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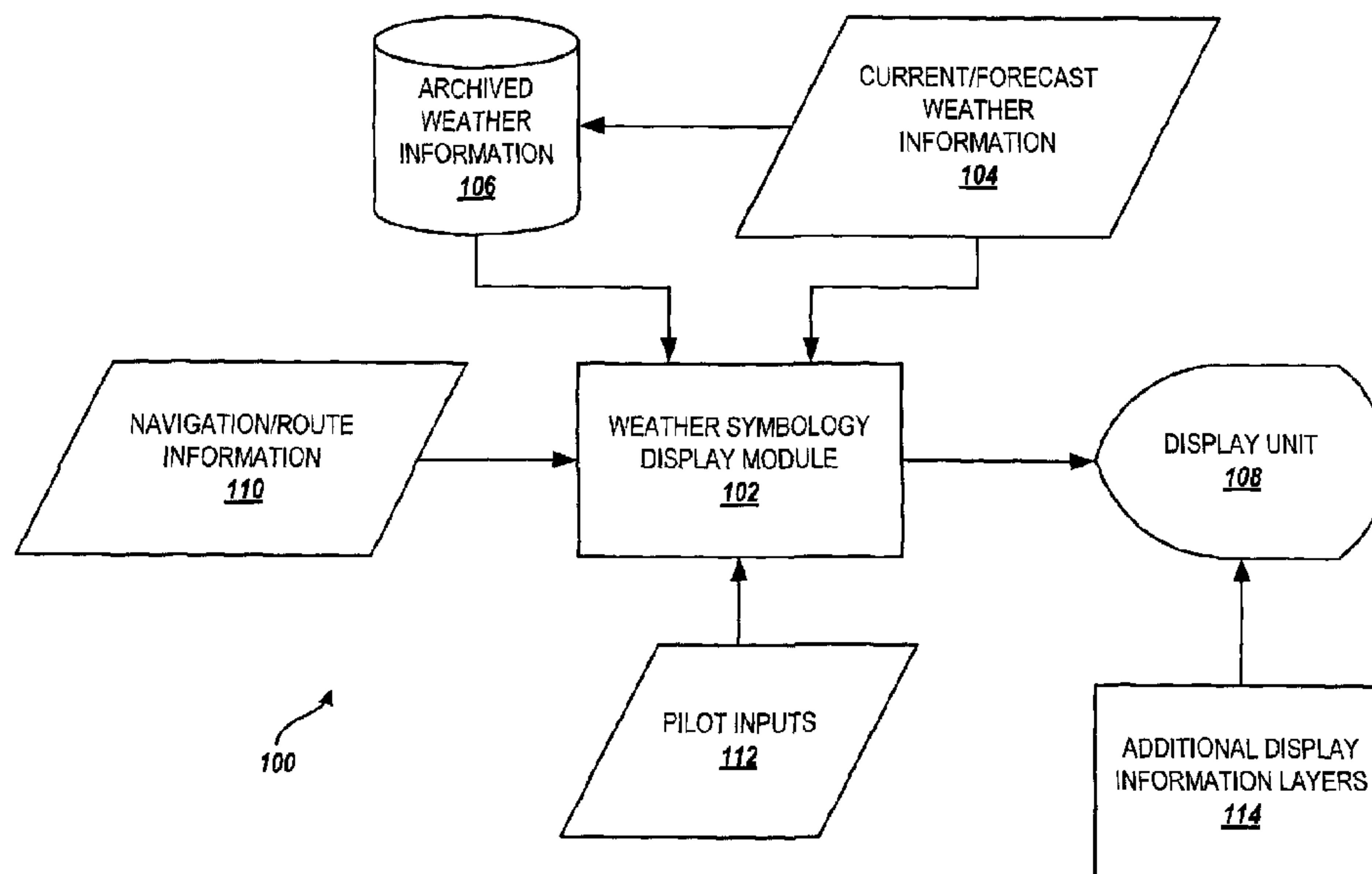
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(54) **Title: TEMPORALLY BASED WEATHER SYMBOLOGY**



(57) **Abrégé/Abstract:**

Methods, systems, and computer-readable media are described herein for integrating geo-spatially enabled and time-encoded textual weather information into a graphical map display. Time-encoded textual weather information regarding one or more geographic locations is received, parsed, and interpreted in light of a temporal context of the graphical map display. Weather symbology relating the weather conditions within the temporal context of the graphical map display is generated from the parsed textual weather information and displayed at positions on the map corresponding to the geographic locations. The weather symbology may include weather pictograms that relate past, current, and future weather conditions at the corresponding geographic locations according to the temporal context of the graphical map display.

TEMPORALLY BASED WEATHER SYMBOLOGY

Abstract

Methods, systems, and computer-readable media are described herein for integrating geo-spatially enabled and time-encoded textual weather information into a graphical map display. Time-encoded textual weather information regarding one or more geographic locations is received, parsed, and interpreted in light of a temporal context of the graphical map display. Weather symbology relating the weather conditions within the temporal context of the graphical map display is generated from the parsed textual weather information and displayed at positions on the map corresponding to the geographic locations. The weather symbology may include weather pictograms that relate past, current, and future weather conditions at the corresponding geographic locations according to the temporal context of the graphical map display.

TEMPORALLY BASED WEATHER SYMBOLOGY

Background

Weather conditions are a critical part of situational-awareness for a flight crew of an aircraft. Certain weather hazards, such as decreased visibility, increased winds, turbulence, precipitation, increased icing potential, convective weather, and the like, may affect the performance of the aircraft as well as the comfort and safety of passengers. Traditionally, the flight crew receives a pre-flight briefing package prior to a flight that includes current and forecast weather information for departure, destination, and alternate airports, as well as airports along the route. This weather information may be in the form of paper printouts containing textual information as well as 2-D weather maps. Particularly during a long flight, however, this information may become outdated, decreasing the effectiveness of pre-flight weather information in maintaining weather situational-awareness en-route.

The flight crew may have access to updated weather information in-flight through radio communications with air-traffic control (“ATC”) or a text-based datalink, such as the Aircraft Communications Addressing and Reporting System (“ACARS”). ACARS is a system for the transmission of short, relatively simple text messaging between aircraft and ground stations via radio or satellite. A pilot may utilize ACARS to request current and forecast weather information regarding a particular airport, as well as to be alerted to significant weather phenomena that affect the safety of all aircraft, such as turbulence, icing, volcanic ash, and the like.

The weather information received via ACARS or other communication, however, is predominately textual in nature. In many cases, the flight crew must mentally map this textual current and forecast weather information to navigational maps covering the aircraft’s current route in order to determine any potential impact of the weather conditions. In addition, the flight crew may infer weather trends from the information received at various times during the flight in order to better forecast the conditions that may occur in subsequent portions of the flight. These mental operations may increase the workload of the flight crew, which may be especially critical in certain phases of flight, such as preparation for landing or an emergency diversion, as well as create opportunities for errors to occur.

It is with respect to these considerations and others that the disclosure made herein is presented.

Summary

It should be appreciated that this Summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This Summary is not intended to be used to limit the scope of the claimed subject matter.

Methods, systems, and computer-readable media are described herein for integrating geospatially enabled and time-encoded textual weather information into a graphical map display. According to embodiments presented herein, time-encoded textual weather information regarding one or more geographic locations is received, parsed, and interpreted in light of a temporal context of the graphical map display. Weather symbology relating the weather conditions within the temporal context of the graphical map display is generated from the parsed textual weather information and displayed at positions on the map corresponding to the geographic locations. In one embodiment, the weather symbology comprises weather pictograms that relate past, current, and future weather conditions at the corresponding geographic locations according to the temporal context of the graphical map display.

In accordance with one embodiment, there is provided a non-transitory computer-readable storage medium. The non-transitory computer-readable storage medium includes computer-executable instructions that, when executed by a computer, cause the computer to receive weather information regarding a first geographic location and a second geographic location along a flight route, and to receive a selection of a projected time of flight via a timeline user-interface control, the projected time of flight corresponding to a time at which an aircraft is flying the flight route and is not positioned at the first geographic location or the second geographic location. The non-transitory computer-readable storage medium further includes computer-executable instructions that, when executed by a computer, further cause the computer to parse and interpret the received weather information to determine weather conditions at the first geographic location and the second geographic location at the

projected time of flight selected via the timeline user-interface control, and display a first weather pictogram at a position on the graphical map display corresponding to the first geographic location and a second weather pictogram at a position on the graphical map display corresponding to the second geographic location. The first weather pictogram includes a first graphical element depicting past weather conditions at the first geographic location at the projected time of flight, a second graphical element adjacent to and abutting the first graphical element and depicting current weather conditions at the first geographic location at the projected time of flight, and a third graphical element adjacent to and abutting the second graphical element and depicting forecasted future weather conditions at the first geographic location at the projected time of flight.

The first graphical element may indicate the current weather conditions through a color-coding or shading associated with the current weather conditions, the second graphical element may indicate the current weather conditions through a color-coding or shading associated with the future weather conditions, and the third graphical element may indicate the past weather conditions through a color-coding or shading associated with the past weather conditions.

The color-coding or shading associated with the current weather conditions, the future weather conditions, and the past weather conditions may indicate flight rules in effect at the geographic location based on the current weather conditions, the future weather conditions, and the past weather conditions respectively.

The weather information may include a plurality of Meteorological Terminal Aviation Routine Weather Reports (METAR reports), unscheduled reports taken when certain criteria have been met (SPECI reports), terminal area forecasts ("TAFs"), significant meteorological information ("SIGMET") advisories, or pilot reports ("PIREPs") regarding the geographic location.

The weather information may be received via a Aircraft Communications Addressing and Reporting System ("ACARS").

Each weather pictogram may be displayed in conjunction with a flight route display.

In accordance with another embodiment, there is provided a system for integrating weather information into a graphical map display of an aircraft. The system includes a display unit in a cockpit of the aircraft, a memory for storing a program containing computer-executable instructions for displaying weather symbology on the display unit, and a processing unit functionally coupled to the memory and the display unit. The processing unit is responsive to the computer-executable instructions and configured to receive weather information regarding a geographic location, and to receive a request for weather conditions at the geographic location according to a first selected point-in-time of a plurality of points-in-time associated with a position of the aircraft within a flight route, the first selected point-in-time corresponding to a time at which the aircraft is flying the flight route and is not positioned at the geographic location. The computer executable instructions further cause the processing unit to determine a temporal context of the graphical map display, the temporal context comprising the first selected point-in-time. The processing unit is responsive to the computer-executable instructions and is further configured to parse and interpret the received weather information to determine weather conditions at the geographic location based upon the temporal context of the graphical map display according to the first selected point-in-time, and display a weather pictogram at a position on the graphical map display corresponding to the geographic location. The weather pictogram relates the weather conditions at the geographic location within the temporal context of the graphical map display according to the first selected point-in-time and includes a first graphical element depicting past weather conditions at the geographic location at the first selected point-in-time, a second graphical element adjacent to and abutting the first graphical element and depicting current weather conditions at the geographic location at the first selected point-in-time, and a third graphical element adjacent to and abutting the second graphical element and depicting forecasted future weather conditions at the geographic location at the first selected point-in-time. The processing unit is responsive to the computer-executable instructions and configured to receive a request for weather conditions at the geographic location according to a second selected point-in-time of the plurality of

points-in-time associated with the position of the aircraft within the flight route, and is configured to parse and interpret the received weather information to determine weather conditions at the geographic location based upon the temporal context of the graphical map display according to the second selected point-in-time, and to display the weather pictogram at a position on the graphical map display corresponding to the geographic location, wherein the weather pictogram is updated to reflect the weather conditions at the geographic location within the temporal context of the graphical map display according to the second selected point-in-time.

The first graphical element may indicate the current weather conditions through a color-coding or shading associated with the current weather conditions. The second graphical element may indicate the current weather conditions through a color-coding or shading associated with the future weather conditions, and the third graphical element may indicate the past weather conditions through a color-coding or shading associated with the past weather conditions.

The color-coding or shading associated with the current weather conditions, the future weather conditions, and the past weather conditions may indicate flight rules in effect at the geographic location based on the current weather conditions, the future weather conditions, and the past weather conditions respectively.

The weather information may include a plurality of Meteorological Terminal Aviation Routine Weather Reports (METAR reports), unscheduled reports taken when certain criteria have been met (SPECI reports), terminal area forecasts ("TAFs"), significant meteorological information ("SIGMET") advisories, or pilot reports ("PIREPs") regarding the geographic location.

The weather information may be received at the aircraft via Aircraft Communications Addressing and Reporting System ("ACARS").

The weather pictogram may be displayed in conjunction with a flight route display.

In accordance with another embodiment, there is provided a computer-implemented method for integrating weather information into a graphical map display. The method involves performing instructions under the control of one or more computer systems to perform the operations of receiving weather information regarding a first geographic location and a second geographic location along a flight route, and receiving a selection of a projected time of flight via a user-interface control, the projected time of flight corresponding to a time at which an aircraft is flying the flight route and is not positioned at the first geographic location or the second geographic location. The method further involves parsing and interpreting the received weather information to determine weather conditions at the first geographic location and the second geographic location at a projected time of flight selected via the user-interface control, and determining a position of an aircraft along the flight route at the first time. The method further involves displaying the flight route on the graphical map display, displaying a first representation of the aircraft at a position on the flight route corresponding to a geographic location of the aircraft at the first time, and displaying a first weather pictogram at a position on the graphical map display corresponding to the first geographic location and a second weather pictogram at a position on the graphical map display corresponding to the second geographic location. The first weather pictogram involves a first graphical element depicting past weather conditions at the first geographic location at the projected time of flight, a second graphical element adjacent to and abutting the first graphical element and depicting current weather conditions at the first geographic location at the projected time of flight, and a third graphical element adjacent to and abutting the second graphical element and depicting forecasted future weather conditions at the first geographic location at the projected time of flight. The method further involves receiving a selection of a second time via a timeline the user-interface control, determining a position of the aircraft along the flight route at the second time, displaying a second representation of the aircraft at a position on the flight route corresponding to a geographic location of the aircraft at the second time, and updating the first weather pictogram and the second weather pictogram corresponding to past, current, and forecasted future weather conditions at the first geographic location and the second geographic location at the second time.

The first graphical element may indicate the current weather conditions through a color-coding or shading associated with the current weather conditions. The second graphical element may indicate the current weather conditions through a color-coding or shading associated with the future weather conditions, and the third graphical element may indicate the past weather conditions through a color-coding or shading associated with the past weather conditions.

The color-coding or shading associated with the current weather conditions, the future weather conditions, and the past weather conditions may indicate flight rules in effect at the geographic location based on the current weather conditions, the future weather conditions, and the past weather conditions respectively.

The time-encoded weather reports may involve a plurality of Meteorological Terminal Aviation Routine Weather Reports (METAR reports), unscheduled reports taken when certain criteria have been met (SPECI reports), terminal area forecasts ("TAFs"), significant meteorological information ("SIGMET") advisories, or pilot reports ("PIREPs") regarding the geographic location.

The time-encoded weather reports may be received over Aircraft Communications Addressing and Reporting System (ACARS).

The features, functions, and advantages discussed herein can be achieved independently in various embodiments of the present invention or may be combined in yet other embodiments, further details of which can be seen with reference to the following description and drawings.

Brief Description of the Drawings

Figure 1 is a block diagram illustrating various aspects of a weather symbology display system of an aircraft, according to embodiments presented herein;

Figure 2 is diagram showing an illustrative temporal-based encoded weather pictogram, according to embodiments presented herein;

Figure 3 is display diagram showing an illustrative graphical map display including integrated, temporally based weather symbology, according to embodiments presented herein;

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Figures 4A and 4B are display diagrams showing changes to the integrated, temporally based weather symbology in the graphical map display resulting from a change to the temporal context of the display, according to embodiments presented herein;

Figure 5 is a flow diagram illustrating one method for integrating geo-spatially enabled and time-encoded textual weather information into a graphical map display, as provided in the embodiments presented herein; and

Figure 6 is a block diagram showing an illustrative computer hardware and software architecture for a computing system capable of implementing aspects of the
5 embodiments presented herein.

Detailed Description

The following detailed description is directed to methods, systems, and computer-readable media for integrating geo-spatially enabled and time-encoded textual
10 weather information into a graphical map display. Utilizing the concepts and technologies described herein, current and forecast textual weather information received at an aircraft may be parsed, interpreted, and graphically depicted in a graphical map display using symbology that intuitively shows current weather conditions as well as past and future trends. Automatically parsing the geo-spatially
15 enabled textual weather information and displaying the information graphically on the map increases the weather situational-awareness of the flight crew of the aircraft while reducing their workload and reducing errors in interpretation of the information. These and other advantages and features will become apparent from the description of the various embodiments below.

20 In the following detailed description, references are made to the accompanying drawings that form a part hereof and that show, by way of illustration, specific embodiments or examples. In referring to the drawings, like numerals represent like elements throughout the several figures.

Figure 1 shows various aspects of a weather symbology display system 100 having
25 the capability to integrate geo-spatially enabled and time-encoded textual weather information into a graphical map display, according to embodiments. In one embodiment, the weather symbology display system 100 is an integrated component of a flight management system (“FMS”), an aeronautical operational control (“AOC”) application, and/or other cockpit avionics systems of an aircraft. In other
30 embodiments, the weather symbology display system 100 may be implemented in a ground-based computing system of an airline’s operation center, an air navigation

service provider (“ANSP”), or ATC. The weather symbology display system **100** may further be implemented in an individual computing device, such as a controller’s workstation, a desktop personal computer (“PC”), a laptop, a notebook, a hand-held device, and the like.

5 The weather symbology display system **100** includes a weather symbology display module **102**. As will be described in detailed herein, the weather symbology display module **102** receives current/forecast weather information **104**, parses the information, interprets it, and displays corresponding temporally based weather symbology depicting past, current, and future weather conditions on a display unit
10 **108** accessible by the weather symbology display system **100**. The weather symbology display module **102** may be implemented as software, hardware, or a combination of the two and may execute on one or more processors or computing devices within the weather symbology display system **100**.

According to embodiments, the current/forecast weather information **104** includes
15 geo-spatially enabled textual information regarding weather conditions at a specific geographic locations or regions. The current/forecast weather information **104** is further time-encoded, i.e., the information regards weather conditions in the context of a specific point-in-time or period. In one embodiment, the weather symbology display module **102** receives current/forecast weather information **104** in the form of
20 short text messages containing weather reports received via ACARS or some other messaging system in the cockpit.

The text-based weather reports may include aviation routine weather reports or aerodrome routine meteorological reports, referred to as “METAR” reports, periodically broadcast by airports or permanent weather observation stations.
25 METAR reports contain encoded information regarding current weather conditions at the airport or station, such as wind speed and direction, visibility, cloud ceiling, temperature, dew point, barometric pressure, and the like. A METAR report may also contain information on precipitation amounts, lightning, runway visual range, and other information that would be of particular interest to the flight crew of an aircraft.
30 METAR reports are typically generated once an hour, but if conditions change significantly, they can be updated in special interim reports (referred to as “SPECI” reports).

METAR reports contain the reported weather information at the airport encoded in a global standard format, although minor differences between codes, abbreviations, units, and other variations may occur between countries. Table 1 shows an example METAR report for Chicago-O'Hare airport ("KORD") broadcast on the 9th day of the month at 11:00 UTC ("091100Z"). The METAR reports winds from 080° at 3 knots ("08003KT"), visibility of 1 statute-mile ("1SM"), light mist ("BR"), broken cloud layer at 500 feet above ground ("BKN005"), temperature of 1° C with a dewpoint at 0° ("01/00"), and an altimeter setting of 29.90 inHg.

METAR KORD 091100Z 08003KT 1SM BR BKN005 01/00 A2990=

Table 1 – Example METAR Text-based Weather Report

Similarly, Table 2 shows an updated weather report ("SPECI") for Chicago-O'Hare Airport ("KORD") broadcast at 12:00 UTC on the same day ("091100Z"), reporting winds now from 060° at 5 knots ("06005KT"), visibility of 2 statute-miles ("2SM"), light mist ("BR"), broken cloud layer at 1000 feet above ground ("BKN010"), temperature of 4° C with a dewpoint at 1° ("04/01"), and a new altimeter setting of 29.91 inHg.

SPECI KORD 091200Z 06005KT 2SM BR BKN010 04/01 A2991=

Table 2 – Example SPECI Text-based Weather Report

The text-based weather reports may also include terminal area forecasts ("TAFs") periodically broadcast by airports in conjunction with the METAR and SPECI reports. TAFs contain forecast information for a five statute-mile radius around the airport, and may apply to a 12, 24, or 30 hour forecast period. Similar to METAR reports, TAFs contain encoded information regarding forecasted conditions in a specified time period according to a standard format. For example, Table 3 shows an example TAF for Chicago-O'Hare airport ("KORD") broadcast on the 9th day of the month at 10:30 UTC ("091030Z") and valid from 11:00 that day to 18:00 the next day. The TAF initially forecasts winds from 080° at 5 knots ("08005KT"), visibility of one-half statute miles ("1/2SM"), light mist ("BR"), and a solid or overcast cloud layer at 500 feet above ground ("OVC005").

TAF KORD 091030Z 0911/1018 08005KT 1/2SM BR OVC005
FM091200 07005KT 1SM BR OVC008

FM091300 06005KT 4SM BKN015=

Table 3 – Example TAF Text-based Weather Forecast

Each of the follow-on lines indicates a new forecast period. For example, at 12:00 UTC (“FM091200”), the TAF forecasts winds changing to 070° at 5 knots (“07005KT”), visibility of one statute-mile (“1SM”), light mist (“BR”), and an overcast cloud layer at 800 feet above ground (“OVC008”). Similarly, at 13:00 UTC (“FM091300”), the TAF forecasts winds changing to 060° at 5 knots (“06005KT”), visibility of four statute-miles (“4SM”), and a broken cloud layer at 1500 feet (“BKN015”). The TAF may contain any number of forecast statements for different periods for the reporting airport or observation station.

It will be appreciated that other sources of geo-spatially enabled and time-encoded textual current/forecast weather information 104 may be available to the weather symbology display module 102 beyond the METAR reports, SPECI reports, and TAFs described above. For example, the current/forecast weather information 104 may include significant meteorological information (“SIGMET”) advisories or pilot reports (“PIREPs”) regarding meteorological information concerning the safety of all aircraft, such as thunderstorms (convective weather), turbulence, icing, volcanic ash, and the like. It is intended that this disclosure include all such sources of geo-spatially enabled and time-encoded textual current/forecast weather information 104.

The METAR reports, SPECI reports, TAFs, SIGMET advisories, PIREPs, and other geo-spatially enabled and time-encoded textual current/forecast weather information 104 may be received by the weather symbology display module 102 via ACARS or other datalink from the reporting airports or observation stations, or through a central reporting service, such as the Aviation Digital Data Service (“ADDS”) operated by the National Oceanic and Atmospheric Administration (“NOAA”). In one embodiment, the weather symbology display module 102 requests and receives text-based weather reports from airports related to the current route of the aircraft, such as the departure airport, the destination airport, one or more alternate airports, as well as other airports or ground stations along the current route.

Alternatively or additionally, the weather symbology display module 102 may receive all text-based weather reports and advisories issued over a broadcast feed,

such as satellite feed from SIRIUS XM RADIO, Inc. of New York, New York. It will be appreciated that any number of datalinks, communication channels, and communication methods may be utilized by the weather symbology display module **102** to receive the current/forecast weather information **104**, and it is intended that
5 this disclosure include all such datalinks, communication channels, and communication methods.

According to a further embodiment, the weather symbology display module **102** or another component of the weather symbology display system **100** saves the received current/forecast weather information **104** to a datastore as archived weather
10 information **106**. The archived weather information **106** may be stored in a storage system or database of the FMS, AOC application, or other avionics system of the aircraft. The weather symbology display module **102** may utilize the archived weather information **106** in conjunction with the current/forecast weather information **104** in displaying the temporally based weather symbology regarding the
15 past, current, and future weather conditions on the display unit **108**, as will be described in more detail below. The display unit **108** may be located in the cockpit of the aircraft and may be a graphical display, such as an electronic flight bag (“EFB”) display, a multi-function display (“MFD”), or a heads-up display (“HUD”) found in a modern “glass cockpit.” Alternatively, the display unit **108** may be a computer
20 monitor, a laptop computer display, a handheld display, or other suitable display device accessible by the weather symbology display system **100**.

In one embodiment, the weather symbology display module **102** displays the temporally based weather symbology in conjunction with the display of a flight route of the aircraft, as will be described below in regard to Figures 3-4B. The weather
25 symbology display module **102** may have access to navigation/route information **110** containing data regarding the flight route, such as the departure airport, the destination airport, one or more alternate airports, as well as airports or other ground stations along the flight route.

The navigation/route information **110** may further contain additional data regarding
30 the navigation of the aircraft, including navigation waypoints, point locations of known hazards, geographic maps, topography maps, satellite maps, and the like. The weather symbology display module **102** may display the temporally based weather

5 symbology in conjunction with additional display information layers **114** displayed by other modules in the weather symbology display system **100**, the FMS, the AOC application, or other avionics systems of the aircraft. For example, the temporally based weather symbology may be displayed in conjunction with a graphical map display shown on the display unit **108**.

10 In another embodiment, the weather symbology display module **102** may receive pilot inputs **112** from the flight crew of the aircraft or other user that affect the display of the temporally based weather symbology on the display unit **108**. The pilot inputs **112** may be received from an electronic flight information system (“EFIS”) control panel, a display select panel (“DSP”), a multi-function control and display unit (“MCDU”), an EFB, or other input controls or data terminals. Pilot inputs **112** may include a selection of the specific display unit **108** in the cockpit on which to display the temporally based weather symbology, identification of the current or proposed flight routes to include in the display, selection of the type of weather symbology to be utilized, a color-coding scheme with which to display the symbology, a range selection for the display, a mode selection for the display, and the like.

20 Figure 2 illustrates one example of temporally based weather symbology displayed by the weather symbology display module **102**, according to one embodiment. The temporally based weather symbology may comprise a weather pictogram **200** displayed on the display unit **108** at a position corresponding to a specific geographic location, for example. According to embodiments, the weather pictogram **200** includes three graphical elements **204**, **206**, and **208**, corresponding to current, future, and past weather conditions at the location, respectively. Each of the graphical elements **204**, **206**, and **208** of the weather pictogram **200** may be color-coded, shaded, or otherwise styled to relate the weather conditions in the context of the corresponding time period. The weather symbology display module **102** may determine the color-coding, shading, or styling utilized for each of the graphical elements **204**, **206**, and **208** based on a relative evaluation of corresponding weather conditions, as parsed and interpreted from the current/forecast weather information **104** and the archived weather information **106**.

According to one embodiment, the weather pictogram **200** includes a first graphical element **204** consisting of a center ring, color-coded to relate the current weather conditions at the corresponding geographic location; a second graphical element **206** consisting of a circle in front of and adjacent to the center ring and color-coded to relate the future weather conditions at the location; and a third graphical element **208** consisting of a circle behind and adjacent to the center ring corresponding to the past weather conditions at the location, as shown in Figure 2. The weather symbology display module **102** may color-code or shade the graphical elements **204**, **206**, and **208** based on rules or schemes established by international standards, regional aviation authorities, airline operation rules, or the like.

In one embodiment, the graphical elements **204**, **206**, and **208** are color-coded based upon Federal Aviation Administration (“FAA”) established flight rules and associated colors, as shown at **210** in Figure 2. The weather symbology display module **102** may parse the cloud ceiling and visibility information from the METAR reports, SPECI reports, and TAFs comprising the current/forecast weather information **104** and the archived weather information **106**, and utilize the defined categories shown in Table 4 to determine the color for shading the graphical elements **204**, **206**, and **208** of the weather pictogram **200**. For example, the weather pictogram **200** shown in Figure 2 may represent the past, current, and future weather conditions of Chicago-O’Hare airport as established at **12:00** UDT by the highlighted portions of the METAR report, the SPECI report, and the TAF described above and shown in Table 1, Table 2, and Table 3, respectively, according to the enumerated FAA flight rules provided in Table 4.

| Category | Color | Ceiling | | Visibility |
|---------------------------------------|---------|-----------------------------------|--------|-----------------------------|
| Low Instrument Flight Rules (“LIFR”) | Magenta | below 500 feet | and/or | less than 1 mile |
| Instrument Flight Rules (“IFR”) | Red | 500 to 1,000 feet | and/or | 1 to 3 miles |
| Marginal Visual Flight Rules (“MVFR”) | Blue | 1,000 to 3,000 feet | and/or | 3 to 5 miles |
| Visual Flight Rules (“VFR”) | Green | greater than 3,000 feet | and | greater than 5 miles |

Table 4 – FAA Flight Condition Rules and Display Colors

It will be appreciated that the weather symbology display module **102** may utilize other color-coding, shading, or styling schemes beyond those described above. For

example, the weather symbology display module **102** may color-code the graphical elements **204**, **206**, and **208** green, yellow, or red to symbolize good conditions, moderate or worsening conditions, and poor conditions, respectively. The relevant conditions may be based on any combination of past, current, and future wind speeds, temperature, visibility, precipitation, convective weather, icing potential, airborne hazards, cloud base, aircraft limits, and the like, available to the weather symbology display module **102** from the current/forecast weather information **104**. It is intended that this disclosure include all such color-coding, shading, or styling schemes. In a further embodiment, the flight crew of the aircraft may select the desired color-coding or shading scheme for the weather pictogram **200** through the use of pilot inputs **112** described above.

Figure **3** is a display diagram showing a flight route display **300** as displayed on a display unit **108** accessible to the weather symbology display system **100**, such as the EFB display in the cockpit of the aircraft. The flight route display **300** may show a line indicating a flight route **302** from the departure airport **304** to the destination airport **306** overlaid on a geographical map. The flight route display **300** may also show one or more alternate airports **308**, as well as a current position indicator **310** indicating the current position of the aircraft along the flight route **302**. The flight route display **300** may further include a current time indicator **312** showing the current time of the display.

According to embodiments, the flight route display **300** may also include temporally based weather symbology displayed by the weather symbology display module **102** on the display unit **108**. For example, as shown in Figure **3**, the weather symbology display module **102** may display a weather pictogram **200A** associated with the departure airport **304**, a weather pictogram **200B** associated with the destination airport, a weather pictogram **200C** associated with alternate airport **308**, as well as any number of weather pictograms **200D-200G** associated with airports or ground stations along the flight route **302**. Each of the weather pictograms **200A-200G** indicates the past, current, and future weather conditions of the associated geographic location as of the current time of the flight route display **300**, as determined by the weather symbology display module **102** from the current/forecast weather information **104** and the archived weather information **106**. In a further embodiment,

the temporally based weather symbology may be displayed by the weather symbology display module **102** in addition to traditional weather indicators, such as the wind barb shown at **314**, at some or all of the associated geographic locations.

Figures **4A** and **4B** show another example of a flight route display **400** that allows the flight crew of the aircraft or other user to modify the temporal context of the display and project the flight route and associated temporally based weather symbology into the future. The flight route display **400** includes a timeline user-interface (“UI”) control **402** and associated slider UI control **404**. The timeline UI control **402** may correspond to the time of flight along the flight route **302** shown in the flight route display **400**. The user may use the associated slider UI control **404** to change the temporal context of the flight route display **400**. The flight route display **400** may further include a projected time indicator **406** indicating the position of the slider UI control **404** along the timeline UI control **402** relative to the current time of the flight route display **400**, as indicated by the current time indicator **312**. The flight route display **400** also includes the current position indicator **310** indicating the position of the aircraft at the current time of the flight route display, as well as a projected position indicator **408** indicating the estimated position of the aircraft at the projected time.

According to embodiments, the weather symbology display module **102** displays the weather pictograms **200A-200G** on the flight route display **400** to indicate the past, current, and future weather conditions at the associated geographic locations as of the projected time, as determined from the current/forecast weather information **104** and the archived weather information **106**. For example, as shown in Figure **4A**, the slider UI control **404** has been positioned along the timeline UI control **402** such that the temporal context of the flight route display **400** is one hour and **54** minutes into the future, as indicated by the projected time indicator **406**. Accordingly, the projected position indicator **408** indicates the estimated position of the aircraft along the flight route **302** at **13:54** UDT, and each of the weather pictograms **200A-200G** indicates the past, current, and future weather conditions at the associated geographic locations as of **13:54** UDT.

Similarly, as shown in Figure **4B**, the slider UI control **404** has been positioned such that the temporal context of the flight route display **400** is two hours and **41** minutes

in the future. The projected position indicator **408** shows the estimated position of the aircraft along the flight route **302** as of **14:41** UDT, and the weather pictograms **200A-200G** indicate the past, current, and future weather conditions at the associated geographic locations as of **14:41** UDT. In one embodiment, the weather symbology display module **102** parses and interprets the METAR reports, SPECI reports, TAFs, SIGMET advisories, PIREPs, and/or other textual weather information comprising the current/forecast weather information **104** and the archived weather information **106** to determine color-coding or shading of each graphical element **204**, **206**, and **208** of the weather pictograms **200A-200G** shown on the flight route display **400** as of the projected time.

It will be appreciated that the temporally based weather symbology displayed by the weather symbology display module **102** may include pictograms and/or graphical elements in other configurations beyond those shown in Figures 2-4B. For example, the temporally based weather symbology may include weather pictograms comprising horizontal or vertical bars consisting of three graphical elements, each corresponding to current, future, and past weather conditions at the geographic location associated with the position of the bar in the display. It is intended that this disclosure include all such pictograms and/or graphical elements.

In a further embodiment, the user may be able to select one of the weather pictograms **200A-200G** shown on the graphical map display, such as the flight route display **300**, **400**, using a movable cursor, stylus, touchscreen, or other input device in order to view the textual weather information, such as the METAR reports, SPECI reports, or TAFs, utilized by the weather symbology display module **102** to generate the selected weather pictogram. It will be further appreciated that the temporally based weather symbology may be displayed by the weather symbology display module **102** in conjunction with other graphical map displays shown on the display unit **108**, such as a NAV display or a moving map display commonly found on modern aircraft cockpit displays, for example.

Turn now to Figure 5, additional details will be provided regarding embodiments presented herein for integrating geo-spatially enabled and time-encoded textual weather information into a graphical map display. It should be appreciated that the logical operations described herein are implemented (1) as a sequence of computer

implemented acts or program modules running on a computing system and/or (2) as interconnected machine logic circuits or circuit modules within the computing system. The implementation is a matter of choice dependent on the performance and other operating parameters of the computing system. Accordingly, the logical operations described herein are referred to variously as operations, structural devices, acts, or modules. These operations, structural devices, acts, and modules may be implemented in software, in firmware, hardware, in special purpose digital logic, and any combination thereof. It should also be appreciated that more or fewer operations may be performed than shown in the figures and described herein. These operations may also be performed in parallel, or in a different order than those described herein.

Figure 5 shows a routine 500 for displaying temporally based weather symbology on a graphical map. For example, the routine 500 may be utilized to display the weather pictograms 200A-200G in conjunction with a flight route display 300, 400 shown on a display unit 108, as described above in regard to Figures 3-4B. In one embodiment, the routine 500 is performed by the weather symbology display module 102 described above in regard to Figure 1. It will be appreciated that the routine 500 may also be performed by another module or component of the weather symbology display system 100, or by any combination of modules and components.

The routine 500 begins at operation 502, where the weather symbology display module 102 receives geo-spatially enabled and time-encoded current/forecast weather information 104. For example, the weather symbology display module 102 may receive METAR reports, SPECI reports, TAFs, SIGMET advisories, PIREPs, and/or other textual weather information regarding the departure airport, the destination airport, and/or other airports or ground stations along a current flight route of the aircraft. The current/forecast weather information 104 may be received via ACARS, a satellite feed, another datalink, or any combination thereof. In addition, the weather symbology display module 102 may store the received current/forecast weather information 104 in a datastore as archived weather information 106, as further described above and regarded Figure 1. It will be appreciated that, in situations where the flight route display 300, 400 is being utilized in conjunction with pre-flight planning and not en route, the current flight route may represent a currently selected or assigned primary route for the aircraft.

From operation **502**, the routine **500** proceeds to operation **504**, where the weather symbology display module **102** determines the temporal context of the graphical map display as well as other display parameters. For example, the weather symbology display module **102** may determine the current time and/or projected time of the flight route display **300, 400** as well as the zoom level of the display, the scope of the display, geographic locations of airports or other ground stations shown in the display, and the like. In addition, the weather symbology display module **102** may further determine a currently selected color-coding or shading scheme selected for the display of the weather symbology, as indicated by pilot inputs **112**, default configuration settings, airline or regional aviation authority requirements, or the like.

The routine **500** proceeds from operation **504** to operation **506**, where the weather symbology display module **102** parses and interprets the received textual current/forecast weather information **104** within the temporal context of the graphical map display. For example, the weather symbology display module **102** may parse the past, current, and forecast weather reports for the geographic locations of interest shown in the graphical map display as of the current time or projected time from the METAR reports, SPECI reports, TAFs, SIGMET advisories, PIREPs, and/or other textual weather information comprising the current/forecast weather information **104** and archived weather information **106**.

The parsed weather reports may then be interpreted in the context of the selected color-coding, shading, or styling scheme to determine the category or other indicator of relevant weather condition for the graphical elements **204, 206, 208** of each weather pictogram **200** to display. For example, in order to generate a weather pictogram **200** corresponding to FAA flight rules at Chicago-O'Hare airport at **12:00** UDT on the ninth day of the month, the weather symbology display module **102** may determine the color-coding or shading for the first graphical element **204** of the pictogram (current conditions) from the highlighted portions of the SPECI report shown above in Table 2, the color-coding or shading for the second graphical element **206** of the pictogram (future conditions) from the highlighted portions of the TAF shown above in Table 3, and the color-coding or shading for the third graphical element **208** of the pictogram (past conditions) from the highlighted portions of the METAR report shown in Table1.

From operation **506**, the routine **500** proceeds to operation **508**, where the weather symbology display module **102** displays the weather pictograms **200** on the graphical map display shown on the display unit **108**. For example, the weather symbology display module **102** may display weather pictograms **200A-200G** at locations in the flight route display **300**, **400** corresponding to the geographic location of the airports or other ground stations shown in the display in the manner described above in regard to Figures 3-4B. From operation **508**, the routine **500** ends. It will be appreciated that as the temporal context or other parameters of the graphical map display change, such as the current or projected time, the zoom level, and/or the scope of the display (as in the NAV display or moving map display of an aircraft en route), the weather symbology display module **102** may repeat the routine **500** to update the displayed temporally based weather symbology from the latest received current/forecast weather information **104**.

Figure 6 shows an illustrative computer **600** capable of executing the software components described herein for integrating geo-spatially enabled and time-encoded textual weather information into graphical map displays, in the manner presented above. The computer **600** may be embodied in single computing device or in a combination of one or more processing units, storage units, and/or other computing devices implemented in the avionics systems of an aircraft, in ground-based computer systems, or a combination of the two. The computer **600** includes one or more central processing units **602** ("CPUs"), a system memory **608**, including a random access memory **614** ("RAM") and a read-only memory **616** ("ROM"), and a system bus **604** that couples the memory to the CPUs **602**.

The CPUs **602** may be standard programmable processors that perform arithmetic and logical operations necessary for the operation of the computer **600**. The CPUs **602** may perform the necessary operations by transitioning from one discrete, physical state to the next through the manipulation of switching elements that differentiate between and change these states. Switching elements may generally include electronic circuits that maintain one of two binary states, such as flip-flops, and electronic circuits that provide an output state based on the logical combination of the states of one or more other switching elements, such as logic gates. These basic switching elements may be combined to create more complex logic circuits,

including registers, adders-subtractors, arithmetic logic units, floating-point units, and the like.

The computer **600** also includes a mass storage device **610**. The mass storage device **610** may be connected to the CPUs **602** through a mass storage controller (not shown) further connected to the bus **604**. The mass storage device **610** and its associated computer-readable media provide non-volatile, non-transitory storage for the computer **600**. The mass storage device **610** may store an FMS, and AOC application, and other avionics systems **618**, as well as specific application modules or other program modules, such as the weather symbology display module **102** described above in regard to Figure 1. The mass storage device **610** may also store data collected or utilized by the various systems and modules, such as the archived weather information **106**.

The computer **600** may store programs and data on the mass storage device **610** by transforming the physical state of the mass storage device to reflect the information being stored. The specific transformation of physical state may depend on various factors, in different implementations of this disclosure. Examples of such factors may include, but are not limited to, the technology used to implement the mass storage device **610**, whether the mass storage device is characterized as primary or secondary storage, and the like. For example, the computer **600** may store information to the mass storage device **610** by issuing instructions through the storage controller to alter the magnetic characteristics of a particular location within a magnetic disk drive device, the reflective or refractive characteristics of a particular location in an optical storage device, or the electrical characteristics of a particular capacitor, transistor, or other discrete component in a solid-state storage device. Other transformations of physical media are possible. The computer **600** may further read information from the mass storage device **610** by detecting the physical states or characteristics of one or more particular locations within the mass storage device.

Although the description of computer-readable media contained herein refers to a mass storage device, such as a hard disk or CD-ROM drive, it should be appreciated by those skilled in the art that computer-readable media can be any available

computer media that can be accessed by the computer **600**. Computer-readable media includes communication media, such as signals, and computer-readable storage media. By way of example, and not limitation, computer-readable storage media includes volatile and non-volatile, removable and non-removable media
5 implemented in any method or technology for the storage of information, such as computer-readable instructions, data structures, program modules, or other data. For example, computer-readable storage media includes, but is not limited to, RAM, ROM, EPROM, EEPROM, flash memory or other solid state memory technology, CD-ROM, digital versatile disks (“DVD”), HD-DVD, BLU-RAY, or other optical
10 storage, magnetic cassettes, magnetic tape, magnetic disk storage or other magnetic storage devices, or any other medium which can be used to store the desired information in a non-transitory fashion and which can be accessed by the computer **600**. According to one embodiment, the computer **600** may have access to computer-readable storage media storing computer-executable instructions that, when executed
15 by the computer, perform the routine **500** for displaying temporally based weather symbology on a graphical map display, as described above in regard to Figure 5.

According to various embodiments, the computer **600** may operate in a networked environment using logical connections to other avionics in the aircraft through a network, such as the network **620**. The computer **600** may connect to the
20 network **620** through a network interface unit **606** connected to the bus **604**. It should be appreciated that the network interface unit **606** may also be utilized to connect to other types of networks and remote computer systems. The computer **600** may also include an input/output controller **612** for providing output to aircraft terminals and displays, such as the display unit **108** described above in regard to
25 Figure 1. Similarly, the input/output controller **612** may provide output to other displays, such as a computer monitor, a printer, or other type of output device. The input/output controller **612** may further receive input from devices, such as an MCDU, an EFIS control panel, a DSP, a keyboard, mouse, electronic stylus, or touch screen associated with the display unit **108**, and the like. It will be further
30 appreciated that the computer **600** may not include all of the components shown in Figure 6, may include other components that are not explicitly shown in Figure 6, or may utilize an architecture completely different than that shown in Figure 6.

Based on the foregoing, it should be appreciated that technologies for integrating geo-spatially enabled and time-encoded textual weather information into a graphical map display are provided herein. Although the subject matter presented herein has been described in language specific to computer structural features, methodological acts, and
5 computer-readable media, it is to be understood that the invention defined in the appended claims is not necessarily limited to the specific features, acts, or media described herein. Rather, the specific features, acts, and mediums are disclosed as example forms of implementing the claims.

While specific embodiments have been described and illustrated, such embodiments
10 should be considered illustrative only and not as limiting the invention as defined by the accompanying claims.

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A non-transitory computer-readable storage medium comprising computer-executable instructions that, when executed by a computer, cause the computer to:

receive weather information regarding a first geographic location and a second geographic location along a flight route;

receive a selection of a projected time of flight via a timeline user-interface control, the projected time of flight corresponding to a time at which an aircraft is flying the flight route and is not positioned at the first geographic location or the second geographic location;

parse and interpret the received weather information to determine weather conditions at the first geographic location and the second geographic location at the projected time of flight selected via the timeline user-interface control; and

display a first weather pictogram at a position on the graphical map display corresponding to the first geographic location and a second weather pictogram at a position on the graphical map display corresponding to the second geographic location, wherein the first weather pictogram comprises a first graphical element depicting past weather conditions at the first geographic location at the projected time of flight, a second graphical element adjacent to and abutting the first graphical element and depicting current weather conditions at the first geographic location at the projected time of flight, and a third graphical element adjacent to and abutting the second graphical element and depicting forecasted future weather conditions at the first geographic location at the projected time of flight.

2. The non-transitory computer-readable storage medium of claim 1, wherein the first graphical element indicates the current weather conditions through a color-coding or shading associated with the current weather conditions, the second graphical element indicates the current weather conditions through a color-coding or shading associated with the future weather conditions, and the third graphical element indicates the past weather conditions through a color-coding or shading associated with the past weather conditions.
3. The non-transitory computer-readable storage medium of claim 2, wherein the color-coding or shading associated with the current weather conditions, the future weather conditions, and the past weather conditions indicates flight rules in effect at the geographic location based on the current weather conditions, the future weather conditions, and the past weather conditions respectively.
4. The non-transitory computer-readable storage medium of claim 1, wherein the weather information comprises a plurality of Meteorological Terminal Aviation Routine Weather Reports (METAR reports), unscheduled reports taken when certain criteria have been met (SPECI reports), terminal area forecasts ("TAFs"), significant meteorological information ("SIGMET") advisories, or pilot reports ("PIREPs") regarding the geographic location.
5. The non-transitory computer-readable storage medium of claim 1, wherein the weather information is received via a Aircraft Communications Addressing and Reporting System ("ACARS").
6. The non-transitory computer-readable storage medium of claim 1, wherein each weather pictogram is displayed in conjunction with a flight route display.
7. A system for integrating weather information into a graphical map display of an aircraft, the system comprising:

a display unit in a cockpit of the aircraft;

a memory for storing a program containing computer-executable instructions for displaying weather symbology on the display unit; and

a processing unit functionally coupled to the memory and the display unit, the processing unit being responsive to the computer-executable instructions and configured to:

receive weather information regarding a geographic location;

receive a request for weather conditions at the geographic location according to a first selected point-in-time of a plurality of points-in-time associated with a position of the aircraft within a flight route, the first selected point-in-time corresponding to a time at which the aircraft is flying the flight route and is not positioned at the geographic location;

determine a temporal context of the graphical map display, the temporal context comprising the first selected point-in-time;

parse and interpret the received weather information to determine weather conditions at the geographic location based upon the temporal context of the graphical map display according to the first selected point-in-time;

display a weather pictogram at a position on the graphical map display corresponding to the geographic location, wherein the weather pictogram relates the weather conditions at the geographic location within the temporal context of the graphical map display according to the first selected point-in-time and comprises a first graphical element depicting past weather conditions at the geographic location at the first selected point-in-time, a second graphical element adjacent to and abutting the first graphical element and depicting

current weather conditions at the geographic location at the first selected point-in-time, and a third graphical element adjacent to and abutting the second graphical element and depicting forecasted future weather conditions at the geographic location at the first selected point-in-time;

receive a request for weather conditions at the geographic location according to a second selected point-in-time of the plurality of points-in-time associated with the position of the aircraft within the flight route;

parse and interpret the received weather information to determine weather conditions at the geographic location based upon the temporal context of the graphical map display according to the second selected point-in-time; and

display the weather pictogram at a position on the graphical map display corresponding to the geographic location, wherein the weather pictogram is updated to reflect the weather conditions at the geographic location within the temporal context of the graphical map display according to the second selected point-in-time.

8. The system of claim 7, wherein the first graphical element indicates the current weather conditions through a color-coding or shading associated with the current weather conditions, the second graphical element indicates the current weather conditions through a color-coding or shading associated with the future weather conditions, and the third graphical element indicates the past weather conditions through a color-coding or shading associated with the past weather conditions.
9. The system of claim 8, wherein the color-coding or shading associated with the current weather conditions, the future weather conditions, and the past weather conditions indicates flight rules in effect at the geographic location based on the current weather conditions, the future weather conditions, and the past weather conditions respectively.

10. The system of claim 7, wherein the weather information comprises a plurality of Meteorological Terminal Aviation Routine Weather Reports (METAR reports), unscheduled reports taken when certain criteria have been met (SPECI reports), terminal area forecasts ("TAFs"), significant meteorological information ("SIGMET") advisories, or pilot reports ("PIREPs") regarding the geographic location.
11. The system of claim 7, wherein the weather information is received at the aircraft via Aircraft Communications Addressing and Reporting System ("ACARS").
12. The system of claim 7, wherein the weather pictogram is displayed in conjunction with a flight route display.
13. A computer-implemented method for integrating weather information into a graphical map display, the method comprising performing instructions under the control of one or more computer systems to perform the operations of:

receiving weather information regarding a first geographic location and a second geographic location along a flight route;

receiving a selection of a projected time of flight via a user-interface control, the projected time of flight corresponding to a time at which an aircraft is flying the flight route and is not positioned at the first geographic location or the second geographic location;

parsing and interpreting the received weather information to determine weather conditions at the first geographic location and the second geographic location at a projected time of flight selected via the user-interface control;

determining a position of an aircraft along the flight route at the first time;

displaying the flight route on the graphical map display;

displaying a first representation of the aircraft at a position on the flight route corresponding to a geographic location of the aircraft at the first time;

displaying a first weather pictogram at a position on the graphical map display corresponding to the first geographic location and a second weather pictogram at a position on the graphical map display corresponding to the second geographic location, wherein the first weather pictogram comprises a first graphical element depicting past weather conditions at the first geographic location at the projected time of flight, a second graphical element adjacent to and abutting the first graphical element and depicting current weather conditions at the first geographic location at the projected time of flight, and a third graphical element adjacent to and abutting the second graphical element and depicting forecasted future weather conditions at the first geographic location at the projected time of flight;

receiving a selection of a second time via a timeline the user-interface control;

determining a position of the aircraft along the flight route at the second time;

displaying a second representation of the aircraft at a position on the flight route corresponding to a geographic location of the aircraft at the second time; and

updating the first weather pictogram and the second weather pictogram corresponding to past, current, and forecasted future weather conditions at the first geographic location and the second geographic location at the second time.

14. The method of claim 13, wherein the first graphical element indicates the current weather conditions through a color-coding or shading associated with the current weather

conditions, the second graphical element indicates the current weather conditions through a color-coding or shading associated with the future weather conditions, and the third graphical element indicates the past weather conditions through a color-coding or shading associated with the past weather conditions.

15. The method of claim 14, wherein the color-coding or shading associated with the current weather conditions, the future weather conditions, and the past weather conditions indicates flight rules in effect at the geographic location based on the current weather conditions, the future weather conditions, and the past weather conditions respectively.
16. The method of claim 13, wherein the time-encoded weather reports comprises a plurality of Meteorological Terminal Aviation Routine Weather Reports (METAR reports), unscheduled reports taken when certain criteria have been met (SPECI reports), terminal area forecasts ("TAFs"), significant meteorological information ("SIGMET") advisories, or pilot reports ("PIREPs") regarding the geographic location.
17. The method of claim 13, wherein the time-encoded weather reports are received over Aircraft Communications Addressing and Reporting System (ACARS).

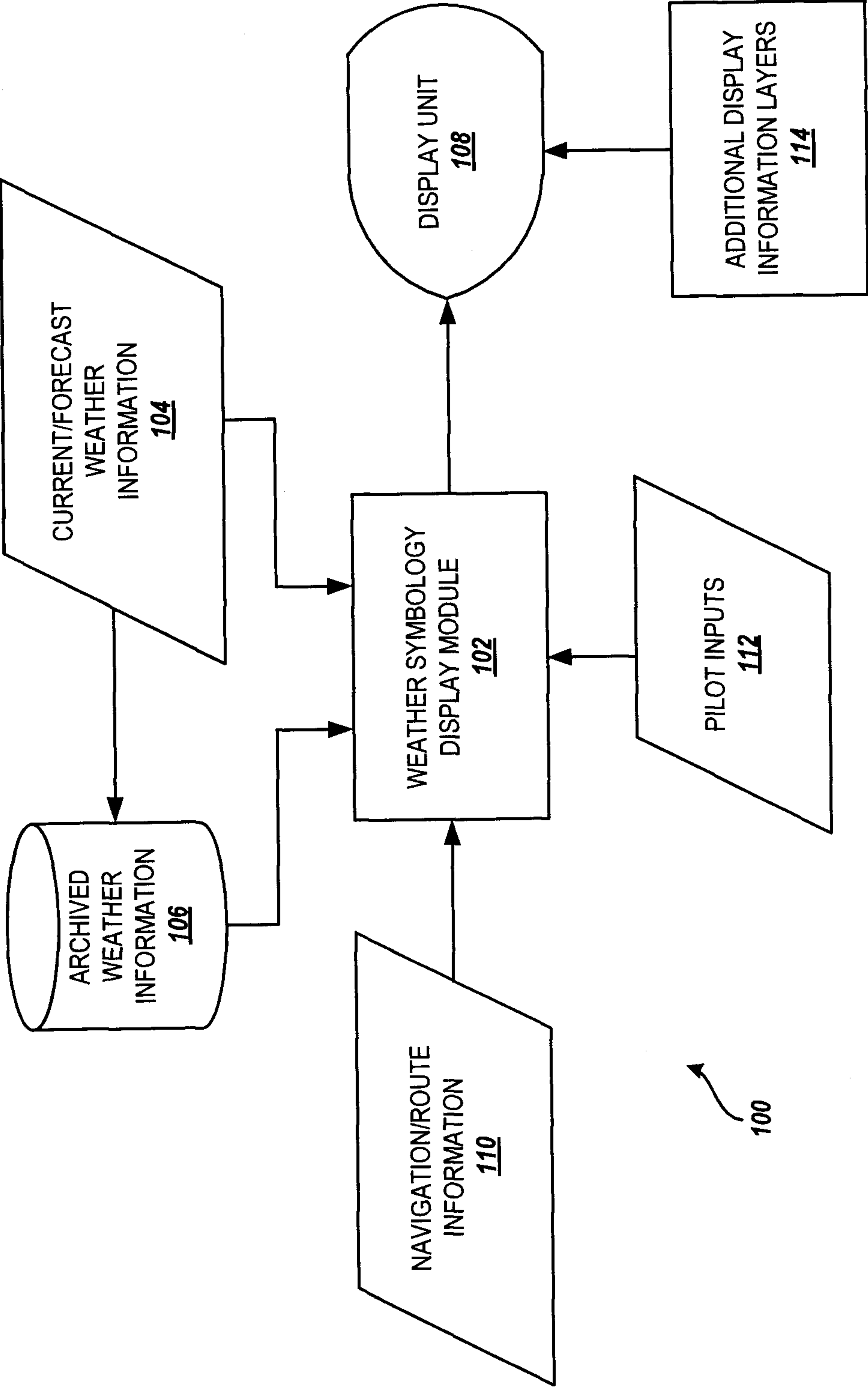
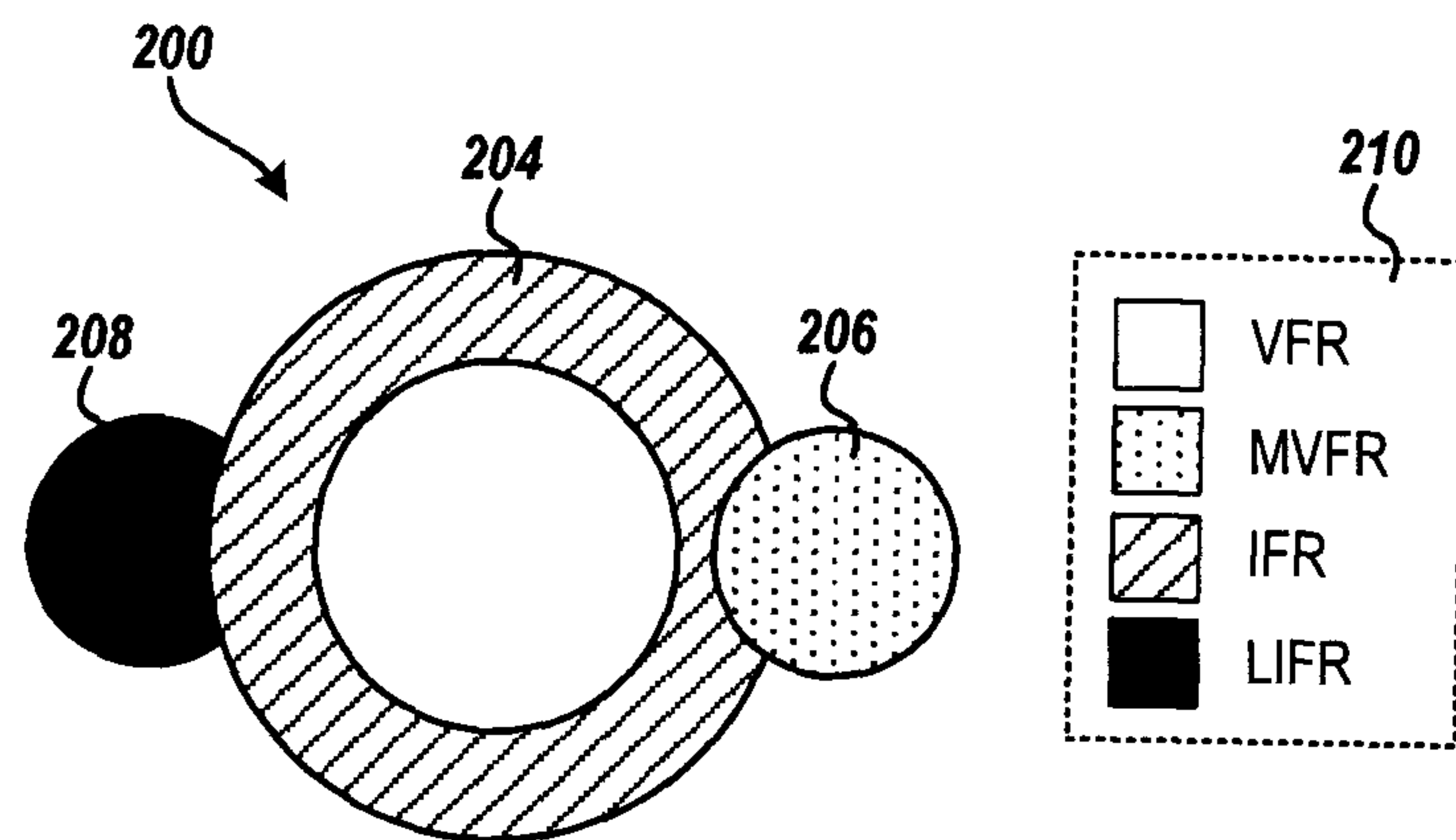
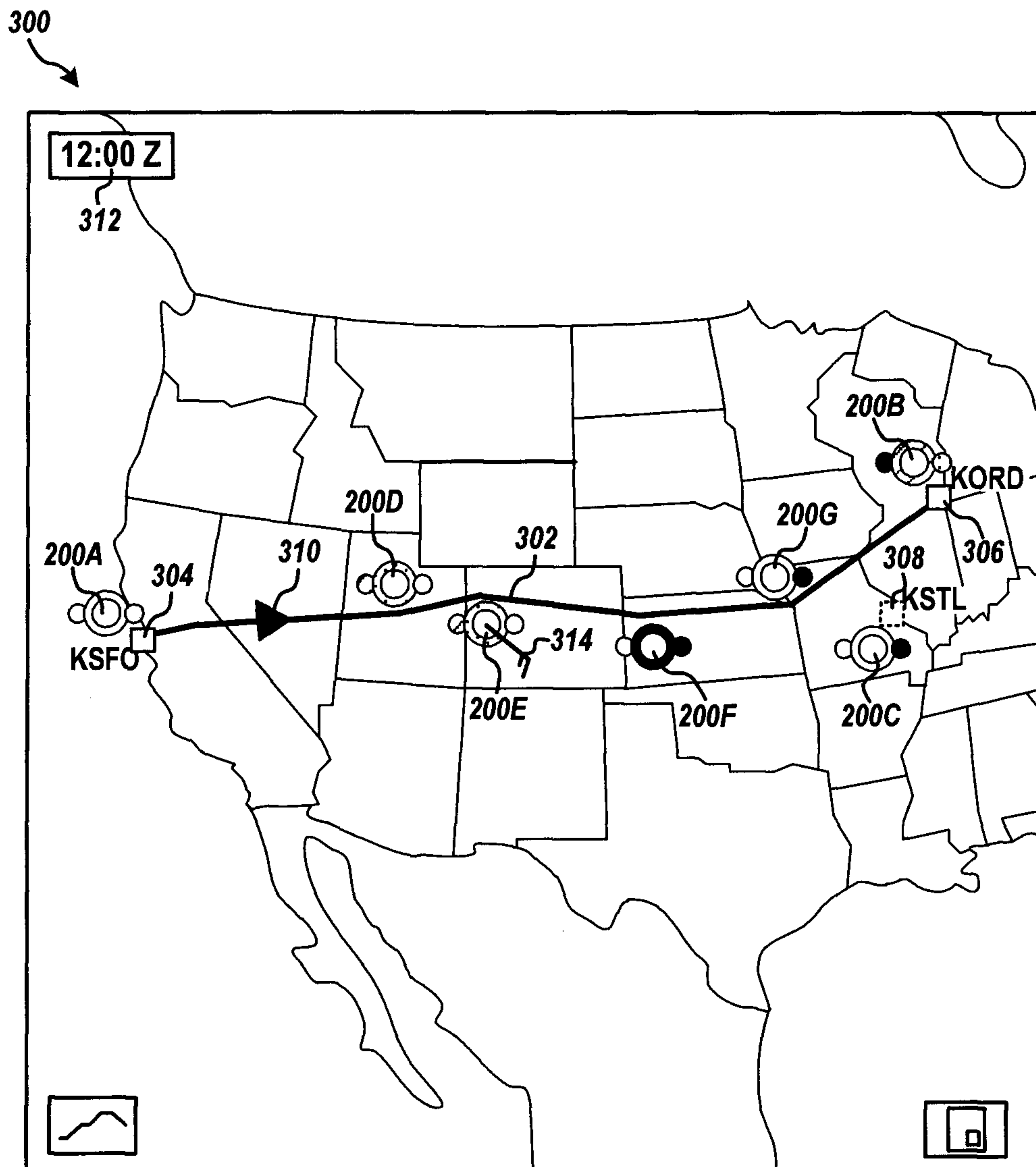


Fig. 1

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**Fig. 2**

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*Fig. 3*

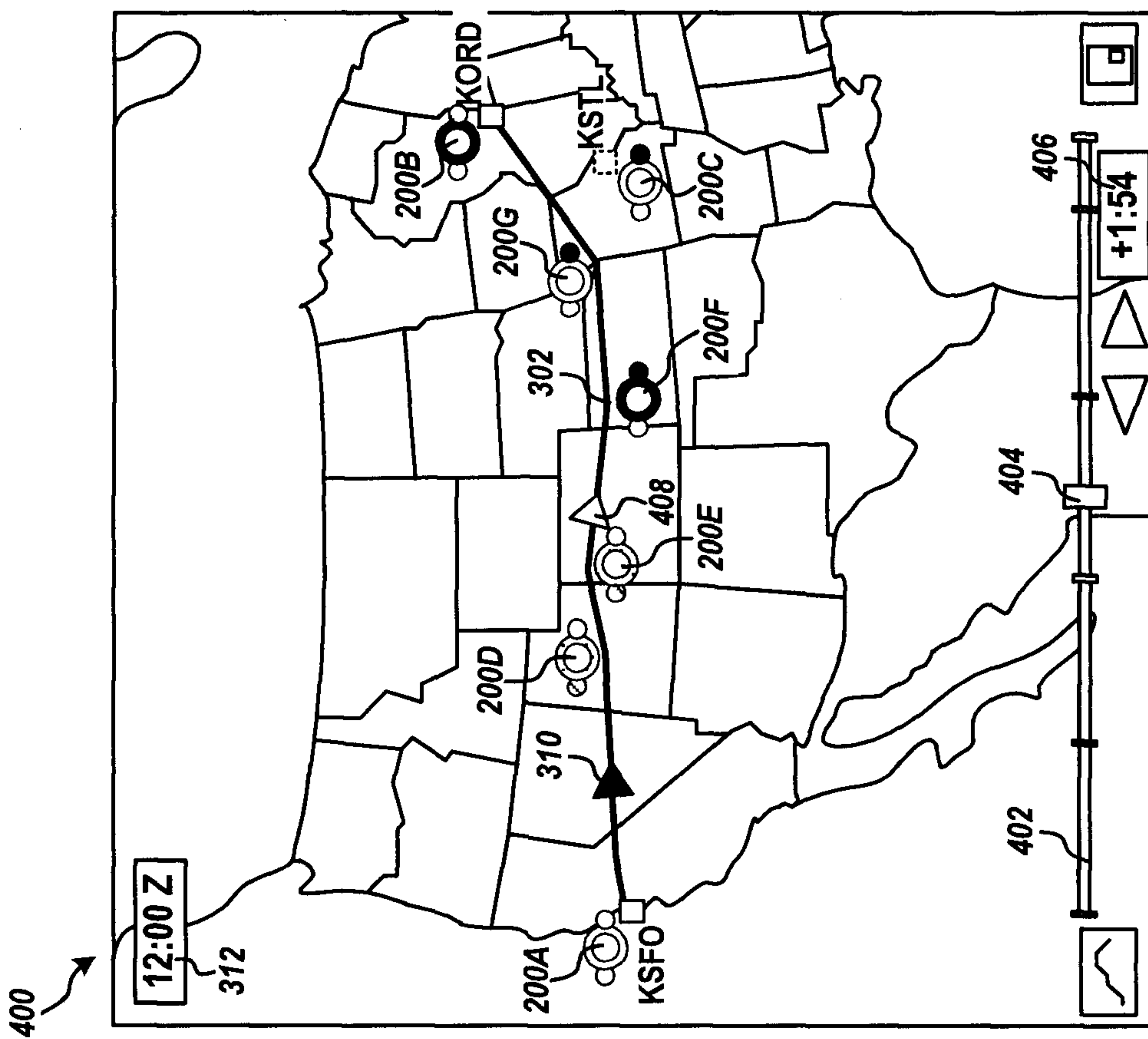


Fig. 4A

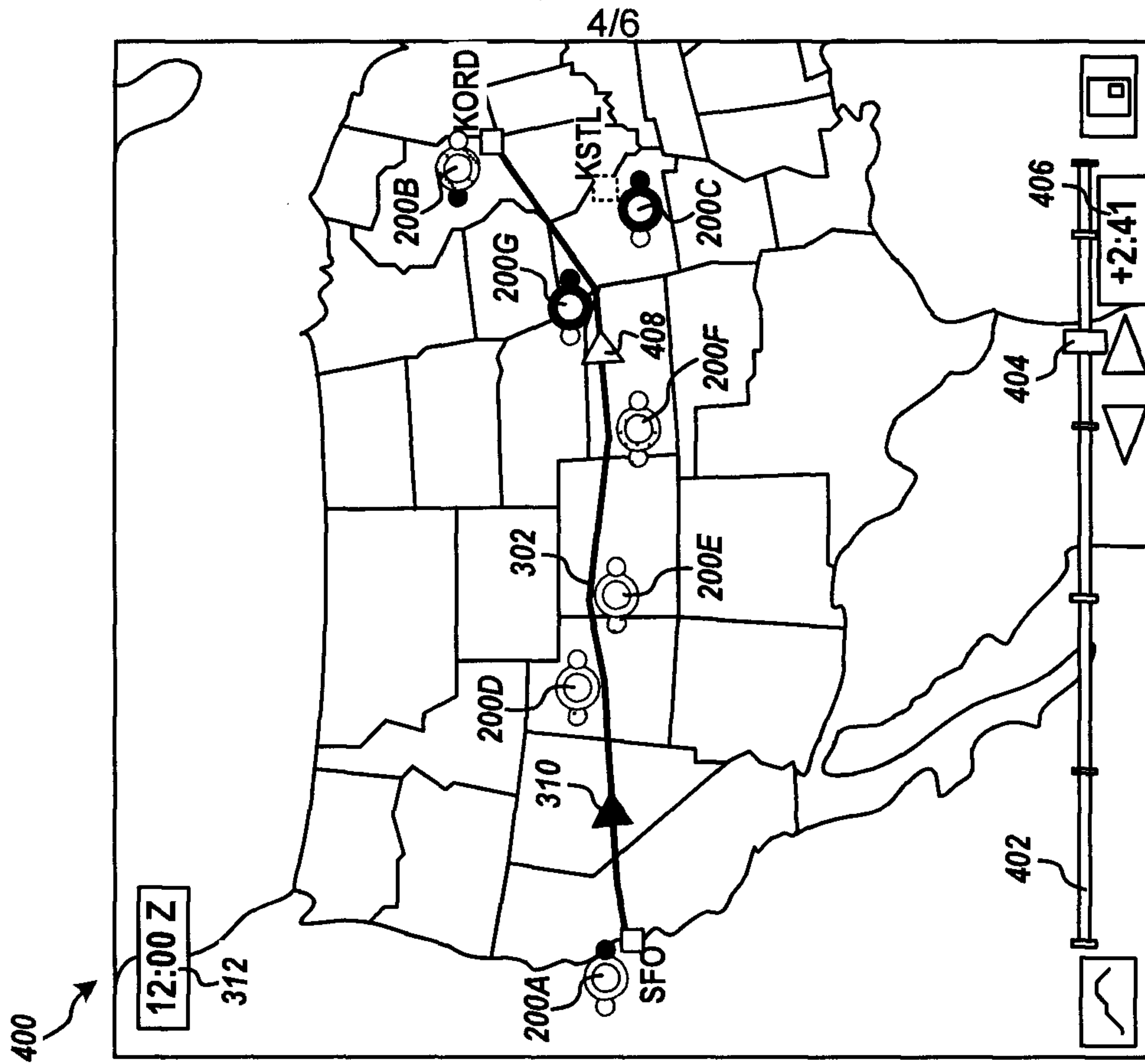
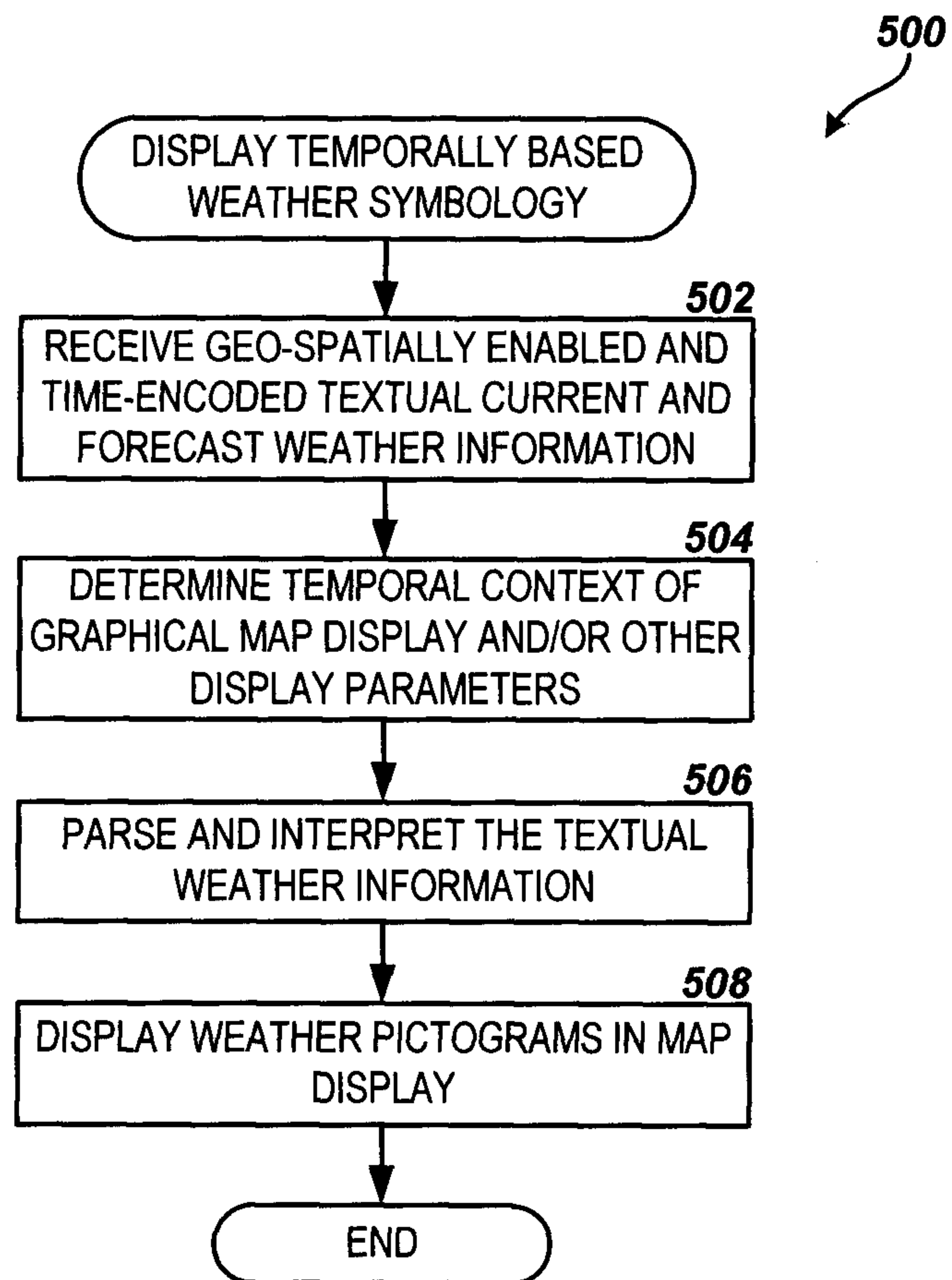


Fig. 4B

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*Fig. 5*

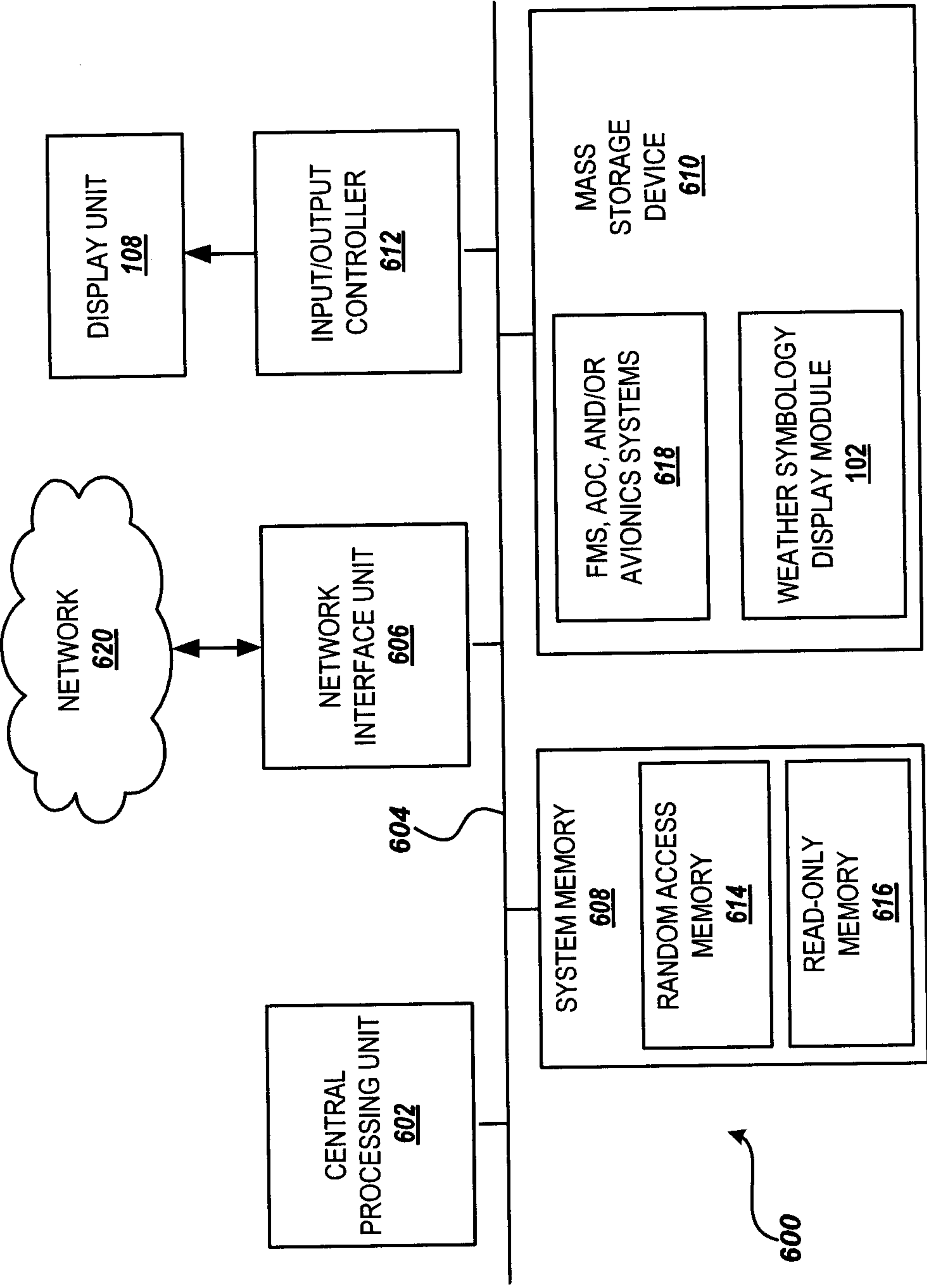


Fig. 6

