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(54) **PROACTIVE OPTICAL TRAJECTORY FOLLOWING SYSTEM**

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(52) **U.S. Cl.** **244/3.16**; 244/3.15; 356/342; 250/372
(58) **Field of Search** 244/3.15, 3.16, 244/3.17, 194, 195; 356/342, 436; 250/372, 373

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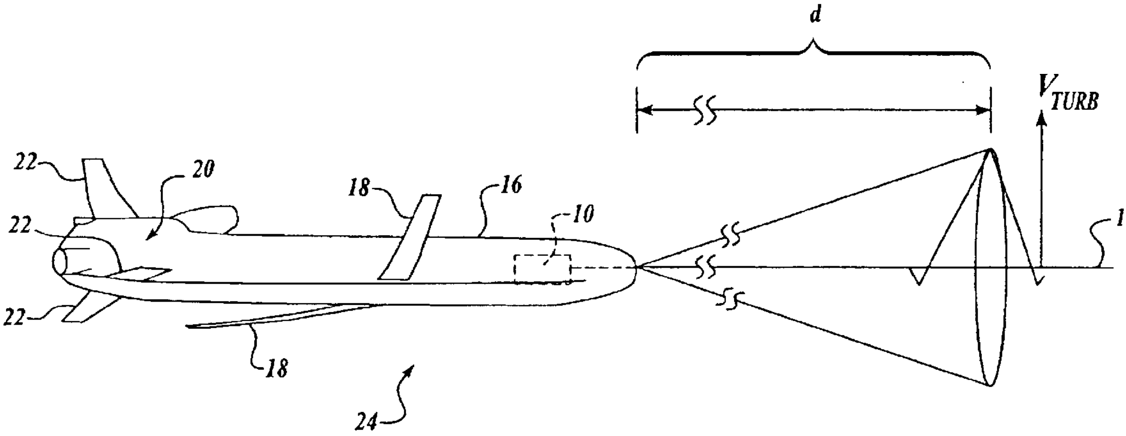
(57) **ABSTRACT**

A system for automatically correcting flight path of an aircraft onto a predetermined trajectory is provided. A sensor is configured to sense speed and direction of air relative to the aircraft at a predetermined distance in front of the aircraft. A navigation system is configured to determine displacement of a flight path of the aircraft from a predetermined trajectory. A processor is coupled to receive the sensed speed and direction of air from the sensor and the displacement of the flight path from the navigation system. The processor includes a first component that is configured to determine whether the speed of the air at the predetermined distance is indicative of turbulence, and a second component that is configured to automatically generate control signals to correct the flight path of the aircraft from the displacement onto the predetermined trajectory by a time when the aircraft enters the turbulence.

62 Claims, 5 Drawing Sheets



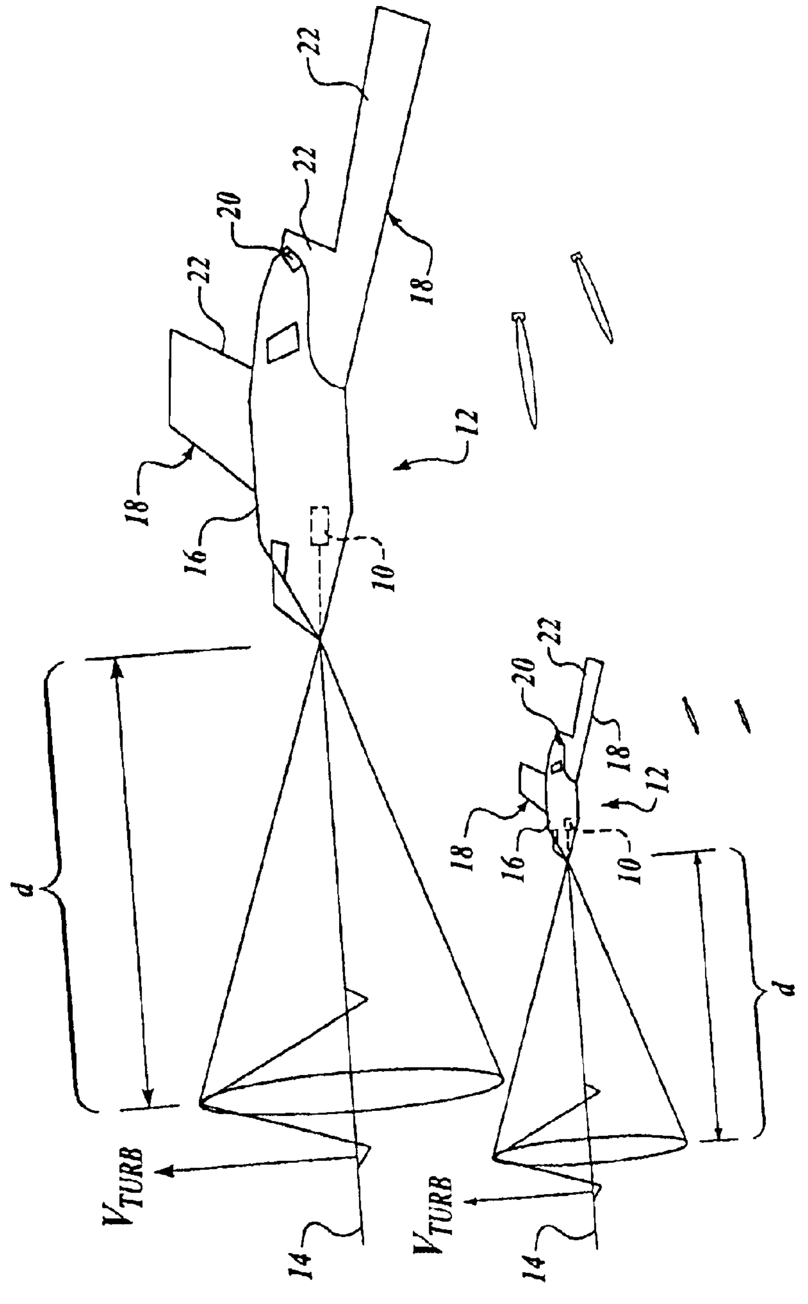


FIG.1A

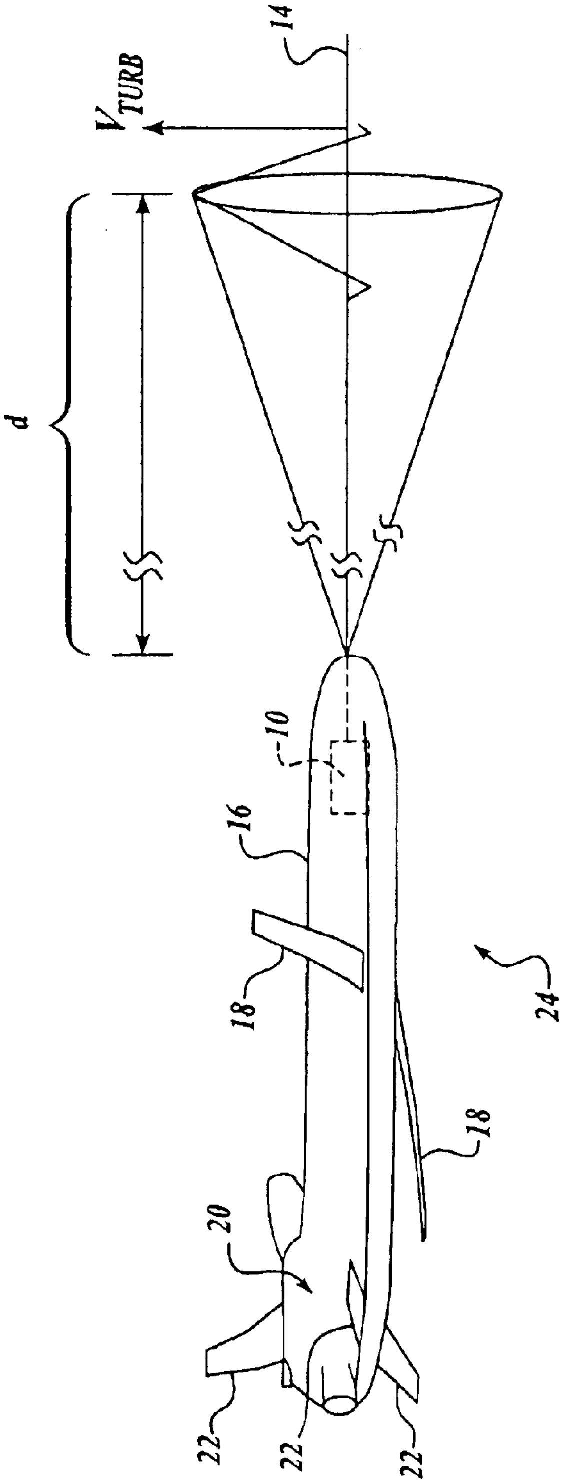


FIG.1B

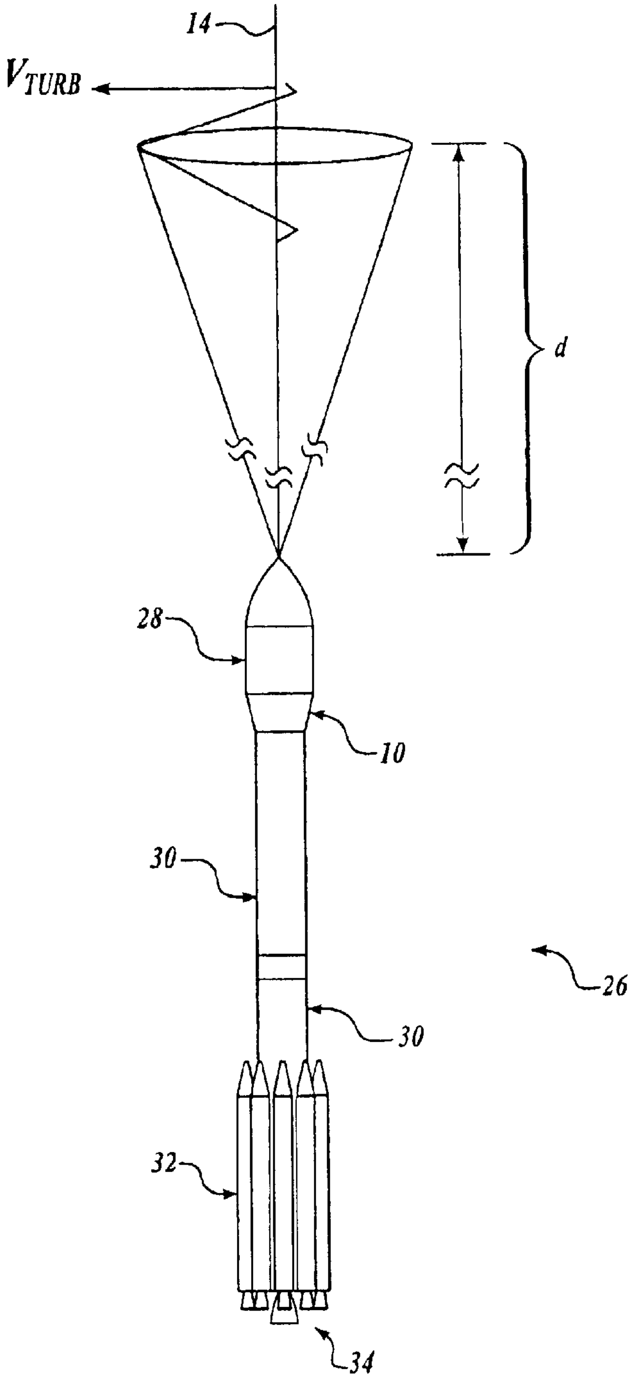


FIG.1C

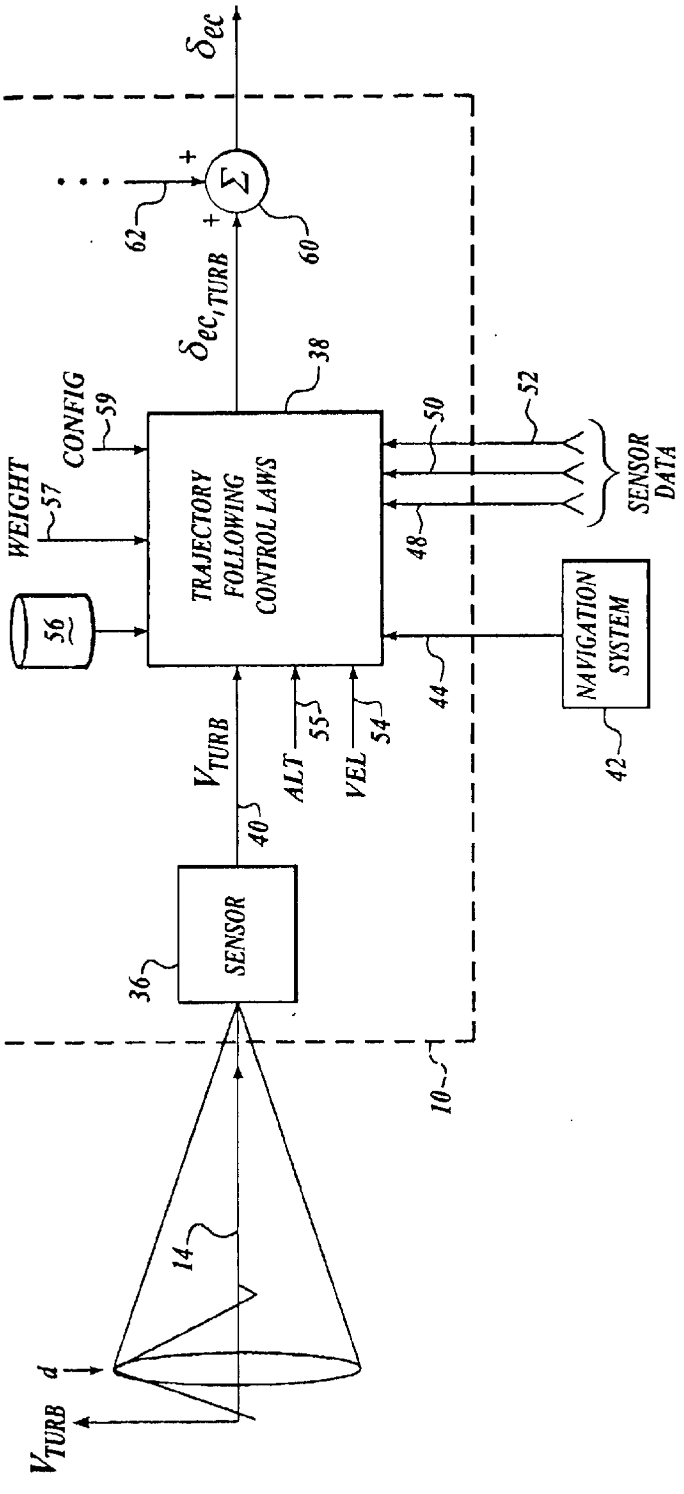

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FIG.2

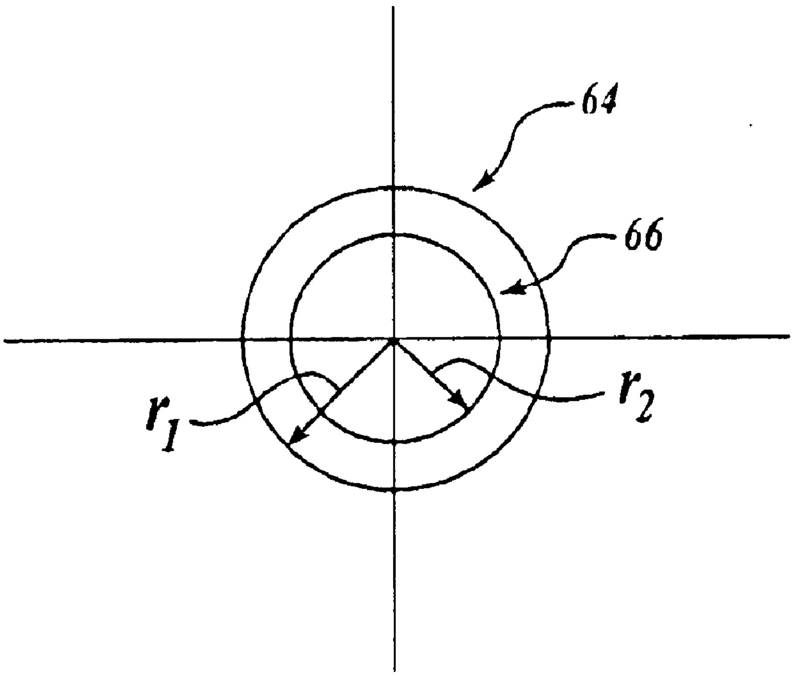

FIG.3

PROACTIVE OPTICAL TRAJECTORY FOLLOWING SYSTEM

RELATED APPLICATION

This patent application is related to a concurrently filed patent application entitled "PROACTIVE OPTICAL WIND SHEER PROTECTION AND RIDE QUALITY IMPROVEMENT SYSTEM", the contents of which are hereby incorporated by reference.

FIELD OF THE INVENTION

The present invention relates generally to avionics and, more specifically, to flight control avionics.

BACKGROUND OF THE INVENTION

Various types of aircraft follow a predetermined trajectory during flight for a variety of reasons. For example, a missile follows a predetermined trajectory to reduce errors in the missile's point of impact. In this example, improving impact error results in a performance improvement for the missile and a safety improvement by possibly reducing any unintended collateral damage that may result from an erroneous impact point.

Other aircraft also follow predetermined trajectories. For example, unmanned air vehicles, such as drones, follow predetermined trajectories to a point of interest where operations, such as reconnaissance operations, may be conducted. In this case, the aircraft follows the predetermined trajectory to reduce errors in reconnaissance or surveillance data gathered by the aircraft as well as improve aircraft performance.

In this context, variations in speed of the air relative to an aircraft can cause development of conditions of varying severity. For example, aircraft frequently encounter turbulence during flight. When an aircraft that is followings a trajectory enters turbulence, the turbulence can displace the flight path of the aircraft from the predetermined trajectory. Current sensing systems for velocity of air relative to an aircraft cannot look ahead of the aircraft. Current sensors include pitot tubes and, therefore, are reactive to pressure of air in which the airplane is flying. As a result, when an aircraft that is following a predetermined trajectory encounters turbulence and its flight path is displaced from the predetermined trajectory that it is following, any correction for displacement from the trajectory is reactive. Therefore, a potential is created for operational errors and sub-optimal aircraft performance.

It would be desirable to proactively correct for turbulence in an aircraft that is following a predetermined trajectory. However, there is an unmet need in the art for a system that proactively corrects for turbulence in an aircraft that is following a trajectory.

SUMMARY OF THE INVENTION

Embodiments of the present invention provide systems and methods for proactively correcting flight path of an aircraft onto a predetermined trajectory. By detecting and proactively responding to turbulence, the present invention automatically corrects the flight path of the aircraft onto the predetermined trajectory as the aircraft encounters the turbulence. By proactively correcting the flight path for turbulence as the aircraft enters the turbulence instead of reacting to the turbulence after a trajectory error has been generated, the present invention mitigates effects of trajectory errors on operation of the aircraft as well as increases flight performance of the aircraft.

Embodiments of the present invention automatically correct flight path of an aircraft onto a predetermined trajectory. A sensor is configured to sense speed of air relative to the aircraft at a predetermined distance in front of the aircraft. A navigation system is configured to determine displacement of a flight path of the aircraft from the predetermined trajectory. A processor is coupled to receive the sensed speed of air from the sensor and the displacement of the flight path from the navigation system. The processor includes a first component that is configured to determine whether the speed of the air at the predetermined distance is indicative of turbulence, and a second component that is configured to automatically generate control signals to correct the flight path of the aircraft from the displacement onto the predetermined trajectory by a time when the aircraft enters the turbulence.

According to an aspect of the invention, the airspeed is sensed by an optical sensor, such as a laser.

According to another aspect, the speed of the air is sensed for turbulence at a relatively short distance in front of the aircraft, such as without limitation, a distance on the order of around 100 feet.

BRIEF DESCRIPTION OF THE DRAWINGS

The preferred and alternative embodiments of the present invention are described in detail below with reference to the following drawings.

FIG. **1A** is a side view of an in-flight aircraft sensing speed of the air according to one embodiment of the present invention;

FIG. **1B** is a side view of an in-flight missile sensing speed of the air according to an embodiment of the present invention;

FIG. **1C** is a side view of a launch vehicle sensing speed of the air according to an embodiment of the present invention;

FIG. **2** is a block diagram of a system of an embodiment of the present invention; and

FIG. **3** is a graph of circle error probability.

DETAILED DESCRIPTION OF THE INVENTION

By way of overview, embodiments of the present invention automatically correct flight path of an aircraft onto a predetermined trajectory. A sensor is configured to sense speed of air relative to the aircraft at a predetermined distance in front of the aircraft. A navigation system is configured to determine displacement of a flight path of the aircraft from the predetermined trajectory. A processor is coupled to receive the sensed speed of air from the sensor and the displacement of the flight path from the navigation system. The processor includes a first component that is configured to determine whether the speed of the air at the predetermined distance is indicative of turbulence, and a second component that is configured to automatically generate control signals to correct the flight path of the aircraft from the displacement onto the predetermined trajectory by a time when the aircraft enters the turbulence.

Referring now to FIG. **1A**, an exemplary system **10** according to an embodiment of the present invention enables aircraft **12** to automatically correct flight path of the aircraft **12** onto a predetermined trajectory **14** by compensating for turbulence, thereby increasing operational accuracy of the aircraft **12** and improving flight performance of the aircraft **12**. The sensor (not shown) senses speed and direction of air relative to the aircraft **12** at a distance d in front of the aircraft **12**. In this exemplary system **10**, the distance d is suitably a relatively short distance in front of the aircraft **12**. For, example, the distance d may be less then 1,000 meters. In one embodiment, the distance d is around 100 feet. However, it will be appreciated that any distance d may be selected as desired for a particular application. As is known, the speed of the air is an air mass velocity that is a vector quantity. The speed of the air is a vector velocity that includes a component V_u along the X direction, a component V_v along the Y direction, and a component V_w along the Z direction. For sake of clarity, the component V_W is the only component shown in FIG. **1**A (and in all other FIGURES, as well) and is labeled as V_{turb}.

As will be explained in detail below, the system **10** generates control signals that cause control of the aircraft **12** to be compensated for detected turbulence to correct the flight path onto the trajectory **14** when the aircraft **12** enters the detected turbulence. As shown in FIG. **1**A, more than one of the aircraft **12** suitably may be flying in formation by following its own predetermined trajectory **14**. As is known, the aircraft **12** includes a fuselage **16**, a pair of wings **18**, and at least one engine **20**. As is also known, the aircraft **12** includes control surfaces **22**. Given by way of nonlimiting example, the aircraft **12** includes an unmanned air vehicle, such as the X-45 Unmanned Combat Air Vehicle manufactured by The Boeing Company. The control surfaces in the exemplary aircraft **12** shown in FIG., **1**A include ailerons and elevons for controlling roll, pitch, and yaw. However, it will be appreciated that other types of aircraft **12** may include the system **10**, and that the control surfaces **22** may be provided depending on the type of the aircraft **12**. For example, the aircraft **12** may include without limitation other types of manned or unmanned air vehicles, such as drones or the like, that may include control surfaces **22** such as ailerons, elevators, and a rudder for controlling roll, pitch, and yaw, respectively.

Other types of vehicles may include the system **10** as desired. Referring now to FIG. **1**B, a missile **24** includes the system **10** for automatically correcting flight path onto the trajectory **14** when turbulence detected at the distance d is entered. The missile **24** may be any type of missile, such as without limitation a Conventional Air Launched Cruise Missile manufactured by The Boeing Company. As is known, the missile **24** includes a fuselage **16**, an engine **20** such as a turbojet engine, and control surfaces **22** such as fins. In the nonlimiting example shown in FIG. **1**B, a pair of wings **18** is optionally provided.

Referring now to FIG. **1**C, given by way of another nonlimiting example, a rocket **26**, such as without limitation a launch vehicle like a Delta **11** launch vehicle manufactured by The Boeing Company, includes the system **10** for correcting flight path of the rocket **26** onto the trajectory **14** when turbulence detected at the distance d is entered. It will be appreciated that correcting the flight path of the rocket **26** for turbulence is applicable up to altitudes of around 100,000 feet or less. As a result, the system **10** corrects the flight path for turbulence during the ascent phase of the flight profile of the rocket **26**. As is known, the rocket **26** includes a payload faring **28**, fuel tanks **30**, strap-on motors **32**, and a main engine **34**. However, it will be appreciated that any type of rocket may include the system **10** as desired.

Referring now to FIG. **2**, a sensor **36** senses the speed and direction of the air relative to the air vehicle, such as the aircraft **12** (FIG. **1**A), the missile **24** (FIG. **1**B), the rocket **26** (FIG. **1**C), or the like, at the distance d in front of the air vehicle. The sensor **36** is suitably any sensing system that is configured to sense speed and direction of the air in front of an air vehicle. In one presently preferred embodiment, the sensor **36** is an optical sensor, such as a laser-based optical air data sensor. An exemplary optical air data sensor that is well-suited for the sensor **26** is a laser Doppler velocimeter available from Optical Air Data Systems, L. P. The laser Doppler velocimeter is described in U.S. Pat. No. 5,272,513, the contents of which are hereby incorporated by reference. Advantageously, the sensor **36** provides a capability to "look ahead" of the air vehicle that permits turbulence to be detected in front of the air vehicle at the distance d. This look-ahead capability permits the system **10** to proactively compensate for turbulence in correcting the flight path of the air vehicle onto the desired trajectory **14** by a time when the air vehicle enters the turbulence.

Trajectory following control laws **38** receives from the sensor **36** a signal **40** that is indicative of the speed of the air relative to the air vehicle at the distance d in front of the air vehicle. The trajectory following control laws **38** also receive a signal **54** that is indicative of velocity of the air vehicle. The trajectory following control laws **38** are implemented within a flight control laws processor. The flight control laws processor is suitably any acceptable flight management computer or the like that is configured to perform calculations and process signals indicative of various flight-related parameters. Flight management computers are well known in the art, and a detailed description of its construction and operation is not necessary for an understanding of the invention.

The trajectory following control laws **38** receives from a navigation system **42** a set of signals **44** that provide information regarding the actual flight path, and positions, attitudes and their rates, of the air vehicle. Navigation systems that generate signals representing the flight path, and positions, attitudes and their rates, of the air vehicle are well known. As a result, an explanation of details of construction and operation of the navigation system **42** is not necessary for an understanding of the present invention.

The trajectory following control laws **38** receives from known sensors (not shown) signals **48**, **50**, and **52** that are indicative of roll rate, pitch rate, and yaw rate, respectively. A signal **54** that is indicative of velocity of the air vehicle and a signal **55** that is indicative of altitude of the air vehicle are also supplied to the trajectory following control laws **38** from known sensors. If desired, signals **57** and **59** that are indicative of weight of the air vehicle and configuration of the air vehicle, respectively, may be provided to the trajectory following control laws **38**. The trajectory following control laws **38** suitably are implemented in any acceptable flight control computer or the like that is configured to perform calculations and process signals indicative of various flight-related parameters. Flight control computers are well known in the art, and a detailed description of its construction and operation is not necessary for an understanding of the invention.

The trajectory following control laws **38** generates turbulence deflection commands $\delta_{ec,\ turb,}$ which are to be inserted into the existing flight control laws of the vehicle. As is known, a set of flight control laws for the air vehicle is stored in storage **56**, such as a memory device, a magnetic or optical disk, a CD-ROM, or the like. The flight control computer retrieves the set of flight control laws from storage **56** and applies position error to the flight control laws. In addition, the flight control laws **38** applies pitch rate, roll rate, and yaw rate (from the signals **48**, **50**, and **52**, respectively) to the control laws. Applying the signals **44**, **48**, **50**, and **52** to the control laws results in a known correction of flight path of an air vehicle that is displaced from a trajectory back onto the trajectory.

It will be appreciated that the known portion of correction of the flight path based on the signals **44**, **48**, **50**, and **52** as described above takes into account position error. Advantageously, according to the present invention, the system **10** also proactively includes effects of turbulence into correction of the flight path back onto the trajectory. The trajectory following control laws **38** retrieves the set of control laws from storage **56** and applies the signal **40** that is indicative of the speed of the air relative to the air vehicle to the control laws for the air vehicle.

Advantageously, the trajectory following control laws **38** takes into account the velocity of the air vehicle via the signal **54**. As a result, the turbulence deflection commands $\delta_{ec,\ turb}$ are output by the trajectory following control laws **38** at a time such that the control surfaces of the air vehicle have already been positioned to compensate for the sensed turbulence according to the control laws for the air vehicle by the time the air vehicle travels the distance d at the velocity at which the air vehicle is traveling.

The trajectory following control laws **38** applies the signals **44**, **48**, **50**, **52**, **40**, **54**, **55**, **57**, and **59** as described above to generate the turbulence deflection commands $\delta_{ec,\ turb}$ to correct flight path of the air vehicle from a displacement back onto the trajectory **14**. Advantageously, the turbulence deflection commands $\delta_{ec,\ turb}$ are output at a time such that the control surfaces of the air vehicle are positioned to compensate for the sensed turbulence according to the control laws for the air vehicle by the time the air vehicle travels the distance d at the velocity indicated by the signal **54**. As a result, correction of the flight path of the air vehicle back onto the trajectory **14** advantageously is compensated for detected turbulence by the time the air vehicle travels the distance d and enters the detected turbulence. Because the control surfaces of the air vehicle are already positioned to compensate for detected turbulence when the air vehicle enters the detected turbulence, any effects of the turbulence advantageously are mitigated by proactive position of the control surfaces as described above.

The turbulence deflection commands $\delta_{ec,\ turb}$ are added to the surface commands within the flight control laws. The flight control laws generates control surface deflection commands δ_{ec} in any acceptable known manner. The flight control laws includes a summer **60**. The turbulence deflection commands $\delta_{ec,\ turb}$ are supplied to one input of the summer **60**. Signals **62** are provided from the flight control laws for the control surfaces **22** (FIGS. **1**A, **1**B and **1**C) to another input of the summer **60**.

The following nonlimiting example of operation of the system **10** is provided for illustrative purposes only. In one nonlimiting example, an air vehicle is traveling at a velocity and is below its trajectory **14**. At the distance d in front of the air vehicle, V_{turb} is detected with a positive component that tends to exert an upward force on the air vehicle. The flight control laws processor **38** retrieves and applies the signals **44**, **48**, **50**, and **52** that are indicative of position error, roll rate, pitch rate, and yaw rate, respectively, to the control laws for the air vehicle. The trajectory following control laws **38** also applies the signals **40**, **54**, **55**, **57**, and **59** that are indicative of V_{turb}, air vehicle velocity, air vehicle altitude, air vehicle weight, and air vehicle configuration, respectively, to the control laws for the air vehicle. As a result, the surface deflection commands δ_{ec} cause the control surfaces **22** (FIGS. **1**A, **1**B, and **1**C) to respond to the turbulence deflection commands $\delta_{ec,\ turb}$ to correct the flight path of the air vehicle upwardly onto the trajectory **14**. Advantageously, at a time when the air vehicle enters the detected turbulence, the turbulence deflection commands $\delta_{ec,\ turb}$ cause the control surfaces **22** (FIGS. **1**A, **1**B, and **1**C) to respond to the surface deflection commands δ_{ec} to compensate for the detected turbulence. It will be appreciated that correcting the flight path upwardly onto the trajectory **14** and simultaneously entering turbulence that exerts an upward force could cause the correction to overshoot the trajectory **14** if turbulence were not compensated. Advantageously, according to the present invention, compensating for the detected turbulence in this nonlimiting example prevents them air vehicle from overshooting above the trajectory **14**.

Referring now to FIG. **3**, it will be appreciated that the present invention advantageously reduces the circle of error probability, that is a measure of accuracy with which an air vehicle, such as a rocket or missile, can be guided. Without benefit of the system **10**, turbulence can only be compensated reactively after the air vehicle is displaced from the trajectory being followed. This results in a circle of error probability **64** having a radius r_1 within which 50% of reliable shots land within a predetermined distance of the target. However, it will be appreciated that automatically and proactively compensating for turbulence when correcting flight path of an air vehicle onto its predetermined trajectory, as described above, results in a circle of error probability **66** having a radius r_2 that is smaller than the radius r_1. That is, proactively compensating for turbulence when correcting trajectory of an air vehicle increases operational accuracy of the air vehicle.

While the preferred embodiment of the invention has been illustrated and described, as noted above, many changes can be made without departing from the spirit and scope of the invention. Accordingly, the scope of the invention is not limited by the disclosure of the preferred embodiment. Instead, the invention should be determined entirely by reference to the claims that follow.

What is claimed is:

1. A system for automatically correcting flight path of an aircraft onto a predetermined trajectory, the system comprising:

- a sensor configured to sense speed of air relative to an aircraft at a predetermined distance in front of the aircraft;
- a navigation system configured to determine displacement of flight path of the aircraft from a predetermined trajectory; and
- a processor coupled to receive the sensed speed of air from the sensor and the displacement of the flight path from the navigation system, the processor including:
  - a first component configured to determine whether the speed of the air at the predetermined distance is indicative of turbulence; and
  - a second component configured to automatically generate control signals to correct the flight path of the aircraft from the displacement onto the predetermined trajectory by a time when the aircraft enters the turbulence.

2. The system of claim **1**, wherein the second component automatically generates the control signals responsive to the indication of turbulence.

3. The system of claim **2**, wherein the second component automatically generates the control signals further responsive to the displacement of the flight path.

4. The system of claim **3**, wherein the displacement of the flight path includes a position error component.

5. The system of claim **1**, wherein the sensor includes an optical sensor.

6. The system of claim **5**, wherein the optical sensor includes a laser.

7. The system of claim **6**, wherein the laser includes a laser Doppler velocimeter system.

8. The system of claim **1**, wherein the predetermined distance is less than around 1,000 meters.

9. The system of claim **8**, wherein the predetermined distance is around 100 feet.

10. The system of claim **1**, wherein the aircraft includes an unmanned aircraft.

11. The system of claim **10**, wherein the unmanned aircraft includes a rocket propelled vehicle.

12. The system of claim **11**, wherein the rocket propelled vehicle includes a missile.

13. The system of claim **10**, wherein the unmanned aircraft includes a drone.

14. A method for automatically correcting flight path of an aircraft onto a predetermined trajectory, the method comprising:

sensing speed of air relative to an aircraft at a predetermined distance in front of the aircraft;

determining whether the speed of the air at the predetermined distance is indicative of turbulence;

determining displacement of a flight path of the aircraft from a predetermined trajectory; and

automatically correcting the flight path of the aircraft from the displacement onto the predetermined trajectory by a time when the aircraft enters the turbulence.

15. The method of claim **14**, wherein automatically correcting the light path includes automatically generating control signals.

16. The method of claim **15**, wherein the control signals are generated responsive to the indication of turbulence.

17. The method of claim **16**, wherein the control signals are further generated responsive to the displacement of the flight path.

18. The method of claim **17**, wherein the displacement of the flight path includes a position error component.

19. The method of claim **14**, wherein automatically correcting the flight path includes automatically positioning control surfaces.

20. The method of claim **14**, wherein the speed of the air is sensed by an optical sensor.

21. The method of claim **20**, wherein the optical sensor includes a laser.

22. The method of claim **21**, wherein the laser includes a laser Doppler velocimeter system.

23. The method of claim **14**, wherein the predetermined distance is less than around 1,000 meters.

24. The method of claim **23**, wherein the predetermined distance is around 100 feet.

25. The method of claim **14**, wherein the aircraft includes an unmanned aircraft.

26. The method of claim **25**, wherein the unmanned aircraft includes a rocket propelled vehicle.

27. The method of claim **26**, wherein the rocket propelled vehicle includes a missile.

28. The method of claim **25**, wherein the unmanned aircraft includes a drone.

29. A system for automatically correcting flight path of an aircraft onto a predetermined trajectory, the system comprising:

an optical sensor configured to sense speed of air relative to an aircraft at a predetermined distance in front of the aircraft;

a navigation system configured to determine displacement of flight path of the aircraft from a predetermined trajectory; and

a processor coupled to receive the sensed speed of air from the sensor and the displacement of the flight path from the navigation system, the processor including:

a first component configured to determine whether the speed of the air at the predetermined distance is indicative of turbulence; and

a second component configured to automatically generate control signals responsive to the indication of turbulence and farther responsive to the displacement of the flight path to correct the flight path of the aircraft from the displacement onto the predetermined trajectory by a time when the aircraft enters the turbulence.

30. The system of claim **29**, wherein the displacement of the flight path includes a position error component.

31. The system of claim **29**, wherein the optical sensor includes a laser.

32. The system of claim **31**, wherein the laser includes a laser Doppler velocimeter system.

33. The system of claim **29**, wherein the predetermined distance is less than around 1,000 meters.

34. The system of claim **33**, wherein the predetermined-distance is around 100 feet.

35. The system of claim **29**, wherein the aircraft includes an unmanned aircraft.

36. The system of claim **35**, wherein the unmanned aircraft includes a rocket propelled vehicle.

37. The system of claim **36**, wherein the rocket propelled vehicle includes a missile.

38. The system of claim **35**, wherein the unmanned aircraft includes a drone.

39. A method for automatically correcting flight path of an aircraft onto a predetermined trajectory, the method comprising:

optically sensing speed of air relative to an aircraft at a predetermined distance in front of the aircraft;

determining whether the speed of the air at the predetermined distance is indicative of turbulence;

determining displacement of a flight path of the aircraft from a predetermined trajectory; and

automatically generating control signals responsive to the indication of turbulence and further responsive to the displacement of the flight path to correct the flight path of the aircraft from the displacement onto the predetermined trajectory by a time when the aircraft enters the turbulence.

40. The method of claim **39**, wherein the displacement of the flight path includes a position error component.

41. The method of claim **39**, wherein the flight path is corrected by positioning control surfaces.

42. The method of claim **39**, wherein the optical sensor includes a laser.

43. The method of claim **42**, wherein the laser includes a laser Doppler velocimeter system.

44. The method of claim **39**, wherein the predetermined distance is less than around 1,000 meters.

45. The method of claim **44**, wherein the predetermined distance is around 100 feet.

46. The method of claim **39**, wherein the aircraft includes an unmanned aircraft.

47. The method of claim **46**, wherein the unmanned aircraft includes a rocket propelled vehicle.

48. The method of claim **47**, wherein the rocket propelled vehicle includes a missile.

49. The method of claim **46**, wherein the unmanned aircraft includes a drone.

50. An aircraft comprising:

a fuselage;

an engine;

control surfaces; and

a system for automatically correcting flight path of an aircraft onto a predetermined trajectory, the system including:

a sensor configured to sense speed of air relative to an aircraft at a predetermined distance in front of the aircraft;

a navigation system configured to determine displacement of flight path of the aircraft from a predetermined trajectory; and

a processor coupled to receive the sensed speed of air from the sensor and the displacement of the flight path from the navigation system, the processor including:

a first component configured to determine whether the speed of the air or the predetermined distance is indicative of turbulence; and

a second component configured to automatically generate control signals to correct the flight path of the aircraft from the displacement onto the predetermined trajectory by a time when the aircraft enters the turbulence.

51. The aircraft of claim **50**, wherein the second component automatically generates the control signals responsive to the indication of turbulence.

52. The aircraft of claim **51**, wherein the second component automatically generates the control signals further responsive to the displacement of the flight path.

53. The aircraft of claim **52**, wherein the displacement of the flight path includes a position error component.

54. The aircraft of claim **50**, wherein the sensor includes an optical sensor.

55. The aircraft of claim **54**, wherein the optical sensor includes a laser.

56. The aircraft of claim **55**, wherein the laser includes a laser Doppler velocimeter system.

57. The aircraft of claim **50**, wherein the predetermined distance is less than around 1,000 meters.

58. The aircraft of claim **57**, wherein the predetermined distance is around 100 feet.

59. The aircraft of claim **50**, wherein the aircraft includes an unmanned aircraft.

60. The aircraft of claim **59**, wherein the unmanned aircraft includes a rocket propelled vehicle.

61. The aircraft of claim **60**, wherein the rocket propelled vehicle includes a missile.

62. The aircraft of claim **59**, wherein the unmanned aircraft includes a drone.

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