



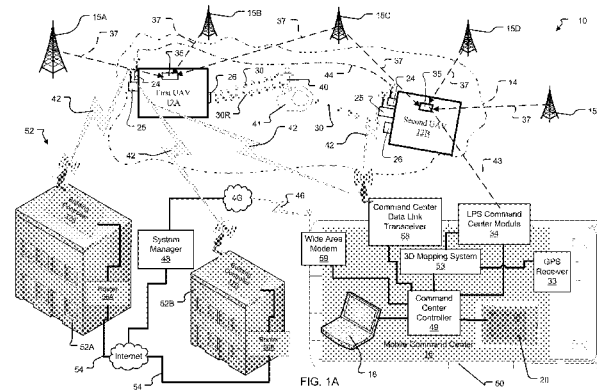
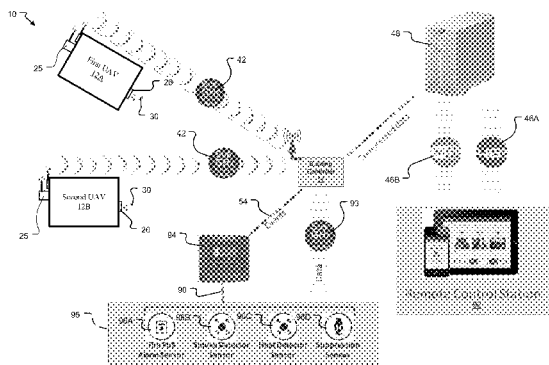
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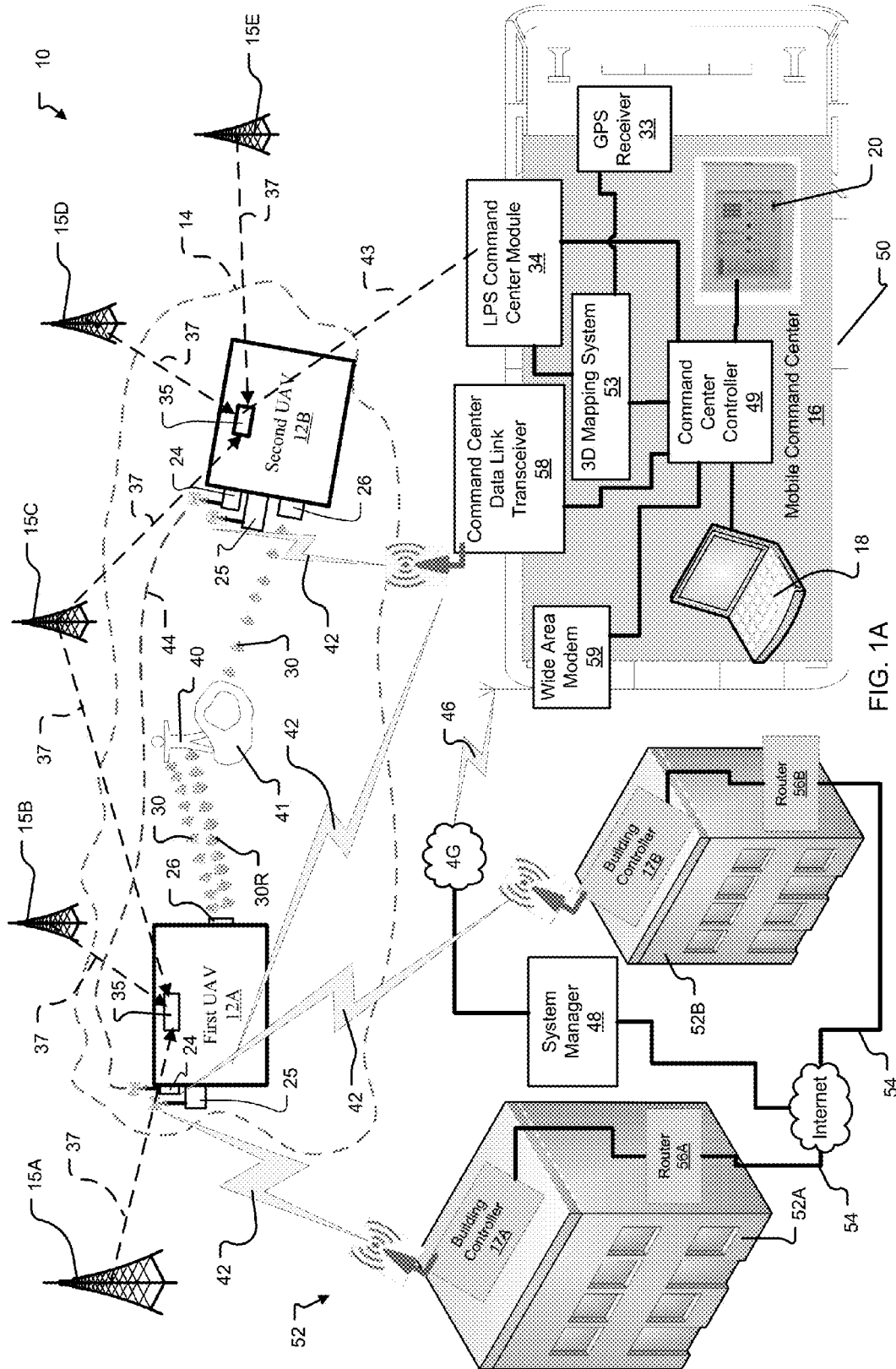
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Sequeira et al.(10) **Pub. No.: US 2017/0088261 A1**(43) **Pub. Date: Mar. 30, 2017**(54) **SEARCH AND RESCUE UAV SYSTEM AND METHOD**(71) Applicant: **Tyco Fire & Security GmbH**,
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ABSTRACT

An unmanned aerial vehicle (UAV) having at least one sensor for detecting the presence of a survivor in a search and rescue area. The at least one sensor is preferably an ultra-wide band (UWB) transceiver sensor. The UAV includes a UAV data link transceiver for wirelessly communicating information concerning the survivor to a command center.





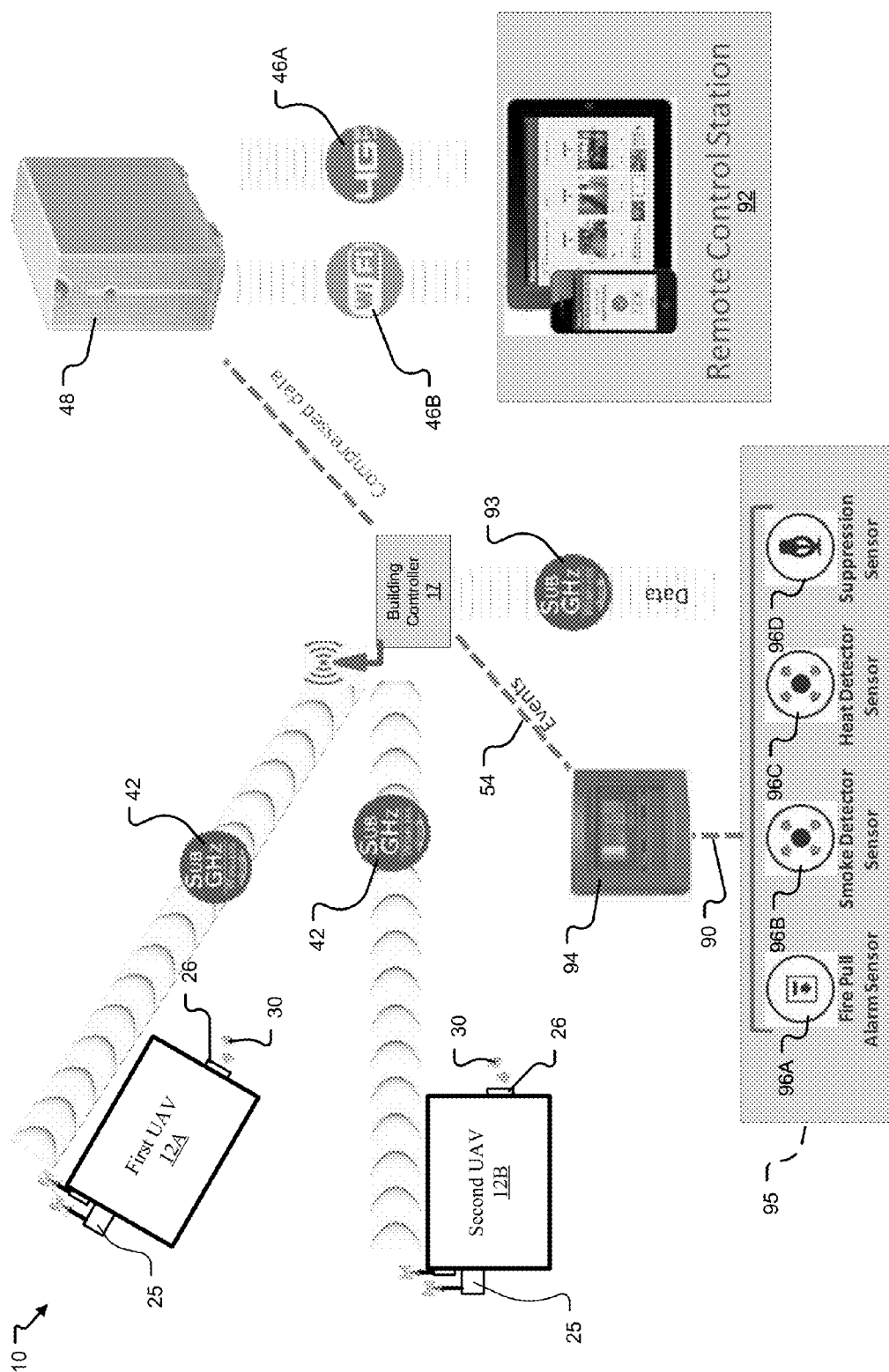


FIG. 1B

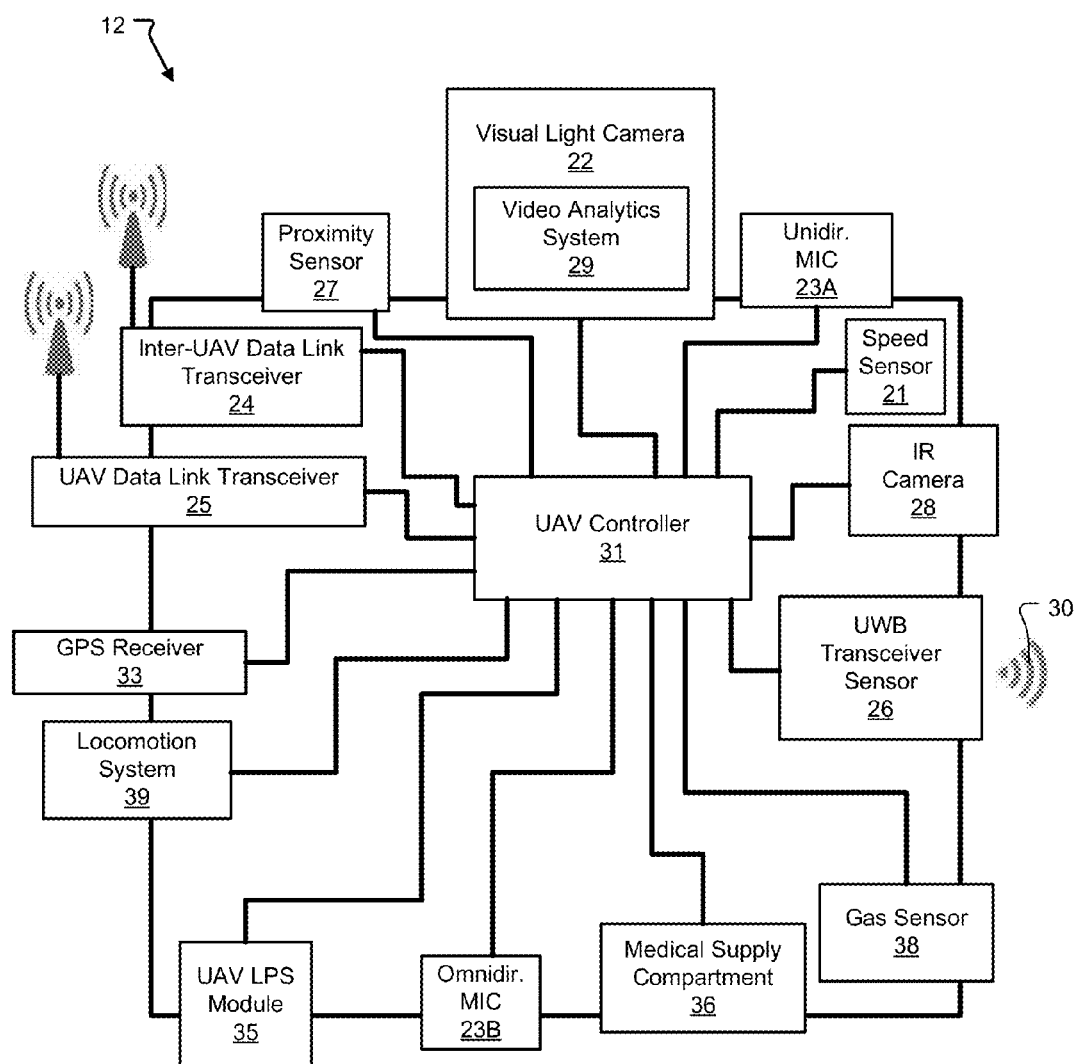


FIG. 2

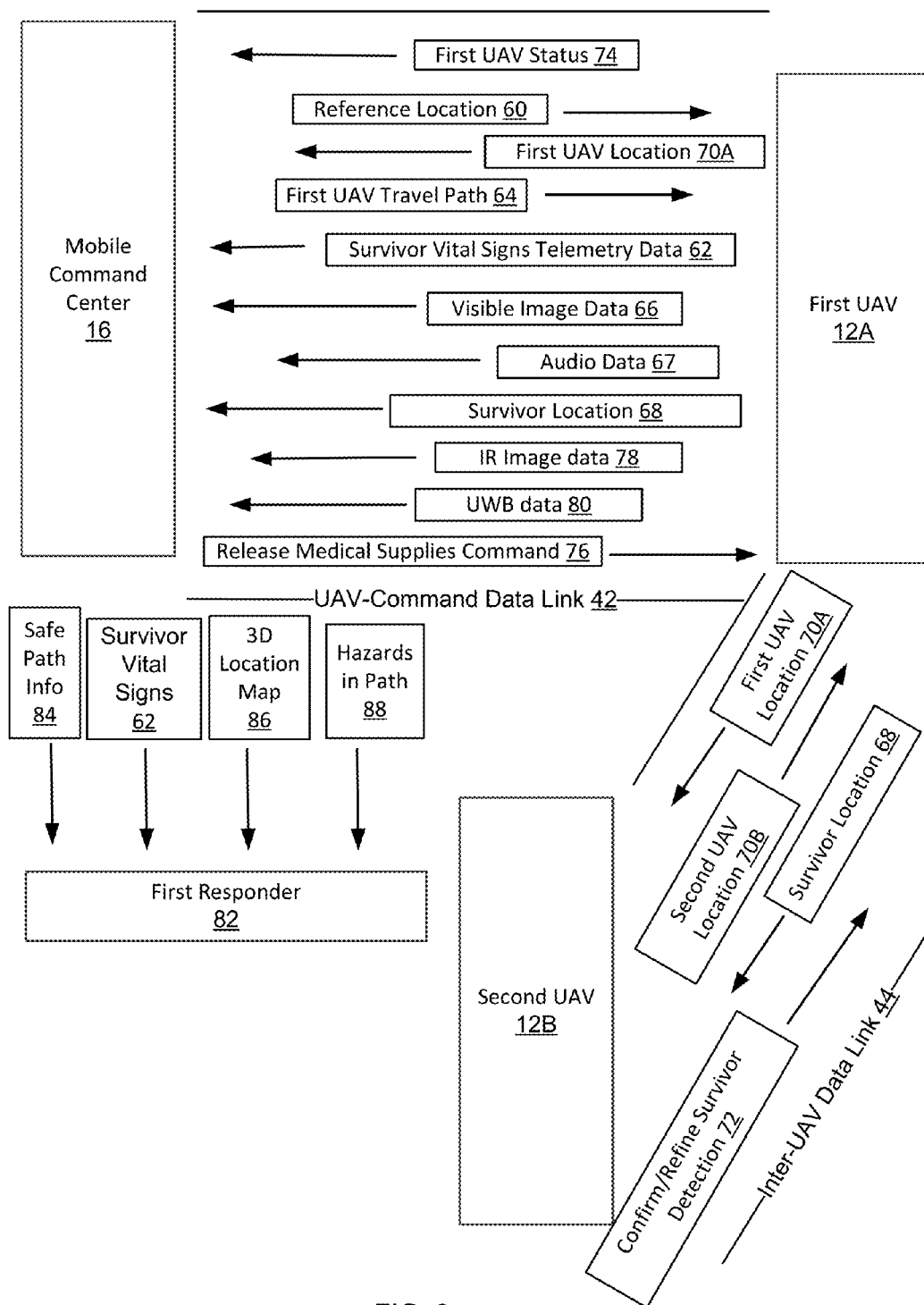


FIG. 3

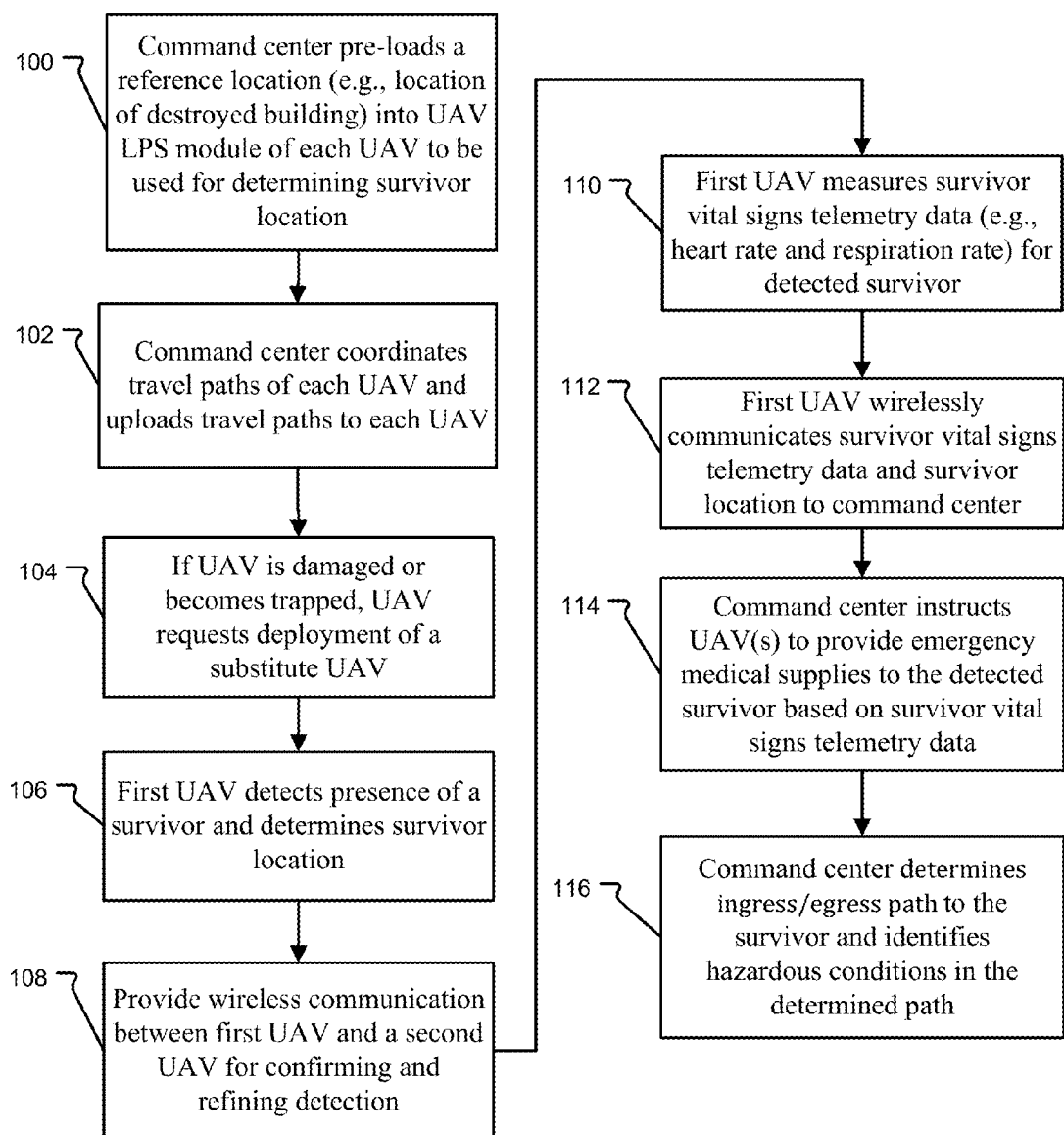


FIG. 4

SEARCH AND RESCUE UAV SYSTEM AND METHOD

BACKGROUND OF THE INVENTION

[0001] Fires, storms, earthquakes, terrorist attacks, and the like can create disaster situations that require search and rescue operations and even recovery operations. For example, survivors can become trapped and buried within debris and rubble as a result of these disaster situations. Additionally, search and rescue operations are also required when individuals become lost or are otherwise unable to return. First responders organize search and rescue operations to locate the trapped or lost survivors. Often, first responders must travel through harmful conditions to find and then help the survivors.

[0002] Unmanned aerial vehicles (UAVs) or drones represent an evolving technology that is becoming more ubiquitous. Currently, UAVs are used for such disparate applications as toys and weapons platforms. They are even being proposed for search and rescue applications. For example, thermal imaging kits are available to augment the imaging capabilities of standard consumer/hobbyist grade UAVs for search and rescue.

SUMMARY OF THE INVENTION

[0003] The present invention is directed toward solutions to accelerate search efforts while reducing the risks to the first responders and survivors. Specifically, the present invention system includes UAVs, or other type of unmanned vehicles, having sensors for detecting the presence of survivors in a search and rescue area. For example, these sensors allow UAVs to locate survivors buried in debris of an infrastructure damaged by earthquakes, storms, fires, etc. The UAVs of the present invention can also include UAV data link transceivers for wirelessly communicating information concerning the survivors to command centers. For example, these UAV data link transceivers allow UAVs to wirelessly communicate survivor vital signs telemetry data to mobile command centers (e.g., fire trucks). In general, the present system provides a solution that speeds up search and rescue operations to survivors while reducing or mitigating danger to first responders and survivors.

[0004] In general, according to one aspect, the invention features an unmanned aerial vehicle (UAV), including: an ultra-wide band (UWB) transceiver sensor for detecting a presence of a survivor in a search and rescue area and a UAV data link transceiver for wirelessly communicating information concerning the survivor to a command center.

[0005] The information concerning the survivor can include survivor vital signs telemetry data. For example, the survivor vital signs telemetry data include the heart and/or respiration rate of the survivor. In embodiments, the UAV data link transceiver is configured to wirelessly communicate the information concerning the survivor via a UAV-command data link to the command center.

[0006] Preferably, the UAV further includes an inter-UAV data link transceiver for wirelessly communicating information concerning the survivor to another UAV.

[0007] Preferably, the UAV further includes a medical supply compartment for holding emergency medical supplies. The medical supply compartment is configured to release medical supplies to the survivor based on the detected presence of the survivor.

[0008] The UAV can also include a UAV local positioning system module for determining the position of the UAV within the area. In examples, the module can receive or generate local positioning signals from multiple local positioning system portable antennas surrounding the search and rescue area for determining a position of the UAV in the search and rescue area.

[0009] The UAV can further include a proximity sensor for detecting the presence of objects in the search and rescue area. A gas sensor can also be included for detecting the presence of different kinds of gases, along with a visible light camera for detecting video.

[0010] In general, according to another aspect, a search and rescue system includes a command center and an unmanned aerial vehicle (UAV). The UAV has at least one sensor for detecting the presence of a survivor in the search and rescue area, and a UAV data link transceiver for wirelessly communicating information concerning the survivor to the command center.

[0011] The at least one sensor is preferably an ultra-wide band (UWB) transceiver sensor.

[0012] Preferably, the command center includes a 3-dimensional mapping system for creating a 3-dimensional contour map of the search and rescue area.

[0013] Preferably, the system further includes a wide-area modem for communicating over a cellular network.

[0014] In general, according to another aspect, the search and rescue method includes deploying an unmanned aerial vehicle (UAV) having an ultra-wide band (UWB) transceiver sensor in a search and rescue area. The UWB transceiver sensor detects the presence of a survivor in the search and rescue area and the UAV wirelessly communicates information concerning the survivor to a command center.

[0015] Preferably, the method further includes determining an ingress/egress path to the survivor. The command center can identify a hazardous condition in the determined ingress/egress path.

[0016] Preferably, the method further includes the UAV requesting deployment of a substitute UAV if the UAV is damaged or trapped.

[0017] The above and other features of the invention, including various novel details of construction and combinations of parts, and other advantages, will now be more particularly described with reference to the accompanying drawings and pointed out in the claims. It will be understood that the particular method and device embodying the invention are shown by way of illustration and not as a limitation of the invention. The principles and features of this invention may be employed in various and numerous embodiments without departing from the scope of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] In the accompanying drawings, reference characters refer to the same parts throughout the different views. The drawings are not necessarily to scale; emphasis has instead been placed upon illustrating the principles of the invention. Of the drawings:

[0019] FIG. 1A is a schematic diagram of a search and rescue system according to the present invention;

[0020] FIG. 1B is a schematic diagram showing further aspects of the search and rescue system;

[0021] FIG. 2 is a block diagram illustrating the components of a UAV according to the present invention;

[0022] FIG. 3 is a schematic diagram illustrating the types of information exchanged between the command center and the first UAV as well as communications between the first UAV and the second UAV; and

[0023] FIG. 4 is a flow chart illustrating the operation of the system.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0024] The invention now will be described more fully hereinafter with reference to the accompanying drawings, in which illustrative embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art.

[0025] As used herein, the term “and/or” includes any and all combinations of one or more of the associated listed items. Further, singular forms and the articles “a”, “an” and “the” are intended to include the plural forms as well, unless expressly stated otherwise. It will be further understood that the terms: includes, comprises, including and/or comprising, when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof. Further, it will be understood that when an element, including a component or subsystem, is referred to and/or shown as being connected or coupled to another element, it can be directly connected or coupled to the other element or intervening elements may be present.

[0026] FIG. 1A depicts a search and rescue system 10, according to one embodiment of the present invention.

[0027] The search and rescue system 10 includes unmanned aerial vehicles (UAVs) 12. As illustrated, the UAVs 12 are deployed to search for survivors 40 in a search and rescue area 14. In this example, a first UAV 12A and a second UAV 12B are deployed. Other examples can include deployment of one UAV 12, three UAVs 12, four UAVs 12, or any other number of UAVs 12 as appreciated by one of skill in the art.

[0028] The UAVs 12 have sensors such as ultra-wide band (UWB) transceiver sensors 26 for detecting survivors 40 in the search and rescue area 14. In one example, the UWB transceiver sensors 26 include radar technology such as UWB S-band multiple-input multiple-output (MIMO) phased array radar systems. In this example, the UWB transceiver sensors 26 include UWB impulse transmitters that transmit UWB radio signals 30 in multiple directions. The UWB radio signals 30 reflect off of objects and survivors 40 as reflected UWB radio signals 30R. The UWB transceiver sensors 26 include receivers for detecting and accepting the reflected UWB radio signals 30R. The UWB transceiver sensors 26 detect survivor vital signs telemetry data as movement or phase shifts in the reflected UWB radio signals 30R. For example, this detected movement of a survivor 40 can include walking and displacement of chest due to respiration rate or heart rate. The respiration rate or heart rate displacements can cause changes in frequency values, phase values, amplitude values, and arrival time values of the reflected UWB radio signals 30R compared to

the transmitted UWB radio signals 30. The UWB transceiver sensors 26 use these value changes to detect a presence of survivors 40 as well as the vital signs telemetry data (heart rates and/or respiration rates) of survivors 40. Further, the UWB transceiver sensors 26 can determine a distance between the UAVs 12 and survivors 40 based on the time difference between transmission of the UWB radio signals 30 and receipt of the reflected UWB radio signals 30R from survivors 40. This distance can be used in determining the survivor's location.

[0029] UWB transceiver sensors 26 are capable of detecting survivors through debris 41 (e.g., a concrete wall). The UWB transceiver sensors 26 can generate UWB radio signals 30 in a large spectral range at low frequencies which enables the UWB radio signals 30 to penetrate through concrete walls or other debris 41. For example, the UWB transceiver sensors 26 can detect survivors 40 through a 10 cm thick concrete wall by using high-speed synthetic-aperture radar (SAR) imaging architecture. The UAVs 12 can use this technology to search for survivors 40 through debris 41.

[0030] UAVs 12 include UAV local positioning system (LPS) modules 35 that provide self positioning. UAVs 12 use the UAV LPS modules 35 to determine their UAV locations in the search and rescue area 14. In one example, the UAV LPS modules 35 receive local position LP signals 37 from multiple LPS portable antennas 15A-15C surrounding the search and rescue area 14. For example, the UAV LPS module 35 determines a UAV location for the UAV 12 by triangulating the UAV location based on received LP signals 37. In particular, the UAV LPS module 35 calculates the time difference between transmission and receipt of an LP signal 37. This time difference is a relative time delay for the particular LPS portable antenna (e.g., first LPS portable antenna 15A). The UAV LPS module 35 uses this time difference to determine the distance between the UAV 12 and the first LPS portable antenna 15A. This distance determination is repeated for the second and third LPS portable antennas 15B-15C based on their respective time delays. In this example, the UAV LPS module 35 triangulates its UAV location based on these determined distances between the UAV 12 and each of the LPS portable antennas 15A-15C. Alternatively, the UAV LPS module 35 can determine the UAV location by transmitting signals which are triangulated from the antennas. The UAV 12 can determine the survivor location based on the UAV location and distance and angle between the UAV 12 and survivor 40.

[0031] The UAVs 12 wirelessly communicate information concerning the survivor 40 to other UAVs 12 via inter-UAV data links 44. Each UAV 12 includes an inter-UAV data link transceiver 24 that enables communication via the inter-UAV data links 44. The inter-UAV data links 44 can be IEEE 802.11. The UAVs 12 use the inter-UAV data link transceivers 24 to continuously communicate with one another during search and rescue operations. For example, this inter-UAV communication eliminates potential overlap searching by a second UAV 12B as well as provides a way for other UAVs 12 to confirm accuracy of survivor detection by a first UAV 12A.

[0032] The UAVs 12 wirelessly communicate information concerning the survivor 40 (e.g., survivor location) to a mobile command center 16 via a UAV-command data link 42. Each UAV 12 includes a UAV data link transceiver 25 that enables communication with the mobile command

center 16. The UAV-command data link 42 can be a sub-gigahertz data link such as a radio frequency (RF) sub-gigahertz data link, Z-wave data link, Zigbee data link, or other sub-gigahertz data link. The mobile command center 16 monitors and controls the UAVs 12 by receiving and sending data via the UAV-command data link 42.

[0033] In one example, the mobile command center 16 is located on a first responder vehicle 50 (e.g., onsite fire truck) and communicates remotely from this location. The mobile command center can be located at other remote locations as appreciated by one of skill in the art.

[0034] In the illustrated example, the mobile command center 16 includes a number of components used in monitoring and controlling the UAVs 12. The mobile command center 16 has a mobile command center controller 49 for directing and monitoring these components.

[0035] The mobile command center 16 has a command data link transceiver 58. The command data link transceiver 58 provides an access point for receiving and sending information and data to and from the UAVs 12.

[0036] The mobile command center 16 has a configurator computer workstation 18. The configurator computer workstation 18 includes a user interface for inputting commands to direct the mobile command center 16 and/or UAVs 12.

[0037] The mobile command center 16 has a mobile command center control panel 20. The mobile command center panel 20 can be used as an additional or alternative user interface for directing the mobile command center 16 and/or UAVs 12. In one example, the mobile command center panel 20 is in wireless communication with a campus alarm system via the campus network 54. The mobile command center panel 20 can receive alarm information for the different buildings 52A, 52B in the campus 52 from this campus alarm system (i.e., monitor campus alarm system). Further, the mobile command center panel 20 can be used to control alarm devices on the campus alarm system.

[0038] The system 10 can determine the UAV location using indirect remote positioning technology. As described above, the UAV LPS module 35 of the second UAV 12B receives LP signals 37 from portable antennas 15C-15E. The UAV LPS module 35 of the second UAV 12B can determine the signal distance for each portable antenna 15C, 15D, 15E as described above based on time delays. Then, the UAV LPS module 35 sends these signal distances as positioning signals 43 to the LPS command center module 34 of the mobile command center 16. Alternatively, the UAV LPS module 35 forwards the measured time delays for each portable antenna 15C, 15D, 15E as positioning signals 43. The LPS command center module 34 positions the second UAV location based on the received positioning signals 43 (signal distances or measure time delays). In particular, the LPS command center module 34 triangulates the UAV position of the second UAV 12B in the search and rescue area 14 based on the signal distances for the portable antennas 15C-15E. Alternatively, the LPS command center module 34 can determine the UAV location by trilateration or multilateration.

[0039] In another example, the UAV location can be determined using remote positioning technology. In this example, the UAV LPS module 35 is a transmitter that sends LP signals 37. The portable antennas 15A-15C are receivers for accepting the LP signals 37. Each receiver determines its distance from the UAV 12 based on the time delay for the LP signal 37 received as described above. The multiple receivers

send these determined signal distances to a central site such as the mobile command center 16 for processing. The mobile command center 16 triangulates, trilaterates, or multilaterates the UAV position based on these determined signal distances.

[0040] In another example, the UAVs can be remotely controlled by a user using feedback control. In this example, the UAV 12 positions itself based on trajectory tracking. In particular, the UAV 12 is configured to track the trajectory movement of a feedback controller and follow this movement in real-time. Thus, this type of local positioning technology relies on a feedback loop to position the UAV 12 continuously.

[0041] Other local positioning technologies such as indirect self-positioning can be used as appreciated by one of skill in the art.

[0042] The mobile command center 16 includes a global positioning system (GPS) receiver 33. The GPS receiver 33 can calculate the mobile command center location (e.g., GPS coordinates) by receiving GPS information from GPS satellites. In particular, the GPS receiver 33 uses the GPS information to determine its distance to each satellite based on time delay between transmission and receipt of the GPS information. The GPS receiver uses these distances to deduce its own location by using trilateration.

[0043] The mobile command center 16 includes a 3-dimensional site mapping system 53 for generating a map of the search and rescue area 14. The 3-dimensional site mapping system 53 receives the mobile command center location from the GPS receiver 33 and/or the UAV location from the LPS command center module 34. The 3-dimensional site mapping system 53 generates a 3-dimensional contour map of the region relative to the mobile command center location. The 3-dimensional site mapping system 53 can generate a 3-dimensional contour map of the region relative to the UAV location. Also, the 3-dimensional site mapping system 53 can generate a 3-dimensional contour map that marks the UAV location relative to the mobile command center location as well as the survivor location. The 3-dimensional site mapping system 53 can generate an ingress/egress path from the mobile command center 16 to the survivor.

[0044] The mobile command center 16 communicates with building controllers 17A, 17B via a system manager 48 in embodiments. The mobile command center 16 uses a wide area modem 59 to communicate information remotely to the system manager 48 via a wide area data link 46 (e.g., over a cellular network such as 4G LTE). The system manager 48 is a router and server combination. The building controllers 17A, 17B access information on the system manager 48 via campus routers 56A, 56B (i.e., Internet connection). For example, the campus routers 56A, 56B connect to the Internet via a campus network 54.

[0045] The building controller 17 may be located within a building 52A, 52B at a campus 52. In the illustrated example, a first building controller 17A is in building one 52A and a second building controller 17B is in building two 52B. The building controllers 17A, 17B access the campus network 54 via respective campus routers 56A, 56B.

[0046] FIG. 1B depicts the search and rescue system 10 showing further aspects of the present invention. As described above, the UAVs 12 communicate with building controllers 17 via UAV-command data links 42 (i.e., using UAV data link transceivers 25).

[0047] In the illustrated embodiment, the search and rescue system 10 include a remote control station 92. The remote control station 92 is configured to monitor and control the UAVs 12 remotely. For example, the remote control station 92 runs interactive mobile applications and services on a display that monitors and controls the UAVs 12. The interactive mobile applications and services provide real-time or near real-time UAV status data, UAV location, survivor location, etc. Also, the interactive mobile applications and services can provide command options for controlling the UAVs 12. The remote control station 92 can include a single display such as a touch-screen display or non-touch screen display for displaying information.

[0048] The remote control station 92 monitors and controls the UAVs 12 (first UAV 12A and second UAV 12B) via the system manager 48 and building controller 17. In particular, the remote control station 92 communicates with the system manager 48 via a wide area data link 46 (e.g., 4G LTE 46A or Wi-Fi 46B). Then, the system manager 48 converts this communication to compressed data and sends the compressed communication to the building controller 17 via wire or wirelessly. The building controller 17 relays the compressed communication to the UAVs 12 (e.g., first UAV 12A or second UAV 12B). Also, the building controller 17 relays information from the UAVs 12 to the system manager 48. The system manager 48 forwards this UAV communication to the remote control station 92 via 4G LTE 46A or Wi-Fi 46B links, in some implementations.

[0049] As illustrated, the same building controller 17 receives building alarm information from fire alarm sensors 95. Fire alarm sensors 95 include fire pull alarm sensor 96A, smoke detector sensor 96B, heat detector sensor 96C, and/or suppression sensor 96D. The building controller 17 can receive the building alarm information directly from the fire alarm sensors 95 via a sensor-command data link 93. The sensor-command data link 93 can be same type of link as the UAV-command data link (e.g., sub-gigahertz data link). Alternatively, the building controller 17 can receive the building alarm information from a fire alarm panel 94. The fire alarm sensors 95 communicate building alarm information to the fire alarm panel 94 via a sensor network 90. Then, the fire alarm panel 94 forwards the building alarm information as “events” to the building controllers 17 via wire or wirelessly.

[0050] FIG. 2 shows a detailed view of various components in the UAV 12.

[0051] The UAV 12 includes a UAV controller 31. The UAV controller 31 monitors and controls UAV components which include various sensing mechanisms. For example, the UAV controller 31 directs sensing mechanisms that are used to detect survivors 40, determine location information, navigate through the search and rescue area 14, identify hazardous conditions in the search and rescue area 14, etc.

[0052] The UAV 12 includes a locomotion system 39 for moving the UAV. Typically, the locomotion system 39 includes at least one motor that powers jets, ducted systems, propellers or multiple rotor arms (e.g., multicopter UAVs such as bi-copters, tri-copters, quadcopters, pentacoverters, hexacoverters, octocoverters, Y4s, Y6s, Vtails, or Xes). For this type of UAV 12, the locomotion system 39 controls movement by varying speed, pitch, and/or orientation of each propeller causing variation in thrust and direction of flight. In another example, the locomotion system 39 includes fixed wings that provide lift similarly to an airplane (e.g., tail-

sitter UAV). In another example, the locomotion system 39 includes a propeller in a pusher configuration (e.g., fixed wing aircraft). Other types of locomotion systems 39 can be used with the UAV 12 as appreciated by one of skill in the art. In fact, the vehicle need not be aerial. Walking or other ground vehicles could also be used.

[0053] The UAV 12 includes a speed sensor 21 used in navigating the UAV 12. In particular, the speed, altitude and direction sensor 21 continuously measures the speed, orientation and direction of the UAV 12. These measurements can be fed into the UAV controller 31. The UAV controller 31 can instruct the locomotion system 39 to increase or decrease thrust to achieve a desired speed for the UAV 12 compared to the measured speed. The speed sensor 21 can use hall-effect sensors, voltage or current feedback of motors, or other speed measurement systems.

[0054] The UAV 12 includes a proximity sensor 27 for detecting a presence of objects in the search and rescue area 14. The UAV controller 31 uses this information to navigate the UAV 12 through the search and rescue area 14 by avoiding obstacles such as trees, boulders, etc. The UAV controller 31 directs the UAV data link transceiver 25 to wirelessly communicate information from the proximity sensor 27 (e.g., detected presence of objects) to the mobile command center 16.

[0055] The UAV 12 can include a unidirectional microphone 23A and an omni-directional microphone 23B for capturing audio data in the search and rescue area 14. The unidirectional microphone 23A (e.g., cardioid microphone or hypercardioid microphone) captures audio predominantly from one direction. The omni-directional microphone 23B captures audio evenly from all directions. In another example, the UAV 12 includes a bidirectional microphone which captures audio from two opposite directions. The UAV controller 31 directs the UAV data link transceiver 25 to wirelessly communicate this audio data to the mobile command center 16.

[0056] The UAV 12A, 12B can also include a visible light camera 22 for capturing video of the search and rescue area 14. The visual light camera 22 forms an image (i.e., generates digital stills and video) by using visible light. The visual light camera 22 typically operates in a 450 to 750 nanometer range. For example, the visual light camera 22 is a charge-coupled device (CCD) or complementary metal-oxide-semiconductor (CMOS) camera. The visual light camera 22 has a variety of applications such as enabling the UAV 12 to avoid obstacles, localization techniques, improved accuracy of navigation, and video feedback. The visual light camera 22 has a video analytics system 29. The video analytics system 29 can be used for image recognition and processing. This video analytics system 29 can be used to confirm the detection of survivors 40 by recognizing the survivors 40. The UAV 12 communicates video from the visible light camera 22 to the mobile command center 16 via the UAV data link transceiver 25.

[0057] The UAV 12 includes an infrared (IR) camera 28 for supplementing detection of survivors 40 and navigation through search and rescue area 14. The IR camera 28 forms an image using infrared radiation. The IR camera 28 typically operates to detect light having wavelengths from 1 to several micrometers, to as long as 14,000 nanometers, or longer. In one example, the IR camera 28 is a thermal imaging camera used to detect heat signatures of survivors 40 and hotspots of fires. In another example, the IR camera

28 provides night vision capabilities which help in navigating the UAV **12**. The IR camera includes either a cooled infrared detector or uncooled infrared detector.

[0058] The UAV **12** includes a gas sensor **38** for detecting a presence of different kinds of gases. For example, the gas sensor **38** can be used to supplement detection of survivors **40**.

[0059] In particular, the gas sensor **38** can detect carbon dioxide levels which can be used to confirm detection of survivors **40**. The UAV data link transceiver **25** wirelessly communicates the detected presence of different gases to the mobile command center **16**.

[0060] The UAV **12** includes a medical supply compartment **36** for holding emergency medical supplies. The medical supply compartment **36** is configured to release medical supplies to survivors **40** based on the detected presence of the survivor. For example, the medical supply compartment **36** can provide water, antibiotics, and/or drugs to survivors **40** as instructed by the mobile command center **16**. For example, a user can input this instruction at the mobile command center **16** based on data received from the UAVs **12**.

[0061] The UAV **12** can also include a GPS receiver **33**. This GPS receiver **33** functions the same as the GPS receiver **33** described above for the mobile command center **16**. In this example, the GPS receiver **33** calculates the UAV location (e.g., GPS coordinates) by receiving GPS information from GPS satellites. The GPS receiver **33** supplements the UAV LPS module in determining the UAV location.

[0062] FIG. 4 illustrates types of information exchanged between the mobile command center **16** and the first UAV **12A**, the first UAV **12A** and the second UAV **12B**, as well as the mobile command center **16** and a first responder **82** during operation of the system **10**. FIG. 5 illustrates a flow chart of the main steps included in the operation of the system **10**.

[0063] Prior to step **100**, UAVs **12** having the UWB transceiver sensors **26**, as described above, are deployed. In step **100**, the mobile command center **16** pre-loads a reference location **60** (e.g., location of destroyed building) into the first UAV **12A** to be used in determining survivor location **68**. For example, as illustrated in FIG. 3, the mobile command center **16** sends the reference location **60** to the first UAV **12A**. The UAV LPS module **35** (FIGS. 1A, 1B) of the first UAV **12A** can use this reference location **60** as a datum to calculate the first UAV location **70A** as geo-spatial coordinates for the first UAV **12A**. Further, as described above, the first UAV **12A** can accurately determine the survivor location **68** based on this calculated first UAV location and the measured distance between the first UAV **12A** and the survivor **40** (FIG. 1A).

[0064] In step **102**, the mobile command center **16** coordinates travel paths for each UAV **12A**, **12B** and uploads the coordinated travel paths to respective UAV **12A**, **12B**. For example, as illustrated in FIG. 3, the first UAV travel path **64** is uploaded to the first UAV **12A**. The travel paths are coordinated so that the second UAV **12B** does not overlap and replicate areas searched by the first UAV **12A**. This coordination also optimizes the search operation.

[0065] During the search and rescue operation, the UAV **12** can continuously send status information to the mobile command center **16**. For example, the first UAV **12A** sends a first UAV status **74** that can include various UAV performance and device information. If the first UAV **12A** is

damaged (i.e., broken down) or trapped, the first UAV **12A** can request deployment of a substitute second UAV **12B** (step **104**). This substitute deployment request may be sent within the first UAV status **74** message. Alternatively, this deployment request may be sent as a separate message from the UAV status **74**.

[0066] In step **106**, the first UAV **12A** detects a presence of a survivor and determines the survivor location **68**. As described above, the survivor location **68** is based on the calculated first UAV location **70A** and the measured distance between the first UAV **12A** and the survivor **40**. As shown in FIG. 3, the first UAV **12A** can wirelessly transmit the determined survivor location **68** to the mobile command center **16**.

[0067] In step **108**, wireless communication is provided between the first UAV **12A** and second UAV **12B** for confirming and refining detection. In particular, these wireless intercommunications between UAVs **12** refine the accuracy of detection by confirming or refining whether survivors **40** were correctly detected. As illustrated in FIG. 3, the first UAV **12A** communicates the first UAV location **70A** and survivor location **68** information to the second UAV **12B** via the inter-UAV data link **44**. The second UAV **12B** communicates the second UAV location **70B** to the first UAV **12A**. For example, based on this information the second UAV **12B** can locate the first UAV **12A** and/or the survivor location and determine whether detection of the survivor **40** is correct. The second UAV **12B** sends a confirm/refine survivor detection message **72** to the first UAV **12A** based on the second UAV's determination of survivor detection.

[0068] In step **110**, the first UAV **12A** measures survivor vital signs telemetry data **62** (e.g., heart rate and respiration rate) for the detected survivor **40**. As shown in FIGS. 2-3, the first UAV **12A** wirelessly communicates the survivor vital signs telemetry data **62** and survivor location **68** to the mobile command center **16** (step **112**). The mobile command center **16** uses the survivor vital signs telemetry data **62** to indicate the overall health condition of the identified survivor **40**. In step **114**, the mobile command center **16** instructs UAV(s) **12** to provide emergency medical supplies to the detected survivor **40** based on the survivor vital signs telemetry data **62**. In particular, the mobile command center **16** sends a release medical supplies command **76** to the first UAV **12A** instructing the first UAV **12A** to release relevant medical supplies for the survivor **40**. The medical supplies provide a temporary medical solution for the survivor **40** until first responders **82** can reach the survivor **40**.

[0069] In step **116**, the mobile command center **16** determines an ingress/egress path (i.e., safe path info **84**) to the survivor **40** and identifies hazardous conditions in the determined path (i.e., hazards in path **88**). Specifically, the mobile command center **16** can use information received from the UAVs **12** to locate and identify hazardous conditions in the determined path to the survivor. The mobile command center **16** can assess the path to the survivor **40** and provide an alternate path if the originally determined path is not usable.

[0070] The mobile command center **16** forewarns first responders **82** of the search and rescue area landscape and survivor health conditions via a display of the configurator computer workstation **18**. For example, as illustrated in FIG. 3, the first responder **82** can view survival vital signs telemetry data **62**, a 3d location map **86**, safe path info **84**, and hazards in path **88**. The first responder **82** can use this

information in making informed decisions, assessing the response priority within the search and rescue area **14**, and providing timely medical attention to the affected survivor **40**.

[0071] The UAVs **12** provide other information to the mobile command center **16** that aid first responders **82** in making informed rescue response decisions. As illustrated in FIG. 3, visible image data **66**, audio data **67**, IR image data **78**, and UWB data **80** are sent from the first UAV **12A** to the mobile command center **16**. This information can be viewed by first responders **82** at the mobile command center **16**. Such information allows first responders **82** to appropriately prioritize rescue response and other search and rescue decisions.

[0072] While this invention has been particularly shown and described with references to preferred embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the scope of the invention encompassed by the appended claims.

What is claimed is:

1. An unmanned aerial vehicle (UAV), comprising:
an ultra-wide band (UWB) transceiver sensor for detecting the presence of a survivor in a search and rescue area; and
a UAV data link transceiver for wirelessly communicating information concerning the survivor to a command center.
2. The UAV of claim 1, wherein the information concerning the survivor includes survivor vital signs telemetry data.
3. The UAV of claim 2, wherein the survivor vital signs telemetry data comprises the heart and/or respiration rate of the survivor.
4. The UAV of claim 1, further comprising an inter-UAV data link transceiver for wirelessly communicating information concerning the survivor to another UAV.
5. The UAV of claim 1, further comprising a medical supply compartment for holding emergency medical supplies, wherein the medical supply compartment is configured to release medical supplies to the survivor based on the detected presence of the survivor.
6. The UAV of claim 1, further comprising a UAV local positioning system module for receiving local positioning signals from multiple local positioning system portable antennas surrounding the search and rescue area for determining the position of the UAV in the search and rescue area.
7. The UAV of claim 1, wherein the UAV data link transceiver is configured to wirelessly communicate the information concerning the survivor via a UAV-command data link to the command center.
8. The UAV of claim 1, further comprising a proximity sensor for detecting the presence of objects in the search and rescue area, wherein the UAV data link transceiver wirelessly communicates the detected presence of objects to the command center.
9. The UAV of claim 1, further comprising a gas sensor for detecting the presence of different kinds of gases,

wherein the UAV data link transceiver wirelessly communicates the detected presence of different gases to the command center.

10. The UAV of claim 1, further comprising a visible light camera for detecting video and communicating the video to the command center.

11. A search and rescue system, comprising:

a command center; and
an unmanned aerial vehicle (UAV) having at least one sensor for detecting the presence of a survivor in a search and rescue area, and a UAV data link transceiver for wirelessly communicating information concerning the survivor to the command center.

12. The system of claim 11, wherein the sensor is an ultra-wide band (UWB) transceiver sensor.

13. The system of claim 11, wherein the command center comprises a local positioning system command center module for receiving and/or local positioning signals from multiple local positioning system portable antennas surrounding the search and rescue area for determining the position of the UAV in the search and rescue area.

14. The system of claim 11, wherein the command center comprises a 3-dimensional mapping system for creating a 3-dimensional contour map of the search and rescue area.

15. The system of claim 11, wherein the command center comprises a wide-area modem for communicating over a cellular network.

16. The system of claim 11, wherein the UAV further comprises an inter-UAV data link transceiver for wirelessly communicating the information concerning the survivor to another UAV.

17. The system of claim 11, wherein UAV data link transceiver is configured to wirelessly communicate the information concerning the survivor via a UAV-command data link to the command center.

18. A search and rescue method, comprising:

deploying an unmanned aerial vehicle (UAV) having an ultra-wide band (UWB) transceiver sensor in a search and rescue area;

the UWB transceiver sensor detecting the presence of a survivor in the search and rescue area; and

the UAV wirelessly communicating information concerning the survivor to a command center.

19. The method of claim 18, further comprising:

the command center loading a reference location into a UAV location positioning system module of the UAV; and

the UAV using the UAV location positioning system module for determining the survivor's location based on a preloaded reference location.

20. The method of claim 18, further comprising determining an ingress/egress path to the survivor.

21. The method of claim 20, further comprising the command center identifying a hazardous condition in the determined ingress/egress path.

22. The method of claim 18, further comprising the UAV requesting deployment of a substitute UAV if the UAV is damaged or trapped.

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