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(54) **SYSTEMS AND METHODS FOR REDUCING CONTROLLER-PILOT REJECTION RATIOS**

(57) Provided are technologically improved systems and methods for reducing controller-pilot data link (CPDLC) rejection ratio on an aircraft. The system is programmed to receive a user provided tentative CPDLC request. The system receives traffic data from an external traffic data source and data from a navigation system and a sensor system. The system predicts whether the tentative CPDLC request will be accepted by air traffic control (ATC), based on the received data. The system further predicts a potential delay time until the ATC will accept the tentative CPDLC request. The system additionally provides one or more alternative CPDLC requests and their potential delay times when the system has predicted that the tentative CPDLC request will be rejected. The system displays this information and receives user selections based thereon. Upon receiving a user selection, a CPDLC request is sent to ATC in accordance with a predicted delay time.

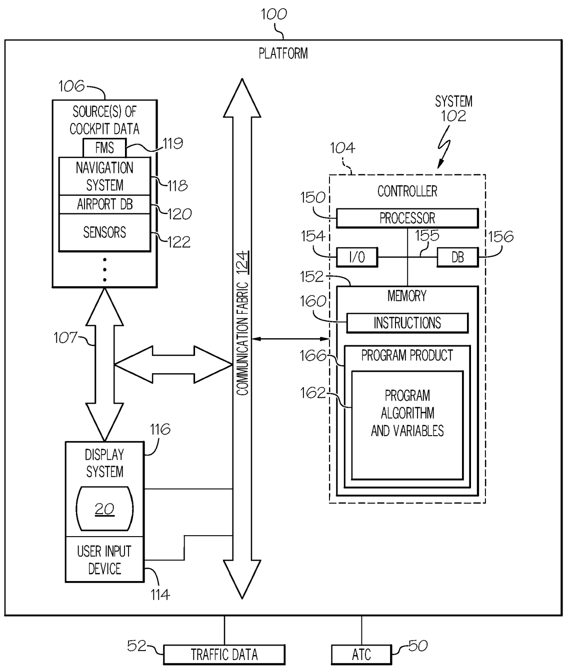

FIG. 1

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Description

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to Indian Provisional Patent Application No. 202011003065, filed January 23, 2020, the entire content of which is incorporated by reference herein.

TECHNICAL FIELD

[0002] The technical field generally relates to communications between aircraft and air traffic control (ATC), and more particularly relates to systems and methods for reducing controller-pilot rejection ratios.

BACKGROUND

[0003] Controller-pilot data link communication (CPDLC) is a means of communication between a controller at ATC and a pilot of an aircraft, generally using a data link for the communication. CPDLC systems include a set of predefined clearance/information/request message elements that correspond to voice phraseology employed during ATC procedures. The controller is provided with the capability to issue to the pilot level assignments, crossing constraints, lateral deviations, route changes and clearances, speed assignments, radio frequency assignments, and various requests for information. The pilot is provided with the capability to respond to the ATC messages, ATC request clearances and information, to report to ATC information, including declaring/rescinding an emergency. The pilot is, in addition, provided with the capability to request conditional clearances (downstream) and information from a downstream air traffic service unit (ATSU). A CPDLC system 'dialogue' includes a sequence of messages between the controller and a pilot relating to a particular transaction (for example a request for clearance and a receipt of a clearance grant). Moreover, one dialogue can include several sequences of messages, each of which is closed by means of appropriate messages, usually of acknowledgement or acceptance. Therefore, available CPDLC systems are burdened with the technical problem of requiring the continued involvement of a human at each end of the communication; from the pilot's perspective this can be very time-consuming and inefficient.

[0004] Accordingly, improved CPDLC systems and methods that reduce the amount of pilot involvement are desirable. It is desirable to make them adaptable, responsive to real-time environmental information and available cockpit data. 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] Provided is a processor implemented method for reducing controller-pilot data link (CPDLC) rejection ratio on an aircraft, comprising: receiving, from a navigation system onboard the aircraft, navigation data for the aircraft; receiving sensor data from a sensor system; receiving traffic data from an external traffic data source; displaying a CPDLC window on a display system; receiving a tentative CPDLC request; processing the navigation data, traffic data, and tentative CPDLC request with airport features data to predict whether the tentative CPDLC request will be accepted; and displaying a dialogue box based upon the prediction, wherein the displayed dialogue box indicates: acceptance upon predicting that the tentative CPDLC request will be accepted; or rejected and an alternative CPDLC request upon predicting that the tentative CPDLC request will not be accepted.

[0007] Also provided is a system for reducing controller-pilot data link (CPDLC) rejection ratio on an aircraft, comprising: a navigation system providing navigation data for the aircraft; a sensor system onboard the aircraft; and a processor operationally coupled to the navigation system and sensor system and configured to: display a CPDLC window on a display system; receive a tentative CPDLC request; receive traffic data from an external traffic data source; process the navigation data, traffic data, and tentative CPDLC request with airport features data to predict whether the tentative CPDLC request will be accepted by air traffic control (ATC), and that air traffic control (ATC) will accept the tentative CPDLC request in a first amount of time; and upon predicting that the tentative CPDLC request will be accepted, display a dialogue box indicating acceptance; and display the first amount of time.

[0008] An embodiment of an aircraft is also provided. The aircraft includes: a navigation system providing navigation data for the aircraft; a sensor system onboard the aircraft; and a processor of a system for reducing controller-pilot data link (CPDLC) rejection ratio, the processor operationally coupled to the navigation system and sensor system and configured to: display a CPDLC window on a display system; receive a tentative CPDLC request; receive traffic data from an external traffic data source; process the navigation data, traffic data, and tentative CPDLC request with airport features data to predict whether the tentative CPDLC request will be accepted by air traffic control (ATC); and display a dialogue box based upon the prediction, wherein the displayed dialogue box indicates: accepted and a first amount of time upon predicting that the tentative CPDLC request will be accepted by ATC in the first amount of time; or rejected, an alternative CPDLC request, and a second amount of time upon predicting that the tentative CPDLC request will not be accepted, but the alternative CPDLC request will be accepted in the second 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 DRAWINGS

[0010] The present application will hereinafter be described in conjunction with the following drawing figures, wherein like numerals denote like elements, and:

FIG. 1 is a block diagram of a system for reducing CPDLC rejection ratios on an aircraft, in accordance with an exemplary embodiment;

FIGS. 2-8 are exemplary dialogue windows generated by the system for reducing CPDLC rejection ratios on an aircraft, in accordance with an exemplary embodiment; and

FIG. 9 is a flow diagram of a method for reducing CPDLC rejection ratios on an aircraft, 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] CPDLC systems generally generate a CPDLC display window on an on-board display system (FIG. 1, 116). CPDLC systems generally render, within that CPDLC display window, predefined CPDLC messages. The pilot utilizes the information displayed on the CPDLC display window to communicate with ATC, to make a request for a clearance, and to perform a variety of other communications based on the predefined CPDLC messages. Some non-limiting examples of predefined CPDLC messages for a pilot to use include:

Departure Clearance Action Message Box

Departure Clearance Uplink Example

Pre-Departure Clearance (PDC) Pop-up

CDR Pop-up

CDR Request Downlink Pop-up

Pushback Clearance Request Pop-up

Pushback / Taxi Pop-up

Taxi Clearance Request Downlink Pop-up

Oceanic Clearance Pop-up

Oceanic Clearance Request Pop-upc

[0013] As mentioned, one CPDLC system dialogue can include several sequences of messages, each sequence being closed by means of appropriate messages, usually of acknowledgement or acceptance. This presents a technical problem in that available CPDLC systems require the continued engagement of a human at each end of the communication. From a pilot's perspective, this continued engagement can be time-consuming and inefficient. Additionally, using the available CPDLC systems, the pilot can only choose the predefined CPDLC messages without being able to consider, or be informed by, the current conditions that the controller at ATC may be considering to approve/reject the request. This can increase a likelihood of a CPDLC rejection. Reacting to a CPDLC rejection from ATC introduces a time delay. The turnaround time for the pilot analyzing the rejection of the CPDLC request, particularly in single-pilot cockpit scenarios, can lead to transmitting further invalid CPDLC requests to ATC and unnecessary time delay for the pilot. Any of the above technical problems can cause an elevated rejection ratio of CPDLC requests. The proposed system for reducing CPDLC rejection ratios (FIG. 1, system **102**) provides a technical solution to at least these technical problems. The figures and descriptions below provide more detail.

[0014] Turning now to FIG. 1, in an embodiment, the system for reducing CPDLC rejection ratios **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.** Exemplary embodiments of the system **102** provide a technical solution to the above-mentioned technical problems in the form of a controller **104** (which may also be referred to herein as a control module) embodying a processor **150** programmed with novel rules and parameters (program **162**).

[0015] In operation, the controller **104** may be operationally coupled to any combination of the following systems and apparatus: one or more sources **106** of cockpit data **107** (including an inertial navigation system/navigation system **118;** a flight management system (FMS) **119;** an airport features database **120;** and a sensor system

122); a communication system and fabric **124;** a display system **116;** and a user input device **114.** In various embodiments, the controller **104** is also operationally coupled to external sources, such as air traffic control (ATC) **50** and external traffic, referred to as traffic data sources **52,** each of which communicate wirelessly with the controller **104.** These functional blocks are described in more detail below.

[0016] In some embodiments, the controller **104** may be integrated within a preexisting mobile platform management system, avionics system, cockpit display system (CDS), flight controls system (FCS), or flight management system (FMS). Although the controller **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 controller is within an EFB or a PED, a display system **116** and a user input device **114** may also be part of the EFB or PED.

[0017] The inertial navigation system **118** provides real-time aircraft state data. 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. The inertial navigation system **118** may be realized as including a global positioning system (GPS), inertial reference system (IRS) or AHRS, or a radio-based navigation system (e.g., VHF omni-directional radio range (VOR) or long-range aid to navigation (LORAN)), and may include one or more navigational radios, barometers, or other sensors suitably configured to support operation of a flight management system (FMS), as will be appreciated in the art. In various embodiments, the data referred to herein as the real-time aircraft state data may be referred to as navigation data. The real-time aircraft state data is made available, generally by way of the communication system and fabric **124,** so other components, such as the controller **104** and the display system **116,** may further process and/or handle the aircraft state data.

[0018] In various embodiments, the communications system and fabric **124** is configured to support instantaneous (i.e., real-time or current) communications between on-board systems, the controller **104,** external traffic data sources **52,** and ATC **50.** As a functional block, the communications system and fabric **124** may represent 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 **124** has bidirectional pilot-to-ATC (air traffic control) communications via a datalink, and any other suitable radio communication system that supports communications between the aircraft **100** and various external source(s).

[0019] The user input device **114** and the controller **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 **116** and/or other elements of the system **102,** as described herein. Depending on the embodiment, the user input device **114** 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 **114** is configured as a touchpad or touchscreen, it may be integrated with the display system **116.** As used herein, the user input device **114** may be used by a pilot to communicate with external sources, to modify or upload the program product **166,** etc. In various embodiments, the display system **116** and user input device **114** are onboard the aircraft **100** and are also operationally coupled to the communication system and fabric **124.** In some embodiments, the controller **104,** user input device **114,** and display system **116** are configured as a control display unit (CDU).

[0020] The controller **104** may perform display processing. As such, the controller **104** generates display commands for the display system **116** to cause the display device **20** to render thereon the various graphical user interface elements, tables, icons, alerts, menus, buttons, and pictorial images, as described herein. The display system **116** is configured to continuously receive and process the display commands from the controller **104,** and, based thereon, to display information in various forms, such as an airport moving map (AMM). The display system **116** includes a display device **20.** In various embodiments described herein, the display system **116** includes a synthetic vision system (SVS). In exemplary embodiments, the display device **20** is realized on one or more electronic display devices, such as a multi-function display (MFD) or a multi-function control display unit (MCDU), configured as any combination of: a head up display (HUD), an alphanumeric display, a vertical situation display (VSD) and a lateral navigation display (ND).

[0021] The controller **104** may perform graphical processing. Responsive to display commands, renderings on the display system **116** may be processed by a graphics system, components of which may be integrated into the display system **116** and/or be integrated within the controller **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. The controller **104** may be said to display various images and selectable options described herein. In practice, this may mean that the controller **104** generates display commands, and, responsive to receiving the display commands from the controller **104,** the display system **116** displays, renders, or otherwise visually conveys on the display device **20,** various graphical images associated with operation of the aircraft **100.**

[0022] Cockpit data **107** generally represents onboard data that is available to the pilot or crew in the cockpit of the aircraft. For example, sources of cockpit data may include the navigation system **118,** an airport features database **120,** a flight management system (FMS) **119,** and sensor system **122.** In various embodiments, cockpit data **107** is communicated to the pilot and crew via graphical displays on the display system **116.** In practice, there are a multitude of cockpit data **107** providing a respective multitude of information and sourced by a multitude of onboard aircraft systems. A variety of types of sensors in sensor system **122** detect various aspects of aircraft performance and aircraft conditions, in addition to sensing external operating conditions, such as weather and other aircraft and objects. Sensor data is output from the sensor system 122 and made available on the communication fabric **124.** The airport features database **120** stores airport maps with features such as runways, taxiways, and gates.

[0023] The controller **104** performs the functions of the system **102.** As used herein, the term "controller" may be interchanged with the term "module;" each 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 controller **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 controller **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.

[0024] Accordingly, in FIG. 1, an embodiment of the controller **104** is depicted as a computer system comprising 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 source during an initialization step of a process; it may also be programmed via a user input device **114.** 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 controller **104** as well as the system **102.**

[0025] The rejection ratio reducing program (shortened to "program" **162**), includes rules and instructions which, when executed by the processor **150,** convert the processor **150**/memory **152** configuration into the controller **104** that performs the functions, techniques, and processing tasks associated with the operation of the system **102.** The program **162** specifically directs the processing of the cockpit data **107** and traffic data to predict whether a tentative CPDLC request will be accepted and causes a dialogue box to be displayed to prompt a user selection based on the prediction (displayed dialogue boxes and related functionality are described in connection with FIGS. 2-3). Novel program **162** and associated stored variables may be stored in a functional form on computer readable media, for example, as depicted, in memory **152.** While the depicted exemplary embodiment of the controller **104** 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.**

[0026] 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 as memory **152** and as program product time-based viewing of clearance requests in certain embodiments.

[0027] In various embodiments, the processor/memory unit of the controller **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 controller **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.

[0028] The I/O interface **154** enables intra controller **104** communication, as well as communications between the controller **104** and other system **102** components, and between the controller **104** and the external data sources via the communication system and fabric **124.** 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 **124** 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.**

[0029] In some embodiments, the database **156** is part of the memory **152.** In various embodiments, the database **156** is integrated, either within the controller **104** or external to it.

[0030] Embodiments of the system **102** for reducing CPDLC rejection ratios on an aircraft generate an enhanced CPLDC window for pilot interaction. Responsive to viewing the displayed enhanced CPDLC window, a pilot or crew makes a CPDLC request; this may be made via a touch screen input or other user input device. Moving now to FIGS. 2-4, a CPDLC pushback/taxi **201** request is depicted. Initially, the pilot makes the CPDLC request; this initial CPDLC request is a tentative request, until further processing is performed. The system **102** displays the tentative CPDLC request in the CPDLC request window (depicted in window **200,** window **300,** and window **400**). In the depicted example, dialogue box **202** indicates that a pushback/taxi has been requested for parking stand **605,** and dialogue box **204** indicates that the day/time for the pushback/taxi request is 12/1244Z (the units of time being in the Zulu time zone in this example).

[0031] Upon receiving the tentative CPDLC request, the system **102** automatically and without further user input, uses received information from surrounding aircraft (provided by one or more traffic data sources **52**), and conditions in the airport (relevant airport conditions information is provided by sources **106** of cockpit data **107)** to predict whether the tentative CPDLC request will be accepted by the controller at ATC. The system dedicates an area **206** on the CPDLC request window **200** to displaying a predicted acceptance or a predicted rejection. In an embodiment, a sub-area **208** within the area **206** is dedicated to predicting an acceptance and a different sub-area **210** within the area **206** is dedicated to predicting a rejection. By providing a dedicated area on the CPDLC request window for these predictions, the pilot can quickly view and ascertain the prediction.

[0032] Further, various embodiments illuminate, or make visually distinguishable (with respect to the background), the sub-area that corresponds to the prediction. For example, in FIG. 3, the accept sub-area **208** may be rendered using a green color that is distinguishable against a different background color. In another example shown in FIG. 4, the reject sub-area **210** may be rendered using a yellow color that is distinguishable against a different background color, and distinguishable from a color used for accept. Upon viewing an accept prediction, a pilot may select a user selectable send button **302** that the system **102** has rendered in the CPDLC window, the selection of which converts the tentative CPDLC request to a CPDLC request and transmits the CPDLC request to ATC without further user input.

[0033] In FIGS. 5-6 a CPDLC parking stand request **501** is depicted. The pilot knows the size of his aircraft **100** and which stand is suitable for his aircraft **100,** and the pilot makes an initial request (which is the tentative request, as before). In these examples, the tentative parking stand request for parking stand **605** is shown in the request window (depicted in window **500** and window **600).** Dialogue box **202** indicates that parking stand **605** has been requested at Day/Time 12/1244Z. However, in this example, in area **206,** a dialogue box is rendered, indicating a predicted rejection of the request in sub-area **210.**

[0034] In various embodiments, responsive to predicting a rejection, the system **102** identifies one or more alternate requests that the pilot could make. In some embodiments, the system **102** renders a selectable dialogue box in the area **206** to indicate that potential alternate requests are available. When the pilot selects the alternate requests option **502,** the one or more alternative requests is rendered on the window **600.** In other embodiments, the one or more alternate requests are immediately rendered in the area **206,** not requiring the user selection of an options button. In addition to providing this beneficial alternative request feature, the system can predict, for each of the one or more alternative requests, when the alternative request is available.

[0035] For each alternative request identified, the system **102** determines and displays an availability, which is an amount of time until the alternative request is predicted to be accepted; said differently, this is an amount of time the system **102** recommends pausing before sending the CPDLC request to air traffic control (ATC) to minimize a chance of a CPDLC rejection. As may be appreciated, the amount of time may be zero, meaning that there is no need to delay before transmitting the CP-DLC request. In FIG. 6, an alternative parking stand **606** is depicted as predicted to be available in two minutes ("available time 2 mins" **604**), and an alternative parking stand **612** is depicted as predicted to be rejected **(606)**.

[0036] Moving now to FIGS. 7-8, a CPDLC pushback request from parking stand **605** is shown in window **700** and window **800.** System **102** has predicted that ATC will accept the request in a first amount of time, defined as an amount of time to pause before sending the tentative CPDLC request to air traffic control (ATC). This is an amount of time the system **102** recommends pausing before sending the CPDLC request to air traffic control (ATC) to minimize a chance of a CPDLC rejection. The system **102** displays the first amount of time, which is two minutes ("available time 2 mins" **702**) in FIG. 7.

[0037] Upon receiving a pilot selection of the send (**704**) button, the system **102** converts the tentative request into a CPDLC request. The system **102** is configured to provide an additional benefit of keeping track of the elapse of time, pausing the transmittal of the CPDLC request for the amount of time predicted (and displayed at **702**), and sending the CPDLC request upon the elapse of the amount of time, without further user input. In various embodiments, the system **102** visually indicates a status of CPDLC transmission while an amount of delay time is counted down. For example, in FIG. 8, the send button **802** itself can be used as an indicator that the transmittal of the CPDLC request has been paused for the amount of time predicted. In various embodiments, the send button can be visually distinguished, can change color and/or a countdown could be displayed in area **206** to show the status of the CPDLC transmission while the predicted delay time is counted down. In other embodiments, a different indicator may be used to show that the transmittal of the CPDLC request has been paused for the amount of time predicted.

[0038] The system **102** described above may be implemented by a processor-executable method for reducing CPDLC rejection ratios **900,** as shown in the flow chart of FIG. 9. For illustrative purposes, the following description of method **900** may refer to elements mentioned above in connection with FIG. 1. In practice, portions of method **900** may be performed by different components of the described system. It should be appreciated that method **900** may include any number of additional or alternative tasks, the tasks shown in FIG. 9 need not be performed in the illustrated order, and method **900** 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. 9 could be omitted from an embodiment of the method **900** as long as the intended overall functionality remains intact.

[0039] The method starts, and at **902** the controller **104** is initialized. As mentioned above, initialization may comprise uploading or updating instructions and applications **160** and CPDLC rejection reducing program **162.**

[0040] At **904,** cockpit data is received. As mentioned before, cockpit data is data from onboard sources such as the navigation system **118,** FMS **119,** and sensor system **122.** Also, as mentioned, the sensor system **122** provides some data about the immediate external environment of the aircraft **100,** which is distinguished from the sources of external data, such as the ATC **50** and traffic data source **52,** which the aircraft receives data from at **906.** At **908,** the enhanced CPDLC request window is rendered on display system **116.** At **910,** a pilot-specified tentative CPDLC request is received. As previously mentioned, the pilot or crew may provide input via various user input devices, and directly on a touch screen display, when implemented. At **912,** the received inputs are processed with airport features data and the system **102** predicts, based thereon, whether the controller at ATC **50** will accept or reject the tentative request; the prediction may have associated therewith, prediction information.

[0041] At **914,** an area **206** is rendered on the enhanced CPDLC request window, and a display dialogue box with the prediction and prediction information is rendered therein. As described above, in connection with FIGS. 2-8, and further described in the following method steps, the prediction information can include a predicted acceptance, a predicted rejection, an alternative recommendation, and one or more predicted delays or pause times. If the prediction is an acceptance at **916,** it is determined at **918** whether there is an associated predicted or recommended delay time. If there is a delay time, the associated delay or pause time is rendered at **920.** A send button (or another similar graphical user interface widget to prompt the user to send/submit/select/ etc.) is rendered at **922,** and at **924,** the CPDLC request is transmitted upon receiving or detecting a user selection of the tentative CPDLC request when it was predicted to be accepted, in accordance with the predicted delay time. Step **924** includes converting the tentative CPDLC request to a CPDLC request and transmitting the CPDLC request to ATC in accordance with the predicted delay time. In other words, if a delay was predicted at **918,** the transmittal occurs after the elapse of the pause time, and if no delay is predicted at **918,** the transmittal immediately occurs.

[0042] When the prediction is that the tentative CPDLC request will be rejected at **916,** any available alternative requests may be indicated at **926.** At **928,** each alternative request is further evaluated as to whether there is a predicted delay time. When there is a predicted delay time, the method moves to **920** and when there is no predicted delay time, the method moves to **922.** As mentioned, at **918** and at **928,** the delay time may be zero; in which case, various embodiments of the system **102** do not display a zero.

[0043] Thus, the proposed system **102** for reducing controller-pilot data link (CPDLC) rejection ratio on an aircraft is a technologically improved CPDLC system that processes current conditions that ATC considers to predict a likelihood of acceptance of the CPDLC request.

This beneficially averts sending CPDLC requests that are likely to be rejected and therefore reduces CPDLC rejection ratios overall. As is readily appreciated, the above examples of the system **102** are non-limiting, and many others may be addressed by the controller **104.**

[0044] Those of skill in the art will appreciate that the various illustrative logical blocks, modules, circuits, and algorithm steps described in connection with the embodiments disclosed herein may be implemented as electronic hardware, computer software, or combinations of both. Some of the embodiments and implementations are described above in terms of functional and/or logical block components (or modules) and various processing steps. However, it should be appreciated that such block components (or modules) may be realized by any number of hardware, software, and/or firmware components configured to perform the specified functions. To clearly illustrate the interchangeability of hardware and software, various illustrative components, blocks, modules, circuits, and steps have been described above generally in terms of their functionality. Whether such functionality is implemented as hardware or software depends upon the application and design constraints imposed on the overall system.

[0045] Skilled artisans may implement the described functionality in varying ways for each application, but such implementation decisions should not be interpreted as causing a departure from the scope of the present invention. For example, an embodiment of a system or a component may employ various integrated circuit components, e.g., memory elements, digital signal processing elements, logic elements, look-up tables, or the like, which may carry out a variety of functions under the control of one or more microprocessors or other control devices. In addition, those skilled in the art will appreciate that embodiments described herein are merely exemplary implementations.

[0046] Further, the various illustrative logical blocks, modules, and circuits described in connection with the embodiments disclosed herein may be implemented or performed with a general-purpose processor, a digital signal processor (DSP), an application specific integrated circuit (ASIC), a field programmable gate array (FPGA) or other programmable logic device, discrete gate or transistor logic, discrete hardware components, or any combination thereof designed to perform the functions described herein. A general-purpose processor may be a microprocessor, but in the alternative, the processor may be any conventional processor, controller, microcontroller, or state machine. A processor may also be implemented as a combination of computing devices, e.g., a combination of a DSP and a microprocessor, a plurality of microprocessors, one or more microprocessors in conjunction with a DSP core, or any other such configuration.

[0047] The steps of the method or algorithm described in connection with the embodiments disclosed herein may be embodied directly in hardware, in a software module executed by a controller or processor, or in a combination of the two. A software module may reside in RAM memory, flash memory, ROM memory, EPROM memory, EEPROM memory, registers, hard disk, a removable disk, a CD-ROM, or any other form of storage medium known in the art. An exemplary storage medium is coupled to the processor such that the processor can read information from, and write information to, the storage medium. In the alternative, the storage medium may be integral to the processor. The processor and the storage medium may reside in an ASIC.

[0048] In this document, relational terms such as first and second, and the like may be used solely to distinguish one entity or action from another entity or action without necessarily requiring or implying any actual such relationship or order between such entities or actions. Numerical ordinals such as "first," "second," "third," etc. simply denote different singles of a plurality and do not imply any order or sequence unless specifically defined by the claim language. The sequence of the text in any of the claims does not imply that process steps must be performed in a temporal or logical order according to such sequence unless it is specifically defined by the language of the claim. When "or" is used herein, it is the logical or mathematical or, also called the "inclusive or." Accordingly, A or B is true for the three cases: A is true, B is true, and, A and B are true. In some cases, the exclusive "or" is constructed with "and;" for example, "one from A and B" is true for the two cases: A is true, and B is true.

[0049] Furthermore, depending on the context, words such as "connect" or "coupled to" used in describing a relationship between different elements do not imply that a direct physical connection must be made between these elements. For example, two elements may be connected to each other physically, electronically, logically, or in any other manner, through one or more additional elements.

[0050] While at least one exemplary embodiment has been presented in the foregoing detailed description of the invention, 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 invention in any way. Rather, the foregoing detailed description will provide those skilled in the art with a convenient road map for implementing an exemplary embodiment of the invention. It being understood that various changes may be made in the function and arrangement of elements described in an exemplary embodiment without departing from the scope of the invention as set forth in the appended claims.

Claims

1. A processor implemented method for reducing controller-pilot data link (CPDLC) rejection ratio on an

aircraft, comprising:

receiving, from a navigation system onboard the aircraft, navigation data for the aircraft;
receiving sensor data from a sensor system;
receiving traffic data from an external traffic data source;
displaying a CPDLC window on a display system;
receiving a tentative CPDLC request;
processing the navigation data, traffic data, and tentative CPDLC request with airport features data to predict whether the tentative CPDLC request will be accepted; and
displaying a dialogue box based upon the prediction,
wherein the displayed dialogue box indicates:
acceptance upon predicting that the tentative CPDLC request will be accepted; or
rejected and an alternative CPDLC request upon predicting that the tentative CPDLC request will not be accepted.

2. The method of claim 1, further comprising:

predicting that air traffic control (ATC) will accept the tentative CPDLC request in a first amount of time; and
displaying the first amount of time.

3. The method of claim 2, further comprising:

predicting that air traffic control (ATC) will accept the alternative CPDLC request in a second amount of time; and
displaying the second amount of time.

4. The method of claim 3, further comprising:
upon detecting a user selection of the tentative CPDLC request when it was predicted to be accepted, converting the tentative CPDLC request to a CPDLC request and transmitting the CPDLC request to ATC without further user input.

5. The method of claim 4, further comprising transmitting the CPDLC request after an elapse of the first amount of time.

6. The method of claim 5, further comprising visually distinguishing a send button to show a status of CPDLC transmission while the first amount of time is counted down.

7. The method of claim 4, further comprising:
upon detecting a user selection of the alternative request, converting the alternative CPDLC request to a CPDLC request and transmitting the CPDLC request to ATC without further user input.

8. The method of claim 7, further comprising transmitting the CPDLC request after an elapse of the second amount of time.

9. The method of claim 8, further comprising visually distinguishing a send button to show a status of CPDLC transmission while the second amount of time is counted down.

10. A system for reducing controller-pilot data link (CPDLC) rejection ratio on an aircraft, comprising:

a navigation system providing navigation data for the aircraft;
a sensor system onboard the aircraft; and
a processor operationally coupled to the navigation system and sensor system and configured to:

display a CPDLC window on a display system;
receive a tentative CPDLC request;
receive traffic data from an external traffic data source;
process the navigation data, traffic data, and tentative CPDLC request with airport features data to predict whether the tentative CPDLC request will be accepted by air traffic control (ATC), and that air traffic control (ATC) will accept the tentative CPDLC request in a first amount of time; and
upon predicting that the tentative CPDLC request will be accepted,
display a dialogue box indicating acceptance; and
display the first amount of time.

11. The system of claim 10, wherein the processor is further configured to:

upon detecting a user selection of the tentative CPDLC request when it was predicted to be accepted,
convert the tentative CPDLC request to a CPDLC request and transmitting the CPDLC request to ATC without further user input.

12. The system of claim 11, wherein the processor is further configured to transmit the CPDLC request after an elapse of the first amount of time.

13. The system of claim 12, wherein the processor is further configured to visually indicate a status of CPDLC transmission while the first amount of time is counted down.

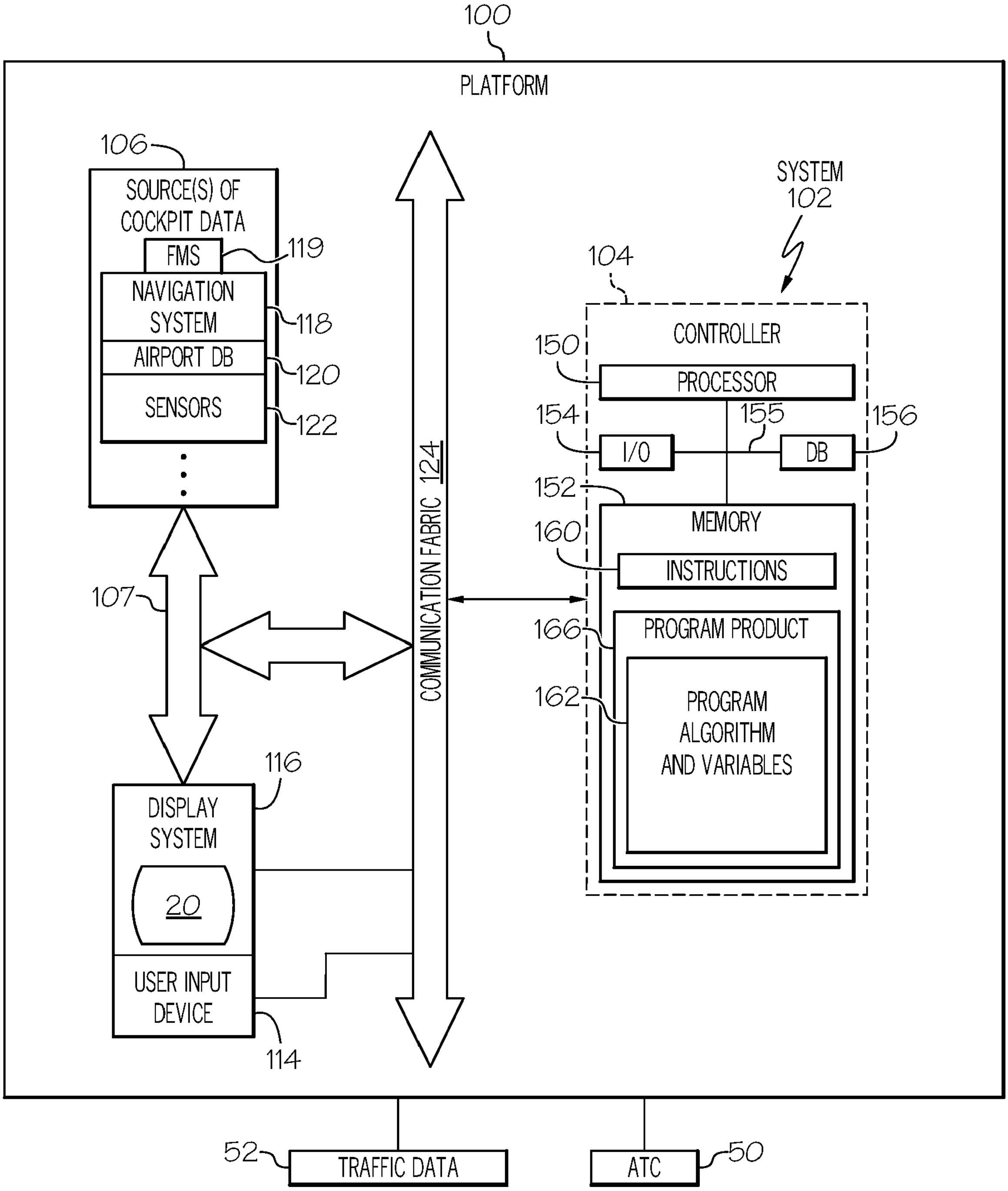
14. The system of claim 10, wherein the processor is further configured to:

upon predicting that the tentative CPDLC request will not be accepted,

display a dialogue box indicating rejection and an alternative CPDLC request;
predict that air traffic control (ATC) will accept the alternative CPDLC request in a second amount of time; and
display the second amount of time.

15. The system of claim 14, wherein the processor is further configured to, upon detecting a user selection of the alternative request:

convert the alternative CPDLC request to a CPDLC request and transmit the CPDLC request to ATC without further user input;
to transmit the CPDLC request after an elapse of the second amount of time; and
visually indicate a status of CPDLC transmission while the second amount of time is counted down.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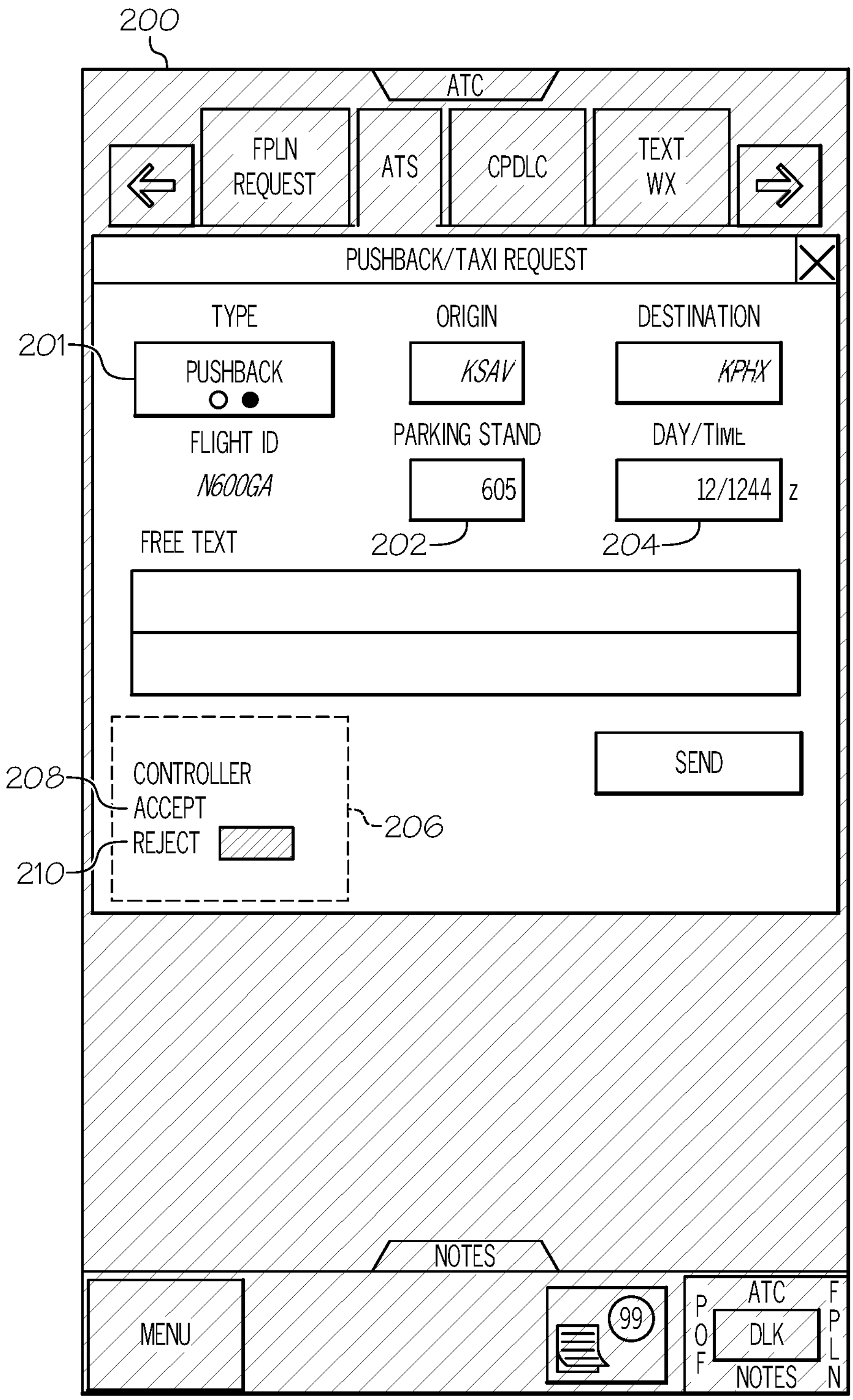
PLATFORM
106
SOURCE(S) OF COCKPIT DATA
FMS
119
NAVIGATION SYSTEM
118
AIRPORT DB
120
SENSORS
122
107
COMMUNICATION FABRIC 124
SYSTEM 102
104
CONTROLLER
150
PROCESSOR
154
I/O
155
DB
156
152
MEMORY
160
INSTRUCTIONS
166
PROGRAM PRODUCT
162
PROGRAM ALGORITHM AND VARIABLES
116
DISPLAY SYSTEM
20
USER INPUT DEVICE
114
52
TRAFFIC DATA
ATC
50

FIG. 1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ATC
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CPDLC
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KPHX
FLIGHT ID
PARKING STAND
DAY/TIME
N600GA
605
12/1244 Z
FREE TEXT
202
204
CONTROLLER
ACCEPT
REJECT
208
210
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SEND
NOTES
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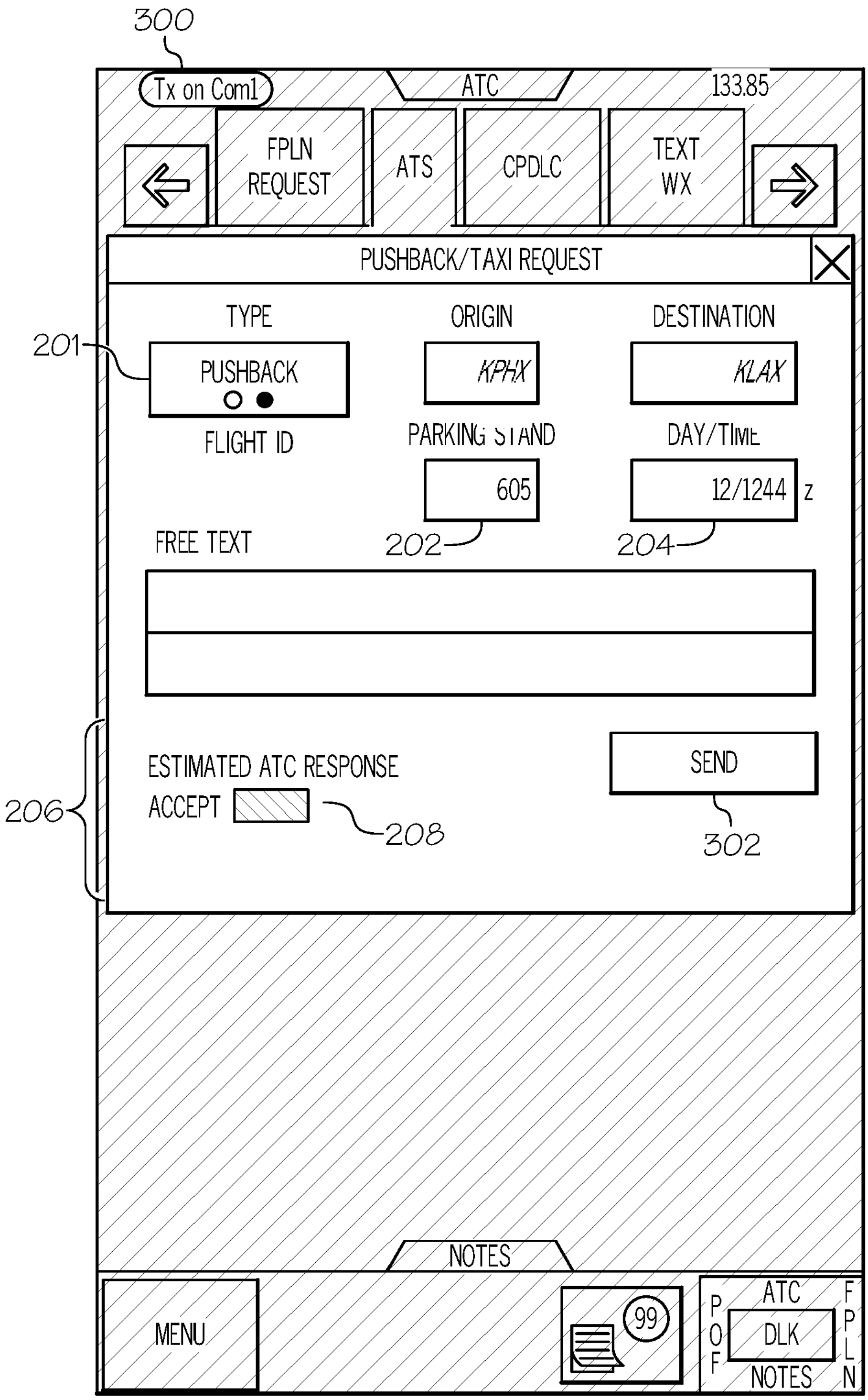
DLK
NOTES
POF
FPLN

FIG. 2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ATS
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PUSHBACK
KPHX
KLAX
FLIGHT ID
PARKING STAND
DAY/TIME
605
12/1244
z
FREE TEXT
202
204
206
ESTIMATED ATC RESPONSE
ACCEPT
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SEND
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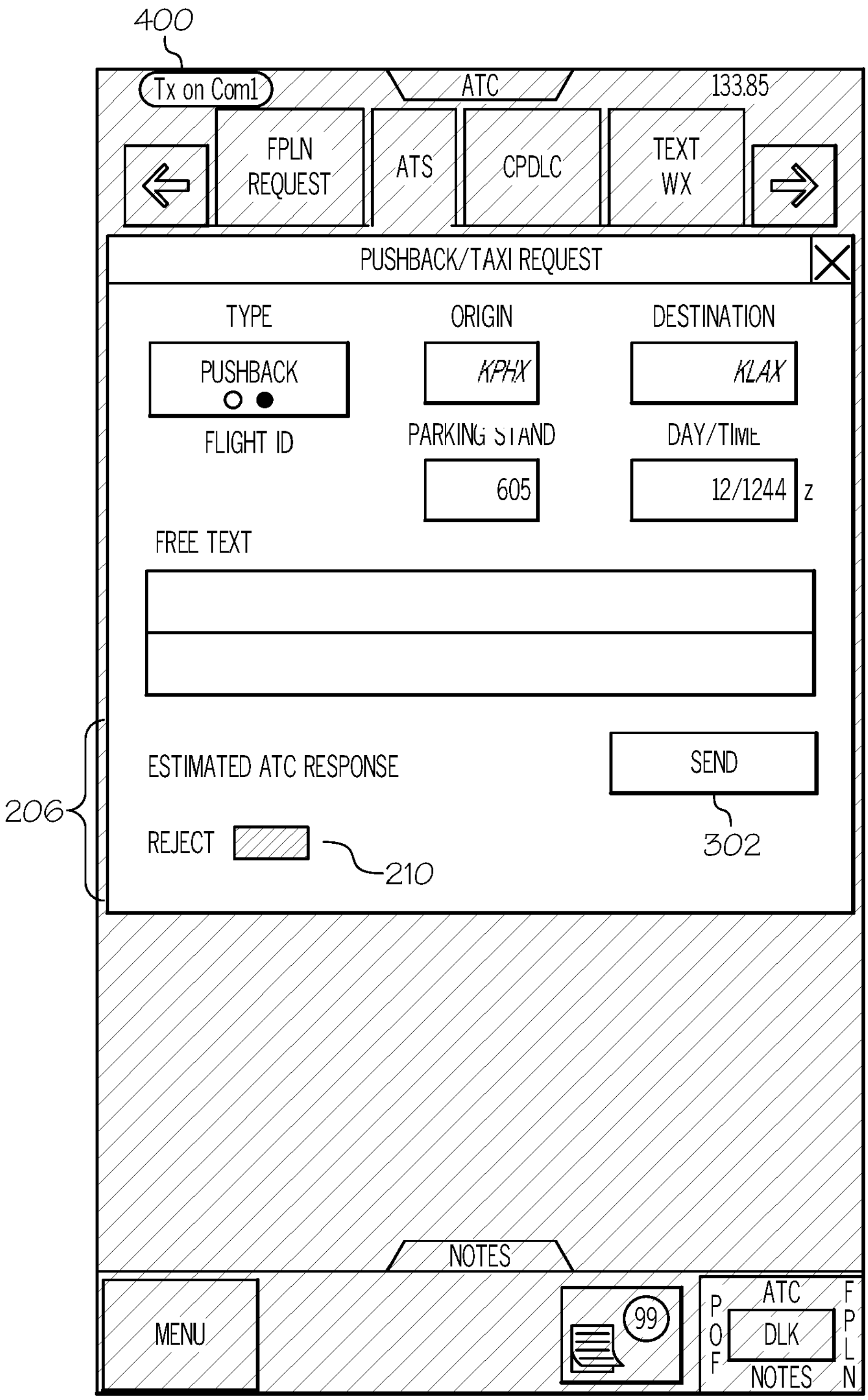
ATC
POF
DLK
FPLN
NOTES

FIG. 3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133.85
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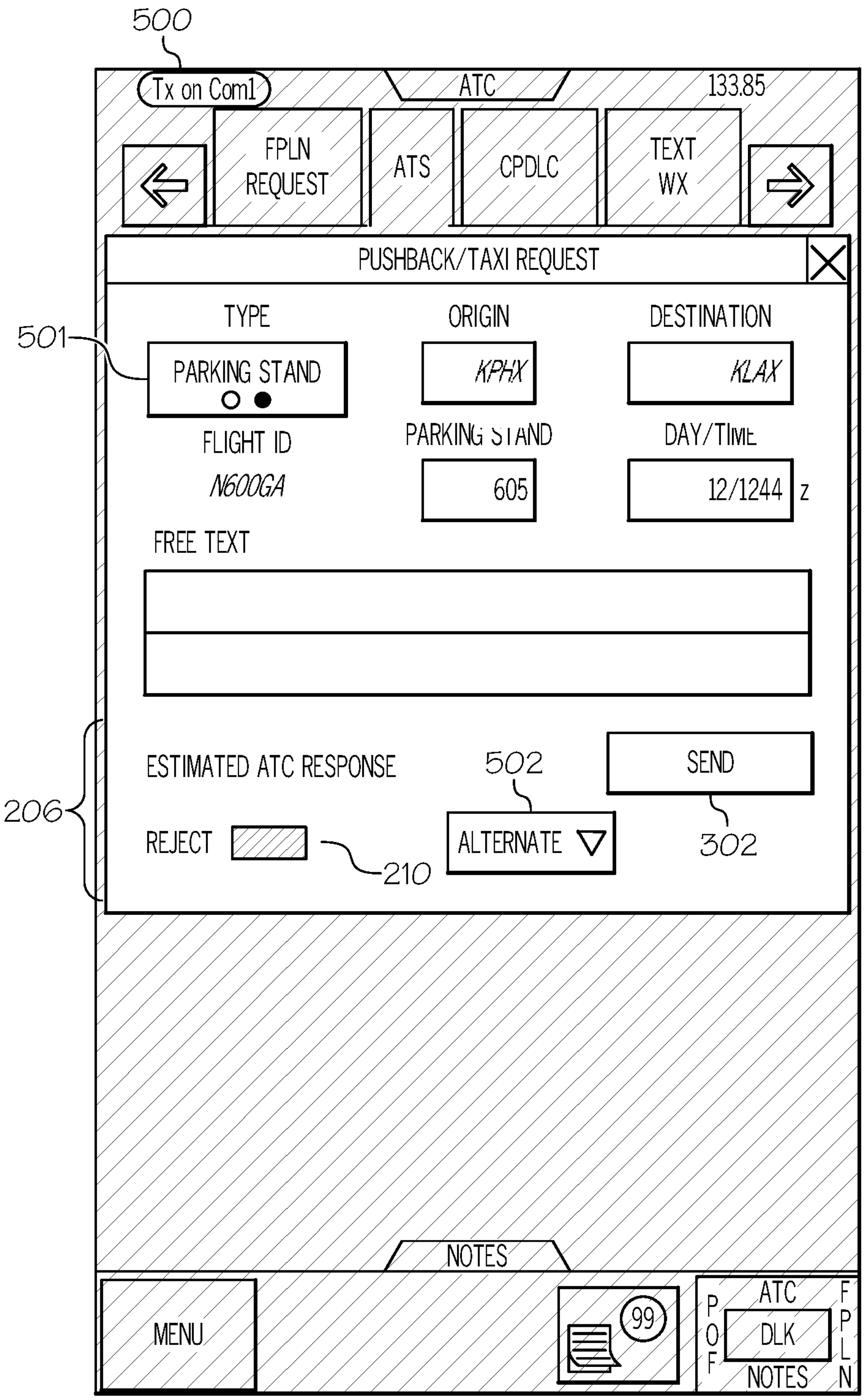
TYPE
ORIGIN
DESTINATION
PUSHBACK
KPHX
KLAX
FLIGHT ID
PARKING STAND
DAY/TIME
605
12/1244
z
FREE TEXT
ESTIMATED ATC RESPONSE
SEND
206
REJECT
210
302
NOTES
MENU
99
POF
ATC
DLK
NOTES
FPLN

FIG. 4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CPDLC
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KPHX
KLAX
FLIGHT ID
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DAY/TIME
N600GA
605
12/1244
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FREE TEXT
ESTIMATED ATC RESPONSE
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302
NOTES
MENU
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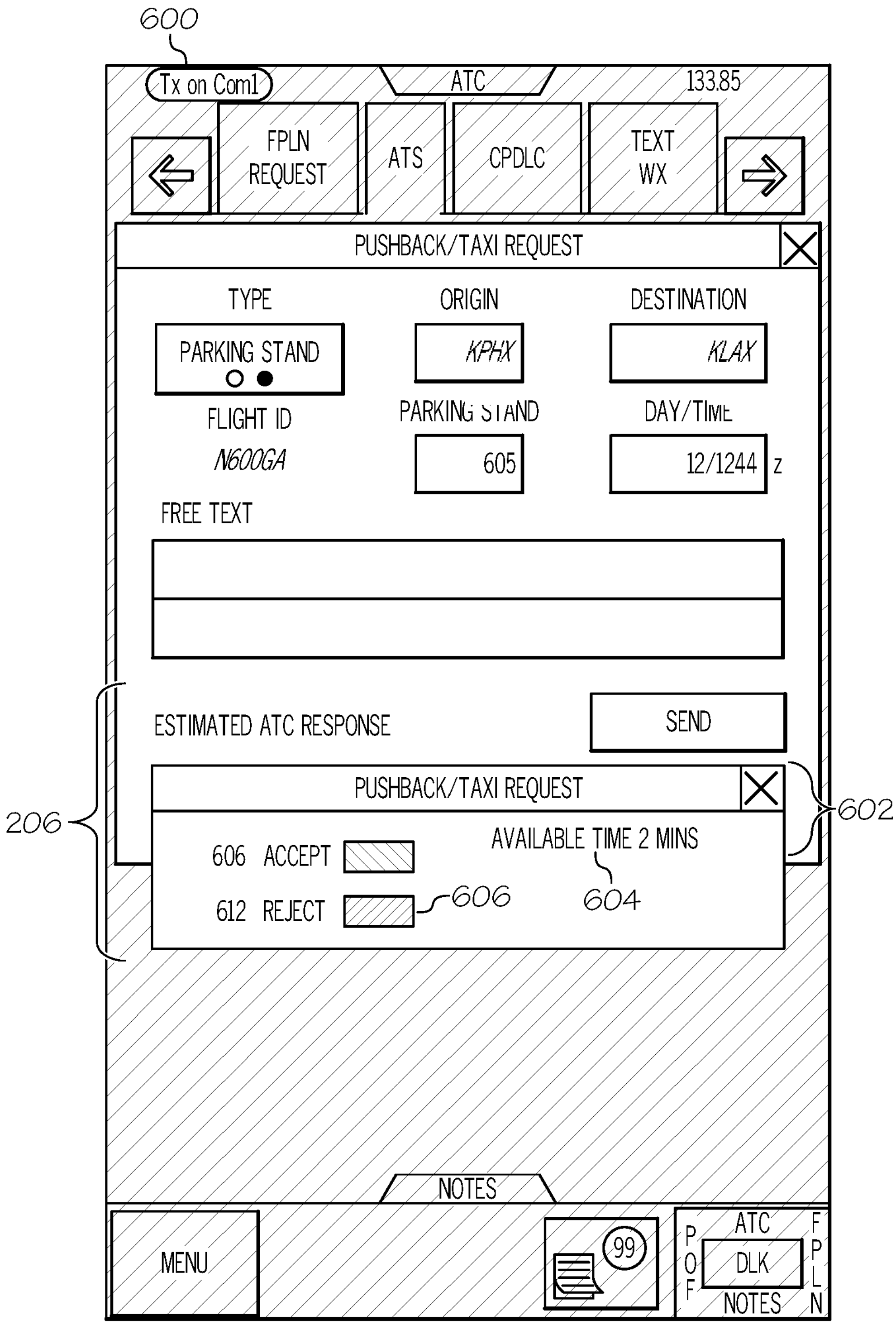
POF
ATC
DLK
NOTES
FPLN

FIG. 5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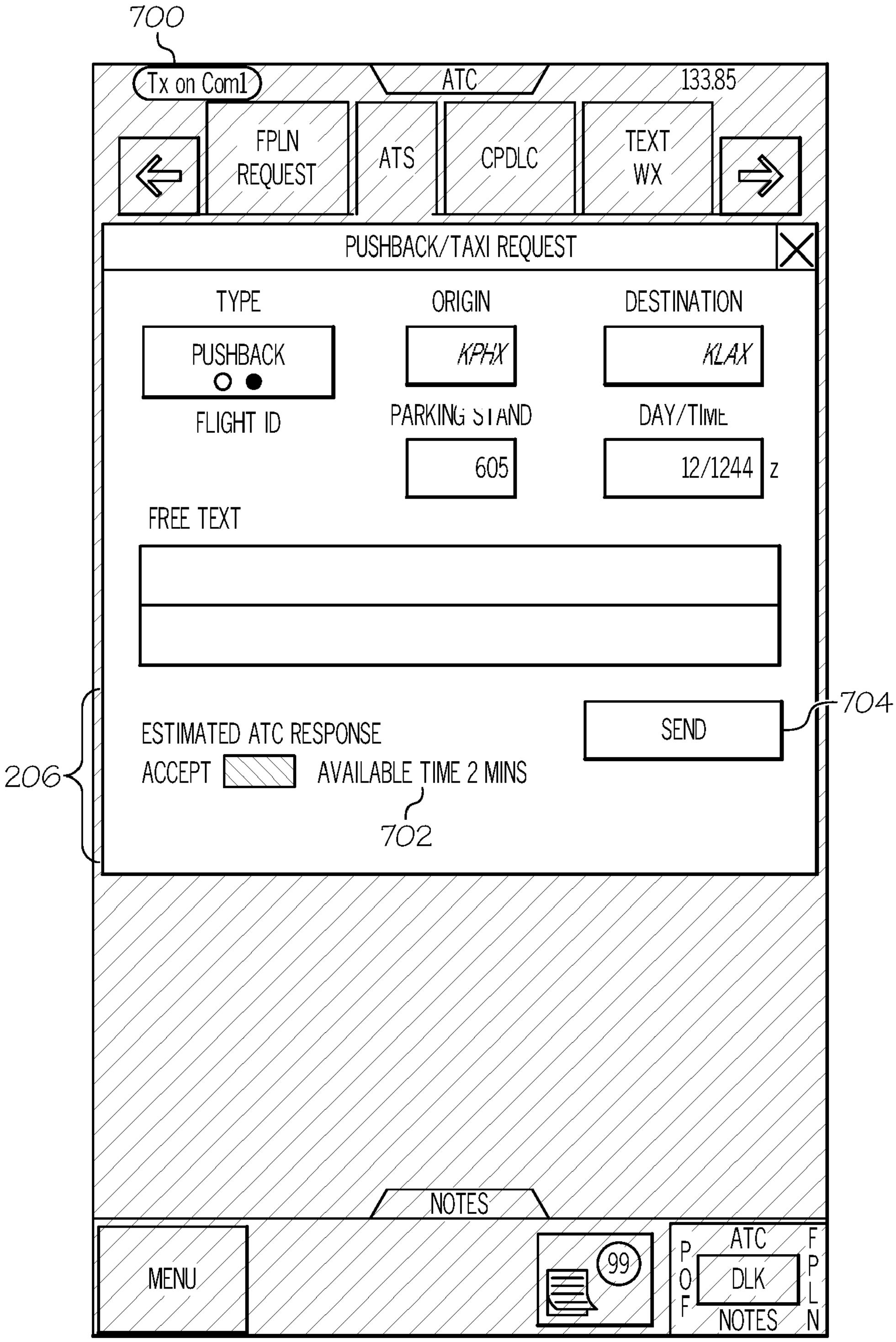
KPHX
KLAX
FLIGHT ID
PARKING STAND
DAY/TIME
N600GA
605
12/1244 z
FREE TEXT
ESTIMATED ATC RESPONSE
SEND
PUSHBACK/TAXI REQUEST
606 ACCEPT
AVAILABLE TIME 2 MINS
612 REJECT
606
604
602
206
NOTES
MENU
99
ATC
DLK
NOTES
POF
FPLN

FIG. 6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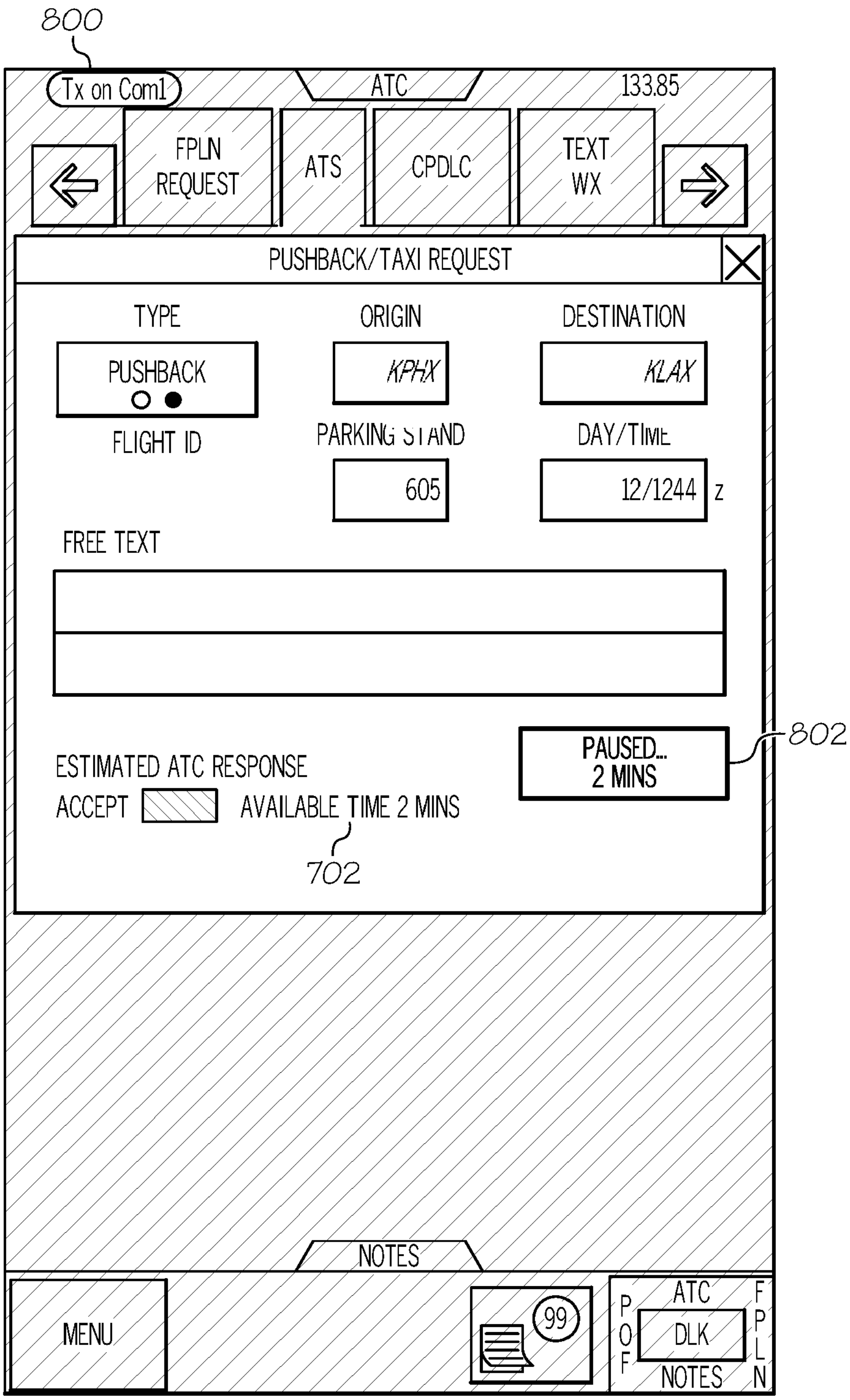
133.85
FPLN REQUEST
ATS
CPDLC
TEXT WX
PUSHBACK/TAXI REQUEST
TYPE
ORIGIN
DESTINATION
PUSHBACK
KPHX
KLAX
FLIGHT ID
PARKING STAND
DAY/TIME
605
12/1244
z
FREE TEXT
ESTIMATED ATC RESPONSE
ACCEPT
AVAILABLE TIME 2 MINS
SEND
704
206
702
NOTES
MENU
99
ATC
DLK
NOTES
POF
FPLN

FIG. 7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Tx on Com1
ATC
133.85
FPLN REQUEST
ATS
CPDLC
TEXT WX
PUSHBACK/TAXI REQUEST
TYPE
ORIGIN
DESTINATION
PUSHBACK
KPHX
KLAX
FLIGHT ID
PARKING STAND
DAY/TIME
605
12/1244
Z
FREE TEXT
ESTIMATED ATC RESPONSE
ACCEPT
AVAILABLE TIME 2 MINS
PAUSED... 2 MINS
802
702
NOTES
MENU
99
ATC
DLK
NOTES
POF
FPLN

FIG. 8

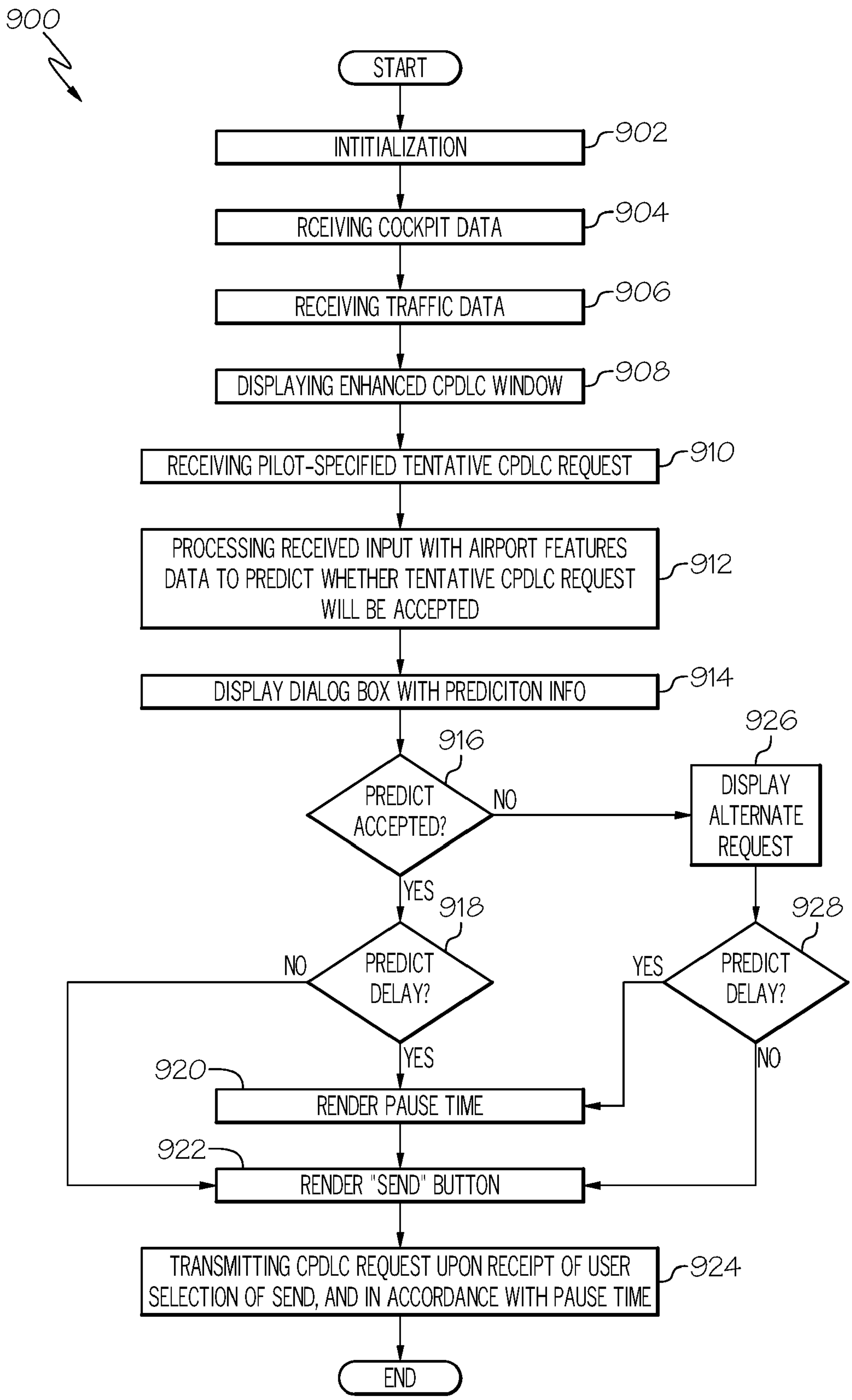
900
START
INTITIALIZATION
902
RCEIVING COCKPIT DATA
904
RECEIVING TRAFFIC DATA
906
DISPLAYING ENHANCED CPDLC WINDOW
908
RECEIVING PILOT-SPECIFIED TENTATIVE CPDLC REQUEST
910
PROCESSING RECEIVED INPUT WITH AIRPORT FEATURES DATA TO PREDICT WHETHER TENTATIVE CPDLC REQUEST WILL BE ACCEPTED
912
DISPLAY DIALOG BOX WITH PREDICITON INFO
914
916
PREDICT ACCEPTED?
NO
926
DISPLAY ALTERNATE REQUEST
YES
918
PREDICT DELAY?
NO
YES
928
PREDICT DELAY?
YES
NO
920
RENDER PAUSE TIME
922
RENDER "SEND" BUTTON
TRANSMITTING CPDLC REQUEST UPON RECEIPT OF USER SELECTION OF SEND, AND IN ACCORDANCE WITH PAUSE TIME
924
END

FIG. 9

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EUROPEAN SEARCH REPORT

Application Number
EP 21 15 1674

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	EP 1 947 624 A1 (HONEYWELL INT INC [US]) 23 July 2008 (2008-07-23) * paragraphs [0001], [0002], [0009] - [0013], [0015], [0018], [0021], [0022], [0026], [0028], [0029] * * figures 2-5 * -----	1-15	INV. G08G5/00 H04B7/185
A	US 2016/161283 A1 (SHAMASUNDAR RAGHU [IN] ET AL) 9 June 2016 (2016-06-09) * paragraphs [0001], [0016], [0018], [0025] * * figure 1 * -----	1-15	
A	US 2008/316057 A1 (MCGUFFIN THOMAS F [US]) 25 December 2008 (2008-12-25) * paragraphs [0004], [0011], [0015] * -----	1-15	

TECHNICAL FIELDS SEARCHED (IPC)

G08G
H04B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	10 June 2021	Roxer, Adam

2

CATEGORY OF CITED DOCUMENTS

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10-06-2021

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Patent documents cited in the description

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