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- (54) **MOBILE DRIFT SENSOR FOR AGRICULTURAL SPRAYING**
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- (*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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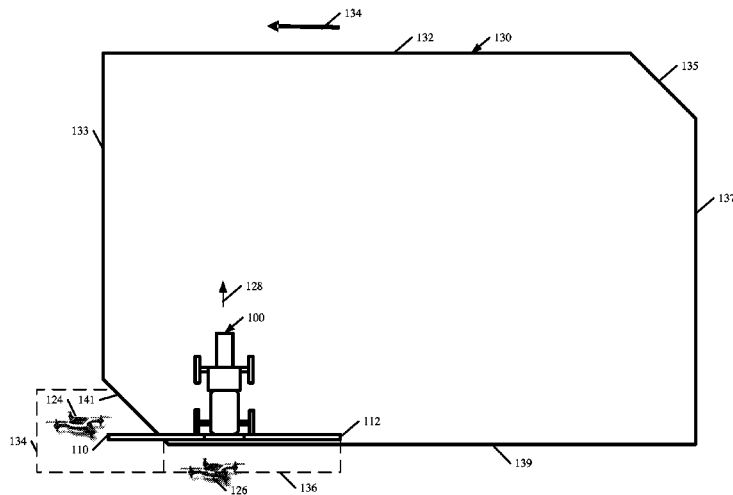
- (51) **Int. Cl.**
 - B05B 12/16** (2018.01)
 - A01B 79/00** (2006.01)
- (Continued)

(57) **ABSTRACT**

Wind speed, wind direction, and field boundary information are detected and used to identify a monitor area indicative of a likely overspray condition. Control signals are generated to deploy an unmanned aerial vehicle (UAV), with a sprayed substance sensor, to the monitor area. The UAV is controlled to reposition it, as a spraying machine moves through the field being sprayed. When an overspray condition is detected, an overspraying signal from the UAV indicating the detected overspray condition is received and overspray processing is performed, based upon the received overspray signal.

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20 Claims, 16 Drawing Sheets



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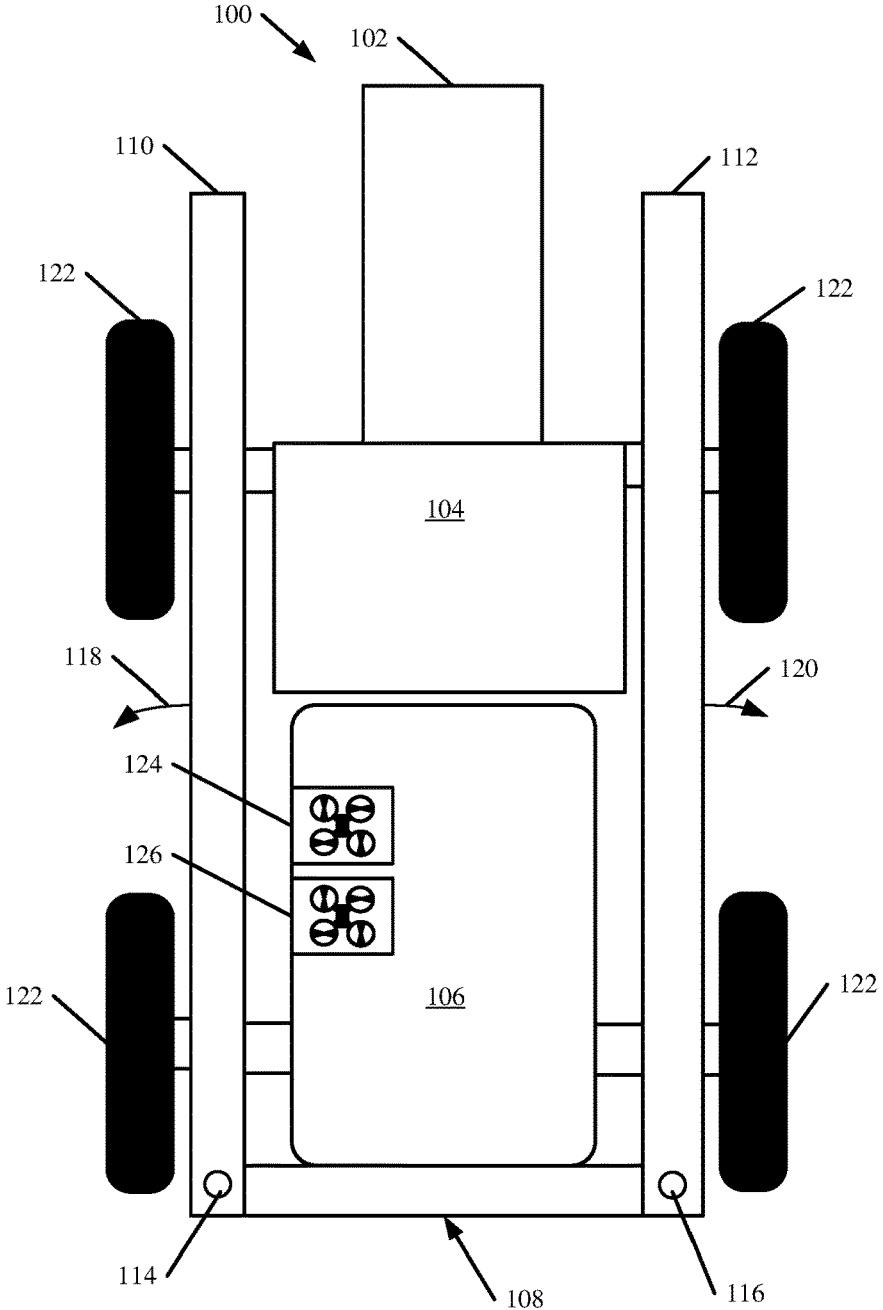


FIG. 1

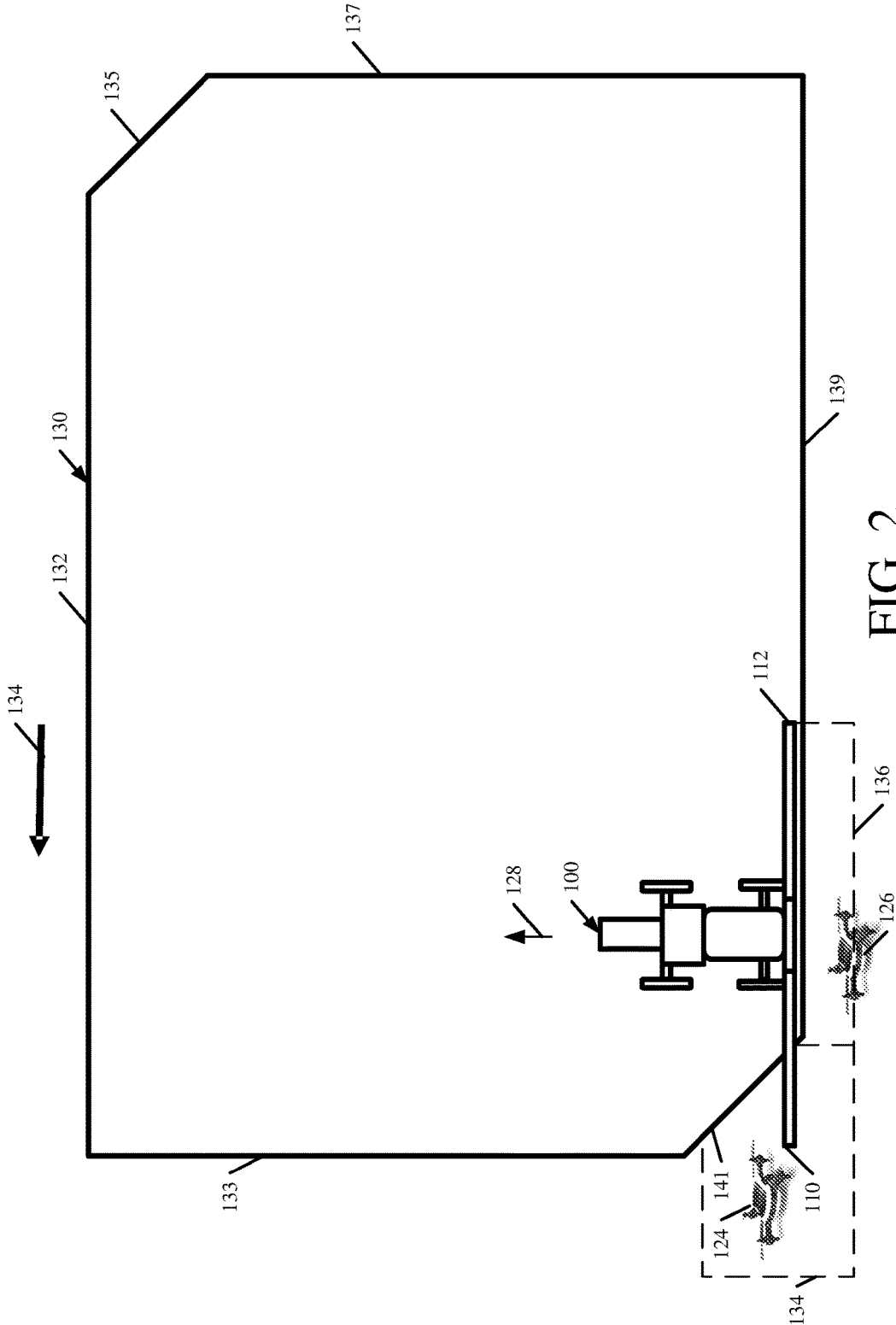


FIG. 2

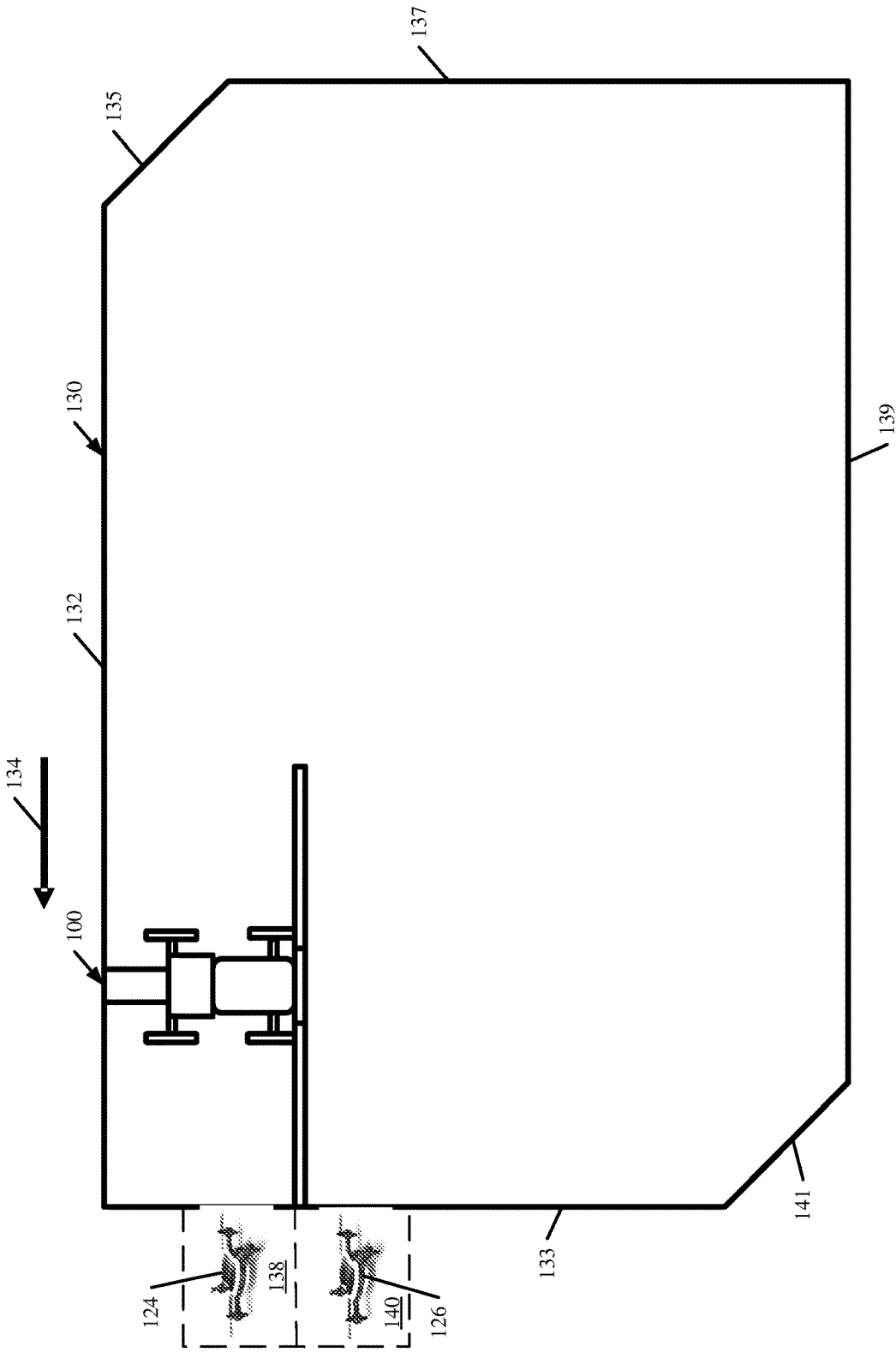


FIG. 3

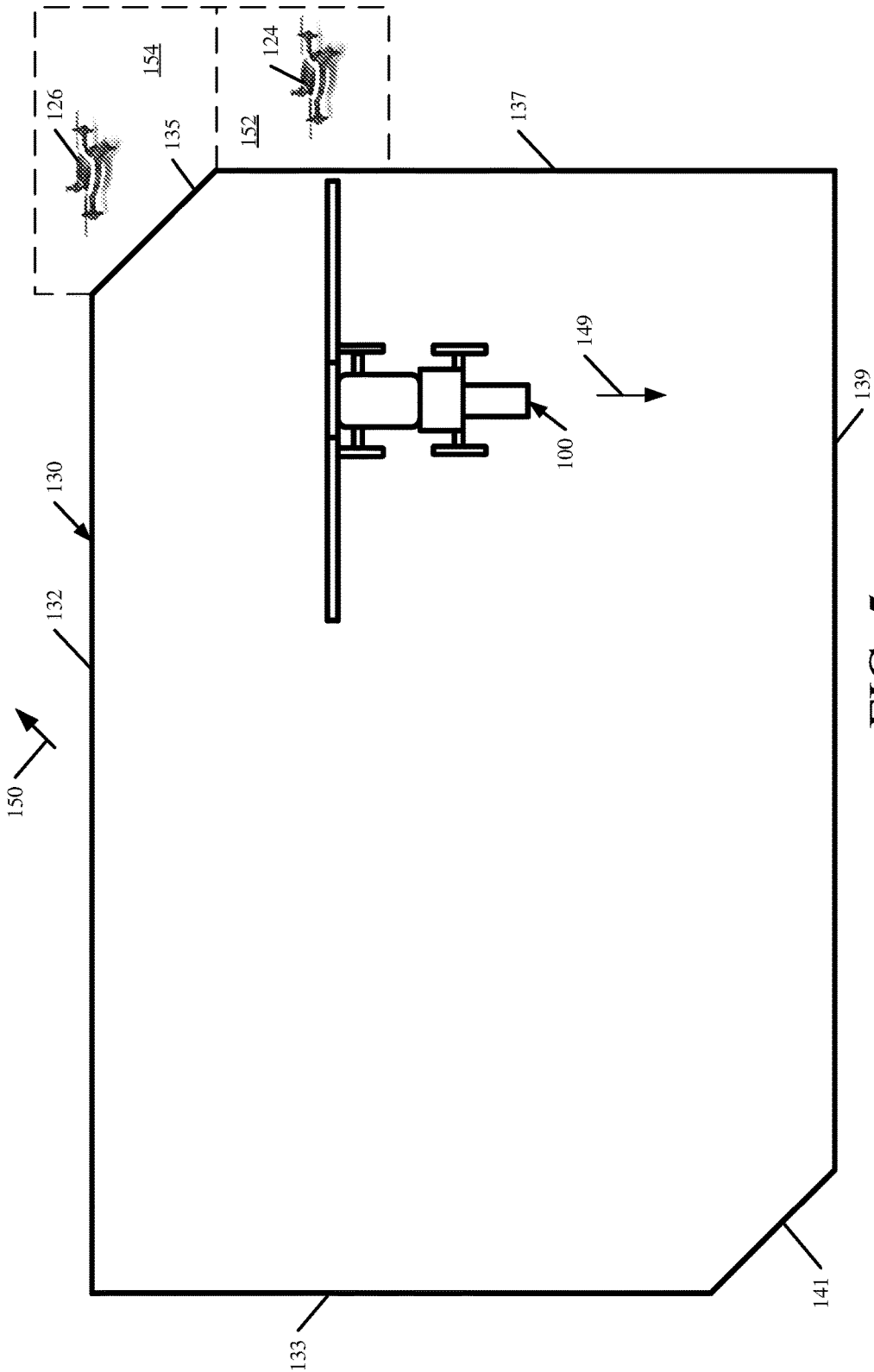


FIG. 5

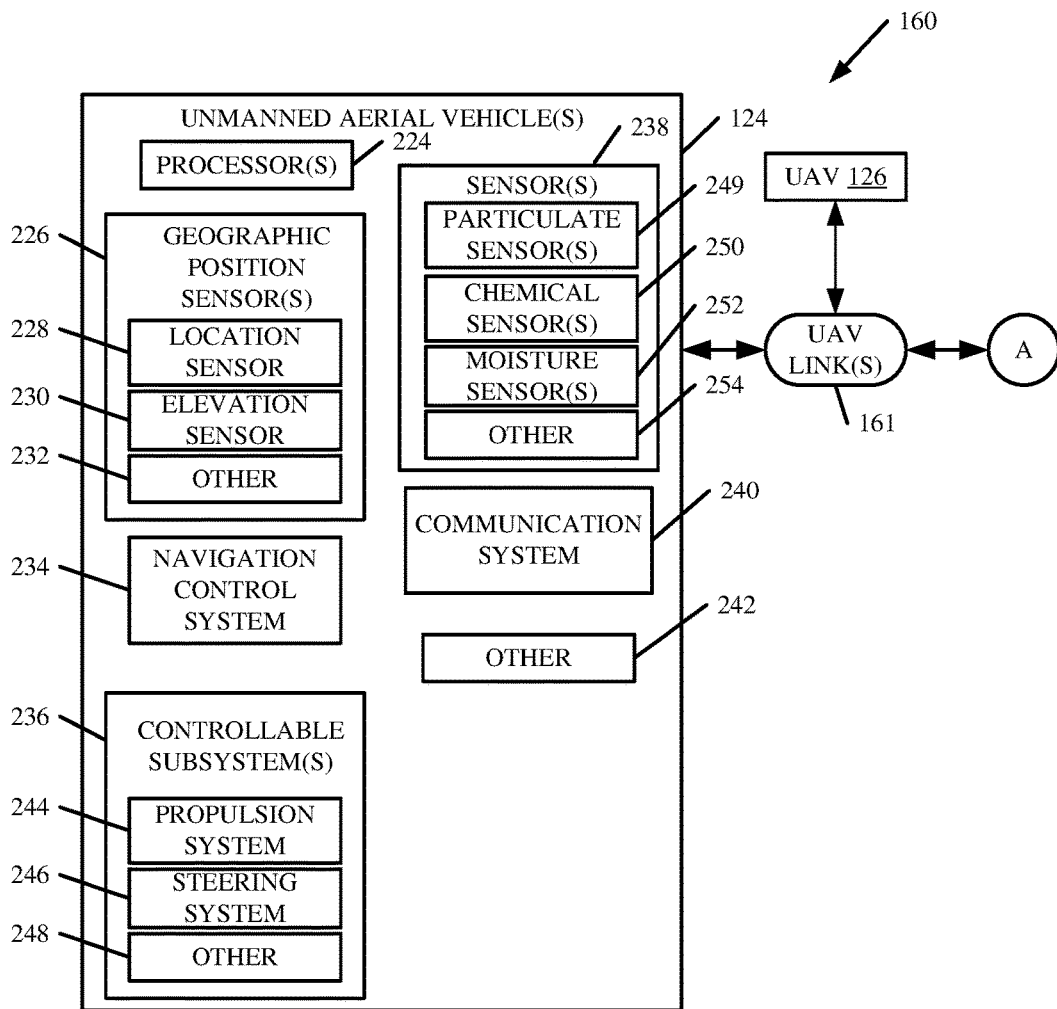


FIG. 6A

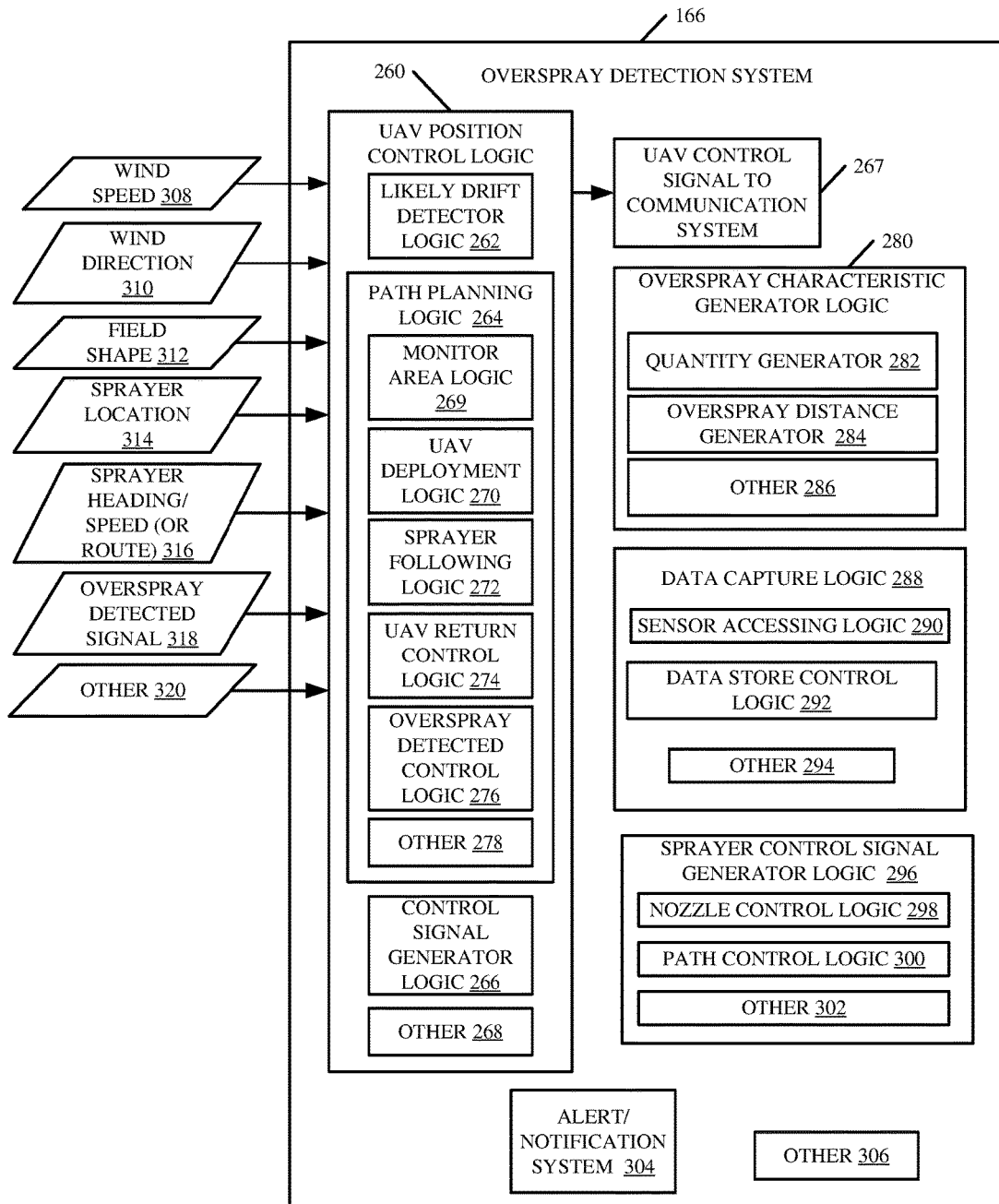


FIG. 7

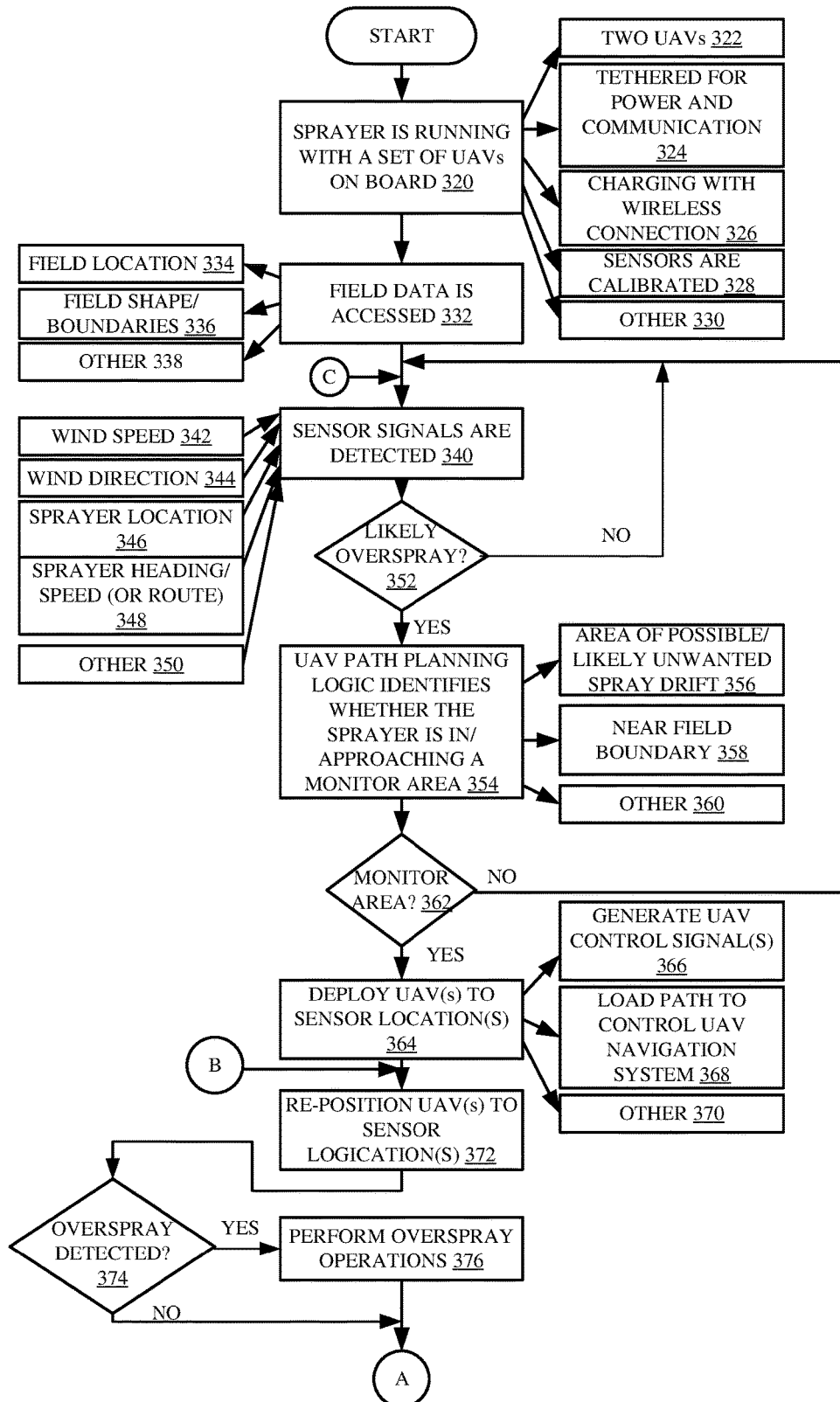


FIG. 8A

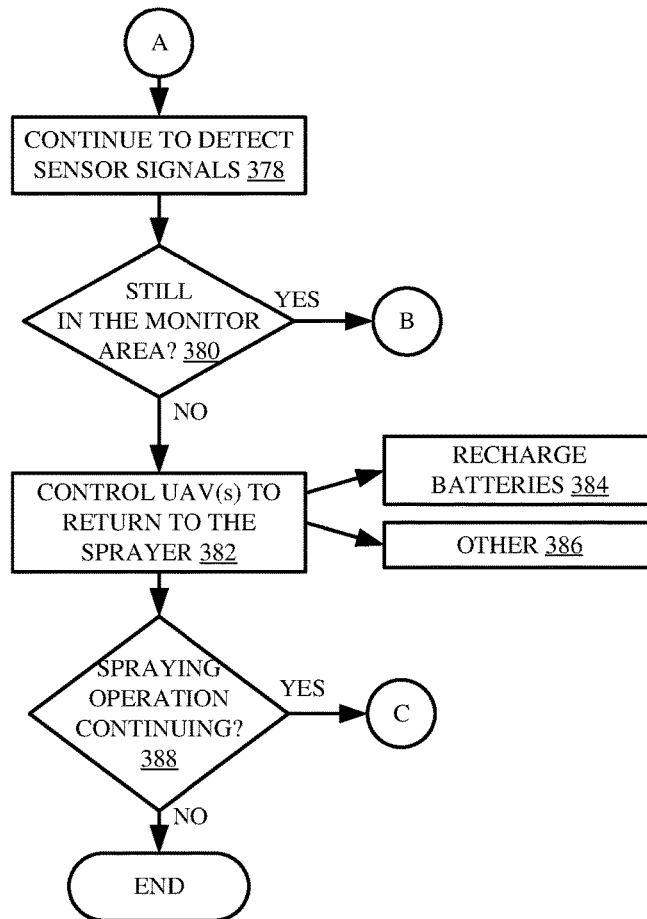


FIG. 8B

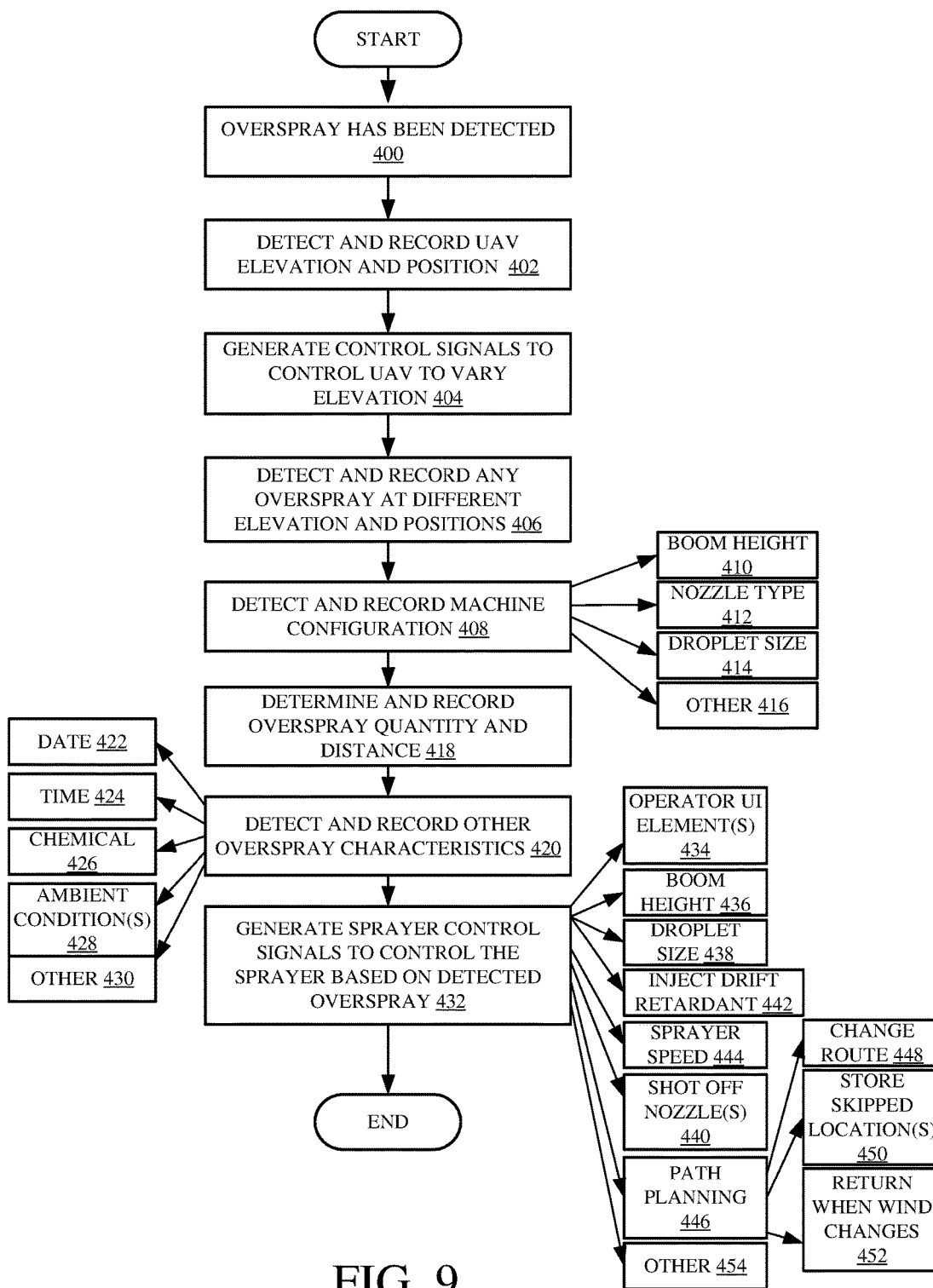


FIG. 9

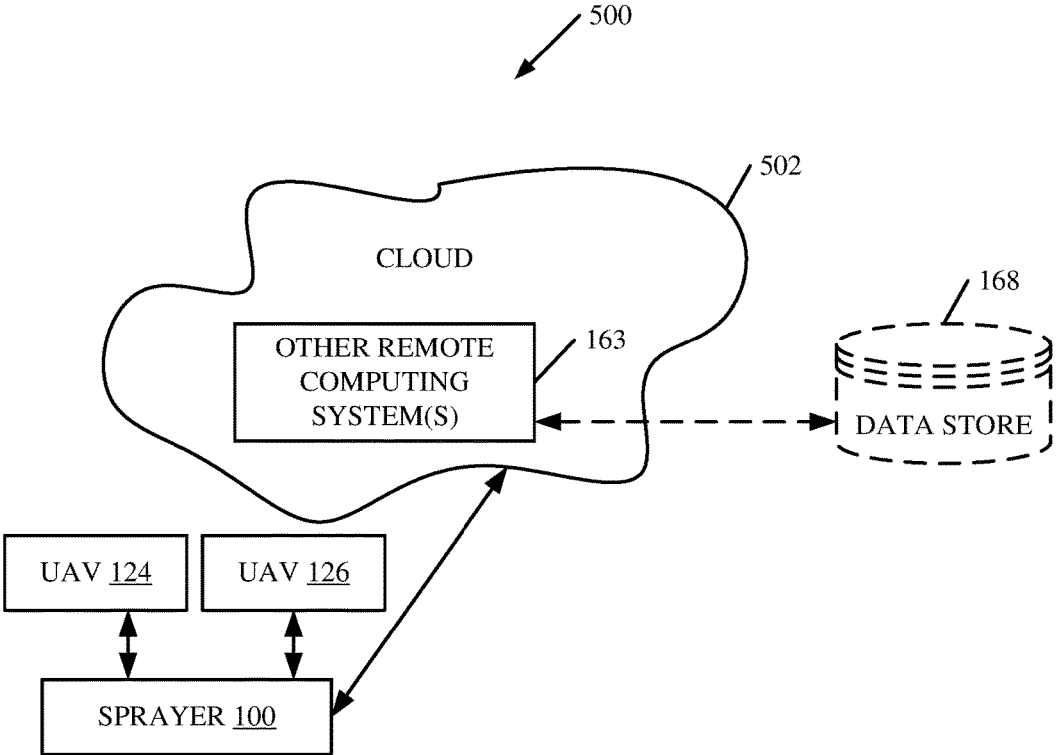


FIG. 10

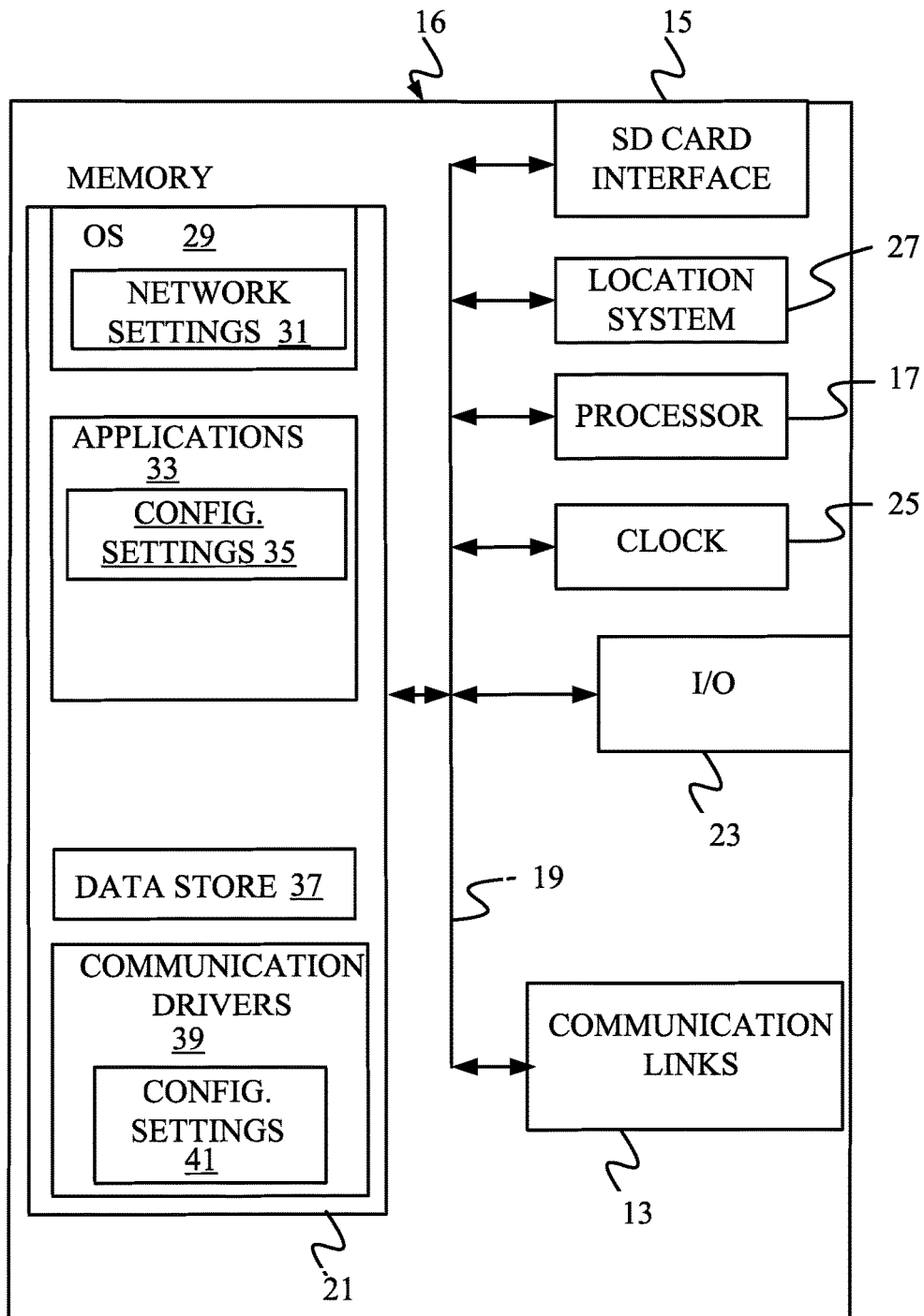


FIG. 11

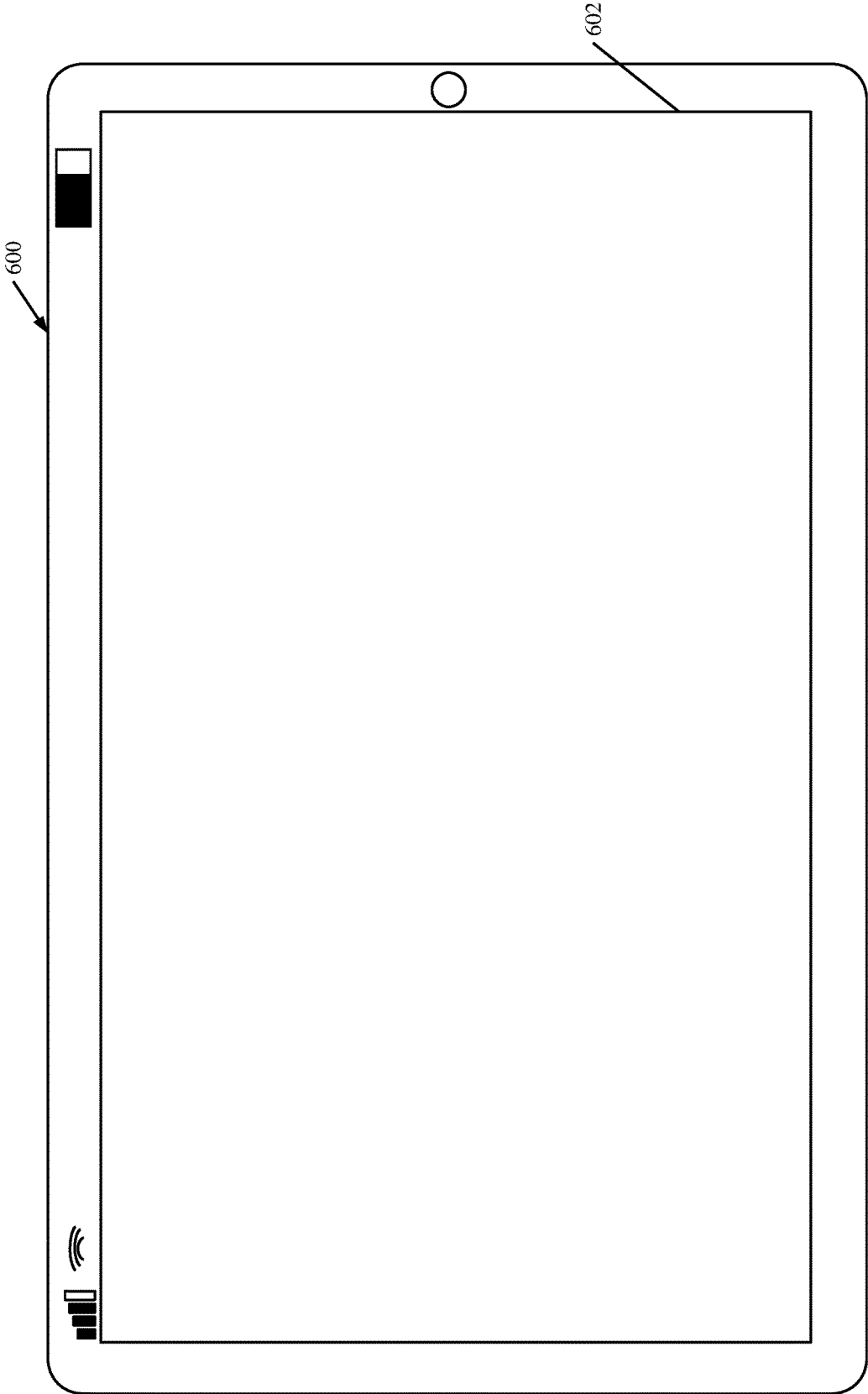


FIG. 12

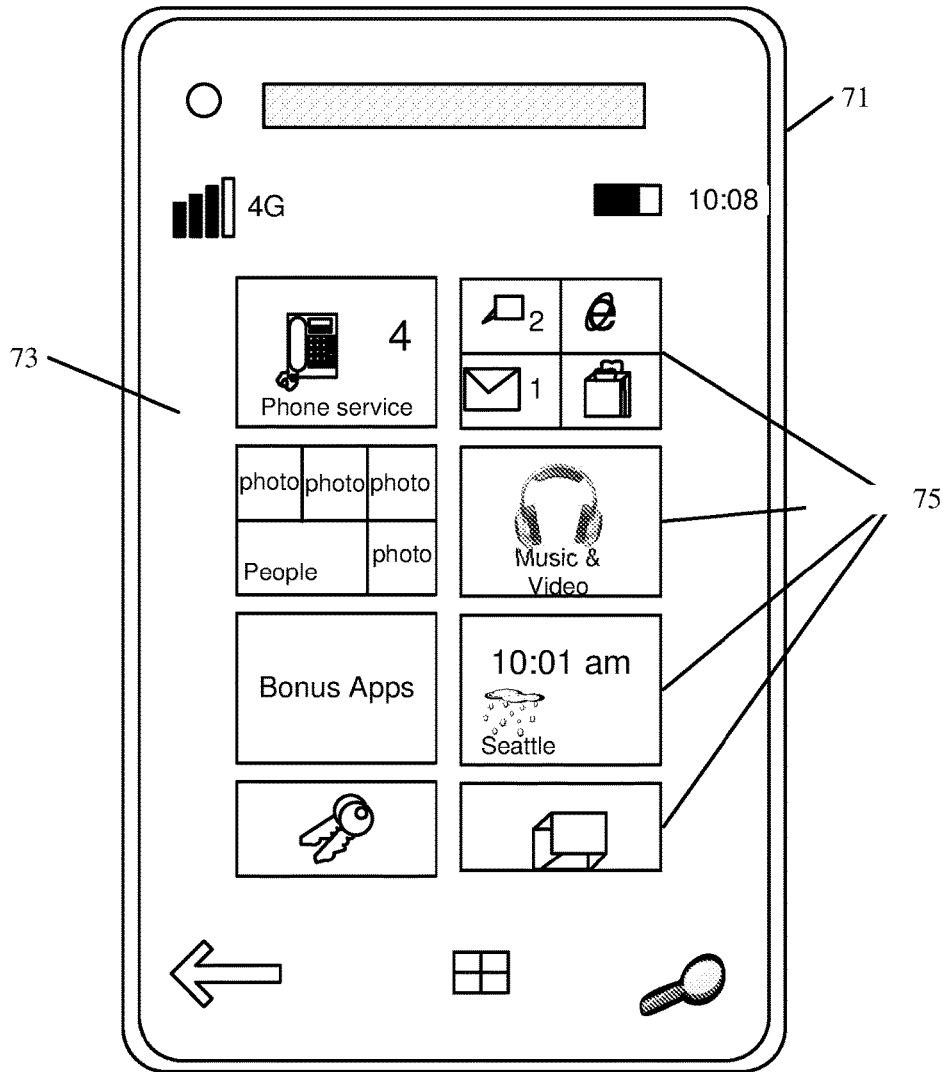


FIG. 13

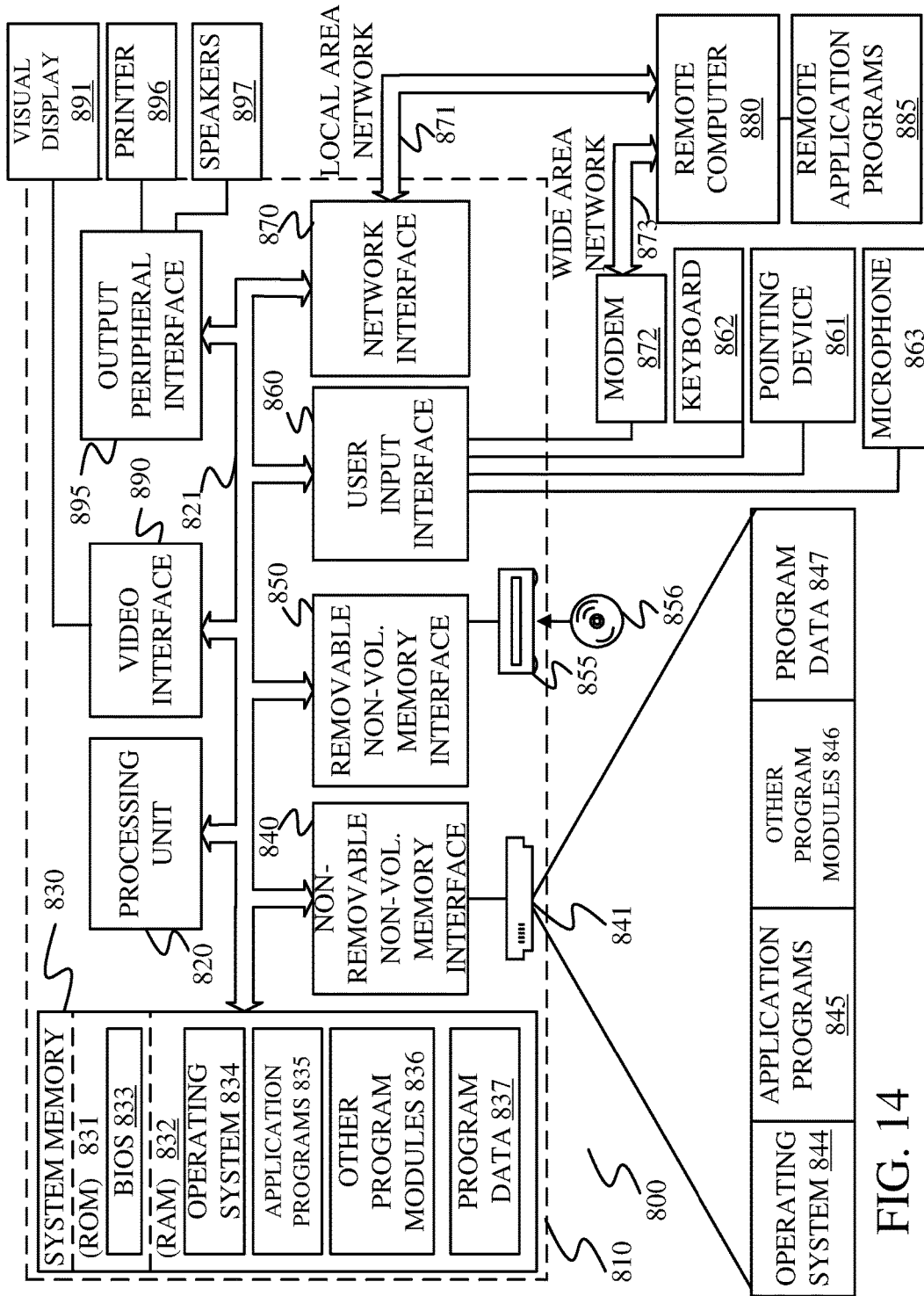


FIG. 14

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MOBILE DRIFT SENSOR FOR AGRICULTURAL SPRAYING

FIELD OF THE DESCRIPTION

The present description relates to drift sensing. More specifically, the present description relates to sensing the drift of a chemical being sprayed by an agricultural sprayer.

BACKGROUND

There are many different types of agricultural machines. One such machine is a sprayer. An agricultural sprayer often includes a tank or reservoir that holds a substance to be sprayed on an agricultural field. The sprayer also includes a boom that is fitted with one or more nozzles that are used to spray the substance on the field. As the sprayer travels through the field, the boom is moved to a deployed position and the substance is pumped from the tank or reservoir, through the nozzles, so that is sprayed or applied to the field over which the sprayer is traveling.

It may be undesirable for the substance being sprayed by a sprayer to cross the field boundaries onto an adjacent piece of land. This can be extremely difficult to detect. For instance, some substances are visible with the human eye. Therefore, if a relatively large amount of the substance has passed the field boundary of the field being treated, it can be discerned by human sight. However, other substances are dispersed or sprayed in droplets or granule sizes that are too small to be observed by the human eye. It can thus be very difficult to detect whether an overspray condition (where the spray drifts across a field boundary) has occurred.

The discussion above is merely provided for general background information and is not intended to be used as an aid in determining the scope of the claimed subject matter.

SUMMARY

Wind speed, wind direction, and field boundary information are detected and used to identify a monitor area indicative of a likely overspray condition. Control signals are generated to deploy an unmanned aerial vehicle (UAV), with a sprayed substance sensor, to the monitor area. The UAV is controlled to reposition it, as a spraying machine moves through the field being sprayed. When an overspray condition is detected, an overspraying signal from the UAV indicating the detected overspray condition is received and overspray processing is performed, based upon the received overspray signal.

This Summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This Summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used as an aid in determining the scope of the claimed subject matter. The claimed subject matter is not limited to implementations that solve any or all disadvantages noted in the background.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a pictorial illustration showing one example of an agricultural spraying machine.

FIGS. 2-5 are pictorial illustrations showing the sprayer illustrated in FIG. 1 deployed in a field, with unmanned aerial vehicles deployed in different monitor areas based on sensed wind speed and wind direction, and based on the boundaries of the field being sprayed.

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FIGS. 6A and 6B (collectively referred to herein as FIG. 6) shows a block diagram showing one example of a spraying architecture.

FIG. 7 is a block diagram showing one example of an overspray detection system in more detail.

FIGS. 8A and 8B (collectively referred to herein as FIG. 8) show a flow diagram illustrating one example of the operation of the architecture illustrated in FIG. 6 in detecting an overspray condition.

FIG. 9 is a flow diagram illustrating one example of the operation of the architecture shown in FIG. 6 in performing overspray operations, when an overspray condition is detected.

FIG. 10 is a block diagram showing the architecture illustrated in FIG. 6 deployed in a cloud computing environment.

FIGS. 11-13 show examples of mobile devices.

FIG. 14 is a block diagram showing one example of a computing environment that can be used in the architecture illustrated in previous FIGS.

DETAILED DESCRIPTION

Some current systems use a fixed sensing apparatus, that is fixed relative to a field boundary, to sense overspray conditions. However, this is relatively costly and cumbersome. Any field for which overspray is to be detected needs the fixed sensing apparatus to be installed. Also, should the field boundary change in the future, then the fixed sensing apparatus must be moved to accommodate the new field boundary.

Given these difficulties, even if an overspray condition can be detected, it can be even more difficult to detect the extent of an overspray condition. For instance, it can be very difficult to detect a quantity of sprayed substance that crossed the field boundary, and a distance that it traveled into an adjacent field. The present description proceeds with respect to deploying mobile sensors to sense overspray conditions.

FIG. 1 is a pictorial illustration of one example of an agricultural sprayer 100. Sprayer 100 illustratively includes an engine in engine compartment 102, an operator's compartment 104, a tank 106, that stores material to be sprayed, and an articulated boom 108. Boom 108 includes arms 110 and 112 which can articulate or pivot about points 114 and 116 to a travel position illustrated in FIG. 1. Agricultural sprayer 100 is supported for movement by a set of traction elements, such as wheels 122. The traction elements can also be tracks, or other traction elements as well. When a spraying operation is to take place, boom arms 110-112 articulate outward in the directions indicated by arrows 118 and 120, to a spraying position respectively. Boom 108 carries nozzles that spray material that is pumped from tank 106 onto a field over which sprayer 100 is traveling. This is described in greater detail below with respect to FIGS. 2-5.

FIG. 1 also shows that, in one example, a set of unmanned aerial vehicles (UAVs) 124-126 are mounted on agricultural sprayer 110 so that they can be carried by agricultural sprayer 110 as it moves to a field to be sprayed, or as it moves through the field. In one example, UAVs 124-126 have sensors (described in greater detail below) that can sense the substance (or the presence and/or quantity of the substance) being sprayed by sprayer 100. They can be mounted to sprayer 100 with a mounting assembly that releasably holds UAVs 124-126 on machine 100. The mounting assembly may also have a charging coupler which charges batteries or other power cells that are used to power

UAVs **124-126**. When the UAVs **124-126** are to be deployed, they can be released from the mounting assembly and controlled to fly to a desired location, as is described in more detail below. It will be appreciated that the UAVs **124-126** can be coupled to machine **100** either using a tethered link or a wireless link.

FIG. **2** is a pictorial illustration showing one example of spraying machine **100** deployed in a field **130** that is defined by a field boundary that includes boundary sections **132**, **133**, **135**, **137**, **139** and **141**. Machine **100** is shown traveling across field **130** generally in a direction indicated by arrow **128**.

In the example shown in FIG. **2**, it is assumed that the wind direction is in the direction generally indicated by arrow **134**. Also, in the example shown in FIG. **2**, as agricultural spraying machine **100** begins to spray a substance from nozzles on boom arms **110** and **112**, the spray may drift across the boundaries of field **130**. For instance, when sprayer **100** is located in the position shown in FIG. **2**, the substance may drift, because of the wind, across boundary **139** in a direction located generally behind machine **100**, in the direction of travel, and across boundary **141** generally to the side of machine **100**.

Therefore, as will be described in greater detail below, UAV position control logic senses the wind direction and wind speed, and also identifies the boundary of field **130**, based upon field boundary data, and generates control signals to control UAVs **124** and **126** to position themselves in monitor areas where an overspray condition is most likely to happen. In the example illustrated in FIG. **2**, it may be determined that it is relatively likely that an overspray condition may happen in a monitor area defined by dashed line **134** and in a monitor area defined by dashed line **136**. Therefore, in one example, the UAV position control logic (described in greater detail below with respect to FIG. **7**) controls UAV **124** to position itself in monitor area **134**, and it controls UAV **126** to position itself in monitor area **136**. If the substance being sprayed by sprayer **100** drifts into those areas, it will be sensed by the sensors on the UAVs and logic on the UAVs will send an overspray signal, indicative of the detected overspray condition, to an overspray detection system on sprayer **100**. This is all described in greater detail below.

In one example, as machine **100** moves in the direction indicated by arrow **128**, the UAV position control logic controls UAVs **124** and **126** to move along with machine **100**, and to position themselves in other monitor areas based upon the position of machine **100**, the wind direction indicated by arrow **134**, the wind speed, etc. FIG. **3** shows one example of this.

Some items shown in FIG. **3** are similar to those shown in FIG. **2**, and they are similarly numbered. It can be seen in FIG. **3** that machine **100** has now traveled to be closely proximate field boundary **132**, but the wind direction is still in the same direction as indicated by arrow **134**. Therefore, any likely overspray is illustratively determined to occur in monitor area **138** and in monitor area **140**. Thus, UAVs **124** and **126** are controlled to position themselves in those two monitor areas.

FIG. **4** shows that machine **100** has now turned to travel in a direction generally indicated by arrow **142**. In addition, the wind direction has now shifted to the direction indicated by arrow **144**. Thus, the overspray (in which the sprayed substance crosses the field boundary **132** of field **130**) is now likely to occur in monitor areas **146** and **148**. Therefore, UAVs **124** and **126** are controlled to position themselves in those two monitor areas, respectively.

FIG. **5** shows that machine **100** has now again turned to move in the direction indicated by arrow **149**. Also, the wind direction has shifted to that shown by arrow **150**. Therefore, it is determined that an overspray condition may occur in monitor areas **152** and **154**. Thus, control signals are generated to control UAVs **124** and **126** to position them in monitor areas **152** and **154**, respectively.

Before describing the operation of sprayer **100** and UAVs **124** and **126** in more detail, a number of other items will first be noted. In one example, it may be that sprayer **100** is traveling through the middle of field **130**. In that case, it may not be near a field boundary. Therefore, it may be determined that there is no monitor zone that needs to be monitored, because there is no relatively high likelihood that an overspray condition may exist. This may also happen when the wind speed is relatively low, when the substance being sprayed is relatively heavy and resistant to drift, or for other reasons. In those instances, then UAVs **124** and **126** can be controlled to return to machine **100** where they can be carried by sprayer **100** and/or recharged, assuming they are coupled to machine **100** using a wireless connection.

In addition, some sprayers **100** may take on the order of 30 minutes to spray a full tank of material. Sprayer **100** may then be refilled by a refill machine. During that time, UAVs **124-126** may also return to spraying machine **100** where they can be recharged, or where the batteries or other power cells can be swapped for charged batteries or power cells.

FIGS. **6A** and **6B** (collectively referred to herein as FIG. **6**) show a block diagram showing one example of a spraying architecture **160** that shows sprayer **100** coupled to UAVs **124-126** over one or more UAV links **161** and other computing systems **163** (which may be remote server systems, farm manger systems, etc.). It should be noted that, architecture **160** can include a sprayer computing system that can be disposed on sprayer **100**, and it can also include a single unmanned aerial vehicle (such as one of UAVs **124** and **126**, or more UAVs). The UAVs **124** and **126** can be similar or different. For purposes of the present description, it will be assumed that they are similar so that only UAV **124** is described in more detail. This is only one example.

UAV **124** illustratively includes one or more processors **224**, one or more geographic position sensors **226** (which can include a location sensor **228**, an elevation sensor **230**, and a wide variety of other sensors **232**), navigation control system **234**, one or more controllable subsystems **236**, one or more sensors **238**, a communication system **240**, and a wide variety of other items **242**. Controllable subsystems **236** can include a propulsion system **244**, a steering system **246**, and other items **248**. Sensors **238** can include a particulate sensor **249**, a chemical sensor **250**, a moisture sensor **252**, and/or other sensors **254**.

Links **161** can be tethered links, or wireless links. If they are tethered links, they can provide power and control signals as well as other communication signals between UAVs **124-126** and sprayer **100**. They can provide similar or different signals if UAV links **161** are wireless links. All of these arrangements are contemplated herein. In the example shown in FIG. **6**, sprayer **100** illustratively includes one or more processors or servers **164**, overspray detection system **166**, data store **168**, communication system **170**, UAV mounting assembly **172**, UAV charging system **174**, one or more geographic positioning sensors **176**, operator interfaces **178** (that are provided for interaction by operator **163**), one or more other sensors **180**, control system **182**, controllable subsystems **184**, and it can include other items **186**. Data store **168** can include field location/shape data **188** which can describe the shape or boundaries of one or more

different fields. Data store **168** can include overspray data **190** which can include a wide variety of different types of data that are collected and stored when an overspray condition is detected. Data store **168** can include a wide variety of other items **192** as well.

Geographic position sensors **176** can include a location sensor **194** (which can be a GPS receiver, a cellular triangulation sensor, a dead reckoning sensor, etc.), a heading and speed sensor **196** that senses the heading and speed of sprayer **100**, and it can include a wide variety of other geographic position sensors **198**. Other sensors **180** can illustratively include wind direction sensor **200**, wind speed sensor **202**, boom height sensor **204** which senses the height of the boom on sprayer **100**, nozzle type sensor **206** which senses or indicates the type of nozzle being used on the sprayer, droplet size sensor **208** which can sense or derive a droplet size (or granule size) of the substance being sprayed by sprayer **100**, ambient condition sensor **210** which can sense such things as temperature, atmospheric pressure, etc. Sensors **180** can include a wide variety of other sensors **212** as well.

Controllable subsystems **184** are illustratively customized by control system **182**. They can include boom position subsystem **213**, a propulsion subsystem **214**, steering subsystem **216**, nozzles **218**, and a wide variety of other subsystems **220**.

Briefly, in operation, UAVs **124** and **126** can be carried by sprayer **100** on UAV mounting assembly **172**. In one example, assembly **172** has an actuatable connector that releasably connects UAVs **124** and **126** to sprayer **100**. When actuated, it illustratively releases UAVs **124** and **126** so that they can be flown to other positions. UAV charging system **174** charges batteries on UAVs **124** and **126**, when they are battery operated. Geographic position sensors **176** illustratively sense the geographic location, heading and speed (or route) of sprayer **100**. Wind direction sensor **200** and wind speed sensor **202** illustratively sense the direction and speed of the wind. Field location/shape data **188** illustratively defines the shape and location of a field that sprayer **100** is treating or is to treat. Overspray detection system **166** illustratively detects when sprayer **100** is approaching a likely monitor area, where an overspray condition may likely occur. When this happens, it illustratively generates control signals to launch UAVs **124-126** from UAV mounting assembly **172** so that they are positioned in the monitor areas. Also, as sprayer **100** moves, overspray detection system **166** illustratively provides signals to navigation control system **234** on the UAVs **124-126** to control their position so that they follow along with sprayer **100**, in monitor areas where an overspray condition is likely to exist, based upon the movement or changing position of sprayer **100**. This is described in greater detail below.

Overspray detection system **166** illustratively receives one or more signals from UAVs **124** and/or **126** indicating detection of an overspray condition. This means that the substance being sprayed by sprayer **100** has crossed the field boundary of the field being treated and is sensed by sensors **238** on one of the UAVs when they are positional in monitor areas. The signal can be received through communication system **170** which can be any of a wide variety of different types of communication systems that can communicate with UAVs **124** and **126** over UAV links **161**.

When an overspray condition is detected, overspray detection system **166** illustratively controls data store **168** to store a wide variety of different types of overspray data, some of which will be described in greater detail below. Control system **182** also illustratively generates control

signals to control various controllable subsystems **184** and operator interfaces **178**. It can control operator interfaces **178** to notify operator **163** that an overspray condition has been detected. It can control propulsion system **214** and steering system **216** to control the direction and speed of sprayer **100**. It can control nozzles **218** to control spraying characteristics of the nozzles, or to shut them off entirely. It can control other subsystems as well, such as to inject drift retardant into the substance being sprayed, among other things.

Navigation control system **234** on UAV **124** illustratively receives navigation signals through communication system **240** which communicates with communication system **170** on sprayer **100** over UAV links **161**. The navigation control system **234** then generates control signals to control propulsion system **244** and steering system **246** on UAV **124** in order to position UAV **124** in a monitor area where an overspray condition is likely.

Sensors **238** generate sensor signals indicative of sensed items. Particulate sensor **249** is configured to sense the presence (and perhaps quantity) of particulate matter. Chemical sensor **250** is illustratively configured to sense the presence (and possibly quantity) of a chemical in the substance being sprayed by sprayer **100**. Moisture sensor **252** is configured to sense the presence (and possibly quantity) of moisture. Any or all of these sensors can be used to detect the substance being sprayed by sprayer **100**. There are a wide variety of different types of sensors that can be used for this. For instance, in one example, a dielectric material is used so that when moisture is on the surface of sensor **252**, it changes the capacitance of a sensing capacitor on sensor **252**. Particulate sensor **249** may be an optical sensor with a light emitting diode (or other radiation source) and a radiation detector. It illustratively detects particulate matter passing between the radiation source and the radiation detector. The particulate sensor **249** may also sense droplets of moisture.

Chemical sensors **250** may illustratively be a chemical sensor which senses the presence of a particular chemical. Sensors **238** can be LIDAR or laser-type sensors which sense the presence of moisture or particulates, or sensors **238** can include a combination of different types of sensors. In one example, sensors **238** illustratively provide a signal that is indicative of the presence of, and possibly an amount of (e.g., a proportion, a weight or size, or otherwise indicative of an amount of) sensed material (liquid, particulate, etc.) that is being sensed. These signals can be provided over UAV links **161** to overspray detection system **126** when an overspray condition is detected. This can be detected in a variety of different ways, such as when a threshold amount of moisture or particulate matter or chemical is detected by one or more of sensors **238**.

A brief description of a more detailed example of overspray detection system **166** will now be provided with respect to FIG. 7. In the example shown in FIG. 7, overspray detection system **166** illustratively includes UAV position control logic **260** which, itself, can include likely drift detector **262**, path planning logic **264**, control signal generator logic **266**, and it can include other items **268**. Path planning logic **264** can include UAV deployment logic **270**, sprayer following logic **272**, UAV return logic **274**, overspray detected control logic **276**, and it can include other items **278**.

Overspray detection system **166** can also include overspray characteristic generator **280** (which, itself, includes quantity generator **282**, overspray distance generator **284**, and it can include other items **286**). Overspray detection

system **166** can include data capture logic **288** (which, itself, can include sensor accessing logic **290**, data store control logic **292**, and other items **294**), sprayer control signal generator logic **296** (which, itself, can include nozzle control logic **298**, path control logic **300**, and other items **302**), alert/notification system **304**, and other items **306**.

Briefly, in operation, likely drift detector **262** illustratively receives the wind speed signal **308**, a wind direction signal **310**, field shape data **312**, sprayer location data **314**, and sprayer heading/speed (or route) data **316** and other data **320**. Based on this information, and possibly based on the drift characteristics of the substance being sprayed (e.g., droplet or particulate size, weight, nozzle type, boom height, sprayer speed, etc.) it detects whether sprayer **100** is approaching, or has entered, an area where the substance that it is spraying will likely pass over a field boundary, and therefore where an overspray condition is likely to happen. When this is detected, it provides a signal indicative of a likely overspray condition to path planning logic **264**. Monitor area logic **269** then calculates the location of one or more monitor areas where the overspray condition is likely to occur. UAV deployment logic **270** then generates signals indicative of those monitor areas and provides those signals to control signal generator logic **266**. Logic **266** generates UAV control signals **267** and sends them to UAVs **124-126** (such as through communication system **170** and links **161**) to position UAVs **124-126** in the one or more monitor areas that have been identified by monitor area logic **169**. It also illustratively generates control signals to detach UAVs **124-126** from the mounting assembly **172** on sprayer **100**, so that they can fly to the desired monitoring areas.

As sprayer **100** moves through the field, monitor area logic **269** (continues to identify monitor areas). Sprayer following logic **272** illustratively receives the sprayer route **316** and sprayer location information **314** as well as the identified monitor areas and/or other information, and controls UAVs **124-126** to follow sprayer **272**, positioning themselves in any monitor areas where an overspray condition is likely to happen, that may be detected by monitor area logic **269**.

When sprayer **100** moves to a position where there are no monitor areas identified, then UAV return control logic **274** indicates this to control signal generator logic **266** which generates UAV control signals causing UAVs **124-126** to return to the mounting assembly **172** on sprayer **100**. Therefore, the UAVs **124-126** are again secured to sprayer **100**.

Overspray detected control logic **276** illustratively receives an overspray detected signal **318** which is a signal from one or more of UAVs **124-126** indicating that an overspray condition has been detected. It then generates signals that are provided to control signal generator logic **266** that generates control signals to control the UAVs to perform overspray operations. For example, it can control the UAVs **124-126** to change elevations or locations to determine whether the substance being sprayed is detected in the monitor area at higher or lower elevations, is detected at a position further from the field boundary, etc.

Also, once an overspray condition is detected, overspray characteristic generator **280** can detect or generate or otherwise derive characteristics of the overspray condition. Quantity generator **282** can generate a quantitative value indicative of the quantity of sprayed substance that has been oversprayed across the field boundary. This can be based upon the droplet size detected by the sensors on the UAVs, based upon the droplet size being sprayed or particulate matter size detected or sprayed, etc. Overspray distance generator **284** can also generate a distance value indicative

of how far the overspray extended across the field boundary. This can be based on the prevailing wind conditions, the elevation of the boom on sprayer **100**, the elevation of the UAVs **124-126** when they detected the overspray condition, etc.

Data capture logic **288** illustratively uses sensor accessing logic **290** to access various sensor data, and data store control logic **292** to control data store **168** on sprayer **100** so that it captures overspray data **190**. Some examples of this are described below.

Sprayer control signal generator logic **296** can use nozzle control logic **298** to control the nozzles or the operation of the nozzles on sprayer **100**. It can use path control logic **300** to change or control the path of sprayer **100** based upon the detected overspray condition. Alert/notification system **304** can control operator interfaces **178** to generate an alert or notification to operator **163** indicative of the detected overspray condition.

FIGS. **8A** and **8B** (collectively referred to herein as FIG. **8**) illustrate a flow diagram showing one example of the operation of architecture **160** in more detail. It is first assumed that sprayer **100** is running and that it has a set of UAVs **124-126** onboard. This is indicated by block **320** in the flow diagram of FIG. **8**. It will be noted that the set of UAVs can include a single UAV, or multiple UAVs (such as two UAVs indicated by block **322**). The UAVs can be tethered to sprayer **100** for power and communication as indicated by block **324**. They can be mounted on mounting assembly **172** and have battery or power cells being charged by UAV charging system **174**. Thus, they can have a wireless connection as indicated by block **326**.

Also, in one example, the sensors **238** on the UAVs are calibrated. This is indicated by block **328**. For instance, readings can be taken from the sensors in clear air (where sprayer **100** is not spraying or applying any substance to a field. The sensor signals, in clear air, can be taken as a baseline value, against which other sensor measurements are compared, when they are deployed.

The sprayer can be running in other ways as well. This is indicated by block **330**.

UAV position control logic **260** then accesses the field location and shape data **188** in data store **168**. This is indicated by block **332** in the flow diagram of FIG. **8**. Accessing field location data is indicated by block **334**, and accessing field shape or boundary data is indicated by block **336**. The other data can be accessed as well, and this is indicated by block **338**.

Likely drift detector **262** then accesses sensor signals of sensors **180** on sprayer **100** to evaluate the sensed variables that are sensed by the various sensors **180**. This is indicated by block **340** in the flow diagram of FIG. **8**. For instance, likely drift detector **262** can obtain wind speed data **342** from the wind speed sensor **202**. It can obtain wind direction data **344** from the wind direction sensor **200**. It can obtain sprayer location data **346** from location sensor **194**. It can obtain sprayer heading/speed (or route) data **348** from the heading/speed sensor **196**. It can obtain a wide variety of other information **350**, such as characteristics of the substance being sprayed or other information as well. Based on the information from the sensors **180**, likely drift detector **262** can determine whether an overspray condition is likely to happen. For instance, if the wind is strong enough, and in the right direction, and if the location of sprayer **100** is near a field boundary, this may indicate that it is likely that an overspray condition may occur. If not, processing simply reverts to block **340** where the sensor signals from sensors **180** on sprayer **100** are monitored.

If so, as indicated at block 352, then path planning logic 264 determines whether it is time to launch UAVs 124-126 and if so controls them accordingly. For instance, monitor area logic 269 identifies the location of a monitor area where an overspray condition is likely to happen. This is indicated by block 354. As discussed above with respect to FIGS. 1-5, the monitor area can be an area or location of possible or likely unwanted spray drift. This is indicated by block 356. This can be defined based on the location of sprayer 100 being near a field boundary as indicated by block 358, and it can be determined in a wide variety of other ways as indicated by block 360.

If monitor area logic 269 identifies a monitor area that should be monitored for overspray (as indicated by block 362), then it provides a signal indicating this to UAV deployment logic 270, which deploys UAVs 124-126 to sensor locations, in the monitor area that was identified. This is indicated by block 364. UAV deployment logic 270 may illustratively provide an output to control signal generator logic 266 indicating the sensor locations. Control signal generator logic 266 then generates UAV control signals to decouple UAVs 124-126 from mounting assembly 172, to launch UAVs 124-126 and navigate them to their sensor locations in the identified monitor areas. This is indicated by block 366. In another example, control signal generator logic 266 can load a path into the navigation control system 234 on UAVs 124-126 and the UAVs, themselves, can move into the sensor locations. This is indicated by block 368. The UAVs can be deployed to the sensor locations in other ways as well, and this is indicated by block 370.

As sprayer 100 moves through the field, sprayer following logic 278 illustratively provides an output to control signal generator logic 266 indicating that logic 266 should control UAVs 124-126 to follow the sprayer. This can include the sprayer heading and speed (or route), the location of new monitor areas, etc.). Repositioning the UAVs as the sprayer moves is indicated by block 372.

If, while the UAVs are deployed to their sensor locations, they detect an overspray condition, as indicated by block 374, they illustratively provide a signal to overspray detection system 166 indicating that an overspray condition has been detected. In that case, overspray detection system 166 performs overspray operations, as indicated by block 376. One example of this is described in greater detail below with respect to FIG. 9.

If an overspray condition is not detected, or after the overspray operations have been performed, then UAVs 124-126 continue to move along with sprayer 100 to sense additional overspray conditions, if they occur. This is indicated by block 378.

At some point, monitor area logic 269 will determine that sprayer 100 is not near a monitor area that needs to be monitored, or likely drift detector 262 may detect that the conditions have changed so an overspray condition is unlikely. In that case, UAVs 124-126 need not monitor for an overspray condition any longer. This is indicated by block 380. Thus, UAV return control logic 274 provides signals to control signal generator logic 266 so that logic 266 generates UAV control signals to control the UAVs 124-126 to return them to the UAV mounting assembly 172 on sprayer 100. This is indicated by block 382 in the flow diagram of FIG. 8. In one example, UAV charging system 174 again recharges the batteries on UAVs 124-126. This is indicated by block 384. Other operations can be performed on the UAVs when they return to sprayer 100 as well, and this is indicated by block 386.

The processing in FIG. 8 can continue at block 340, where the sensor signals are detected, until the spraying operation for the current field ends. This is indicated by block 388 in the flow diagram of FIG. 8.

FIG. 9 is a flow diagram illustrating one example of the operation of architecture 160 (shown in FIG. 7) in performing overspray operations (as indicated by block 376 in FIG. 8). It is first assumed, for the sake of FIG. 9, that an overspray condition has been detected, and that one of the UAVs 124-126 has detected the presence of a chemical or moisture in a monitor area, or other indication that an overspray has occurred in a monitor area where the UAV is positioned. This is indicated by block 400 in the flow diagram of FIG. 9.

Sensor accessing logic 290 in data capture logic 288 then accesses sensors to obtain sensor values of the sensed variables, and data store control logic 292 controls data store 168 to store those values to record that the overspray was detected and to record certain variable values corresponding to the detected overspray condition. In one example, sensor accessing logic 290 accesses the signal provided by location sensor 228 on UAV 124 (assuming UAV 124 is the UAV that sensed the overspray condition), as well as the signal value generated by elevation sensor 230. These values are indicative of the location and elevation of the UAV that detected the overspray condition. Data store control logic 292 then controls data store 168 to store that UAV elevation and position as part of the overspray data 190 recorded for this overspray condition. This is indicated by block 402 in the flow diagram of FIG. 9.

Overspray detected control logic 276 (in overspray detection system 166 shown in FIG. 7) then generates signals to control the UAV to vary its elevation, so that the various elevations where an overspray condition is detected can be determined. Generating control signals to control the UAV to move to various elevations is indicated by block 404. The sensors 238 on the UAV then detect whether an overspray condition is present at the various elevations. If so, the data capture logic 298 records the elevation and position of the UAV that is detecting the overspray condition. This is indicated by block 406 in FIG. 9.

Sensor accessing logic 290 can then access the sensor signals (or values indicative of the sensed variables) from a variety of different sensors, to obtain and record that information. For instance, in one example, sensor accessing logic 290 accesses machine configuration sensors to detect a variety of different machine configuration settings or characteristics. Data store control logic 292 can then store the machine configuration that exists at the time of the detected overspray condition as well. This is indicated by block 408. For instance, sensor accessing logic 290 can access boom height sensor 204 to record boom height. This is indicated by block 410. It can access nozzle type sensor or nozzle setting sensor 206 to record the nozzle type or setting of the nozzles being used on the sprayer 100. This is indicated by block 412. It can access droplet size sensor 208 to identify the droplet size of droplets being sprayed by sprayer 100. It can also generate an indication of the droplet size from the signals generated by sensors 238 on the UAV. Obtaining droplet size information is indicated by block 414. Logic 290 can access a wide variety of other machine configuration settings or sensors and record those as well. This is indicated by block 416.

Overspray characteristic generator 280 can then obtain or calculate or otherwise identify different characteristics of the detected overspray condition. For instance, quantity generator 282 can illustratively identify or estimate a quantity of

the sprayed substance that has crossed the field boundary. This can be determined, for instance, based upon the droplet size, based upon the wind speed and wind direction, based upon the elevations at which the overspray detection is detected by the UAV, based upon the boom height, or based upon a wide variety of other items. Overspray distance generator **284** can also generate an output indicative of a distance that the overspray extended across the field boundary. This can be done by positioning the UAV that detected the overspray condition further away from the field boundary until the presence of the sprayed substance is no longer detected. It can also be calculated or estimated based upon, again, the wind speed and wind direction, the boom height, the droplet size or chemical being sprayed, the various elevations at which the overspray condition was detected, among other things. Determining and recording overspray quantity and distance is indicated by block **418** in the flow diagram of FIG. **9**. Data capture logic **288**, or other items in overspray detection system **166** or elsewhere can also detect and record other overspray characteristics. This is indicated by block **420**. For instance, they can detect the date **422**, the time of day **424**, the particular chemical or product being sprayed **426**, ambient weather conditions **428**, or other characteristics **430**.

Sprayer control signal generator logic **296** can then illustratively generate control signals to control various controllable subsystems **184** on sprayer **100**, based upon the detected overspray condition. This is indicated by block **432** in the flow diagram of FIG. **9**. In one example, sprayer control signal generator logic **296** generates control signals to control operator interfaces **178** to show an operator user interface element (such as a warning, an alert, or another indication) indicative of the detected overspray condition. This is indicated by block **434**. Sprayer control signal generator logic **296** can generate control signals to control the boom position subsystem **213** to control the boom height. This is indicated by block **436**. Nozzle control logic **298** can generate control signals to control nozzles **218**. For instance, it can modify the nozzles to control the droplet size of the droplets being sprayed. This is indicated by block **438**. By way of example, if the droplet size is increased, it may be less likely that the substance will cross a field boundary. It can shut off the nozzles as indicated by block **440**, or a subset of the nozzles (such as those closest to the field boundary). It can inject drift retardant **442** into the sprayed substance. In one example, path control logic **300** illustratively controls the sprayer speed of sprayer **100**. This is indicated by block **444**. In another example, path control logic **300** generates control signals to control the propulsion subsystem **214** and steering subsystem **216** of sprayer **100** to change the path or route of sprayer **100**. Performing path planning is indicated by block **446**. It can change the sprayer route as indicated by block **448**. It can also store locations along the route of sprayer **100** where the nozzles were turned off. This is indicated by block **450**. It can then control sprayer **100** to return to the spots that were skipped, when the wind changes or when other conditions change so that an overspray condition is less likely. This is indicated by block **452**. It will be appreciated that a wide variety of other control signals can be generated to control other items on sprayer **100**. This is indicated by block **454**.

The present discussion has mentioned processors and servers. In one embodiment, the processors and servers include computer processors with associated memory and timing circuitry, not separately shown. They are functional parts of the systems or devices to which they belong and are

activated by, and facilitate the functionality of the other components or items in those systems.

Also, a number of user interface displays have been discussed. They can take a wide variety of different forms and can have a wide variety of different user actuatable input mechanisms disposed thereon. For instance, the user actuatable input mechanisms can be text boxes, check boxes, icons, links, drop-down menus, search boxes, etc. They can also be actuated in a wide variety of different ways. For instance, they can be actuated using a point and click device (such as a track ball or mouse). They can be actuated using hardware buttons, switches, a joystick or keyboard, thumb switches or thumb pads, etc. They can also be actuated using a virtual keyboard or other virtual actuators. In addition, where the screen on which they are displayed is a touch sensitive screen, they can be actuated using touch gestures. Also, where the device that displays them has speech recognition components, they can be actuated using speech commands.

A number of data stores have also been discussed. It will be noted they can each be broken into multiple data stores. All can be local to the systems accessing them, all can be remote, or some can be local while others are remote. All of these configurations are contemplated herein.

Also, the figures show a number of blocks with functionality ascribed to each block. It will be noted that fewer blocks can be used so the functionality is performed by fewer components. Also, more blocks can be used with the functionality distributed among more components.

FIG. **10** is a block diagram of sprayer **100**, shown in FIG. **6**, except that it communicates with elements in a remote server architecture **500**. In an example remote server architecture **500** can provide computation, software, data access, and storage services that do not require end-user knowledge of the physical location or configuration of the system that delivers the services. In various embodiments, remote servers can deliver the services over a wide area network, such as the internet, using appropriate protocols. For instance, remote servers can deliver applications over a wide area network and they can be accessed through a web browser or any other computing component. Software or components shown in FIG. **6** as well as the corresponding data, can be stored on servers at a remote location. The computing resources in a remote server environment can be consolidated at a remote data center location or they can be dispersed. Remote server infrastructures can deliver services through shared data centers, even though they appear as a single point of access for the user. Thus, the components and functions described herein can be provided from a remote server at a remote location using a remote server architecture. Alternatively, they can be provided from a conventional server, or they can be installed on client devices directly, or in other ways.

In the example shown in FIG. **10**, some items are similar to those shown in FIG. **6** and they are similarly numbered. FIG. **10** specifically shows that remote systems **163** can be located at a remote server location **502**. Therefore, sprayer **100** accesses those systems through remote server location **502**.

FIG. **10** also depicts another example of a remote server architecture. FIG. **10** shows that it is also contemplated that some elements of FIG. **6** are disposed at remote server location **502** while others are not. By way of example, data store **168** can be disposed at a location **502** or separate from location **502**, and accessed through the remote server at location **502**. Regardless of where they are located, they can be accessed directly by sprayer **100**, through a network

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(either a wide area network or a local area network), they can be hosted at a remote site by a service, or they can be provided as a service, or accessed by a connection service that resides in a remote location. Also, the data can be stored in substantially any location and intermittently accessed by, or forwarded to, interested parties. For instance, physical carriers can be used instead of, or in addition to, electromagnetic wave carriers. In such an embodiment, where cell coverage is poor or nonexistent, another mobile machine (such as a fuel truck) can have an automated information collection system. As the sprayer comes close to the fuel truck for fueling, the system automatically collects the information from the sprayer using any type of ad-hoc wireless connection. The collected information can then be forwarded to the main network as the fuel truck reaches a location where there is cellular coverage (or other wireless coverage). For instance, the fuel truck may enter a covered location when traveling to fuel other machines or when at a main fuel storage location. All of these architectures are contemplated herein. Further, the information can be stored on the sprayer until the sprayer enters a covered location. The sprayer, itself, can then send the information to the main network.

It will also be noted that the elements of FIG. 6, or portions of them, can be disposed on a wide variety of different devices. Some of those devices include servers, desktop computers, laptop computers, tablet computers, or other mobile devices, such as palm top computers, cell phones, smart phones, multimedia players, personal digital assistants, etc.

FIG. 11 is a simplified block diagram of one illustrative example of a handheld or mobile computing device that can be used as a user's or client's hand held device 16, in which the present system (or parts of it) can be deployed. For instance, a mobile device can be deployed in the operator compartment of sprayer 100 for use in generating, processing, or displaying the overspray data and position data. FIGS. 12-13 are examples of handheld or mobile devices.

FIG. 11 provides a general block diagram of the components of a client device 16 that can run some components shown in FIG. 6, that interacts with them, or both. In the device 16, a communications link 13 is provided that allows the handheld device to communicate with other computing devices and under some embodiments provides a channel for receiving information automatically, such as by scanning. Examples of communications link 13 include allowing communication through one or more communication protocols, such as wireless services used to provide cellular access to a network, as well as protocols that provide local wireless connections to networks.

In other examples, applications can be received on a removable Secure Digital (SD) card that is connected to an interface 15. Interface 15 and communication links 13 communicate with a processor 17 (which can also embody processors or servers from other FIGS.) along a bus 19 that is also connected to memory 21 and input/output (I/O) components 23, as well as clock 25 and location system 27.

I/O components 23, in one embodiment, are provided to facilitate input and output operations. I/O components 23 for various embodiments of the device 16 can include input components such as buttons, touch sensors, optical sensors, microphones, touch screens, proximity sensors, accelerometers, orientation sensors and output components such as a display device, a speaker, and or a printer port. Other I/O components 23 can be used as well.

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Clock 25 illustratively comprises a real time clock component that outputs a time and date. It can also, illustratively, provide timing functions for processor 17.

Location system 27 illustratively includes a component that outputs a current geographical location of device 16. This can include, for instance, a global positioning system (GPS) receiver, a LORAN system, a dead reckoning system, a cellular triangulation system, or other positioning system. It can also include, for example, mapping software or navigation software that generates desired maps, navigation routes and other geographic functions.

Memory 21 stores operating system 29, network settings 31, applications 33, application configuration settings 35, data store 37, communication drivers 39, and communication configuration settings 41. Memory 21 can include all types of tangible volatile and non-volatile computer-readable memory devices. It can also include computer storage media (described below). Memory 21 stores computer readable instructions that, when executed by processor 17, cause the processor to perform computer-implemented steps or functions according to the instructions. Processor 17 can be activated by other components to facilitate their functionality as well.

FIG. 12 shows one example in which device 16 is a tablet computer 600. In FIG. 12, computer 600 is shown with user interface display screen 602. Screen 602 can be a touch screen or a pen-enabled interface that receives inputs from a pen or stylus. It can also use an on-screen virtual keyboard. Of course, it might also be attached to a keyboard or other user input device through a suitable attachment mechanism, such as a wireless link or USB port, for instance. Computer 600 can also illustratively receive voice inputs as well.

FIG. 13 shows that the device can be a smart phone 71. Smart phone 71 has a touch sensitive display 73 that displays icons or tiles or other user input mechanisms 75. Mechanisms 75 can be used by a user to run applications, make calls, perform data transfer operations, etc. In general, smart phone 71 is built on a mobile operating system and offers more advanced computing capability and connectivity than a feature phone.

Note that other forms of the devices 16 are possible.

FIG. 14 is one embodiment of a computing environment in which elements of FIG. 6, or parts of it, (for example) can be deployed. With reference to FIG. 14, an example system for implementing some embodiments includes a general-purpose computing device in the form of a computer 810. Components of computer 810 may include, but are not limited to, a processing unit 820 (which can comprise processors or servers from other FIGS.), a system memory 830, and a system bus 821 that couples various system components including the system memory to the processing unit 820. The system bus 821 may be any of several types of bus structures including a memory bus or memory controller, a peripheral bus, and a local bus using any of a variety of bus architectures. Memory and programs described with respect to FIG. 1 can be deployed in corresponding portions of FIG. 14.

Computer 810 typically includes a variety of computer readable media. Computer readable media can be any available media that can be accessed by computer 810 and includes both volatile and nonvolatile media, removable and non-removable media. By way of example, and not limitation, computer readable media may comprise computer storage media and communication media. Computer storage media is different from, and does not include, a modulated data signal or carrier wave. It includes hardware storage media including both volatile and nonvolatile, removable

and non-removable media implemented in any method or technology for storage of information such as computer readable instructions, data structures, program modules or other data. Computer storage media includes, but is not limited to, RAM, ROM, EEPROM, flash memory or other memory technology, CD-ROM, digital versatile disks (DVD) or other optical disk storage, magnetic cassettes, magnetic tape, magnetic disk storage or other magnetic storage devices, or any other medium which can be used to store the desired information and which can be accessed by computer **810**. Communication media may embody computer readable instructions, data structures, program modules or other data in a transport mechanism and includes any information delivery media. The term “modulated data signal” means a signal that has one or more of its characteristics set or changed in such a manner as to encode information in the signal.

The system memory **830** includes computer storage media in the form of volatile and/or nonvolatile memory such as read only memory (ROM) **831** and random access memory (RAM) **832**. A basic input/output system **833** (BIOS), containing the basic routines that help to transfer information between elements within computer **810**, such as during start-up, is typically stored in ROM **831**. RAM **832** typically contains data and/or program modules that are immediately accessible to and/or presently being operated on by processing unit **820**. By way of example, and not limitation, FIG. **14** illustrates operating system **834**, application programs **835**, other program modules **836**, and program data **837**.

The computer **810** may also include other removable/non-removable volatile/nonvolatile computer storage media. By way of example only, FIG. **14** illustrates a hard disk drive **841** that reads from or writes to non-removable, nonvolatile magnetic media, an optical disk drive **855**, and nonvolatile optical disk **856**. The hard disk drive **841** is typically connected to the system bus **821** through a non-removable memory interface such as interface **840**, and optical disk drive **855** are typically connected to the system bus **821** by a removable memory interface, such as interface **850**.

Alternatively, or in addition, the functionality described herein can be performed, at least in part, by one or more hardware logic components. For example, and without limitation, illustrative types of hardware logic components that can be used include Field-programmable Gate Arrays (FPGAs), Application-specific Integrated Circuits (e.g., ASICs), Application-specific Standard Products (e.g., ASSPs), System-on-a-chip systems (SOCs), Complex Programmable Logic Devices (CPLDs), etc.

The drives and their associated computer storage media discussed above and illustrated in FIG. **14**, provide storage of computer readable instructions, data structures, program modules and other data for the computer **810**. In FIG. **14**, for example, hard disk drive **841** is illustrated as storing operating system **844**, application programs **845**, other program modules **846**, and program data **847**. Note that these components can either be the same as or different from operating system **834**, application programs **835**, other program modules **836**, and program data **837**.

A user may enter commands and information into the computer **810** through input devices such as a keyboard **862**, a microphone **863**, and a pointing device **861**, such as a mouse, trackball or touch pad. Other input devices (not shown) may include foot pedals, steering wheels, levers, buttons, a joystick, game pad, satellite dish, scanner, or the like. These and other input devices are often connected to the processing unit **820** through a user input interface **860** that is coupled to the system bus, but may be connected by other

interface and bus structures. A visual display **891** or other type of display device is also connected to the system bus **821** via an interface, such as a video interface **890**. In addition to the monitor, computers may also include other peripheral output devices such as speakers **897** and printer **896**, which may be connected through an output peripheral interface **895**.

The computer **810** is operated in a networked environment using logical connections (such as a local area network—LAN, or wide area network WAN) to one or more remote computers, such as a remote computer **880**.

When used in a LAN networking environment, the computer **810** is connected to the LAN **871** through a network interface or adapter **870**. When used in a WAN networking environment, the computer **810** typically includes a modem **872** or other means for establishing communications over the WAN **873**, such as the Internet. In a networked environment, program modules may be stored in a remote memory storage device. FIG. **14** illustrates, for example, that remote application programs **885** can reside on remote computer **880**.

It should also be noted that the different examples described herein can be combined in different ways. That is, parts of one or more examples can be combined with parts of one or more other examples. All of this is contemplated herein.

A first example includes a mobile agricultural sprayer, comprising:

a frame;

a tank configured to carrying a substance to be sprayed;

a spraying mechanism that sprays the substance;

likely drift detector logic that receives sprayer location information indicative of a geographic location of the sprayer, a wind sensor signal indicative of a value of a sensed wind variable and field characteristic data indicative of a geographical characteristic of a field, and generates an overspray likely signal when a likely overspray condition is identified, based on the sprayer location information, the value of the sensed wind variable and the geographical characteristic of the field; and

an overspray detection system that generates control signals to deploy a mobile sensor, that senses a spray variable indicative of a presence of the substance, to a sensor location corresponding to the likely overspray condition, and that receives an overspray detected signal indicative of the mobile sensor sensing the presence of the substance at the sensor location.

A second example includes the mobile agricultural sprayer of any or all previous examples wherein the likely drift detector logic is configured to receive, as the wind sensor signal, a wind speed signal indicative of wind speed, and a wind direction signal indicative of wind direction and to generate the overspray likely signal based on the wind speed and wind direction.

A third example includes the mobile agricultural sprayer of any or all previous examples wherein the likely drift detector logic is configured to receive, as the field characteristic data, boundary information indicative of a geographic location of boundaries of the field, and to generate the overspray likely signal based on the geographic location of the boundaries of the field.

A fourth example includes the mobile agricultural sprayer of any or all previous examples wherein the mobile sensor comprises:

an unmanned aerial vehicle (UAV); and

a substance sensor mounted to the UAV to sense the spray variable.

A fifth example includes the mobile agricultural sprayer of any or all previous examples and further comprising:

a UAV mounting assembly coupled to the frame and configured to detachably couple the UAV to the frame to be carried by the frame; and

UAV deployment logic configured to generate a control signal to detach the UAV from the mounting assembly and to generate the control signals to deploy the UAV to the sensor location.

A sixth example includes the mobile agricultural sprayer of any or all previous examples wherein the overspray detection system comprises:

monitor area logic configured to identify a monitor area where the likely overspray condition will occur and to generate a monitor area signal indicative of the identified monitor area; and

mobile sensor deployment logic that generates the control signals to deploy the UAV to the sensor location within the monitor area, based on the monitor area signal.

A seventh example includes the mobile agricultural sprayer of any or all previous examples wherein the overspray detection system comprises:

overspray detected control logic configured to receive the overspray detected signal from the UAV and to generate a control signal to vary an elevation of the UAV in the monitor area and to determine whether the overspray detected signal is received from the UAV at the varied elevation.

An eighth example includes the mobile agricultural sprayer of any or all previous examples wherein the overspray detected control logic is configured to generate a control signal to vary a distance of the UAV from the field boundary and to determine whether the overspray detected signal is received from the UAV at the varied distance.

A ninth example includes the mobile agricultural sprayer of any or all previous examples wherein the overspray detection system comprises:

an overspray quantity generator configured to generate an overspray quantity indicator indicative of a quantity of the substance corresponding to the detected overspray condition.

A tenth example includes the mobile agricultural sprayer of any or all previous examples wherein the overspray detection system comprises:

an overspray distance generator configured to generate an overspray distance indicator indicative of a distance that the substance drifted across the field boundary, corresponding to the detected overspray condition.

An eleventh example includes the mobile agricultural sprayer of any or all previous examples wherein the spraying mechanism comprises a set of nozzles and a pump and wherein the overspray detection system comprises:

sprayer control signal generator logic configured to generate sprayer control signals to control at least one of the pump and the set of nozzles based on the overspray detected signal.

A twelfth example includes the mobile agricultural sprayer of any or all previous examples wherein the overspray detection system comprises:

path control logic configured to generate path control signals to control a path of the mobile agricultural sprayer based on the overspray detected signal.

A thirteenth example includes an overspray detection system, comprising:

likely drift detector logic that receives sprayer location information indicative of a geographic location of a mobile agricultural sprayer in a field, wind sensor signals indicative of a value of a sensed wind direction and a sensed wind

speed, and field characteristic data indicative of a geographic boundary of the field, and that generates an overspray likely signal when a likely overspray condition is identified, based on the sprayer location information, the value of the sensed wind direction and wind speed and the geographic boundary of the field;

unmanned aerial vehicle (UAV) deployment logic that generates control signals to deploy a UAV, carrying a substance sensor that senses a sensed variable indicative of a presence of a substance sprayed by the mobile agricultural sprayer, to a sensor location corresponding to the likely overspray condition; and

overspray detected control logic that receives an overspray detected signal indicative of the mobile sensor sensing the presence of the substance at the sensor location and generates overspray control signals to perform overspray operations based on the overspray detected signal received.

A fourteenth example includes the overspray detection system of any or all previous examples and further comprising:

monitor area logic configured to identify a monitor area where the likely overspray condition will occur and to generate a monitor area signal indicative of the identified monitor area, wherein the UAV deployment logic generates the control signals to deploy the UAV to the sensor location within the monitor area, based on the monitor area signal.

A fifteenth example includes the overspray detection system of any or all previous examples and further comprising:

UAV return logic configured to generate control signals to return the UAV to the mobile agricultural sprayer based on the likely drift detector logic detecting that the likely overspray condition is no longer present.

A sixteenth example includes the overspray detection system of any or all previous examples and further comprising:

sprayer following logic configured to generate control signals to control the UAV to reposition itself to a new monitor location based on movement of the mobile agricultural sprayer to a new location.

A seventeenth example includes a computer implemented method of controlling a mobile agricultural sprayer, comprising:

receiving sprayer location information indicative of a geographic location of the sprayer;

receiving a wind sensor signal indicative of a value of a sensed wind variable;

receiving field boundary data indicative of a geographic boundary of a field;

generating an overspray likely signal when a likely overspray condition is identified, indicating that a substance sprayed by the mobile agricultural sprayer is likely to cross the boundary of the field, based on the sprayer location information, the value of the sensed wind variable and the geographic boundary of the field; and

generating control signals to deploy a mobile sensor, that senses a spray variable indicative of a presence of the substance, to a sensor location corresponding to the likely overspray condition.

An eighteenth example includes the computer implemented method of any or all previous examples and further comprising:

receiving an overspray detected signal indicative of the mobile sensor sensing the presence of the substance at the sensor location; and

generating overspray control signals to perform overspray operations based on the overspray detected signal.

A nineteenth example includes the computer implemented method of any or all previous examples wherein the mobile sensor comprises an unmanned aerial vehicle (UAV) and wherein generating overspray control signals comprises:

generating a control signal to vary an elevation of the UAV and determining whether the overspray detected signal is received from the UAV at the varied elevation.

A twentieth example includes the computer implemented method of any or all previous examples wherein the mobile sensor comprises an unmanned aerial vehicle (UAV) and wherein generating overspray control signals comprises:

generating a control signal to vary a distance of the UAV from the field boundary and determining whether the overspray detected signal is received from the UAV at the varied distance.

Although the subject matter has been described in language specific to structural features and/or methodological acts, it is to be understood that the subject matter defined in the appended claims is not necessarily limited to the specific features or acts described above. Rather, the specific features and acts described above are disclosed as example forms of implementing the claims.

What is claimed is:

1. A mobile agricultural sprayer, comprising:
 - a frame;
 - a tank configured to carry a substance to be sprayed;
 - a spraying mechanism that sprays the substance;
 - likely drift detector logic that receives sprayer location information indicative of a geographic location of the sprayer, a wind sensor signal indicative of a value of a sensed wind variable and field characteristic data indicative of a geographical characteristic of a field, and generates an overspray likely signal when a likely overspray condition is identified, based on the sprayer location information, the value of the sensed wind variable and the geographical characteristic of the field; and
 - an overspray detection system that generates control signals to deploy a mobile sensor, that senses a spray variable indicative of a presence of the substance, to a sensor location corresponding to the likely overspray condition, and that receives an overspray detected signal indicative of the mobile sensor sensing the presence of the substance at the sensor location.
2. The mobile agricultural sprayer of claim 1 wherein the likely drift detector logic is configured to receive, as the wind sensor signal, a wind speed signal indicative of wind speed, and a wind direction signal indicative of wind direction and to generate the overspray likely signal based on the wind speed and wind direction.
3. The mobile agricultural sprayer of claim 2 wherein the likely drift detector logic is configured to receive, as the field characteristic data, boundary information indicative of a geographic location of boundaries of the field, and to generate the overspray likely signal based on the geographic location of the boundaries of the field.
4. The mobile agricultural sprayer of claim 3 wherein the mobile sensor comprises:
 - an unmanned aerial vehicle (UAV); and
 - a substance sensor mounted to the UAV to sense the spray variable.
5. The mobile agricultural sprayer of claim 4 and further comprising:
 - a UAV mounting assembly coupled to the frame and configured to detachably couple the UAV to the frame to be carried by the frame; and

UAV deployment logic configured to generate a control signal to detach the UAV from the mounting assembly and to generate the control signals to deploy the UAV to the sensor location.

6. The mobile agricultural sprayer of claim 5 wherein the overspray detection system comprises:

monitor area logic configured to identify a monitor area where the likely overspray condition will occur and to generate a monitor area signal indicative of the identified monitor area; and

mobile sensor deployment logic that generates the control signals to deploy the UAV to the sensor location within the monitor area, based on the monitor area signal.

7. The mobile agricultural sprayer of claim 6 wherein the overspray detection system comprises:

overspray detected control logic configured to receive the overspray detected signal from the UAV and to generate a control signal to vary an elevation of the UAV in the monitor area and to determine whether the overspray detected signal is received from the UAV at the varied elevation.

8. The mobile agricultural sprayer of claim 7 wherein the overspray detected control logic is configured to generate a control signal to vary a distance of the UAV from the field boundary and to determine whether the overspray detected signal is received from the UAV at the varied distance.

9. The mobile agricultural sprayer of claim 8 wherein the overspray detection system comprises:

an overspray quantity generator configured to generate an overspray quantity indicator indicative of a quantity of the substance corresponding to the detected overspray condition.

10. The mobile agricultural sprayer of claim 8 wherein the overspray detection system comprises:

an overspray distance generator configured to generate an overspray distance indicator indicative of a distance that the substance drifted across the field boundary, corresponding to the detected overspray condition.

11. The mobile agricultural sprayer of claim 6 wherein the spraying mechanism comprises a set of spreaders that spread granular material and wherein the overspray detection system comprises:

sprayer control signal generator logic configured to generate spreader control signals to control at least one of the spreaders in the set of spreaders based on the overspray detected signal.

12. The mobile agricultural sprayer of claim 6 wherein the overspray detection system comprises:

path control logic configured to generate path control signals to control a path of the mobile agricultural sprayer based on the overspray detected signal.

13. An overspray detection system, comprising:

likely drift detector logic that receives sprayer location information indicative of a geographic location of a mobile agricultural sprayer in a field, wind sensor signals indicative of a value of a sensed wind direction and a sensed wind speed, and field characteristic data indicative of a geographic boundary of the field, and that generates an overspray likely signal when a likely overspray condition is identified, based on the sprayer location information, the value of the sensed wind direction and wind speed and the geographic boundary of the field;

unmanned aerial vehicle (UAV) deployment logic that generates control signals to deploy a UAV, carrying a substance sensor that senses a sensed variable indicative of a presence of a substance sprayed by the mobile

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agricultural sprayer, to a sensor location corresponding to the likely overspray condition; and
overspray detected control logic that receives an overspray detected signal indicative of the mobile sensor sensing the presence of the substance at the sensor location and generates overspray control signals to perform overspray operations based on the overspray detected signal received.

14. The overspray detection system of claim 13 and further comprising:

monitor area logic configured to identify a monitor area where the likely overspray condition will occur and to generate a monitor area signal indicative of the identified monitor area, wherein the UAV deployment logic generates the control signals to deploy the UAV to the sensor location within the monitor area, based on the monitor area signal.

15. The overspray detection system of claim 14 and further comprising:

UAV return logic configured to generate control signals to return the UAV to the mobile agricultural sprayer based on the likely drift detector logic detecting that the likely overspray condition is no longer present.

16. The overspray detection system of claim 14 and further comprising:

sprayer following logic configured to generate control signals to control the UAV to reposition itself to a new monitor location based on movement of the mobile agricultural sprayer to a new location.

17. A computer implemented method of controlling a mobile agricultural sprayer, comprising:

receiving sprayer location information indicative of a geographic location of the sprayer;
receiving a wind sensor signal indicative of a value of a sensed wind variable;

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receiving field boundary data indicative of a geographic boundary of a field;

generating an overspray likely signal when a likely overspray condition is identified, indicating that a substance sprayed by the mobile agricultural sprayer is likely to cross the boundary of the field, based on the sprayer location information, the value of the sensed wind variable and the geographic boundary of the field; and
generating control signals to deploy a mobile sensor, that senses a spray variable indicative of a presence of the substance, to a sensor location corresponding to the likely overspray condition.

18. The computer implemented method of claim 17 and further comprising:

receiving an overspray detected signal indicative of the mobile sensor sensing the presence of the substance at the sensor location; and
generating overspray control signals to perform overspray operations based on the overspray detected signal.

19. The computer implemented method of claim 18 wherein the mobile sensor comprises an unmanned aerial vehicle (UAV) and wherein generating overspray control signals comprises:

generating a control signal to vary an elevation of the UAV and determining whether the overspray detected signal is received from the UAV at the varied elevation.

20. The computer implemented method of claim 18 wherein the mobile sensor comprises an unmanned aerial vehicle (UAV) and wherein generating overspray control signals comprises:

generating a control signal to vary a distance of the UAV from the field boundary and determining whether the overspray detected signal is received from the UAV at the varied distance.

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