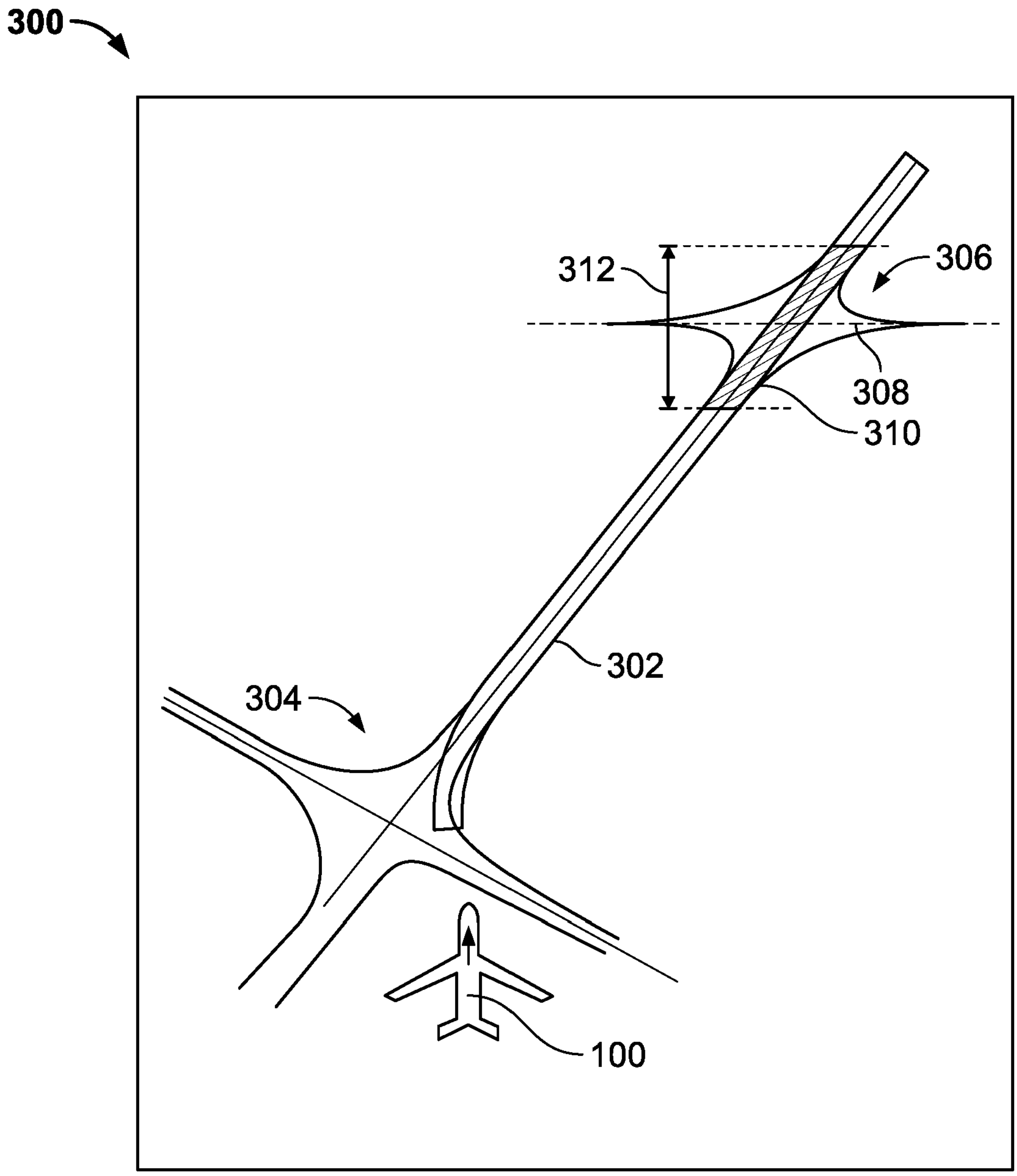

FIG. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 22 19 5044

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The present search report has been drawn up for all claims

2

Place of search	Date of completion of the search	Examiner
The Hague	26 January 2023	Datondji, Sokèmi

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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