PORTABLE GROUND BASED AUGMENTATION SYSTEM

BACKGROUND INFORMATION

1. Field:

The present disclosure relates generally to aircraft and, in particular, to providing navigation information to aircraft. Still more particularly, the present disclosure relates to a method and apparatus for sending navigation information to an aircraft to guide the aircraft to a landing site.

2. Background:

When an aircraft approaches an airport, navigation information may be received from one or more systems to aid in guiding the aircraft. For example, an instrument landing system (ILS), a microwave landing system (MLS), a global positioning satellite (GPS) system, and other types of systems may be used to provide navigation information to the aircraft for use in guiding the aircraft to a runway.

Augmentation systems on the ground at airports provide information that may be used by the aircraft to increase the accuracy of the global navigation satellite system (GNSS) receiver in the aircraft. The satellites transmit signals processed by these augmentation systems.

These types of augmentation systems transmit correction information for measured satellite pseudo-ranges. The corrections are difference-calculated ranges indicated by the satellites and the known fixed positions. These systems are in a reference position that has been very accurately surveyed.

The receiver in the reference position receives a global navigation satellite system (GNSS) signal and uses the expected ranges derived from the known position to calculate ranging corrections. The augmentation system receives pseudo-ranges from receivers and compares that with expected pseudo-ranges

with the difference being an error correction. The process of generating the information is often referred to as augmentation and the error or corrections are also referred to as pseudo-range correction data.

The augmentation system then transmits this pseudo-range correction data to the global navigation satellite system receiver in the aircraft for use in correcting measurements made by the system in the aircraft. This pseudo-range correction data is used by the aircraft to obtain a more accurate location of the aircraft.

Many of these augmentation systems at airports are permanent ground installations with the antennas for receiving signals from the satellites in pre-surveyed locations. In some cases, portability is desired to allow for temporary use at an airport or other location with a runway or landing strip where aircraft may land.

Some augmentation systems that provide pseudo-range correction data are portable and can be moved from one location to another. These currently used portable augmentation systems, however, take an amount of time to set up and become operational that is often longer than desired. The size and complexity of the equipment in the currently used portable augmentation systems causes the time and effort needed to set up the system to be longer than desired. With the complexity of these systems, often times specialized training is needed by human operators to operate and set up currently used portable augmentation systems.

Also, the locations for antennas are identified and set up from surveys of the location made ahead of time. This process is the same as one performed for permanent installations of these systems and also adds to the time needed to set up an augmentation system. As a result, time is needed to perform and obtain a survey for placement of the antennas in the receivers. As a result, setting up currently used portable augmentation

systems does not occur as quickly as desired in many cases. For example, a situation may occur in which an aircraft may be diverted to another location for landing in which an augmentation system is not available. In this situation, pseudo-range correction data for the aircraft may not be available as soon as desired depending on the amount of time available to set up a currently used portable augmentation system before information is needed by the aircraft.

As a result, the portability and ease of setting up and using currently used portable augmentation systems are not as great as desired. Therefore, it would be desirable to have a method and apparatus that takes into account at least some of the issues discussed above, as well as other possible issues.

SUMMARY

In one illustrative embodiment, a portable augmentation system comprises a group of reference receivers and a navigation information generator. The group of reference receivers receives satellite signals and identifies raw pseudo-range data and satellite data parameters from the satellite signals. The raw pseudo-range data and the satellite data parameters form satellite data. The navigation information generator receives the satellite data from the group of reference receivers and identifies a level of accuracy for the group of reference receivers based on the satellite data. Further, the navigation information generator indicates when a group of locations of the group of reference receivers does not meet a desired level of accuracy. Still further, the navigation information generator generates messages using navigation information from the satellite data when the group of reference receivers has the desired level of accuracy.

In another illustrative embodiment, a method of generating navigation information for an aircraft is presented. Satellite signals are received at a group of reference receivers at a group of locations. A level of accuracy is identified for the group of reference receivers based on satellite data formed from the satellite signals. It is indicated when the group of locations of the group of reference receivers does not meet a desired level of accuracy. Messages are generated using the navigation information from the satellite data when the group of reference receivers has the desired level of accuracy.

In yet another illustrative embodiment, an apparatus comprises a group of reference receivers, a transmitter system, and a navigation information generator. The group of reference receivers receives satellite signals and identifies raw pseudo-range data and a group of satellite data parameters in the satellite signals. The raw pseudo-range data and the group of

satellite data parameters form satellite data. The transmitter system transmits messages to an aircraft. The navigation information generator has a satellite data processor that receives the satellite data from the group of reference receivers. The navigation information generator also generates the messages with navigation information from the satellite data and configuration data. The navigation information generator sends the messages to the aircraft over the transmitter system. Further, the navigation information generator includes an operation application that controls operation of the group of reference receivers, the transmitter system, and the navigation information generator. Still further, the navigation information generator includes a configuration application that receives user input to access configuration data used by the satellite data processor to generate the messages. Even further, the navigation information generator includes a configuration database for the configuration data.

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

BRIEF DESCRIPTION OF THE DRAWINGS

The novel features believed characteristic of the illustrative embodiments are set forth in the appended claims. The illustrative embodiments, however, as well as a preferred mode of use, further objectives and features thereof, will best be understood by reference to the following detailed description of an illustrative embodiment of the present disclosure when read in conjunction with the accompanying drawings, wherein:

Figure 1 is an illustration of an aircraft navigation environment in accordance with an illustrative embodiment;

Figure 2 is an illustration of a block diagram of an aircraft navigation environment in accordance with an illustrative embodiment;

Figure 3 is an illustration of a block diagram of a portable augmentation system in accordance with an illustrative embodiment;

Figure 4 is an illustration of a block diagram of a navigation information generator in accordance with an illustrative embodiment;

Figure 5 is an illustration of a data flow for generating messages in accordance with an illustrative embodiment;

Figure 6 is an illustration of a data flow for determining whether a desired level of accuracy has been met for a group of reference receivers in accordance with an illustrative embodiment;

Figure 7 is an illustration of a block diagram of a reference receiver entry in accordance with an illustrative embodiment;

Figure 8 is an illustration of a block diagram of a message definition entry in accordance with an illustrative embodiment;

Figure 9 is an illustration of an aircraft navigation environment in accordance with an illustrative embodiment;

Figure 10 is an illustration of a satellite data processor in accordance with an illustrative embodiment;

Figure 11 is an illustration of a graphical user interface for managing configuration data in accordance with an illustrative embodiment;

Figure 12 is an illustration of a graphical user interface for an operations application of a portable augmentation system in accordance with an illustrative embodiment;

Figure 13 is an illustration of a graphical user interface for an operations application of a portable augmentation system in accordance with an illustrative embodiment;

Figure 14 is an illustration of a flowchart of a process for generating navigation information in a portable augmentation system in accordance with an illustrative embodiment;

Figure 15 is an illustration of a flowchart of a process for sending navigation information from a portable augmentation system in accordance with an illustrative embodiment;

Figure 16 is an illustration of a flowchart of a process for performing a self-survey in accordance with an illustrative embodiment; and

Figure 17 is an illustration of a block diagram of a data processing system in accordance with an illustrative embodiment.

DETAILED DESCRIPTION

The illustrative embodiments recognize and take into account one or more different considerations. For example, the illustrative embodiments recognize and take into account that the design of currently available augmentation systems are not as portable as desired and take more time to set up than desired. For example, currently available systems may be transported using trucks and are not portable by a single human operator.

Also, the illustrative embodiments recognize and take into account that the currently used portable augmentation systems lack a user interface that allows for managing the portable augmentation system. For example, an interface that provides a desired amount of interaction by a human operator to set up and configure the portable augmentation system at the location or in some other location is currently unavailable.

As another example, the illustrative embodiments recognize and take into account that finding positions for the receivers currently involves surveying the location ahead of time to obtain a position that is precise for calculating the pseudo-range correction data. This process is more time consuming than desired.

Thus, the illustrative embodiments provide a method and apparatus for generating navigation information for an aircraft. For example, an apparatus comprises a group of reference receivers at a group of locations that receives satellite signals. The apparatus identifies a level of accuracy for the group of reference receivers based on satellite data formed from the satellite signals. The apparatus then indicates when the group of locations of the group of reference receivers does not meet a desired level of accuracy.

With reference now to the figures, and in particular, with reference to **Figure 1**, an illustration of an aircraft navigation

environment is depicted in accordance with an illustrative embodiment. In this example, aircraft navigation environment **100** comprises aircraft **102**. Aircraft **102** flies over surface of earth **104** and approaches airport **106**.

Aircraft **102** has a global positioning system receiver. The aircraft receives signals **108** from satellites **110**. In this example, satellites **110** include satellite **112**, satellite, **114**, satellite **116**, and satellite **118**.

The global positioning system receiver in aircraft **102** identifies a position of aircraft **102** using signals **108**. The accuracy of the position identified by the reference receiver in aircraft **102** is not as precise as desired in this illustrative example.

In the illustrative example, portable augmentation system **120** generates navigation information that may be used by aircraft **102** to increase the accuracy in identifying the position of aircraft **102**. For example, portable augmentation system **120** identifies pseudo-range correction data from signals **108**. The pseudo-range correction data forms navigation information that is sent to aircraft **102** over signals **122**. The navigation information may include other information used by aircraft **102** to operate at airport **106**. For example, the navigation information may also include at least one of guidance information, runway information, or other suitable navigation information.

As used herein, the phrase "at least one of," when used with a list of items, means different combinations of one or more of the listed items may be used and only one of each item in the list may be needed. In other words, at least one of means any combination of items and number of items may be used from the list but not all of the items in the list are required. The item may be a particular object, thing, or a category.

For example, without limitation, "at least one of item A, item B, or item C" may include item A, item A and item B, or

item B. This example also may include item A, item B, and item C or item B and item C. Of course, any combinations of these items may be present. In other examples, "at least one of" may be, for example, without limitation, two of item A; one of item B; and ten of item C; four of item B and seven of item C; or other suitable combinations.

Aircraft **102** may increase the accuracy in identifying its position by receiving the pseudo-range correction data in the navigation information sent in signals **122** from portable augmentation system **120**. The pseudo-range correction data in the navigation information is used by aircraft **102** to adjust the position that aircraft **102** identified from signals **108** such that the position is identified with increased accuracy. In other words, the pseudo-range correction data in the navigation information sent over signals **122** may be used to "augment" the position identified by aircraft **102**.

In this illustrative example, portable augmentation system **120** has features that overcome technical problems present with other currently used portable augmentation systems that provide navigation information to aircraft **102**. In one illustrative example, portable augmentation system **120** has a self-survey mechanism that allows portable augmentation system **120** to be set up and operated without a survey of the area being performed prior to the set up of portable augmentation system **120**. In this manner, the time needed to make portable augmentation system **120** operational is reduced as compared to a portable augmentation system that uses a survey of a location for the portable augmentation system that is performed ahead of time.

Also, in another illustrative example, portable augmentation system **120** has increased ease of use by human operators setting and operating portable augmentation system **120**. A user interface is provided with software modules in an architecture that increase the speed at which portable augmentation system **120** may be set up and operated by a human

operator. With the user interface, changes in the configuration of portable augmentation system **120** may occur at the location of use more quickly and easily.

The illustration of aircraft navigation environment **100** in **Figure 1** is not meant to limit the manner in which other illustrative embodiments may be implemented. For example, the navigation information may be used during other times during the operation of aircraft **102** other than landing at airport **106**. For example, correction information may be transmitted in the navigation information for use by aircraft **102** in following a flight plan while in a cruising phase of flight. As another example, satellites **110** may include other number of satellites, such as 5, 8, 24 or some other number of satellites.

Turning next to **Figure 2**, an illustration of a block diagram of an aircraft navigation environment is depicted in accordance with an illustrative embodiment. Aircraft navigation environment **100** in **Figure 1** is an illustration of one physical implementation of aircraft navigation environment **200** shown in block form in this figure.

As depicted, aircraft **202** has phases of flight **204** while operating in aircraft navigation environment **200**. In this illustrative example, aircraft **202** is in landing phase **206**. In landing phase **206**, aircraft **202** lands at location **208**. Location **208** may be an airport, a runway on a field, an area of land, or some other suitable location.

In this illustrative example, aircraft **202** has receiver **210**. Receiver **210** receives satellite signals **212** from satellites **214** in satellite navigation system **216**.

As depicted, satellites **214** in satellite navigation system **216** send satellite signals **212** that allow receiver **210** to determine position **218** of receiver **210**. Position **218** of receiver **210** is also position **218** of aircraft **102**. Receiver **210** is at least one of a global navigation satellite system

receiver, or other suitable type of receiver that determines position **218** of aircraft **102**.

In the illustrative example, one or more groups of satellites **214** may be part of one or more global navigation satellite systems. These groups may be referred to as constellations. A group of satellites **214** may be a global navigation satellite system (GNSS). The groups of satellites **214** may be part of Global Positioning Satellite (GPS) System, Global Navigation Satellite System (GLONASS), or some other suitable satellite navigation system.

As depicted, receiver **210** identifies position **218** of aircraft **202** from satellite signals **212**. Position **218** is a location of aircraft **202** in three-dimensional space. Position **218** may be described using longitude, latitude, and altitude. In some illustrative examples, position **218** also may include an orientation of aircraft **202**.

In the illustrative example, position **218** identified by receiver **210** may not have a desired level of accuracy. The accuracy of position **218** of aircraft **202** may be increased with navigation information **220** sent to aircraft **202** over signals **222** from portable augmentation system **224**.

Portable augmentation system **224** receives satellite signals **212** from satellites **214** and generates navigation information **220** using satellite signals **212**. In particular, portable augmentation system **224** generates pseudo-range correction data **232** and sends this information in navigation information **220** to aircraft **202** over signals **222**.

Aircraft **202** uses pseudo-range correction data **232** to correct pseudo-range data **234** identified by receiver **210** in aircraft **202**. The correction results in identifying position **218** with a higher level of accuracy than without pseudo-range correction data **232**. This type of correction may be referred to as an augmentation to pseudo-range data **234**.

In the illustrative example, portable augmentation system **224** may be moved from a first location to a second location and set up more quickly as compared to other portable augmentation systems. With greater accuracy, increased safety and efficiency is present for operating aircraft. For example, increased accuracy allows for reduced separation distances between aircraft. In other words, more aircraft may operate the same airspace with a desired level of safety.

With reference next to **Figure 3**, an illustration of a block diagram of a portable augmentation system is depicted in accordance with an illustrative embodiment. In this illustrative example, components that may be found in portable augmentation system **224** are shown. As depicted, portable augmentation system **224** includes receiver system **300**, transmitter system **302**, and navigation information generator **304**.

Receiver system **300** includes a group of reference receivers **308**. The group of reference receivers **308** may be implemented using any hardware, software, or combination thereof that receives satellite signals **212** from satellites **214** and processes satellite signals **212**.

As depicted, the group of reference receivers **308** may receive more than one frequency per satellite in satellites **214**. Also, the group of reference receivers **308** may be configured to receive satellite signals **212** from a plurality of constellations of satellites **214**.

A constellation of satellites **214** is a group of satellites working in concert. Such a constellation may be considered to be a plurality of satellites with coordinated ground coverage, operating together under shared control, and synchronized so that they overlap well in coverage and complement rather than interfere with the coverage of other satellites. For example, groups of satellites **214** such as Global Positioning Satellite (GPS) System, Global Navigation Satellite System (GLONASS), or

other suitable satellite navigation systems are examples of constellations.

As used herein, a "group of," when used with reference to items means one or more items. For example, a group of reference receivers **308** means one or more reference receivers.

In this illustrative example, the group of reference receivers **308** receives satellite signals **212**. The group of reference receivers **308** identifies pseudo-range data **310** and a group of satellite data parameters **318** from satellite signals **212** received by the group of reference receivers **308**. Satellite data parameters **318** include at least one of satellite identification, satellite clock correction coefficients data, satellite position data, carrier waves, ranging codes, atmospheric error data, or other suitable types of data from a satellite for determining position information from satellite signals.

In this example, pseudo-range data **310** is raw pseudo-range data **312**. Raw pseudo-range data **312** is data about pseudo-ranges identified from satellite signals **212** without including any corrections or changes.

Raw pseudo-range data **312** and the group of satellite data parameters **318** form satellite data **320** in this example. The group of reference receivers **308** send the satellite data to navigation information generator **304**.

Based on raw pseudo-range data **312** and known position **314** of portable augmentation system **224**, portable augmentation system **224** generates pseudo-range correction data **232** using satellite data **320** to form navigation information **220**. In the illustrative example, navigation information generator **304** sends navigation information **220** in messages **322** over signals **222** to aircraft **202** over transmitter system **302**. Signals **222** are radio frequency (RF) signals in this illustrative example.

As depicted, the accuracy of pseudo-range correction data **232** depends on the accuracy of known position **314** for the group

of reference receivers **308**. In these illustrative examples, known position **314** is currently based on performing a survey of the site where portable augmentation system **224** is to be set up. The survey includes human operators surveying a reference point such as that on a runway.

Then, an identification of the position for each reference receiver is made. All of the data collected during the surveys is then processed and entered into a data structure for use by portable augmentation system **224**. The data structure may be selected from one of a file, a linked list, a table, a database, or some other suitable data structure.

With currently used augmentation systems, placing the group of reference receivers **308** in precise locations identified for these devices is important to obtaining desired level of accuracy **350** for pseudo-range correction data **232**. An incorrect placement may result in an inability to obtain desired level of accuracy **350** for pseudo-range correction data **232**.

In the illustrative example, the amount of time needed to set up portable augmentation system **224** is reduced as compared to currently available portable augmentation systems. In particular, the time needed to perform a survey of a site may be avoided or reduced in the illustrative example.

Navigation information generator **304** allows an identification of level of accuracy **352** of pseudo-range correction data **232** to be made prior to operating portable augmentation system **224**. Navigation information generator **304** performs self-survey **354** to determine whether level of accuracy **324** for pseudo-range correction data **232** has desired level of accuracy **328**. This determination is based on whether level of accuracy **324** has desired level of accuracy **328**. For example, navigation information generator **304** receives satellite data **320** from the group of reference receivers **308** and identifies level of accuracy **324** for the group of reference receivers **308** based on satellite data **320**.

Navigation information generator **304** generates indicator **355** identifying whether group of locations **326** of the group of reference receivers **308** meet desired level of accuracy **328**. With an indication in indicator **355** that group of locations **326** of the group of reference receivers **308** does not meet desired level of accuracy **328**, one or more of the group of reference receivers **308** may be moved to new locations **342** or removed from the group of reference receivers **308**.

In an illustrative example, self-survey **354** may be performed when no prior survey for group of locations **326** is present. In this manner, the time and planning needed to perform surveys prior to deploying portable augmentation system **224** may be avoided.

Additionally, if a survey has been performed ahead of time, self-survey **354** may be performed to determine whether the survey provides a desired level of accuracy. Self-survey **354** may provide a verification of the accuracy of the prior survey.

The prior survey may identify group of locations **326**. One or more of group of locations **326** may not provide a desired level of accuracy for a number of different reasons. For example, the survey may have been accurate in identifying group of locations **326**. As another example, a building, a sound barrier, or some other object may block one or more of the group of reference receivers **308** from receiving satellite signals **212** with a desired level of accuracy.

Thus, self-survey **354** may be used to verify a prior survey. In this manner, self-survey **354** may be used to ensure that a desired level of accuracy is achieved.

Navigation information generator **304** generates messages **322** using navigation information **220** from satellite data **320** when the group of reference receivers **308** have desired level of accuracy **328**. Messages **322** may then be transmitted to aircraft **202** over transmitter system **302**.

In one illustrative example, group of locations **326** is a first group of locations **326**, level of accuracy **324** for the group of reference receivers **308** based on satellite data **320** is first level of accuracy **330** for the first group of locations **326** for the group of reference receivers **308**. In this example, satellite data **320** is first satellite data **332**.

In the example, subsequent to portion **334** of the group of reference receivers **308** being moved to a second group of locations **326** that is different than the first group of locations **326**, navigation information generator **304** identifies second level of accuracy **336** for the group of reference receivers **308** based on a second satellite data **320** identified from satellite signals **212** by the group of reference receivers **308**. In the illustrative examples, second level of accuracy **336** based on the second satellite data **320** may be identified subsequent to portion **334** of the group of reference receivers **308** being one or more of re-powered and re-configured.

As depicted, navigation information generator **304** may be implemented in software, hardware, firmware or a combination thereof. When software is used, the operations performed by navigation information generator **304** may be implemented in program code configured to run on a processor unit. When firmware is used, the operations performed by navigation information generator **304** may be implemented in program code and data and stored in persistent memory to run on a processor unit. When hardware is employed, the hardware may include circuits that operate to perform the operations in navigation information generator **304**.

In the illustrative examples, the hardware may take the form of a circuit system, an integrated circuit, an application specific integrated circuit (ASIC), a programmable logic device, or some other suitable type of hardware configured to perform a number of operations. With a programmable logic device, the device may be configured to perform the number of operations.

The device may be reconfigured at a later time or may be permanently configured to perform the number of operations. Examples of programmable logic devices include, for example, a programmable logic array, a programmable array logic, a field programmable logic array, a field programmable gate array, and other suitable hardware devices. Additionally, the processes may be implemented in organic components integrated with inorganic components and may be comprised entirely of organic components excluding a human being. For example, the processes may be implemented as circuits in organic semiconductors.

In the illustrative example, navigation information generator **304** may be located in computer system **338**. Computer system **338** is one or more computers. When more than one computer is present in computer system **338**, those computers may be in communication with each other through a communications medium such as a network.

Further, increased portability may be provided for portable augmentation system **224** through group of cases **340** that are man portable. Group of cases **340** may hold the group of reference receivers **308**, transmitter system **302** that transmits messages **322** to aircraft **202**, and navigation information generator **304**.

With reference next to **Figure 4**, an illustration of a block diagram of a navigation information generator is depicted in accordance with an illustrative embodiment. In this illustrative example, a number of different components that may be used to implement navigation information generator **304** are shown in this figure. As depicted, navigation information generator **304** includes satellite data processor **400**, operation application **402**, configuration application **404**, and self-surveyor **405**.

As depicted, satellite data processor **400** receives satellite data **320** from the group of reference receivers **308** and generates messages **322** with navigation information **220** from satellite data **320** and configuration data **406**. Message

definitions in configuration data **406** and satellite data **320** are used by satellite data processor **400** to generate messages **322**.

In this illustrative example, configuration data **406** is located in configuration database **414**. Configuration database **414** is located in navigation information generator **304** in this example. Satellite data processor **400** sends messages **322** to aircraft **202** over transmitter system **302**.

As depicted, operation application **402** controls operation of the group of reference receivers **308** in receiver system **300**, transmitter system **302**, and navigation information generator **304**. In the illustrative example, navigation information generator **304** includes user interface **408** that allows human operator **410** to interact with operation application **402**. In the illustrative example, user interface **408** may be graphical user interface **422**. For example, configuration application **404** and operation application **402** display graphical user interface **422** and receive user input **412** through graphical user interface **422**.

In other illustrative examples, the operator may be another device or computer user that interacts with operation application **402** through user interface **408**. In this type of implementation, user interface **408** may be a library of application programming interfaces (APIs) for some other type of interface.

In the illustrative example, configuration application **404** receives user input **412** from human operator **410** to access configuration data **406** used by satellite data processor **400** to generate messages **322**. Configuration data **406** includes values or other information for use in messages **322**. This access may be at least one of reading, writing, or editing configuration data **406**.

Configuration data **406** is included in messages **322** with pseudo-range correction data **232** to form navigation information **220** in this illustrative example. Navigation information **220** may also include at least one of take off information, landing

information, approach information, missed approach information, or other suitable information.

In the illustrative example, self-surveyor **405** in navigation information generator **304** performs self-survey **354**. As depicted, self-surveyor **405** identifies group of locations **326** where the group of reference receivers **308** were placed and indicates whether the group of reference receivers **308** provide desired level of accuracy **328** at group of locations **326**. As a result, a first reference receiver in the group of reference receivers **308** may be placed at a new location that has not been surveyed prior to the first reference receiver being placed at the new location.

In this depicted example, configuration data **406** may also include information for the group of reference receivers **308** in receiver system **300**. Configuration data **406** may be used to set parameters in the group of reference receivers **308** and may include information used to determine if the group of reference receivers **308** have desired level of accuracy **328**. For example, desired level of accuracy **328** may be in configuration data **406**.

Further, in this illustrative example, configuration application **404** is first configuration application **416**. Also, second configuration application **418** is located on computer system **420**. Second configuration application **418** on computer system **420** receives user input **412** at computer system **420** to access configuration data **406** used by satellite data processor **400** to generate messages **322**.

Turning now to **Figure 5**, an illustration of a data flow for generating messages is depicted in accordance with an illustrative embodiment. As depicted, navigation information generator **304** receives satellite data **320** from the group of reference receivers **308**. In this illustrative example, navigation information generator **304** generates navigation information **220** from satellite data **320**.

As depicted, message definitions **502** are used by navigation information generator **304** in this process for generating messages **322**. Message definitions **502** specify formats of navigation information **220** in messages **322**.

In this illustrative example, each message definition in message definitions **502** is for generating a message of a particular type that contains data from navigation information **220**. The formats specified by message definitions **502** identify the data in navigation information **220** that is used to generate messages **322**.

In the illustrative example, navigation information generator **304** generates messages **322** using navigation information **220** in the formats specified by message definitions **502**. For example, a pseudo-range correction message definition in message definitions **502** may specify how pseudo-range correction data **232** from navigation information **220** are placed in messages **322** for aircraft. Message definitions **502** may include at least one of a type 1 message definition with differential corrections for 100 second smoothed pseudo-ranges, a type 2 message definition with portable augmentation system geographic information, a type 4 message definition with approach and landing information, an industry defined message definition, message definitions defined by a human operator of navigation information generator **304**, or other suitable types of message definitions.

Turning next to **Figure 6**, an illustration of a data flow for determining whether a desired level of accuracy has been met for a group of reference receivers is depicted in accordance with an illustrative embodiment. As depicted, reference receiver **604** and reference receiver **608** are examples of reference receivers in the group of reference receivers **308**.

In the illustrated example, self-surveyor **405** receives satellite data **602** from reference receiver **604** and satellite data **606** from reference receiver **608**. Satellite data **602** and

satellite data **606** are examples of satellite data **320** in **Figure 3**. As depicted, satellite data **602** is different than satellite data **606**.

In this illustrative example, self-surveyor **405** identifies location **610** where reference receiver **604** was placed using satellite data **602**. Self-surveyor **405** also identifies level of accuracy **612** of location **610** using satellite data **602**. For example, reference receiver **604** may send location **610** and level of accuracy **612** of location **610** in satellite data **602**.

As depicted, self-surveyor **405** identifies location **614** where reference receiver **608** was placed using satellite data **606**. Self-surveyor **405** also identifies level of accuracy **616** of location **614** using satellite data **606**. For example, reference receiver **608** may send location **614** and level of accuracy **616** of location **614** in satellite data **606**. Location **610** and location **614** are examples of locations in group of locations **326** in **Figure 3**.

In this illustrative example, self-surveyor **405** uses a group of desired levels of accuracy **618** for the group of reference receivers **308** to identify whether level of accuracy **612** and level of accuracy **616** together meet desired level of accuracy **350** for pseudo-range correction data **232**. Desired level of accuracy **620** for reference receiver **604** and desired level of accuracy **622** for reference receiver **608** are examples of desired level of accuracy **328** in **Figure 3**. As depicted, desired level of accuracy **620** may be the same as desired level of accuracy **622**. Desired level of accuracy **620** may be different than desired level of accuracy **622**.

In the illustrated example, self-surveyor **405** determines whether desired level of accuracy **350** has been met for pseudo-range correction data **232** based on a group of rules **624** for the group of desired levels of accuracy **618** for the group of reference receivers **308**. For example, a rule in the group of rules **624** may specify that one or more of the group of receivers

must meet their required level of accuracy in the group of desired levels of accuracy **618** for the group of reference receivers **308**.

As another example, another rule in the group of rules **624** may specify that two or more of the group of reference receivers **308** must meet the required accuracy for the two or more of the group of reference receivers **308**, or some other suitable type of rule. This rule that two or more of the group of reference receivers **308** may be used by self-surveyor **405** when redundancy is required.

As depicted, self-surveyor **405** generates indicator **355** based on the determination as to whether desired level of accuracy **350** has been meet for pseudo-range correction data **232** based on the group of rules **624** for the group of desired levels of accuracy **618** for group of reference receivers **308**. Indicator **355** includes at least one of level of accuracy **612**, level of accuracy **616**, the group of desired levels of accuracy **618**, location **610** for reference receiver **604**, location **614** for reference receiver **608**, the determination as to whether desired level of accuracy **350** has been meet for pseudo-range correction data **232**, or other suitable types of information about desired level of accuracy **350** of pseudo-range correction data **232**.

In this illustrative example, indicator **355** may be presented in a number of different ways. For example, indicator **355** may be selected from at least one of an email, a text message, a popup window with a message, a graphical indicator, a sound, a color, text, flashing graphics, icons, a light on a hardware panel, or in some other suitable manner.

With reference next to **Figure 7**, an illustration of a block diagram of a reference receiver entry is depicted in accordance with an illustrative embodiment. As depicted, reference receiver entry **700** is an example of an entry in configuration database **414** in **Figure 4**. Reference receiver entry **700** includes

information for a reference receiver in the group of reference receivers **308**.

In this illustrative example, reference receiver entry **700** includes a number of different fields. As depicted, reference receiver entry **700** includes reference receiver identifier **702**, desired level of accuracy **704**, and reference receiver parameters **706**.

In the illustrative example, reference receiver identifier **702** identifies a reference receiver in the group of reference receivers **308** in **Figure 3**. Reference receiver identifier **702** is at least one of a serial number, names, alpha numeric text for pointing, or in some other manner to identify a reference receiver. For example, reference receiver identifier **702** may be alphanumeric text.

In this example, reference receiver identifier **702** may be assigned to the reference receiver in the group of reference receivers **308**. Desired level of accuracy **704** is a level of accuracy desired for a reference receiver identified by reference receiver identifier **702** in this illustrative example.

As depicted, reference receiver parameters **706** may be sent to the reference receiver identified by reference receiver identifier **702** to set values for parameters that the reference receiver uses to operate and process satellite signals. Reference receiver parameters **706** include at least one of satellite data rates, satellite data types, or other suitable parameters for specifying operations of the reference receiver identified by reference receiver identifier **702**.

With reference next to **Figure 8**, an illustration of a block diagram of a message definition entry is depicted in accordance with an illustrative embodiment. As depicted, message definition entry **800** is an example of an entry in configuration database **414** in **Figure 4**.

In this illustrative example, message definition entry **800** includes a number of different fields. As depicted, message

definition entry **800** includes message type identifier **802** and message definition **804**.

Message type identifier **802** identifies message definition **804** in this illustrative example. Message type identifier **802** is a type of message in messages **322** in **Figure 3**. Message definition **804** is an example of a message definition in message definitions **502** in **Figure 5**.

For example, message definition **804** may be a type 4 message containing a final approach segment (FAS) data block. In this example, message definition **804** may include parameters for at least one of data set length, operation type, service provider identifier, airport identifier, runway number, runway letter, approach performance designator, route indicator, reference path data selector, reference path identifier, Landing Threshold Point /Fictitious Threshold Point latitude, Landing Threshold Point /Fictitious Threshold Point longitude, Landing Threshold Point /Fictitious Threshold Point height, delta Flight Path Alignment Point latitude, delta Flight Path Alignment Point longitude, approach threshold crossing height, approach Threshold Crossing Height units selector, glide path angle, course width at threshold, delta length offset, final approach segment Cycle Redundancy Check, or other suitable parameters for a Type 4 message definition.

In illustrative example, message definition **804** may include parameters for at least one of time of validity, additional message flag, number of measurements, measurement type, low frequency correction information, ephemeris decorrelation parameter, ranging source ephemeris cycle redundancy check, ranging source availability duration information and the ranging source data for multiple measurement blocks including ranging source identifier, issue of data, pseudo-range correction, range rate correction, statistical bound of the signal in space errors, estimates of the error resulting from specific reference

receiver measurements on the pseudo-range corrections, or other suitable parameters for a Type 1 message definition.

Turning now to **Figure 9**, an illustration of an aircraft navigation environment is depicted in accordance with an illustrative embodiment. In **Figure 9**, an example of an implementation for components in aircraft navigation environment **200** is shown in this figure.

In this illustrative example, satellite **902** and satellite **904** are examples of satellites in group of satellites **214** in **Figure 2**. Satellite **902** and satellite **904** send satellite signals **212** that allow reference receiver **906** and reference receiver **908** to determine the positions of reference receiver **906** and reference receiver **908**.

As depicted, satellite **902** is part of a first constellation of a Global Positioning Satellite System. Satellite **904** is part of a second constellation of a Global Navigation Satellite System in this illustrative example. In the illustrative example, satellite signals **212** include signals sent over a first range of frequencies from satellite **902** and signals sent over a second range of frequencies from satellite **904**.

As depicted, reference receiver **906** receives satellite signals **212** through a group of antennas **910** and reference receiver **908** receives satellite signals **212** through a group of antennas **912**. Each antenna in the group of antennas **910** and the group of antennas **912** is designed to receive one or more portions of satellite signals **212**. In this illustrative example, each antenna in the group of antennas **910** and the group of antennas **912** is located on at least one of a tripod, a reference receiver, a parked vehicle, or some other type of platform for an antenna to receive satellite signals **212**.

In this illustrative example, reference receiver **906** sends satellite data **914** to navigation information generator **304**. Reference receiver **908** sends satellite data **916** to navigation

information generator **304**. Satellite data **914** and satellite data **916** are examples of satellite data **320** in **Figure 3**.

With reference next to **Figure 10**, an illustration of a satellite data processor is depicted in accordance with an illustrative embodiment. In this illustrative example, controller **1002** is an example of an implementation for satellite data processor **400**. In this illustrative example, controller **1002** orchestrates flow of data and messages between other components of satellite data processor **400**.

As depicted, controller **1002** receives control commands **1004** from operation application **402**. Control commands **1004** are for managing components of portable augmentation system **224**. Control commands **1004** include at least one of a command to start processing of satellite signals by the group of reference receivers **308**, a command to start processing of satellite signals by a selected reference receiver in the group of reference receivers **308**, a command to stop processing of satellite signals by the group of reference receivers **308**, a command to stop processing of satellite signals by a selected reference receiver in the group of reference receivers **308**, a command to re-start processing of satellite signals by the group of reference receivers **308**, a command to re-start processing of satellite signals by a selected reference receiver in the group of reference receivers **308**, a command to send reference receiver parameters to a selected reference receiver in the group of reference receivers **308**, and other suitable types of commands for processing by controller **1002**.

For example, controller **1002** retrieves reference receiver parameters **706** from reference receiver entry **700** in configuration data **406** and sends reference receiver parameters **706** to the reference receiver when controller **1002** receives a command to send reference receiver parameters **706** to a reference receiver identified by reference receiver identifier **702**. As another example, controller **1002** starts processing of satellite

signals by the group of reference receivers **308** by at least one of powering up the group of reference receivers **308** or sending a group of start commands to the group of reference receivers **308** when controller **1002** receives a command to start processing satellite signals by the group of reference receivers **308**.

As depicted, data processor **1006** is a component in satellite data processor **400** that receives satellite data **320** from the group of reference receivers **308**. In this illustrative example, data processor **1006** uses a group of data descriptors **1008** to parse satellite data **320**. Each data descriptor in the group of data descriptors **1008** may be unique to a provider of a reference receiver in the group of reference receivers **308**.

As depicted, data descriptors **1008** specify how to retrieve portions of navigation information **220** from satellite data **320**. The group of data descriptors **1008** can be modified by a human operator through operation application **402**. The group of data descriptors **1008** may be stored in configuration data **406**.

In this illustrative example, data processor **1006** uses time information embedded in satellite data **320** to add time stamps to portions of navigation information **220** retrieved from satellite data **320**. As depicted, data processor **1006** sends satellite data **320** and navigation information **220** to controller **1002** after retrieving navigation information **220** and adding time stamps to portions of navigation information **220**.

As depicted, controller **1002** uses augmentation processor **1010** and navigation information **220** to calculate pseudo-range correction data **232**. For example, augmentation processor **1010** may identify pseudo-range correction data **232**.

In this illustrative example, controller **1002** uses integrity monitor **1012** to generate integrity measurements **1014**. As depicted, integrity measurements **1014** are based on satellite data **320**. For example, integrity measurements **1014** may be used to identify whether an issue exists in satellite data **320** based on uncharacteristic variations in satellite data **320**.

In the illustrative example, controller **1002** uses message builder **1016** to generate messages **322**. As depicted, message builder **1016** generates messages **322** using navigation information **220** in formats specified by message definitions **502**.

As depicted, controller **1002** uses a group of data recorders **1018** to store at least one of satellite data **320**, control commands **1004**, configuration data **406**, indicator **355**, systems health information generated by various components in satellite data processor, or operations performed by components of satellite data processor **400** in storage **1020**. Controller **1002** uses data packager **1022** to store portions of storage **1020** in storage **1024**. For example, data packager **1022** may use a universal serial bus (USB) to access storage **1024** to store a portion of storage **1020** in storage **1024**.

The illustration of aircraft navigation environment **200** and the different components in aircraft navigation environment **200** in **Figures 2-10** is not meant to imply physical or architectural limitations to the manner in which an illustrative embodiment may be implemented. Other components in addition to or in place of the ones illustrated may be used. Some components may be unnecessary. Also, the blocks are presented to illustrate some functional components. One or more of these blocks may be combined, divided, or combined and divided into different blocks when implemented in an illustrative embodiment.

For example, a power supply may be included in navigation information generator **304** or may be a separate component. The power supply is connected to the group of reference receivers **308**, transmitter system **302**, and navigation information generator **304**. As another example, computer system **420** may be at a different location than navigation information generator **304**.

With reference next to **Figure 11**, an illustration of a graphical user interface for managing configuration data is depicted in accordance with an illustrative embodiment. As

depicted, graphical user interface **1102** is an implementation of graphical user interface **422** shown in block form in **Figure 4**. Display **1100** is an example of a display on computer system **420** in **Figure 4** where graphical user interface **1102** is presented.

In this illustrative example, reference receiver **1104** is a window in graphical user interface **1102** used by a human operator to set desired levels of accuracy for reference receivers in the group of reference receivers **308** and to set reference receiver parameters for reference receivers in the group of reference receivers **308**. For example, a human operator may select a reference receiver in the group of reference receivers **308** by entering a reference receiver identifier for the reference receiver in reference receiver identifier **1106**. In this example, a desired level of accuracy for the reference receiver is retrieved from configuration data **406** and shown in desired level of accuracy **1108**. Reference receiver parameters for reference receiver **1104** are retrieved from configuration data **406** and shown in reference receiver parameters **1110**.

Further, in this example, the human operator may set a desired level of accuracy for reference receiver **1104**. For example, the desired level may be set by editing desired level of accuracy **1108** and setting reference receiver parameters **1110** for reference receiver **1104** by editing reference receiver parameters **1110**.

As depicted, save **1114** is a button in graphical user interface **1102** selected by a human operator to store the desired level of accuracy for the reference receiver shown in desired level of accuracy **1108** and the receiver parameters for the reference receiver shown in reference receiver parameters **1110** in configuration data **406**. In this illustrative example, send to receiver **1116** is a button in graphical user interface **1102** selected by a human operator to send the desired level of accuracy for the reference receiver shown in desired level of accuracy **1108** and the receiver parameters for the reference

receiver shown in reference receiver parameters **1110** to the reference receiver.

In this illustrative example, message definition entry **1118** is a window in graphical user interface **1102** used by a human operator to set message definitions used by satellite data processor **400** to generate messages **322**. For example, a human operator may select a message definition in configuration data **406** by entering a message type identifier for the message definition in message type identifier **1120**. In this example, a message definition matching the message type identifier is retrieved from configuration data **406** and shown in message definition **1122**. Further, in this example, the human operator may set the message definition used by satellite data processor **400** to generate messages of the type matching message type identifier **1120** by editing message definition **1122**. As depicted, save **1126** is a button in graphical user interface **1102** selected by a human operator to store the message definition shown in message definition **1122** in configuration data **406**.

With reference next to **Figure 12**, an illustration of a graphical user interface for an operations application of a portable augmentation system is depicted in accordance with an illustrative embodiment. Display **1200** is an example of a display on computer system **420** in **Figure 4** where graphical user interface **1202** is presented. As depicted, graphical user interface **1202** is an implementation of graphical user interface **422** shown in block form in **Figure 4**. In this illustrative example, a group of reference receivers is shown on graphical user interface **1202** as table **1204**. As depicted, table **1204** includes reference receiver identifiers for the group of reference receivers in column **1206**, levels of accuracy for the group of reference receivers in column **1208**, a group of locations of the group of reference receivers in column **1210**, and indications of whether the group of locations of the group of reference receivers meet a desired level of accuracy in

column **1212**. Reference receiver **1214** and reference receiver **1216** in table **1204** are examples of a group of reference receivers **308** shown in **Figure 3**.

As depicted, start all **1218** is a button in graphical user interface **1202** selected by a human operator to send a start command to all reference receivers shown in table **1204**. Stop all **1219** is a button in graphical user interface **1202** selected by a human operator to send a stop command to all reference receivers shown in table **1204**. Reset all **1220** is a button in graphical user interface **1202** selected by a human operator to send a re-start command to all reference receivers shown in table **1204**.

In this illustrative example, start **1222** is a button in graphical user interface **1202** selected by a human operator to send a start command to reference receiver **1214**. Stop **1224** is a button in graphical user interface **1202** selected by a human operator to send a stop command to reference receiver **1214**. Reset **1226** is a button in graphical user interface **1202** selected by a human operator to send a re-start command to reference receiver **1214**. In this illustrative example, start **1228** is a button in graphical user interface **1202** selected by a human operator to send a start command to reference receiver **1216**. Stop **1230** is a button in graphical user interface **1202** selected by a human operator to send a stop command to reference receiver **1216**. Reset **1232** is a button in graphical user interface **1202** selected by a human operator to send a re-start command to reference receiver **1216**.

As depicted, configure **1234** is a button in graphical user interface **1202** selected by a human operator to display graphical user interface **1102** in **Figure 11** to manage configuration for reference receiver **1214**. As also depicted, configure **1236** is a button in graphical user interface **1202** selected by a human operator to display graphical user interface **1102** in **Figure 11** to manage configuration for reference receiver **1216**. In this

illustrative example, switch to map view **1240** is a button in graphical user interface **1202** selected by a human operator to display another type of graphical user interface that shows group of reference receivers **308** on a map.

With reference next to **Figure 13**, an illustration of a graphical user interface for an operations application of a portable augmentation system is depicted in accordance with an illustrative embodiment. Display **1300** is an example of a display on computer system **420** in **Figure 4** where graphical user interface **1302** is presented. As depicted, graphical user interface **1302** is an implementation of graphical user interface **422** shown in block form in **Figure 4**. For example, graphical user interface **1302** may be displayed when switch to map view **1240** is selected in **Figure 12**.

In this illustrative example, map **1304** on graphical user interface **1302** is a representation of an area where portable augmentation system **224** is located. For example, map **1304** may be at least one of a point cloud, a topographic map, a road map, a weather map, or other suitable types of maps for showing obstacles that reduce accuracy of location information derived from satellite signals **212**. As used herein, a point cloud is a set of data points in a coordinate system that represent surface areas.

As depicted, map **1304** includes ground **1306** on which reference receiver **1308**, reference receiver **1310**, and reference receiver **1312** are located. Reference receiver **1308**, reference receiver **1310**, and reference receiver **1312** are examples of reference receivers **308**.

In this illustrative example, map **1304** includes runway **1314**, mountain **1316**, building **1318**, and building **1320**. As depicted, a human operator may use indicator **1322** to determine whether to re-locate the group of reference receivers. Indicator **1322** is an example of indicator **355** in **Figure 3**. In this illustrative example, switch to table view **1324** is a button

in graphical user interface **1302** that displays graphical user interface **1202** in **Figure 12**.

Turning next to **Figure 14**, an illustration of a flowchart of a process for generating navigation information in a portable augmentation system is depicted in accordance with an illustrative embodiment. The process illustrated in **Figure 14** may be implemented in portable augmentation system **224**.

The process begins by receiving satellite signals at a group of reference receivers at a group of locations (operation **1400**). Thereafter, the process identifies raw pseudo-range data and satellite data parameters from the satellite signals (operation **1402**).

Next, the process identifies a level of accuracy for the group of reference receivers based on the satellite data (operation **1404**). The process indicates when the group of locations of the group of reference receivers does not meet a desired level of accuracy (operation **1406**). The process generates messages using navigation information from the satellite data when the group of reference receivers have the desired level of accuracy (operation **1408**), with the process terminating thereafter.

Operations **1400-1408** may be repeated any number of times to process additional satellite signals at the group of reference receivers at the group of locations. Additionally, operations **1400-1408** may be repeated any number of times to process additional satellite signals at the group of reference receivers at a different group of locations for the group of reference receivers.

Turning next to **Figure 15**, an illustration of a flowchart of a process for sending navigation information from a portable augmentation system is depicted in accordance with an illustrative embodiment. The process illustrated in **Figure 15** may be implemented in portable augmentation system **224**.

The process begins by receiving satellite signals at a group of reference receivers at a group of locations (operation **1500**). Thereafter, the process identifies raw pseudo-range data and satellite data parameters from the satellite signals (operation **1502**).

Next, the process identifies a level of accuracy for the group of reference receivers based on the satellite data (operation **1504**). The process then determines whether the identified level of accuracy meets a desired level of accuracy (operation **1506**).

As depicted, if the desired level of accuracy has not been met, the process indicates that the group of locations of the group of reference receivers does not meet the desired level of accuracy (operation **1508**), with the process terminating thereafter. Otherwise, the process generates messages using navigation information from the satellite data (operation **1510**). The process then sends the generated messages to aircraft over a transmitter system using the navigation information (operation **1512**), with the process terminating thereafter. Operations **1500-1512** may be repeated any number of times to process at least one of additional satellite signals at the group of reference receivers at the group of locations or additional satellite signals at the group of reference receivers at a different group of locations for the group of reference receivers.

Turning next to **Figure 16**, an illustration of a flowchart of a process for performing a self-survey is depicted in accordance with an illustrative embodiment. The process illustrated in **Figure 16** may be implemented in portable augmentation system **224**. In particular, the different operations may be performed by self-surveyor **405**.

The process begins by starting a group of reference receivers (operation **1600**). Thereafter, the process receives a

group of locations for a portion of the group of reference receivers from the portion (operation **1602**).

Next, the process receives levels of accuracy for the group of locations from the portion (operation **1604**). The process determines whether the levels of accuracy for the group of locations for the portion meet a group of rules for a group of desired levels of accuracy for the group of reference receivers (operation **1606**).

As depicted, when the group of rules has not been met, the process indicates that the group of locations for the portion of the group of reference receivers does not meet the group of rules for the group of desired levels of accuracy for the group of reference receivers (operation **1608**), with the process returning to operation **1602**. When the indication is made that the group of locations for the portion of the group of reference receivers does not meet the group of rules for the group of desired levels of accuracy for the group of reference receivers, a human operator may use graphical user interface **422** to identify information about the group of reference receivers. Additionally, the human operator may use a device to generate a point cloud of the area where the group of receivers is located for use as map **1304** in **Figure 13**. Otherwise, when the group of rules has been met, the process indicates that the group of locations for the portion of the group of reference receivers meets the group of rules for the group of desired levels of accuracy for the group of reference receivers (operation **1610**), with the process terminating thereafter.

Operations **1602-1610** may be repeated any number of times. For example, operations **1602-1610** may be repeated continuously, or when at least one of a change has occurred to configuration data, a change has occurred to the group of locations for the portion, an amount of time has elapsed since the last time the process was run, a human operator selects a command to perform a self-survey, or other suitable reasons to repeat the process.

The flowcharts and block diagrams in the different depicted embodiments illustrate the architecture, functionality, and operation of some possible implementations of apparatuses and methods in an illustrative embodiment. In this regard, each block in the flowcharts or block diagrams may represent at least one of a module, a segment, a function, or a portion of an operation or step. For example, one or more of the blocks may be implemented as program code, in hardware, or a combination of the program code and hardware. When implemented in hardware, the hardware may, for example, take the form of integrated circuits that are manufactured or configured to perform one or more operations in the flowcharts or block diagrams. When implemented as a combination of program code and hardware, the implementation may take the form of firmware.

In some alternative implementations of an illustrative embodiment, the function or functions noted in the blocks may occur out of the order noted in the figures. For example, in some cases, two blocks shown in succession may be executed substantially concurrently, or the blocks may sometimes be performed in the reverse order, depending upon the functionality involved. Also, other blocks may be added in addition to the illustrated blocks in a flowchart or block diagram.

For example, additional operations may be performed in the process illustrated in **Figure 16**. In one illustrative example, after performing operation **1608**, the process may stop using satellite data from a reference receiver in the portion that has a respective level of accuracy that does not meet a desired level of accuracy for the reference receiver.

Turning now to **Figure 17**, an illustration of a block diagram of a data processing system is depicted in accordance with an illustrative embodiment. Data processing system **1700** may be used to implement one or more computers in computer system **338** in **Figure 3** or computer system **420** in **Figure 4**, as well as other hardware, mobile phones, tablet computers, or

computers that may implement processes in illustrative examples. As depicted, data processing system **1700** includes communications framework **1702**, which provides communications between processor unit **1704**, storage devices **1706**, communications unit **1708**, input/output unit **1710**, and display **1712**. In some cases, communications framework **1702** may be implemented as a bus system.

Processor unit **1704** is configured to execute instructions for software to perform a number of operations. Processor unit **1704** may comprise a number of processors, a multi-processor core, and/or some other type of processor, depending on the implementation. In some cases, processor unit **1704** may take the form of a hardware unit, such as a circuit system, an application specific integrated circuit (ASIC), a programmable logic device, or some other suitable type of hardware unit.

Instructions for the operating system, applications, and/or programs run by processor unit **1704** may be located in storage devices **1706**. Storage devices **1706** may be in communication with processor unit **1704** through communications framework **1702**. As used herein, a storage device, also referred to as a computer readable storage device, is any piece of hardware capable of storing information on a temporary and/or permanent basis. This information may include, but is not limited to, data, program code, and other information.

Memory **1714** and persistent storage **1716** are examples of storage devices **1706**. Memory **1714** may take the form of, for example, a random access memory or some type of volatile or non-volatile storage device. Persistent storage **1716** may comprise any number of components or devices. For example, persistent storage **1716** may comprise a hard drive, a flash memory, a rewritable optical disk, a rewritable magnetic tape, or some combination of the above. The media used by persistent storage **1716** may or may not be removable.

Communications unit **1708** allows data processing system **1700** to communicate with other data processing systems and devices. Communications unit **1708** may provide communications using physical communications links, wireless communications links, or some combination thereof.

Input/output unit **1710** allows input to be received from and output to be sent to other devices connected to data processing system **1700**. For example, input/output unit **1710** may allow user input to be received through a keyboard, a mouse, and/or some other type of input device. As another example, input/output unit **1710** may allow output to be sent to a printer connected to data processing system **1700**.

Display **1712** is configured to display information to a user. Display **1712** may comprise, for example, without limitation, a monitor, a touch screen, a laser display, a holographic display, a virtual display device, or some other type of display device.

In this illustrative example, the processes of the different illustrative embodiments may be performed by processor unit **1704** using computer-implemented instructions. These instructions may be referred to as program code, computer usable program code, or computer readable program code and may be read and executed by one or more processors in processor unit **1704**.

In these examples, program code **1718** is located in a functional form on computer readable media **1720**, which is selectively removable, and may be loaded onto or transferred to data processing system **1700** for execution by processor unit **1704**. Program code **1718** and computer readable media **1720** together form computer program product **1722**. In this illustrative example, computer readable media **1720** may be computer readable storage media **1724** or computer readable signal media **1726**.

Computer readable storage media **1724** is a physical or tangible storage device used to store program code **1718** rather

than a medium that propagates or transmits program code **1718.** Computer readable storage media **1724** may be, for example, without limitation, an optical or magnetic disk or a persistent storage device that is connected to data processing system **1700.**

Alternatively, program code **1718** may be transferred to data processing system **1700** using computer readable signal media **1726.** Computer readable signal media **1726** may be, for example, a propagated data signal containing program code **1718.** This data signal may be an electromagnetic signal, an optical signal, and/or some other type of signal that can be transmitted over physical and/or wireless communications links.

The illustration of data processing system **1700** in **Figure 17** is not meant to provide architectural limitations to the manner in which the illustrative embodiments may be implemented. The different illustrative embodiments may be implemented in a data processing system that includes components in addition to or in place of those illustrated for data processing system **1700.** Further, components shown in **Figure 17** may be varied from the illustrative examples shown.

Thus the illustrative embodiments provide a method and apparatus for providing a desired level of portability to augmentation systems. In one or more illustrative examples, reduced time and effort is needed to set up a portable augmentation system with a desired level of precision in generating pseudo-range correction data. In an illustrative example, a self-survey process, as described above, reduces pre-planning, time, and effort needed by eliminating the need for a survey to be performed prior to setting up the portable augmentation system.

The description of the different illustrative embodiments has been presented for purposes of illustration and description, and is not intended to be exhaustive or limited to the embodiments in the form disclosed. Many modifications and variations will be apparent to those of ordinary skill in the

art. Further, different illustrative embodiments may provide different features as compared to other desirable embodiments. The embodiment or embodiments selected are chosen and described in order to best explain the principles of the embodiments, the practical application, and to enable others of ordinary skill in the art to understand the disclosure for various embodiments with various modifications as are suited to the particular use contemplated.

CLAIMS:

What is claimed is:

1. A portable augmentation system comprising:

a group of reference receivers that receives satellite signals and identifies raw pseudo-range data and a group of satellite data parameters from the satellite signals, wherein the raw pseudo-range data and the group of satellite data parameters form satellite data; and

a navigation information generator that receives the satellite data from the group of reference receivers and identifies a level of accuracy for the group of reference receivers based on the satellite data; indicates when a group of locations of the group of reference receivers does not meet a desired level of accuracy; and generates messages using navigation information from the satellite data when the group of reference receivers has the desired level of accuracy.

2. The portable augmentation system of claim 1 further comprising:

a transmitter system that transmits the messages to an aircraft, wherein the navigation information generator sends the messages to the aircraft over the transmitter system.

3. The portable augmentation system of claim 1 or 2, wherein the group of locations is a first group of locations, the level of accuracy for the group of reference receivers based on the satellite data is a first level of accuracy for the first group of locations for the group of reference receivers, the satellite data is first satellite data, and further comprising:

subsequent to a portion of the group of reference receivers being moved to a second group of locations that is different than the first group of locations, the navigation information

generator identifies a second level of accuracy for the group of reference receivers based on second satellite data identified from the satellite signals by the group of reference receivers.

4. The portable augmentation system of any one of claims 1 to 3, wherein the level of accuracy for the group of reference receivers based on the satellite data is a first level of accuracy for the group of reference receivers, the satellite data is first satellite data, and further comprising:

subsequent to a portion of the group of reference receivers being one or more of re-powered and re-configured, the navigation information generator identifies a second level of accuracy for the group of reference receivers based on second satellite data formed from the satellite signals from the group of reference receivers.

5. A method of generating navigation information for an aircraft, the method comprising:

receiving satellite signals at a group of reference receivers at a group of locations;

identifying a level of accuracy for the group of reference receivers based on satellite data formed from the satellite signals;

indicating when the group of locations of the group of reference receivers does not meet a desired level of accuracy; and

generating messages using the navigation information from the satellite data when the group of reference receivers has the desired level of accuracy.

6. The method of claim 5 further comprising:

sending the messages generated using the navigation information to the aircraft over a transmitter system.

7. The method of claim 5 or 6, wherein the group of locations is a first group of locations, the level of accuracy for the group of reference receivers based on the satellite data is a first level of accuracy for the first group of locations for the group of reference receivers, the satellite data is first satellite data formed from the satellite signals, and further comprising:

identifying a second level of accuracy for the group of reference receivers based on second satellite data formed from the satellite signals from the group of reference receivers when a portion of the group of reference receivers are one or more of re-powered, re-configured, and moved to a second group of locations that is different than the first group of locations.

8. An apparatus comprising:

a group of reference receivers that receives satellite signals and identifies raw pseudo-range data and a group of satellite data parameters in the satellite signals, wherein the raw pseudo-range data and the group of satellite data parameters form satellite data;

a transmitter system that transmits messages to an aircraft; and

a navigation information generator having a satellite data processor that receives the satellite data from the group of reference receivers, generates the messages with navigation information from the satellite data and configuration data, and sends the messages to the aircraft over the transmitter system; an operation application that controls operation of the group of reference receivers, the transmitter system, and the navigation information generator; and a configuration application that receives user input to access.

9. The apparatus of claim 8, wherein the satellite data processor generates pseudo-range corrections using the satellite data to form the navigation information.

10. The apparatus of claim 8 or 9, wherein the navigation information generator further comprises:

a self-surveyor that performs a self-survey.

11. The apparatus of claim 10, wherein the self-survey identifies a group of locations where the group of reference receivers were placed and indicates whether the group of reference receivers provide a desired level of accuracy at the group of locations.

12. The apparatus of any one of claims 8 to 11, wherein the configuration data includes values for the messages; and

wherein the group of reference receivers receive more than one frequency per satellite.

13. The apparatus of any one of claims 8 to 12, wherein the group of reference receivers is configured to receive the satellite signals from a plurality of constellations of satellites.

14. The apparatus of any one of claims 8 to 13, wherein the navigation information includes at least one of take off information, landing information, approach information, or missed approach information.