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(54) **SYSTEM AND METHOD FOR INSPECTION OF STRUCTURES AND OBJECTS BY SWARM OF REMOTE UNMANNED VEHICLES**

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H04N 7/18 (2006.01)

(52) **U.S. Cl.** **701/24**; 348/144

(58) **Field of Classification Search** 701/23, 701/24, 25, 26, 29; 700/245, 264; 180/167, 180/168; 348/144

See application file for complete search history.

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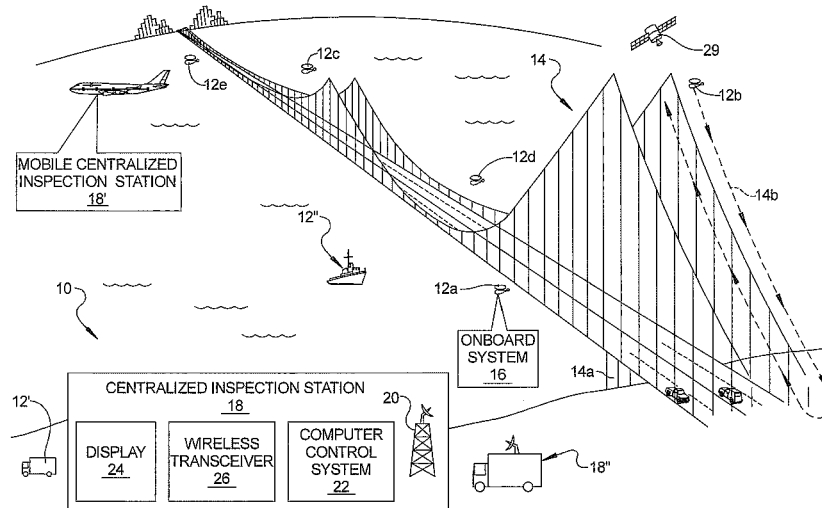
Assistant Examiner — Marthe Marc-Coleman

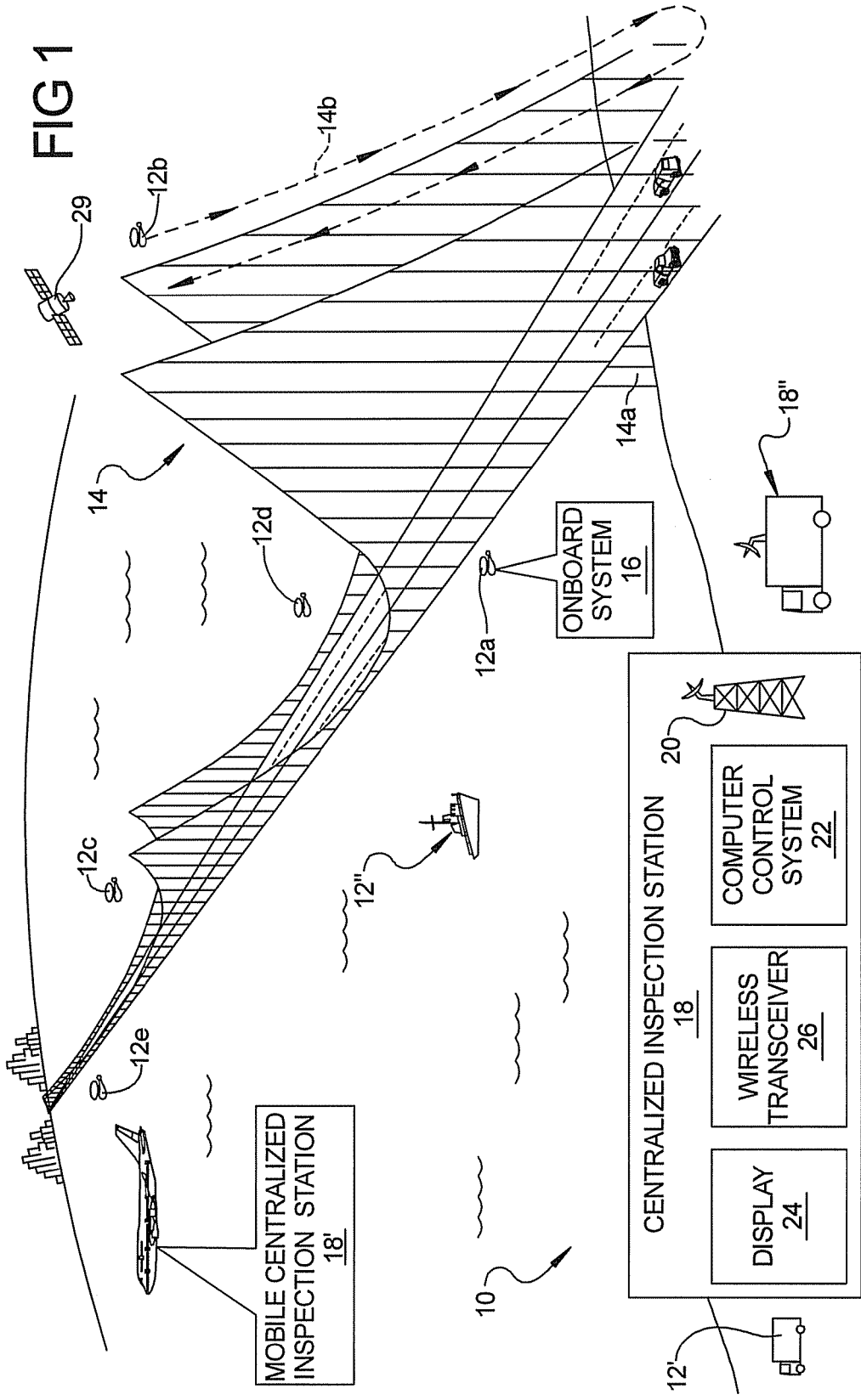
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(57) **ABSTRACT**

A method for inspecting structures that includes using a plurality of independent unmanned mobile vehicles. The unmanned mobile vehicles are equipped with a control and guidance system for enabling each unmanned mobile vehicle to operate autonomously. Each unmanned mobile vehicle may be programmed with an operating program that defines a path of travel for it, relative to a structure to be inspected. The unmanned mobile vehicles are deployed so that they cooperatively form a swarm that travels about the structure. At least one of said unmanned mobile vehicles is used to obtain inspection data of a portion of the structure as it executes its respective operating program.

21 Claims, 3 Drawing Sheets





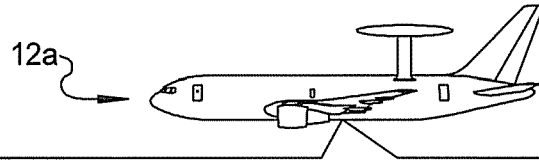


FIG 2

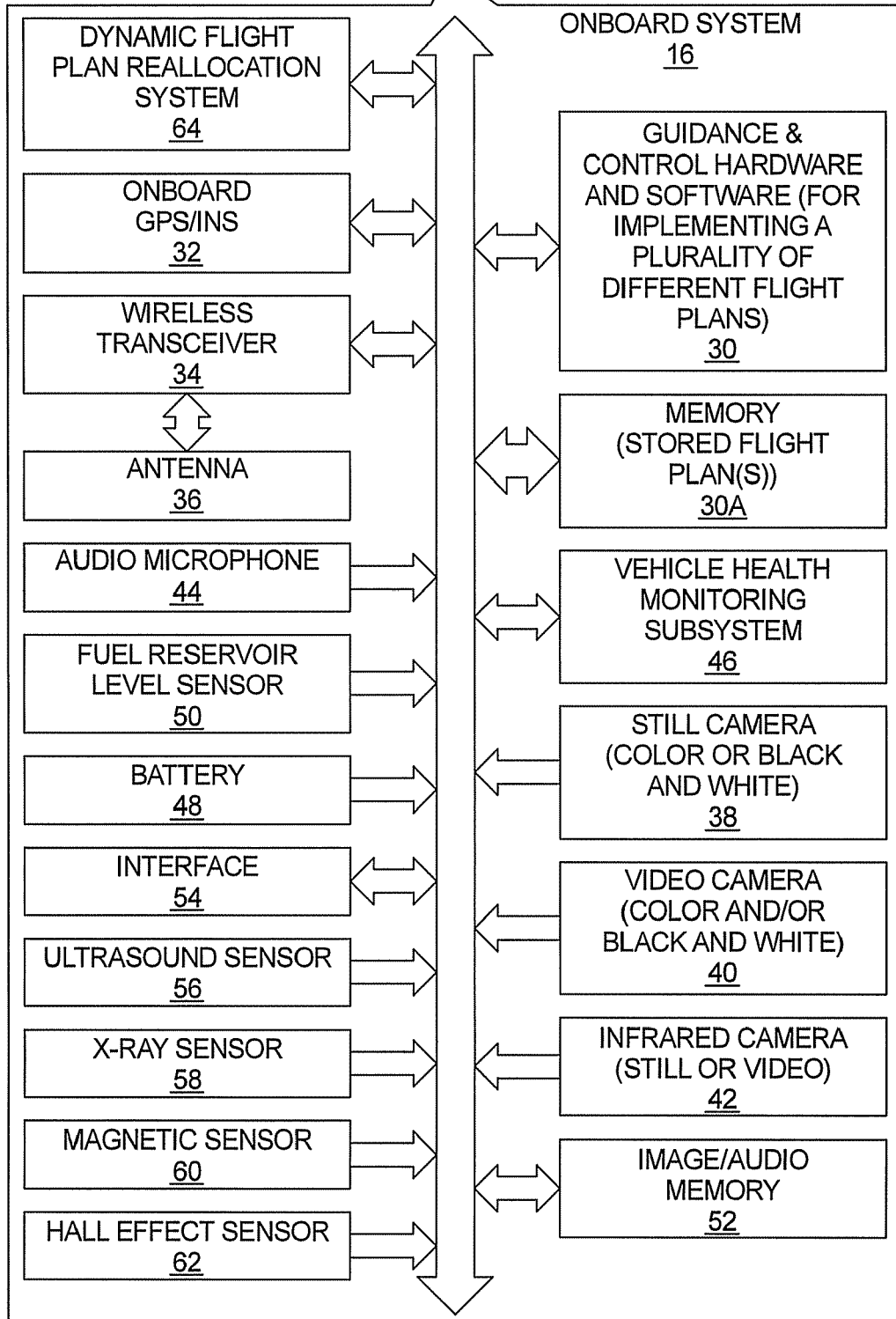
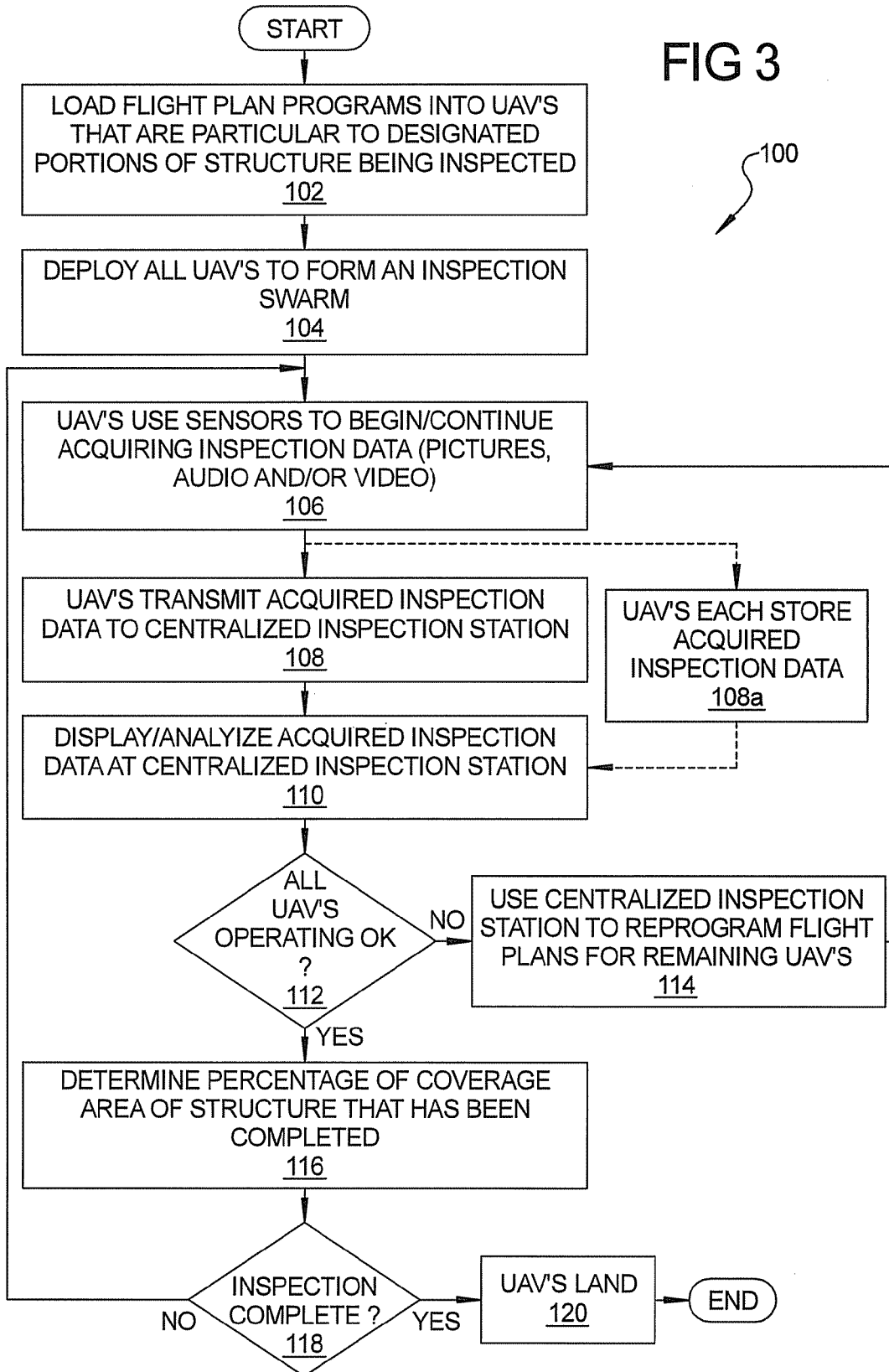


FIG 3



SYSTEM AND METHOD FOR INSPECTION OF STRUCTURES AND OBJECTS BY SWARM OF REMOTE UNMANNED VEHICLES

CROSS-REFERENCE TO RELATED APPLICATIONS

This application takes priority from U.S. Patent Application Nos. 61/032,624 filed Feb. 29, 2008, and 61/032,609 filed Feb. 29, 2008. The disclosures of the above applications are incorporated herein by reference.

This application is related in general subject matter to U.S. patent application Ser. No. 12/124,511, entitled "TRAFFIC AND SECURITY MONITORING SYSTEM AND METHOD" (Boeing Reference 08-0125A) filed concurrently herewith and assigned to the Boeing Company. This disclosure of this application is incorporated herein by reference.

FIELD

The present disclosure relates to systems and methods for performing inspection activities, and more particularly to a system and method for enabling remote inspection of structures or objects by a plurality of unmanned mobile vehicles.

BACKGROUND

The statements in this section merely provide background information related to the present disclosure and may not constitute prior art.

In-person human based inspections of structures and various types of objects can be time consuming, expensive, difficult and often dangerous for an individual to perform. Examples of structures that pose significant challenges in inspecting are bridges, dams, levees, power plants, power lines or electrical power grids, water treatment facilities; oil refineries, chemical processing plants, high rise buildings, infrastructure associated with electric trains and monorail support structures, just to name a few.

The use of static cameras (i.e., fixedly mounted cameras) to provide periodic pictures of a structure or object requiring periodic visual inspection has met with limited effectiveness. Static cameras have a limited field-of-view. Therefore, inspecting a large area, such a power line stretching hundreds of meters or more, is difficult or impossible without using a large number of such cameras. Furthermore, once a camera is mounted in place, it may not be easily accessible for repair or maintenance. The mounting of the camera may require it to be exposed to the elements, which can decrease the reliability and/or cost of operation of the camera.

A static camera mounted near a top of a bridge, to obtain periodic pictures of a structural portion of the bridge, may also be difficult and/or costly to access by an individual if a repair or maintenance becomes necessary. The act of requiring an individual to access a camera mounted high atop a bridge, dam, etc., could also entail significant risk to human safety for the worker or workers charged with such a task.

Occasionally an infrastructure may require inspection where because of environmental, chemical or biological elements the inspection would place a human worker at significant risk to his or her health. Such a situation might be found inside a manufacturing facility, where a periodic regular inspection of a portion of the facility or machines operating within it, in areas where harmful chemicals may be present, needs to be made. Inspection of structural portions of an offshore oil drilling platform would be another example where environmental factors could make the inspection of

various parts of the platform by humans fraught with hazard. Still other structures, for example large antennas or telescopes located on mountains, can present situations where inspection by a human presents significant risk to the individual's safety.

In some inspection applications human piloted helicopters have been used to inspect various infrastructures. However, human piloted helicopters can be expensive to operate in terms of asset cost (helicopter, fuel and maintenance) and operational cost (pilot salary). In addition, inspection is limited by the available number of pilots and helicopters and can be hazardous in some instances, such as during rain or dust storms. Also, the use of human piloted helicopters is sometimes simply not possible during inclement weather.

Remote controlled (RC) helicopters are lower in cost but require a trained RC pilot, and thus inspecting a large area with multiple helicopters requires a large number of expensive trained RC pilots. In addition, precision inspection and the time duration during which an inspection operation may be performed can be limited because of the available number of RC pilots and RC helicopters.

SUMMARY

In one aspect the present disclosure relates to a method for inspecting structures. The method may comprise:

- using a plurality of independent unmanned mobile vehicles;

- equipping each of the unmanned mobile vehicles with a control and guidance system for enabling each unmanned mobile vehicle to operate autonomously;

- programming each unmanned mobile vehicle with an operating program that defines a path of travel for each unmanned mobile vehicle, relative to a structure to be inspected;

- deploying each unmanned mobile vehicle so that the unmanned mobile vehicles cooperatively form a swarm that travels about the structure; and

- using at least one of the unmanned mobile vehicles to obtain inspection data of a portion of the structure as it executes its respective operating program.

In another aspect a method for inspecting structures is disclosed. The method may comprise:

- using a plurality of independent unmanned mobile vehicles;

- equipping each of the unmanned mobile vehicles with a control and guidance system for enabling each unmanned mobile vehicle to operate autonomously;

- programming each unmanned vehicle with an operating program that defines a unique path of travel for each unmanned mobile vehicle, relative to a structure to be inspected;

- deploying each unmanned mobile vehicle so that the unmanned mobile vehicles cooperatively form a swarm that travels about the structure;

- using the unmanned mobile vehicles to obtain images of portions of the structure as each unmanned mobile vehicle executes its respective operating program; and

- causing each unmanned mobile vehicle to wirelessly transmit the images to a remote centralized inspection station.

In another aspect of the present disclosure a system is disclosed for inspecting structures. The system may comprise:

- a plurality of independent unmanned mobile vehicles;
- each of the unmanned mobile vehicles having a control and guidance system for enabling each unmanned mobile vehicle to operate autonomously;

each of the unmanned mobile vehicles including an operating program that defines a path of travel for each unmanned mobile vehicle, relative to a structure to be inspected, so that in operation the unmanned mobile vehicles cooperatively form a swarm that moves about the structure; and

at least one of the unmanned mobile vehicles including an imaging device to obtain an image of a portion of the structure as it executes its respective operating program.

Further areas of applicability will become apparent from the description provided herein. It should be understood that the description and specific examples are intended for purposes of illustration only and are not intended to limit the scope of the present disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

The drawings described herein are for illustration purposes only and are not intended to limit the scope of the present disclosure in any way.

FIG. 1 is a block diagram of one implementation of a system in accordance with the present disclosure;

FIG. 2 is a block diagram of the onboard system that may be carried on each of the UAVs shown in FIG. 1; and

FIG. 3 is a flowchart of major operations that may be performed by the system of FIG. 1.

DETAILED DESCRIPTION

The following description is merely exemplary in nature and is not intended to limit the present disclosure, application, or uses.

Referring to FIG. 1, there is shown a system **10** for inspecting structures. The system **10** includes a plurality of unmanned mobile vehicles **12** that may be used move around a structure **14** requiring periodic inspection. In this example the unmanned mobile vehicles are illustrated as unmanned aerial vehicles, and more specifically as unmanned rotorcraft (hereinafter after simply referred to as "UAVs" **12**), although it will be appreciated that other forms of unmanned vehicles such as unmanned land vehicles **12'** and unmanned marine vessels **12"** (both surface and underwater) could readily be adapted for use with the present system **10**. Also, while the structure **14** is illustrated as a bridge, the system **10** is equally well adapted for use in inspecting a wide range of other structures including, but not limited to, power lines, power generating facilities, power grids, dams, levees, stadiums, large buildings, large antennas and telescopes, water treatment facilities, oil refineries, chemical processing plants, high rise buildings, and infrastructure associated with electric trains and monorail support structures. The system **10** is also particularly well suited for use inside large buildings such as manufacturing facilities and warehouses. Virtually any structure that would be difficult, costly, or too hazardous to inspect by a human piloted vehicle or a human remote controlled (RC) vehicle may potentially be inspected using the system **10**.

In FIG. 1, only five UAVs **12a-12e** are shown to avoid cluttering the drawing. However, it will be appreciated that a greater or lesser plurality of UAVs **12** could be implemented to meet the needs of a specific inspection task. For large structures such as the bridge **14** shown in FIG. 1, potentially 10-20 UAVs **12** may be desired. Smaller structures may only require 2-5 UAVs to perform the needed inspection task. Each UAV **12a-12e** includes an onboard system **16** that is able to navigate the UAV **12** in accordance with a preprogrammed flight plan and to enable inspection data for the structure being inspected to be obtained. The inspection data may

comprise pictures, video or audio data, as will be explained in more detail in the following paragraphs.

The preprogrammed flight plan carried by each UAV **12a-12e** enables each UAV to follow a unique flight path around a portion of the structure. For Example, UAV **12a** may include a flight plan that enables it to fly out to the bridge **14** and circle repeatedly around column **14a**, while the flight program of UAV **12b** causes UAV **12b** to fly down and up along path **14b**. UAV **12c** may be assigned to fly back and forth under the bridge **14** closely along its horizontal steel structures. Thus, it will be appreciated that for each UAV **12a-12b**, its preprogrammed flight plan (and therefore flight path), is unique and is formed with respect to a designated portion of the structure that it is intended to inspect. In this manner each UAV **12** can traverse a specific designated portion of the bridge **14**. Once airborne, the UAVs **12a-12e** form what can be viewed as a "swarm" of vehicles that enable an extremely thorough inspection of various areas of a structure may otherwise be difficult, costly and/or hazardous for a human piloted vehicle to inspect. Generally, the larger the plurality of UAVs **12** employed in any given inspection task, the shorter the time it will take to complete the inspection task.

For inspection applications, it is anticipated that unmanned rotorcraft, such as unmanned helicopters, may be especially advantageous for use as the UAVs **12**. This is because of the ability of an unmanned helicopter to hover and move at very slow speeds. The vertical take-off and landing capability of remote controlled unmanned helicopters also may be highly advantageous in many applications, especially when operating inside of structures or facilities such as manufacturing plants, warehouses, etc., or when inspecting complex facilities such as oil refineries or chemical processing that may have many tall structures clustered (e.g., smoke stacks) clustered closely together. In these applications, the use of a fixed wing unmanned vehicle would necessitate a clear, lengthy area for take-off and landing, and would be difficult, if not impossible, to maneuver around the various vertical structures or within a building. The ability to hover and/or move only vertically, if needed, enables unmanned remote controlled helicopters fly close to and inspect large vertical structures such as vertical support posts of bridges, antennas, or closely against other vertical surfaces such as dams, where the use of a fixed wing unmanned vehicle may have difficulty inspecting.

The UAVs **12** could also be deployed from another airborne vehicle, such as a large transport helicopter or fixed wing aircraft. Such a deployment would obviously save fuel for the UAVs **12**, which would enable them to stay airborne for a longer period of time than would otherwise be possible if the UAVs **12** had to take off from a ground based location under their own power.

The system **10** further may include a remote centralized inspection station **18** for receiving wireless communications from each of the UAVs **12a-12e**. The centralized inspection station **18** may include an antenna **20**, a computer control system **22**, a display **24** for viewing by an inspection technician or operator, such as an CRT, LCD or plasma screen, and a wireless transceiver. The wireless transceiver **26** is in communication with the antenna **20** for enabling wireless communication between the computer control system **22** and the onboard system **16** of each UAV **12a-12e**. The computer control system **22** may be used to send commands or to monitor various operating performance parameters of each UAV **12a-12e** such as fuel remaining, battery power remaining, etc. The computer control system **22** may also be used generate commands to alter the flight plan of any one of the UAVs **12**, as will be described in the following paragraphs.

While the centralized inspection station **18** is illustrated as being a terrestrial based station, it could just as readily be formed as a mobile inspection station **18'** on an aircraft or human piloted rotorcraft. A land based, mobile inspection station **18''** could also be formed. Accordingly, the centralized inspection station **18** does not necessarily need to be a fixed structure or facility. It is also possible for each of the UAVs **12a-12e** to communicate with the centralized inspection station **18** via a transponded satellite **29** and/or using a wide area network or a local area network.

Referring to FIG. 2, the onboard system **16** that may be carried by each UAV **12a-12e** is shown. It will be appreciated, however, that the onboard system **16** carried by each UAV **12a-12e** could include different components, depending on the specific portion of the structure that a given UAV **12** is programmed to inspect. Thus, it is not necessary that the onboard system **16** of each UAV be identical.

The onboard system **16** may include a guidance and control hardware and software system **30** that is able to implement one or more different, stored flight plans from a memory **30a**. The onboard system **30** may include a global positioning system (GPS)/inertial navigation system **32** for controlling the orientation of its associated UAV **12** and assisting in carrying out the preprogrammed flight plan stored in the memory **30a**. A wireless transceiver **34** and an on board antenna **36** enable bidirectional, wireless electromagnetic wave communications with the centralized inspection station **18**.

The onboard system **16** may also include a plurality of different sensors for providing useful inspection information to the centralized inspection station **18**. For example, a still camera (color and/or black and white) **38** may be used to obtain still images of portions of the structure **14** being inspected. A video camera **40** may be used to obtain color and/or black and white video of the bridge **14**. An infrared camera **42** could also be used to obtain infrared still images or infrared video. An audio microphone **44** could be used to pick up audio signals emanating from the structure being inspected. This feature could be particularly valuable for inspecting large machines inside a manufacturing facility, where the presence of specific types of sounds might be indicative of an imminent machine or component failure. For example, the detection of grinding sounds coming from an elevated portion of a large machine might indicate that a bearing failure is imminent, but such sounds might otherwise not be perceptible by individuals working on a floor of the manufacturing facility where other noise sources are present to mask the grinding noise.

The onboard system **16** may also include a vehicle health monitoring subsystem **44**, a battery **48** for powering the electronic devices carried on the UAV **12**, as well as a fuel level sensor **50**. The vehicle health monitoring subsystem **44** may be used to monitor the battery level of the battery **48** and the fuel reservoir level sensor **50** and generate suitable signals that may be periodically transmitted to the centralized inspection station **18**. If an issue develops with any one of the UAVs **12**, for example a sudden drop in battery power to an unacceptable level, this enables the centralized inspection station **18** to be wirelessly informed of this condition. The centralized inspection station **18** may then wirelessly upload modified flight programs to the other UAVs **12** that would enable the remaining UAVs **12** to finish the needed inspection task.

The onboard system **16** may optionally also include an image/audio memory **52** for maintaining electronic copies of the images, video or audio captured during an inspection process. If this option is implemented, then an interface **54** may be included on each UAV **12** that enables an external

device, for example a lap top computer, to be coupled to the interface **54** and used to download the stored images and/or audio obtained during the previously executed inspection process. The interface **54** could be formed by a conventional RS-232, RS-422, or any other suitable interface. The interface **54** could also be implemented using Blue-tooth technology so that a wireless connection can be made with the image/audio memory **52**. The interface **54** could also be used for enabling a wired connection to the UAV **12** to upload programs or other information without the need for a wireless transceiver to be used on the UAV **12**. The use of the image/audio memory **52** may be advantageous in environments where periodic high levels of electromagnetic interference are to be expected, which could affect the ability of the acquired images and audio data to be reliably transmitted via electromagnetic wave signals to the centralized inspection station **18**.

The onboard system **16** may also include additional sensors such as an ultrasound sensor, an X-Ray sensor **58**, a magnetic sensor **60** or a Hall Effect sensor **62**. It will be appreciated that the specific type of inspection operation(s) that the system **10** is expected to be used to perform will likely determine the specific form of sensors that will need to be included in the onboard system.

The onboard system **16** may also optionally include a dynamic flight reallocation plan system **64**. The dynamic flight plan reallocation system **64** may be used to dynamically change the flight plan used for each UAV **12a-12e** in the event one of the UAVs becomes inoperable for any reason, is required to land because of a fuel, battery or detected sensor problem, or for any other reason. By "dynamically" change, it is meant that the system **64** is able to automatically and virtually instantaneously determine which one of a plurality of alternative flight plans should be implemented by the remaining UAVs **12** still in operation so that the overall inspection task can be completed by the remaining UAVs. Thus, if UAV **12a** becomes inoperable for any reason, or one of its sensors becomes inoperable, the dynamic flight plan reallocation system **64** of each UAV **12b-12e** determines which one of a plurality of alternative pre-stored flight plans it should implement for the remaining UAVs **12b-12d** to be able carry out the remainder of the entire inspection task, and the guidance and control hardware **30** will then implement the alternative flight plan in real time. By "real time" it is meant essentially instantaneously. The alternative flight plans may be stored in a memory that is included within the dynamic flight plan reallocation system **64**, or the alternative flight plans may be stored in the memory **30A**.

Referring to FIG. 3, a flowchart **100** is illustrated that sets forth the operations of one exemplary implementation of the system **10**. At operation **102** a flight plan program is loaded into the flight plan memory **30a** of each UAV **12a-12e**. The flight plan is specific to a designated portion (or portions) of the bridge **14** that the UAV **12** is assigned to inspect. The flight plan is such that it causes its associated UAV **12** to travel on a flight path that takes it sufficiently close to a predetermined portion of the bridge **14** to obtain the needed inspection data, which in this example would be either still images or video.

At operation **104** the UAVs **12a-12e** are deployed to form an inspection "swarm". When the UAVs **12** reach the bridge **14** they each begin acquiring inspection data for the portion of the bridge that they have been designated to inspect. The inspection data may consist of still images, video, audio, or even a combination thereof. At operation **108** the UAVs **12a-12e** transmit their acquired inspection data to the centralized inspection station **18** via their transceivers **34** and antennas **36**. Alternatively the UAVs **12a-12e** could each store their

acquired inspection data in their image/audio memory **52** for future downloading once they land, as indicated at operation **108a**.

At operation **110**, if the acquired inspection data has been transmitted wirelessly from the UAVs **12a-12e**, then it may be displayed and/or analyzed using the display **24** and/or computer control system **22** of the centralized inspection station **22**. At operation **112** a check is then made to make sure that all of the UAVs **12a-12e** are operating properly. If the vehicle health monitoring subsystem **46** on any of the UAVs **12a-12e** has reported a problem with a component or a problem that requires the UAV to land immediately, this condition will be reported to the centralized inspection station **18** via a wireless signal from the affected UAV **12**. At this point, the computer control system **22** of the centralized inspection station **18** may be used to transmit a new, alternative flight plan to each of the UAVs **12** that remain in service. This enables the remaining UAVs **12** to carry out the remainder of the inspection task. The new, alternative flight plan could instead be provided to merely one or more of the remaining UAVs, rather than to all of the remaining UAVs. Operations **106-112** may then be repeated. Alternatively, if implemented, the dynamic flight plan reallocation system **64** on each UAV **12** may be used to dynamically determine and implement a new flight that enables the remaining UAVs to complete the inspection task.

At operation **116** a determination is made of the percentage of coverage area of the bridge **14** that has been inspected. For example, it may be accepted that once about 99% of the bridge **14** has been inspected, that a guaranteed probability of detection of a defect or flaw has reached a certain value, and the task may be considered to be completed. The predetermined probability of detection value is checked at operation **118** to determine if the inspection task is essentially now complete. If so, the UAVs **12a-12e** will land, as indicated at operation **120**. If not, then operations **106-112** are repeated until the predetermined probability of detection value has been reached.

The system **10** and methodology described herein may be used to inspect a wide range of structures and objects, both stationary and moving. An example of a moving object that may require inspection is a fixed wing aircraft in flight. Using the system **10**, the UAVs **12** could be used to fly above, behind, below, or possibly even ahead of the aircraft while it is in flight. The UAVs **12** may be used to obtain images or audio data of the fixed wing aircraft, such as the position of flaps or ailerons, that may be used for real time analysis (i.e., essentially instantaneous analysis). Alternatively, the collected inspection data may be saved by each of the UAVs **12** and downloaded at a later time for analysis.

A particular advantage of the system **10** is that the data acquired by each UAV **12** may be either downlinked in real time to the centralized inspection station **18**, thus permitting real time analysis of the data, or saved for analysis at a later time. For data such as video, that requires greater bandwidth to downlink, this feature may be advantageous in certain applications where bandwidth of the downlink is limited, and any potential flaws in the structure being inspected would not be of such nature as to produce conditions that threaten human safety or property. Yet other applications will exist where it would be important to be immediately apprised of a major structural flaw, such as on a bridge heavily traveled by cars and trucks. In such an instance, if a major structural flaw was discovered on a bridge, the real time downlinking capability of the system **10** would enable the acquired inspection images to be processed in real time.

It will be appreciated that the system **10** and methodology will also have particular utility with regard to the inspection of

structures that are submerged, or partially submerged, underwater. By using suitable submersible unmanned vehicles, inspection data such as pictures or video of submerged portions of bridges, oil drilling platforms, and even submerged portions of ships can be obtained for analysis.

The various embodiments of the system **10** all provide the advantage that a human operator is not required to pilot each inspection vehicle, nor is a human operator required to remotely control each inspection vehicle. In many applications this is expected to provide a significant cost savings. The system **10** is also beneficial from the standpoint that human pilots do not need to be used in inspection applications that would pose a significant risk to human safety or health.

While various embodiments have been described, those skilled in the art will recognize modifications or variations which might be made without departing from the present disclosure. The examples illustrate the various embodiments and are not intended to limit the present disclosure. Therefore, the description and claims should be interpreted liberally with only such limitation as is necessary in view of the pertinent prior art.

What is claimed is:

1. A method for inspecting structures, comprising:

using a plurality of independent unmanned mobile vehicles;

equipping each of said unmanned mobile vehicles with a control and guidance system for enabling each said unmanned mobile vehicle to operate autonomously;

programming each said unmanned mobile vehicle with an operating program that defines a predetermined path of travel for each said unmanned mobile vehicle, relative to a structure to be inspected, and;

deploying each said unmanned mobile vehicle so that said unmanned mobile vehicles cooperatively form a swarm that travels about said structure, with each of said unmanned vehicles following its respective said predetermined path of travel relative to the structure, and further such that each said unmanned mobile vehicle inspects only a designated portion of the structure; and using said unmanned mobile vehicles to obtain inspection data in accordance with their respective inspected portions of the structure, as obtained while each said unmanned mobile vehicle executes its respective said operating program, so that an entirety of said structure is inspected.

2. The method of claim **1**, wherein using said unmanned mobile vehicles to obtain inspection data for a portions of said structure comprises using a camera on said at least one unmanned mobile vehicle to image an image of a portion of said structure.

3. The method of claim **1**, wherein each of said unmanned mobile vehicles obtains images of portions of said structure while executing its respective said operating program.

4. The method of claim **1**, wherein programming each said unmanned mobile vehicle with an operating program that defines said predetermined path of travel, relative to a structure to be inspected, comprises programming each said unmanned mobile vehicle with a unique operating program that causes each said unmanned mobile vehicle to follow said predetermined path of travel, relative to said structure.

5. The method of claim **4**, wherein each said unmanned mobile vehicle obtains a plurality of images of said structure while following said predetermined path of travel.

6. The method of claim **5**, wherein each said unmanned mobile vehicle stores said plurality of images of said structure in an onboard memory.

7. The method of claim 6, wherein said stored images comprise a video stream.

8. The method of claim 1, further comprising using at least one of said unmanned mobile vehicles to wirelessly communicate said inspection data to a remote centralized inspection station for analysis.

9. The method of claim 1, wherein using a plurality of unmanned mobile vehicles comprises using a plurality of unmanned rotorcraft.

10. The method of claim 1, further comprising using a remote centralized inspection station to communicate with said unmanned mobile vehicles and to wirelessly modify said operating programs associated with remaining ones of said mobile unmanned vehicles in real time when one of said unmanned mobile vehicles becomes inoperable.

11. The method of claim 1, wherein using a plurality of unmanned mobile vehicles comprises using one of:

- a plurality of unmanned land vehicles;
- a plurality of unmanned aerial vehicles; and
- a plurality of unmanned marine vehicles.

12. A method for inspecting structures, comprising: using a plurality of independent unmanned mobile vehicles;

equipping each of said unmanned mobile vehicles with a control and guidance system for enabling each said unmanned mobile vehicle to operate autonomously;

programming each said unmanned mobile vehicle with an operating program that defines a predetermined, unique path of travel for each said unmanned mobile vehicle, each said predetermined, unique path of travel relating to only a designated portion of a structure being inspected;

deploying each said unmanned mobile vehicle so that said unmanned mobile vehicles cooperatively form a swarm with each travelling about said structure in accordance with its respective said predetermined, unique path of travel;

using said unmanned mobile vehicles to obtain images of only portions of said structure, in accordance with their respective said operating programs, as each said unmanned mobile vehicle executes its respective said operating program, so that said unmanned mobile vehicles collectively inspect an entirety of said structure; and

causing each said unmanned mobile vehicle to wirelessly transmit said images to a remote centralized inspection station.

13. The method of claim 12, wherein using a plurality of unmanned mobile vehicles comprises using at least one of:

- a plurality of airborne mobile vehicles;
- a plurality of mobile land vehicles; and
- a plurality of mobile marine vehicles.

14. The method of claim 13, wherein using said unmanned mobile vehicles to obtain images of portions of said structure comprises obtaining at least one of:

- color images of portions of said structure;
- color video of portions of said structure;
- black and white images of portions of said structure;
- infrared images of portions of said structure; and
- infrared video of portions of said structure.

15. The method of claim 12, wherein using a plurality of unmanned mobile vehicles comprises using a plurality of unmanned rotorcraft.

16. The method of claim 12, further comprising equipping each of said unmanned mobile vehicles with a health monitoring system to monitor at least one operational parameter thereof.

17. The method of claim 12, wherein said images are provided to said remote centralized inspection station in real time.

18. The method of claim 12, further comprising equipping each of said unmanned mobile vehicles with an audio pickup device to pick up audio signals emanating from said structure.

19. A system for inspecting structures, comprising: a plurality of independent unmanned mobile vehicles; each of said unmanned mobile vehicles having a control and guidance system for enabling each said unmanned mobile vehicle to operate autonomously;

each of said unmanned mobile vehicles including an operating program that defines a predetermined path of travel for each said unmanned vehicle, relative to only a designated portion of a structure to be inspected, so that in operation said unmanned mobile vehicles cooperatively form a swarm that moves about said structure in accordance with their respective said predetermined paths of travel to cooperatively inspect an entirety of said structure; and

at least one of said unmanned mobile vehicles including an imaging device to obtain an image of a portion of said structure as it executes its respective said operating program.

20. The system of claim 19, further comprising a remote centralized inspection station in wireless communication with each of said unmanned mobile vehicles, and

said at least one of said unmanned mobile vehicles including a wireless transceiver for wirelessly transmitting said image to said remote centralized inspection station while travelling along its said predetermined path of travel.

21. The system of claim 19, wherein said remote centralized inspection station includes a wireless transceiver for wirelessly communicating a different operating program to said at least one unmanned vehicle to assign a new path of travel to said at least one unmanned mobile vehicle.

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