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Drymon

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(54) **UTILIZING HIGH ALTITUDE LONG ENDURANCE UNMANNED AIRBORNE VEHICLE TECHNOLOGY FOR AIRBORNE SPACE LIFT RANGE SUPPORT**

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(52) **U.S. Cl.** .... **244/3.14**; 244/3.11; 244/158 R; 244/172; 701/2; 701/3; 342/52; 342/58; 342/60; 342/62

(58) **Field of Search** .... 244/3.1, 3.11, 244/3.14, 3.15, 3.19, 158 R, 160, 162, 3.12, 172; 342/13, 52–58, 60, 62, 61, 63; 701/1–8

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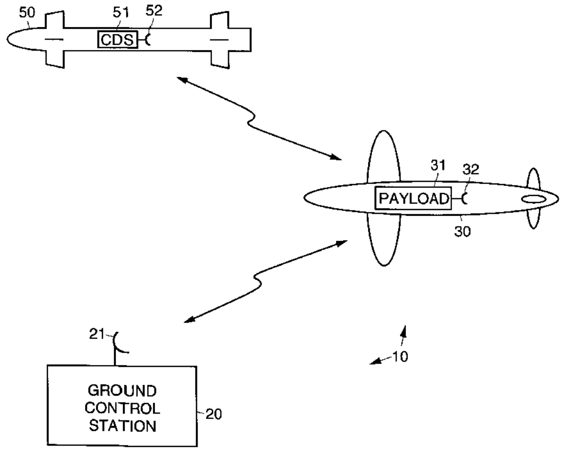
(57) **ABSTRACT**

A mobile space lift range system using a ground control station and an unmanned airborne vehicle that relayed data to and from a space lift vehicle to control it. The unmanned airborne vehicle may selectively include one or more sensor systems, a radar system, a command and telemetry system, and a user test system. The unmanned airborne vehicle is a high attitude, long endurance vehicle that provides a flexible, mobile range to support launch-anywhere space lift scenarios.

13 Claims, 2 Drawing Sheets



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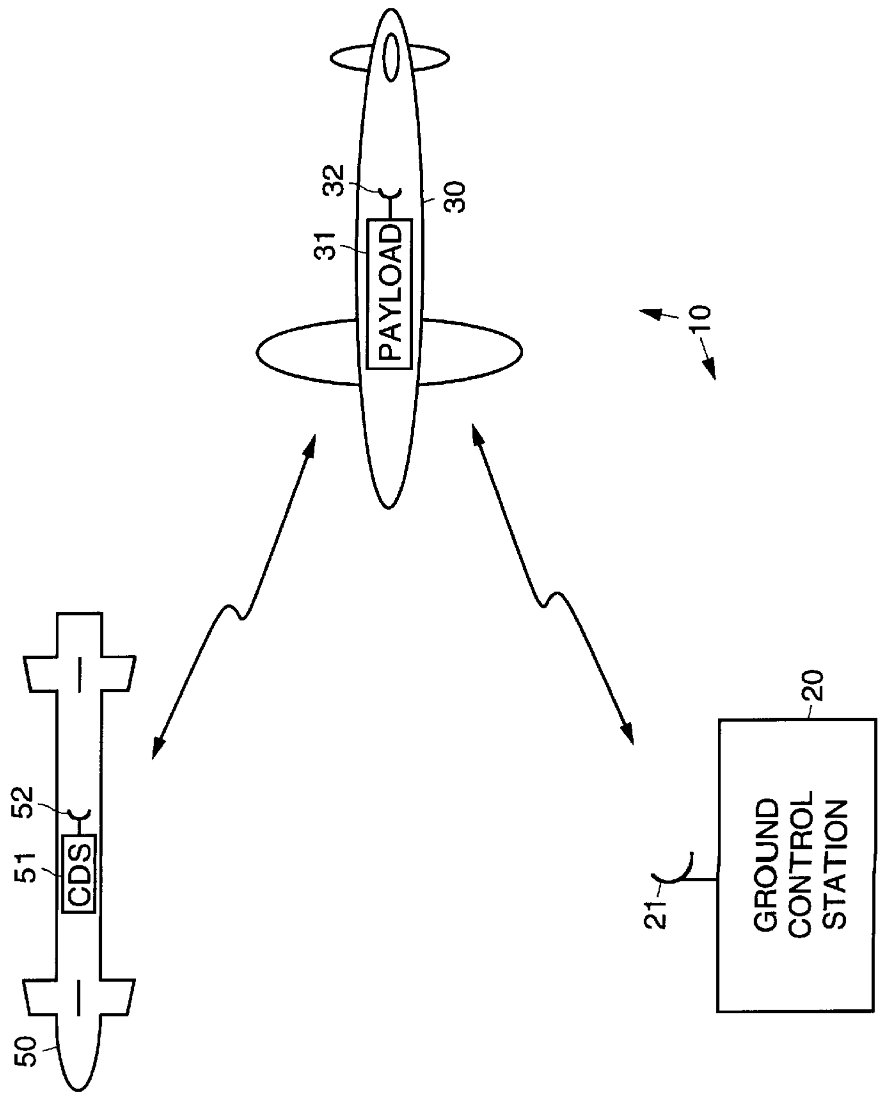


Fig. 1

10
30
31
PAYLOAD
32
50
51
CDS
52
20
GROUND CONTROL STATION
21

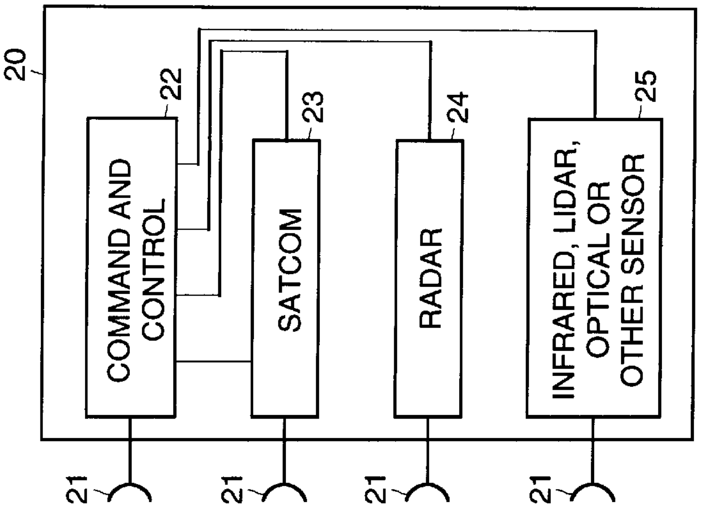
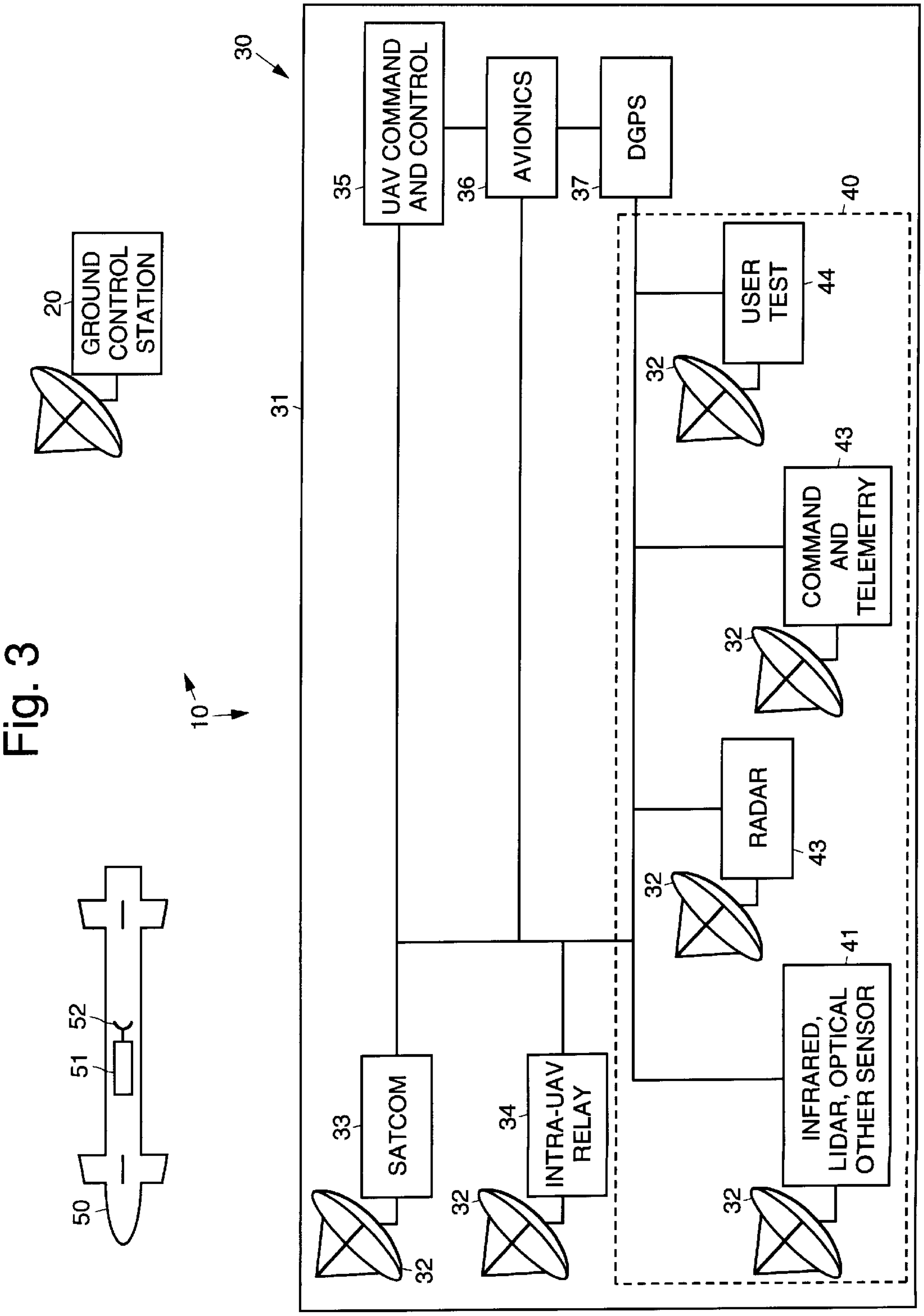


Fig. 2

20
22
COMMAND AND CONTROL
23
SATCOM
24
RADAR
25
INFRARED, LIDAR, OPTICAL OR OTHER SENSOR
21
21
21
21

Fig. 3


10
20
GROUND CONTROL STATION
50
51
52
30
31
32
33
SATCOM
34
INTRA-UAV RELAY
35
UAV COMMAND AND CONTROL
36
AVIONICS
37
DGPS
40
41
INFRARED, LIDAR, OPTICAL OTHER SENSOR
43
RADAR
43
COMMAND AND TELEMETRY
44
USER TEST

UTILIZING HIGH ALTITUDE LONG ENDURANCE UNMANNED AIRBORNE VEHICLE TECHNOLOGY FOR AIRBORNE SPACE LIFT RANGE SUPPORT

BACKGROUND

The present invention relates generally to space lift ranges, and more particularly, to a space lift system comprising an unmanned airborne vehicle that is used to implement a mobile space lift range.

Conventional space lift ranges for use in support of lifting payloads into space utilizing rockets and similar vehicles have been either ground based or space based. Ground-based space lift ranges are restrictive in that only specific predefined range layouts can be used due to range limitations that are required to exist between the ground control station and the space lift vehicle. Space-based space lift ranges are expensive since satellite links are required to communicate with the space lift vehicle. Recently deployed launch vehicles and concepts are more mobile than traditional systems. The Russians are offering Low Earth Orbit (LEO) services from Nuclear Submarines and the U.S. Navy is launching from sea-borne platforms. Pegasus and VenturStar can be launched from practically anywhere. Conversely, range systems have remained fixed requiring mobile launchers to travel to the range to acquire range services.

Heretofore, there have been no mobile space lift ranges for use in support of lifting payloads into space. Furthermore, no mobile space lift range has heretofore been developed that uses an unmanned airborne vehicle as a means to communicate with a space lift vehicle.

It would therefore be desirable to have a mobile space lift range that uses an unmanned airborne vehicle that provides flexibility when compared to conventional space lift ranges.

SUMMARY OF THE INVENTION

The present invention provides for an architectural approach for a mobile space lift range system that utilizes a high attitude, long endurance, unmanned airborne vehicle to provide a mobile space lift range. The present system extends traditional the use of unmanned airborne vehicle technology to provide a flexible, mobile range to support launch-anywhere space lift scenarios.

The unmanned airborne vehicle is a high attitude, long endurance airborne platform that provides a fully reusable aeronautical vehicle designed to serve as a global stratospheric low-cost airborne mission payload platform. The unmanned airborne vehicle or airborne payload platform is designed for operational use at altitudes between about 15 and 30 kilometers. The unmanned airborne vehicle is also designed to provide airborne operation for days, weeks, or longer, depending upon operational requirements.

More particularly, the mobile lift range system comprises a ground control station and an unmanned airborne vehicle that is used to relay data to and from a space lift vehicle such as a rocket, for example. The unmanned airborne vehicle in accordance with the present invention includes a variety of systems including one or more sensor systems, a radar system, a telemetry and command system, and a user test system.

The use of an unmanned airborne vehicle to implement the present mobile space lift range system has several advantages as a platform for space lift range applications. These advantages include long on-station endurance, very high altitude operation capability, the unmanned airborne vehicle may be deployed across vast geographic expanses, the unmanned airborne vehicle is responsive to real-time redirection and the solution is more cost effective than either traditional ground-based ranges or space-based ranges. These advantages allow the range to be virtual rather than fixed, resulting in maximum flexibility.

The unmanned airborne vehicle can support both orbital and sub-orbital missions. In addition, the unmanned airborne vehicles has a simple design with no egress systems, minimum avionics, fundamental or no hydraulics, and is lightweight, resulting in reduced airframe load and stress. Engines for the unmanned airborne vehicle are designed for lower loads and can easily be repaired or simply replaced at preset intervals. These unique capabilities are realized with the added advantage of programmable autonomous operation, eliminating the cost of a pilot and crew.

Unmanned airborne vehicles are cost efficient compared to both satellite (space-based) systems and ground-based systems. Also, the unmanned airborne vehicles are reusable with regular payload servicing and may be readily enhanced as technology improves. The unmanned airborne vehicle operates at a fraction of the orbital distance of low earth orbiting satellites, and as mentioned above, offers advantages that implement flexible and cost effective space lift range applications. The unique combination of altitude, endurance and selective payload enables a variety of interesting missions to be implemented that are not achievable using conventional space-based and ground-based systems.

Unmanned airborne vehicles employed in the present system are operationally feasible and economical, and fill a distinct niche as a low cost alternative technology for use in lieu of small satellite low earth orbit (LEO) space systems and manned aeronautical or terrestrial systems. Furthermore, the present system may also be used in areas requiring weather sensors, area surveillance, telemetry relay, and telecommunications.

BRIEF DESCRIPTION OF THE DRAWINGS

The various features and advantages of the present invention may be more readily understood with reference to the following detailed description taken in conjunction with the accompanying drawing figures, wherein like reference numerals designate like structural elements, and in which:

FIG. **1** illustrates an architecture of an exemplary space lift range system in accordance with the principles of the present invention;

FIG. **2** illustrates details of an exemplary ground control station of the system of FIG. **1**; and

FIG. **3** illustrates details of an exemplary unmanned airborne vehicle used in the system of FIG. **1**.

DETAILED DESCRIPTION

Referring to the drawing figures, FIG. **1** illustrates an architecture of an exemplary space lift range system **10** in accordance with the principles of the present invention. The space lift range system **10** comprises a ground control station **20** that communicates and controls one or more unmanned airborne vehicles **30** or airborne payload platforms **30** that in turn communicate with or track a space lift vehicle **50**, such as a rocket, for example.

The ground control station **20** provides for communication with and control of the one or more unmanned airborne vehicles **30** and is integrated using commercially available components. The ground control station provides an interface for user communications with the space lift vehicle via the airborne vehicles. Communication between the ground control station **20** and the one or more unmanned airborne vehicles **30** is illustrated by means of an antenna **21** in FIG. **1**).

The a space lift vehicle **50** includes a guidance and control, health and status telemetry, and command destruct system (CDS) **51** that communicates with the unmanned airborne vehicle **30** by way of a communication system **52** (illustrated by means of an antenna **52** in FIG. **1**). The space lift vehicle **50** may be launched along a flight path that is not constrained by the physical location of the ground control station **20**, or of a satellite used in a conventional space-based system.

FIG. **2** illustrates details of an exemplary ground control station **20** of the system **10** of FIG. **1**. The exemplary ground control station **20** comprises a command and control system **22**, a satellite communication (SATCOM) system **23**, a radar processing system **24**, and a sensor processing system **25**, each of which communicate to the user via user interface and to the unmanned vehicle by way of a communication system **21**, such as is generally shown as an antenna **21**.

The command and control system **22** functions to provide for commanding of the unmanned airborne vehicle to control the altitude and route of flight as well as the functions of the command and sensor equipment aboard the airborne vehicle. The command and control system **22** may be a commercially available system manufactured by Aurora Flight Sciences, for example.

The satellite communication system **23** typically functions to communicate with a satellite (not shown) that may be used to communicate with the space lift vehicle **50**. The satellite communication system **23** used in the ground control station **20** may be a commercially available system manufactured by Aurora Flight Sciences, for example.

The radar system **24** functions to track the space lift vehicle **50** during its flight and track the unmanned airborne vehicle **30** during its flight. The radar system **24** may be a commercially available system manufactured by Ericsson Microwave, for example.

The sensor processing system **25** functions to convert sensor data into user defined functionality. The sensor processing system **25** may be constructed using commercially available components manufactured by TriStar Array Systems, for example.

FIG. **3** illustrates details of an exemplary unmanned airborne vehicle **30** used in the system of FIG. **1**. The exemplary unmanned airborne vehicle **30** comprises a conventional airframe, such as one designed and built by the assignee of the present invention. Alternatively, the airframe of the unmanned airborne vehicle **30** may be procured from other commercial sources, including Aurora Flight Sciences, and AeroVironment, for example.

The unmanned airborne vehicle **30** is typically designed for operational use at altitudes between about 15 and 30 kilometers. This is achieved by the aircraft structure being constructed from lightweight composite materials. A high aspect ratio wing also increases range by minimizing induced drag. To reduce fuel consumption, The aircraft may be powered by efficient piston engines. 4-Cylinder, fuel-injected engines are turbocharged in three stages for operation in thin air at high altitudes. The unmanned airborne vehicle **30** is also designed to provide airborne operation for days, weeks, or longer, depending upon mission requirements. This is achieved by selecting a payload size and propulsion methodology (electric for example) that meets mission duration requirements.

The unmanned airborne vehicle **30** includes a payload **31** (also shown in FIG. **1**) that is integrated using commercially available components having a common command and control interface. The payload **31** communicates with the ground control station **20** and the space lift vehicle **50** using various systems that will be described in more detail below. Communication is achieved using a variety of communication systems **32** (illustrated by means of a antenna **32** in FIG. **1**).

The unmanned airborne vehicle **30** includes a number of systems that have heretofore been used on an unmanned airborne vehicle for other purposes. These systems include a satellite communication (SATCOM) system **33**, an intra UAV relay **34**, a UAV command and control system **35**, an avionics system **36**, and a differential global positioning system (DGPS) **37**.

The satellite communication system **33** provides a communication link or relay between the satellite communication system **23** located in the control station **20** and the satellite (not shown) that is in turn used to communicate with the space lift vehicle **50**. The satellite communication system **33** employed in the unmanned airborne vehicle **30** may be a commercially available system manufactured by Rockwell Collins, for example.

The intra UAV relay **34** is a low bandwidth (bandwidth constricted) communications link that is used to communicate between several space lift vehicles **50**. The intra UAV relay **34** may be a commercially available system manufactured by Aurora Flight Sciences, for example.

The avionics system **36** is a system that provides flight control input and status such as airspeed, altitude, location, and attitude. The avionics system **36** may be a commercially available system manufactured by Aurora Flight Sciences, for example.

The differential global positioning system (DGPS) **37** is a system that processes timing signals received from the global positioning system (GPS) satellite system in order to determine accurate location and altitude. The digital global positioning system **37** may be a commercially available system manufactured by Orbital Sciences Corp, for example.

The design and operation of each of the above-described conventional systems used in the unmanned airborne vehicle **30** are generally well-understood by those skilled in the art. The design and operation of the remaining systems that implement the present invention are also generally well-understood by those skilled in the art.

The unmanned airborne vehicle **30** includes one or more additional systems (which may be used alone or in combination) that implement the space lift range system **10** in accordance with the present invention. These systems include one or more sensor systems **41**, a radar system **42**, a telemetry and command system **43**, and a user test system **44**. The sensor systems **41**, radar system **42**, command and telemetry system **43**, and user test system **44** have not heretofore been employed in an unmanned airborne vehicle **30** to implement a space lift range system **10**.

The sensor systems **41** may include an infrared, LIDAR, optical, or other sensor **36**. The infrared sensor **36** may be a commercially available infrared sensor **36** manufactured by Hughes Space and Communications Company, for example. The LIDAR sensor **36** may be a commercially available LIDAR sensor **36** NASA Multi-center Airborne Coherent Atmospheric Wind Sensor, for example. The optical sensor **36** may be a commercially available optical sensor **36** manufactured by Instro Precision Limited, for example.

Information derived onboard the unmanned airborne vehicle **30** using the infrared, LIDAR, optical, or other sensor **36** is relayed via the command and telemetry system **43** to the ground control station **20**.

The telemetry and command system **43** is a system that receives telemetry from the space lift vehicle and transmits commands to the space lift vehicle. The telemetry and command system **43** may be a commercially available command and telemetry system **43** manufactured by Cincinnati Electronics, for example. The command and telemetry system **43** may be used to communicate user mission package simulation data to and from the user test system **44**.

The radar system **42** functions to track the space lift vehicle **50** during its flight. The radar system **42** may be a multiple object tracking radar system **42**, for example **30**. Positional information derived from the multiple object tracking radar **35** onboard the unmanned airborne vehicle **30** is relayed to the control system **20** via the command and telemetry system **43**. The radar system **42** may be a commercially available system manufactured by Ericsson Microwave, for example. Radar signals generated by the radar system **42** are relayed to the ground control station **20** for processing.

The user test system **44** is a system that allows a user to test specific aspects relating to the space lift vehicle **50** and which may change from mission to mission.

The payload bay in the unmanned airborne vehicle **30** is designed to provide for interchangeability of components, without additional integration costs. This makes the mission of the unmanned airborne vehicle **30** as flexible as possible with minimum cost to a user. A published payload interface to the unmanned airborne vehicle **30** permits users to fly LEO packages at high altitude for testing purposes further extending the utility of the unmanned airborne vehicle **30**.

A variety of equipment packages to support various missions may be installed in the unmanned airborne vehicle **30** to provide the numerous range capabilities. FIG. **3** illustrates certain of these capabilities. Different sensor systems **41** may be employed for different flight scenarios or operating conditions. The use of the radar system **43** permits tracking of the space lift vehicle **50** beyond the normal range of the radar system **24** in the ground control station **20**. This readily permits long range extended flight plans to be implemented to test the space lift vehicle **50**.

Thus, a space lift system employing an unmanned airborne vehicle that is used to implement a mobile space lift range has been disclosed. It is to be understood that the above-described embodiment is merely illustrative of some of the many specific embodiments that represent applications of the principles of the present invention. Clearly, numerous and other arrangements can be readily devised by those skilled in the art without departing from the scope of the invention.

What is claimed is:

1. A system for assisting the launch of a vehicle into space, comprising:

an unmanned airborne vehicle that flies a controllable flight plan and that comprises a command and telemetry system for communicating with and commanding the vehicle that is to be launched into space; and

a ground control station that communicates with and controls the unmanned airborne vehicle and that communicates with and controls the vehicle that is to be launched into space by way of the unmanned airborne vehicle.

2. The system recited in claim **1** wherein the command and telemetry system comprises a system that allows users to receive telemetry from the vehicle that is to be launched into space and to transmit commands to that vehicle.

3. The system recited in claim **1** further comprising a sensor system.

4. The system recited in claim **3** wherein the sensor system comprises an infrared sensor system.

5. The system recited in claim **3** wherein the sensor system comprises a LIDAR sensor system.

6. The system recited in claim **3** wherein the sensor system comprises an optical sensor system.

7. The system recited in claim **1** further comprising a radar system.

8. The system recited in claim **7** wherein the radar system comprises a multiple object tracking radar system.

9. The system recited in claim **1** further comprising a user test system.

10. The system recited in claim **9** wherein the user test system comprises a system for testing specific aspects of the vehicle that is to be launched into space.

11. The system recited in claim **1** wherein the command and telemetry system communicates user mission package simulation data to and from the user test system.

12. The system recited in claim **1** wherein the vehicle that is to be launched into space comprises a rocket.

13. The system recited in claim **1** further comprising a plurality of unmanned airborne vehicles.

* * * * *