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(54) **CONTROLLED RANGE AND PAYLOAD FOR UNMANNED VEHICLES, AND ASSOCIATED SYSTEMS AND METHODS**

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(51) **Int. Cl.**
G05D 1/00 (2006.01)
B64C 39/02 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***B64C 39/024*** (2013.01); ***B64C 19/00*** (2013.01); ***G05D 1/0055*** (2013.01); ***G06Q 10/10*** (2013.01); ***G06Q 50/18*** (2013.01); ***G06Q 50/26*** (2013.01); *Y10T 29/49826* (2015.01)

(58) **Field of Classification Search**
CPC B64C 39/024; B64C 19/00; C06Q 10/10; G06Q 50/18; G06Q 50/26; Y02T 29/49826; G07C 5/008; G07C 5/0841; H04W 4/046
USPC .... 701/2, 3, 13, 14, 15, 33.4; 340/439; 244/75 R, 158.1; 29/428
See application file for complete search history.

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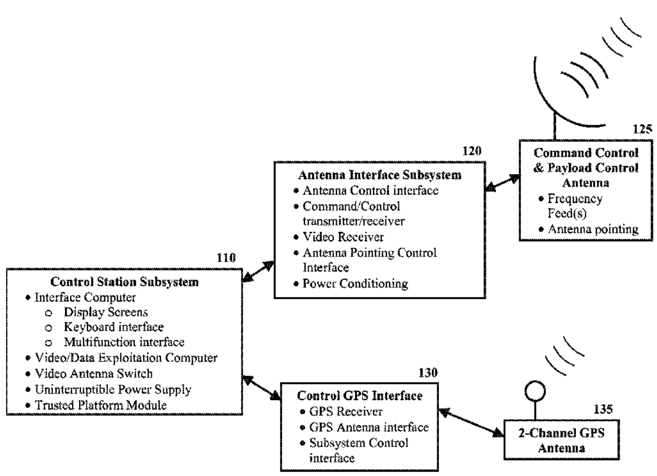
(57) **ABSTRACT**

The presently disclosed technology is directed generally to unmanned vehicle systems and methods configured to satisfy a first set of export control regulations, such as those within the jurisdiction of one government entity or international body (e.g., the U.S. Department of Commerce) without falling within the purview of a second set of export control regulations, such as export control regulations within the jurisdiction of another government entity or international body (e.g., the U.S. Department of State). Through limited range of operation, limited payload types, limited capabilities, and tamper-proof or tamper-resistant features, embodiments of the unmanned vehicle system are designed to fall within the purview and under control of one agency and not within the purview and under control of another agency.

17 Claims, 7 Drawing Sheets



(51) **Int. Cl.**

G06Q 10/10	(2012.01)
G06Q 50/18	(2012.01)
G06Q 50/26	(2012.01)
B64C 19/00	(2006.01)

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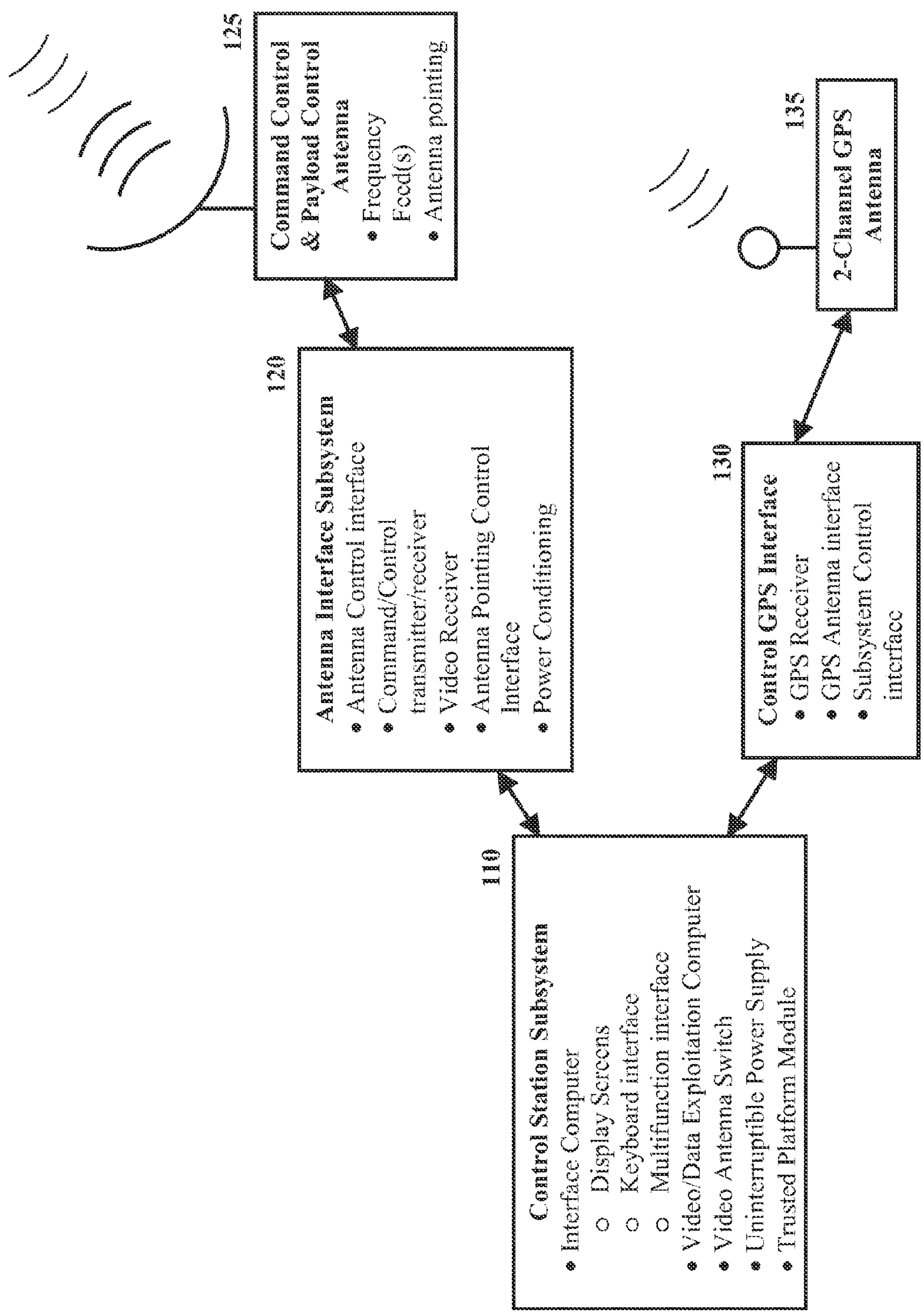

125
Command Control & Payload Control Antenna
• Frequency Feed(s)
• Antenna pointing
120
Antenna Interface Subsystem
• Antenna Control interface
• Command/Control transmitter/receiver
• Video Receiver
• Antenna Pointing Control Interface
• Power Conditioning
110
Control Station Subsystem
• Interface Computer
○ Display Screens
○ Keyboard interface
○ Multifunction interface
• Video/Data Exploitation Computer
• Video Antenna Switch
• Uninterruptible Power Supply
• Trusted Platform Module
130
Control GPS Interface
• GPS Receiver
• GPS Antenna interface
• Subsystem Control interface
135
2-Channel GPS Antenna

FIG. 1

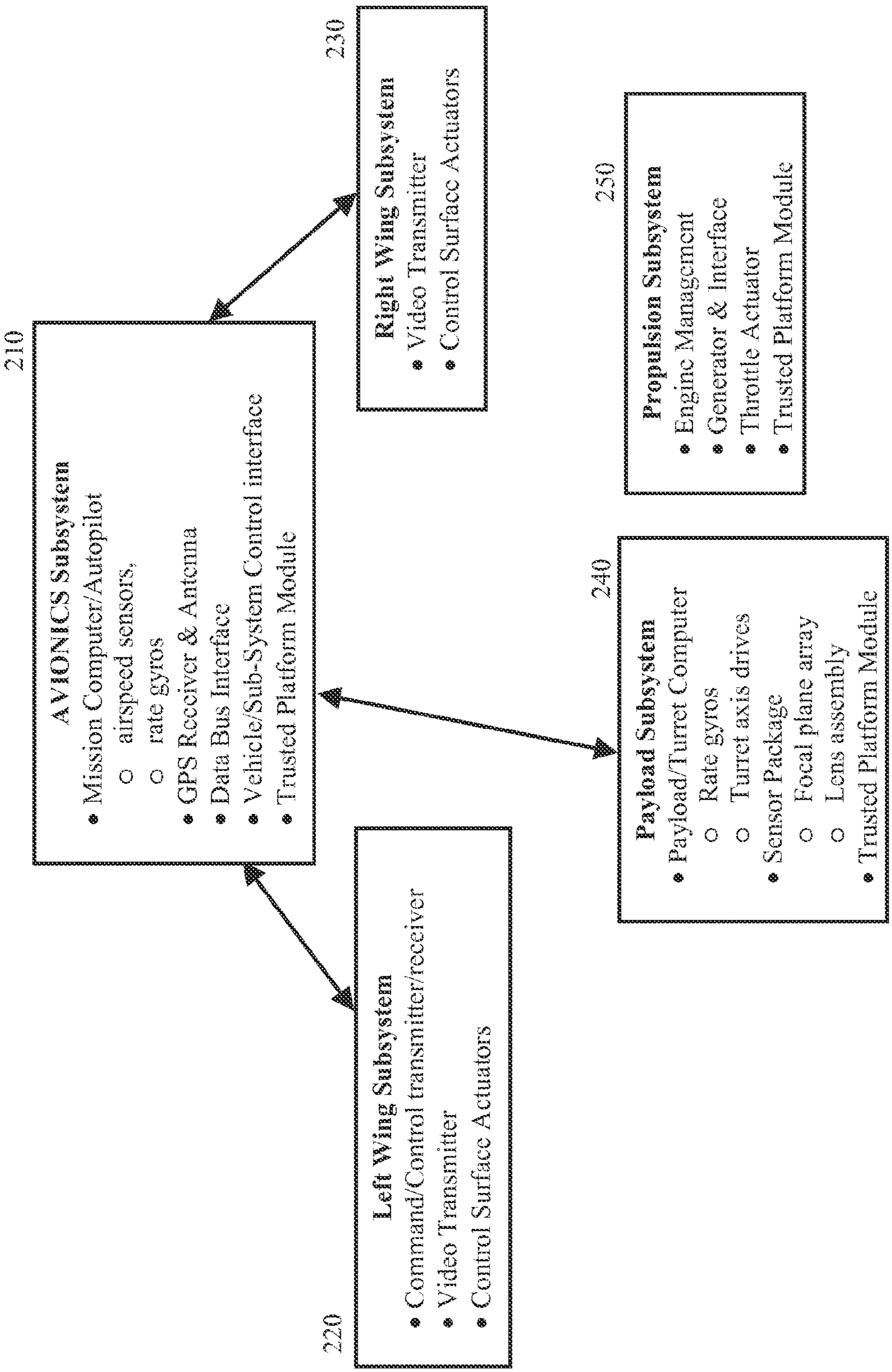
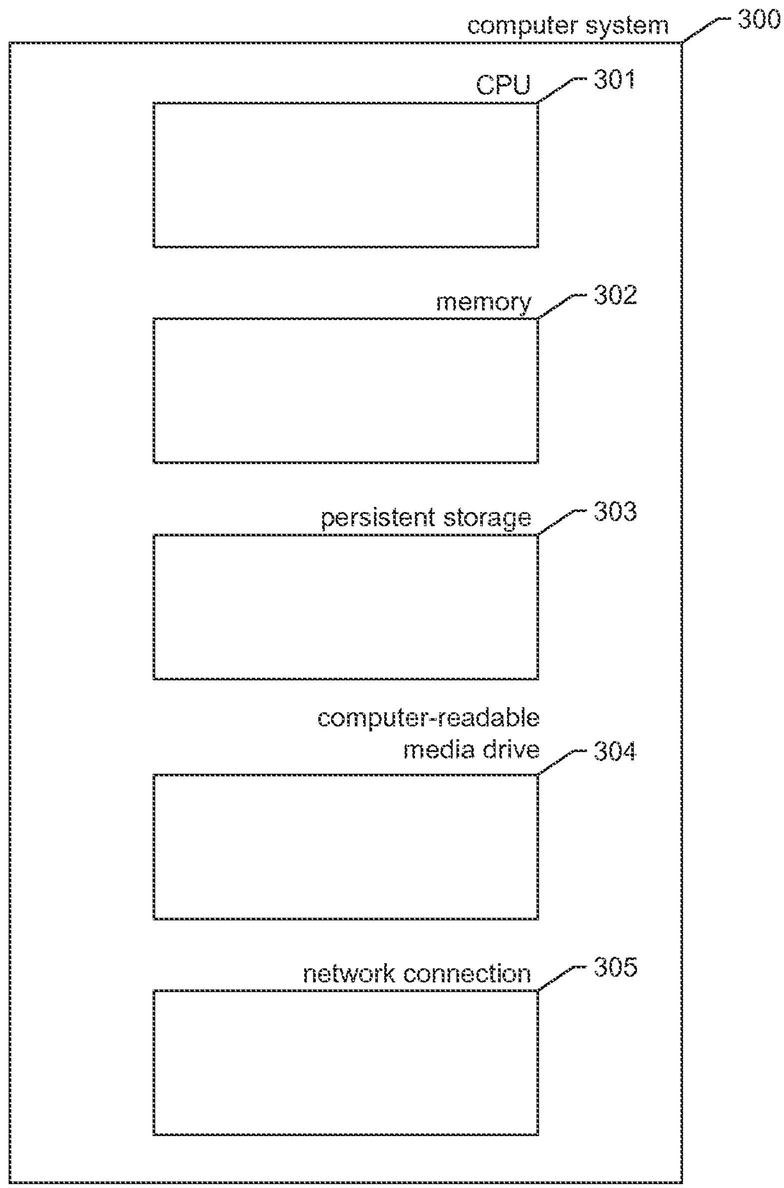

210
AVIONICS Subsystem
Mission Computer/Autopilot
airspeed sensors,
rate gyros
GPS Receiver & Antenna
Data Bus Interface
Vehicle/Sub-System Control interface
Trusted Platform Module
220
Left Wing Subsystem
Command/Control transmitter/receiver
Video Transmitter
Control Surface Actuators
230
Right Wing Subsystem
Video Transmitter
Control Surface Actuators
240
Payload Subsystem
Payload/Turret Computer
Rate gyros
Turret axis drives
Sensor Package
Focal plane array
Lens assembly
Trusted Platform Module
250
Propulsion Subsystem
Engine Management
Generator & Interface
Throttle Actuator
Trusted Platform Module

FIG. 2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CPU
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memory
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persistent storage
303
computer-readable
media drive
304
network connection
305

FIG. 3

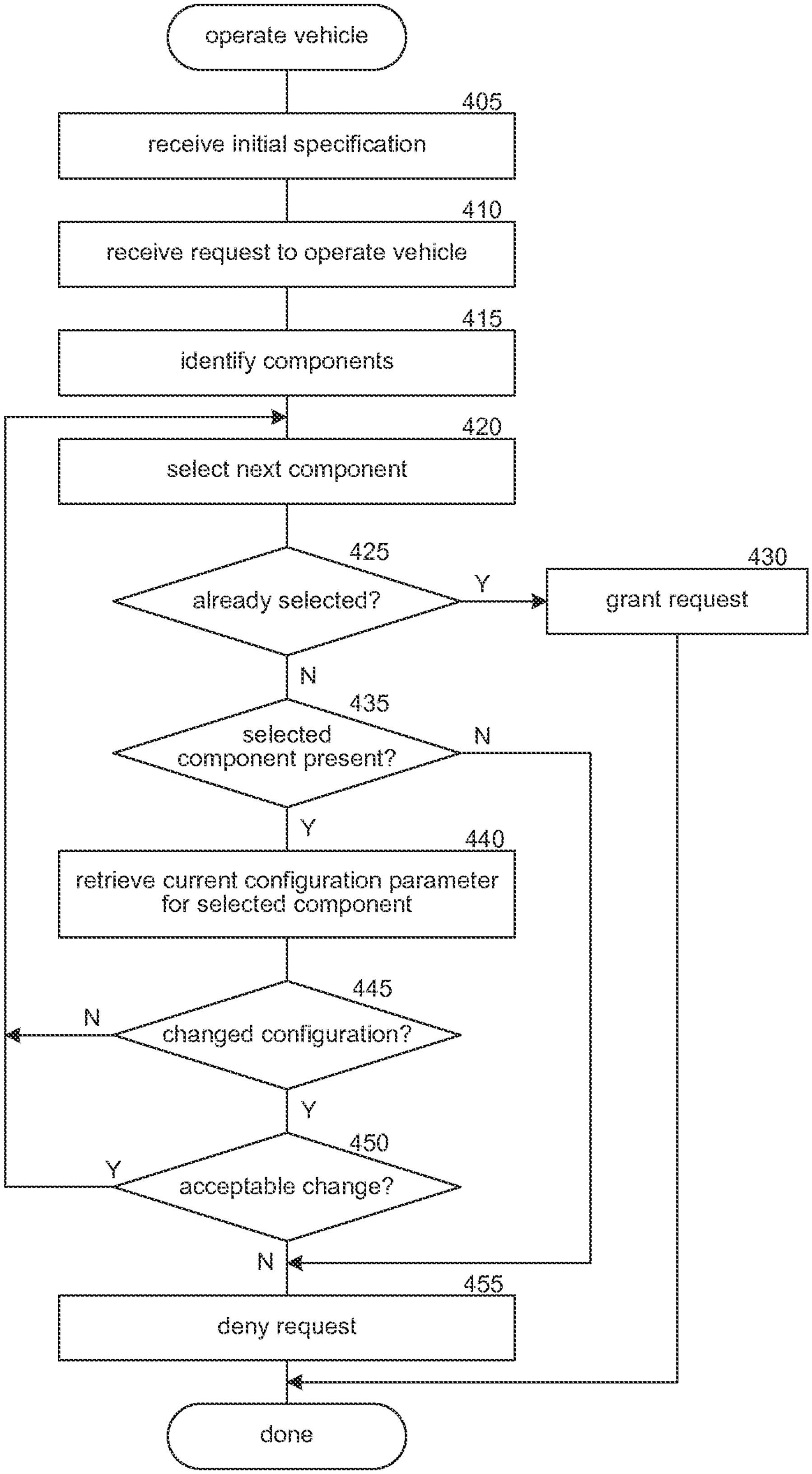
operate vehicle
405
receive initial specification
410
receive request to operate vehicle
415
identify components
420
select next component
425
already selected?
Y
430
grant request
N
435
selected component present?
N
Y
440
retrieve current configuration parameter for selected component
445
N
changed configuration?
Y
450
Y
acceptable change?
N
455
deny request
done

FIG. 4

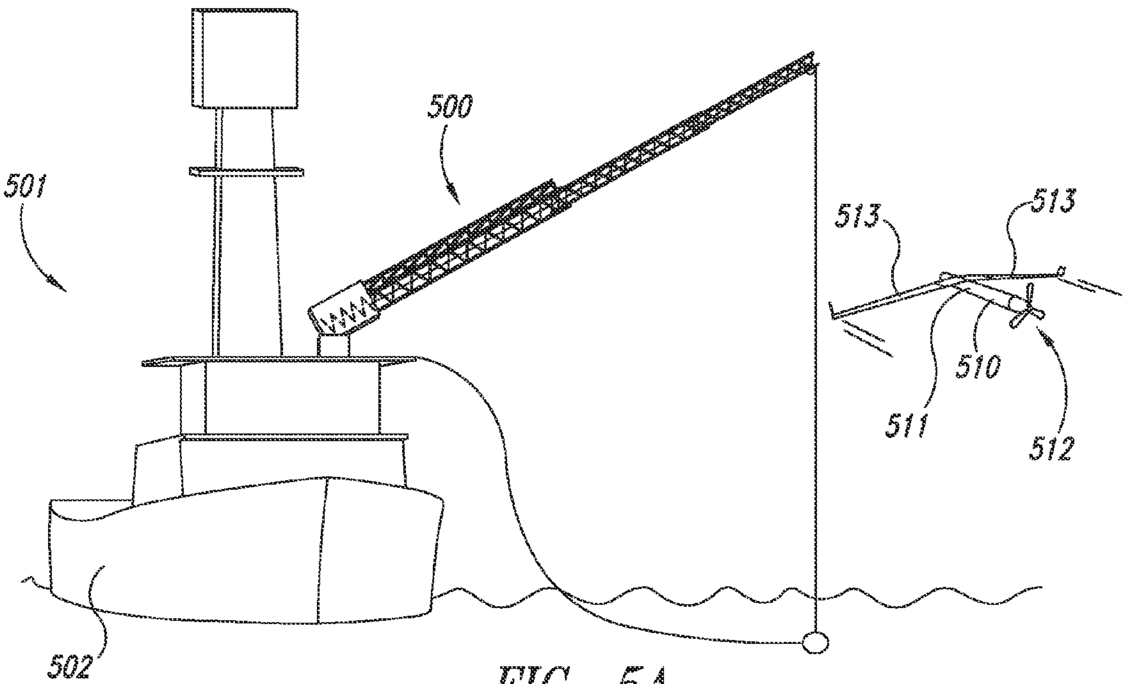
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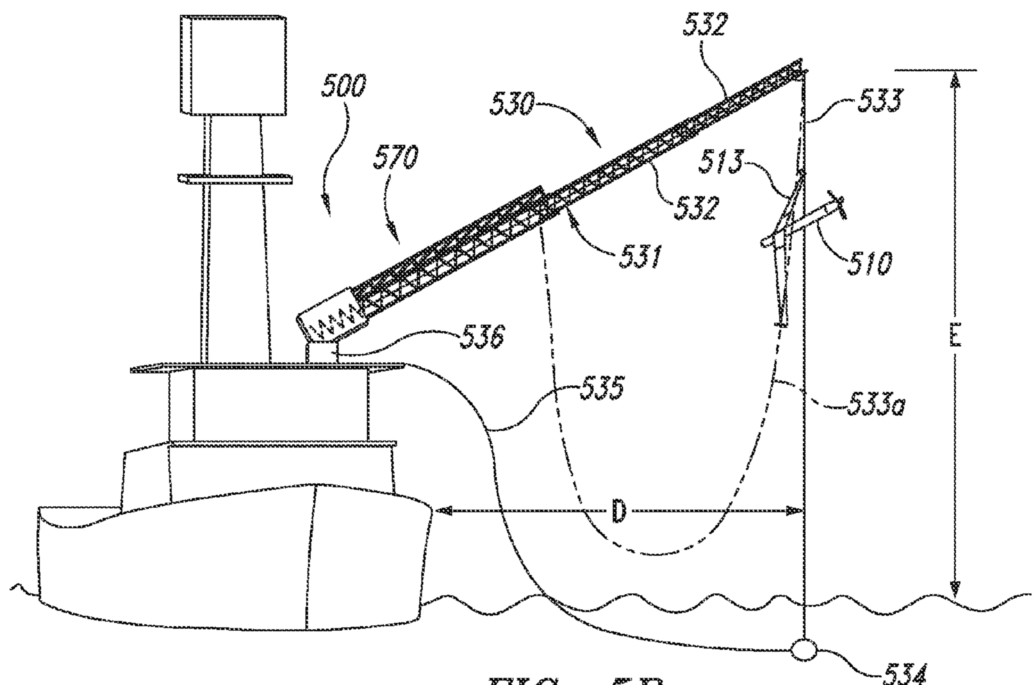
FIG. 5A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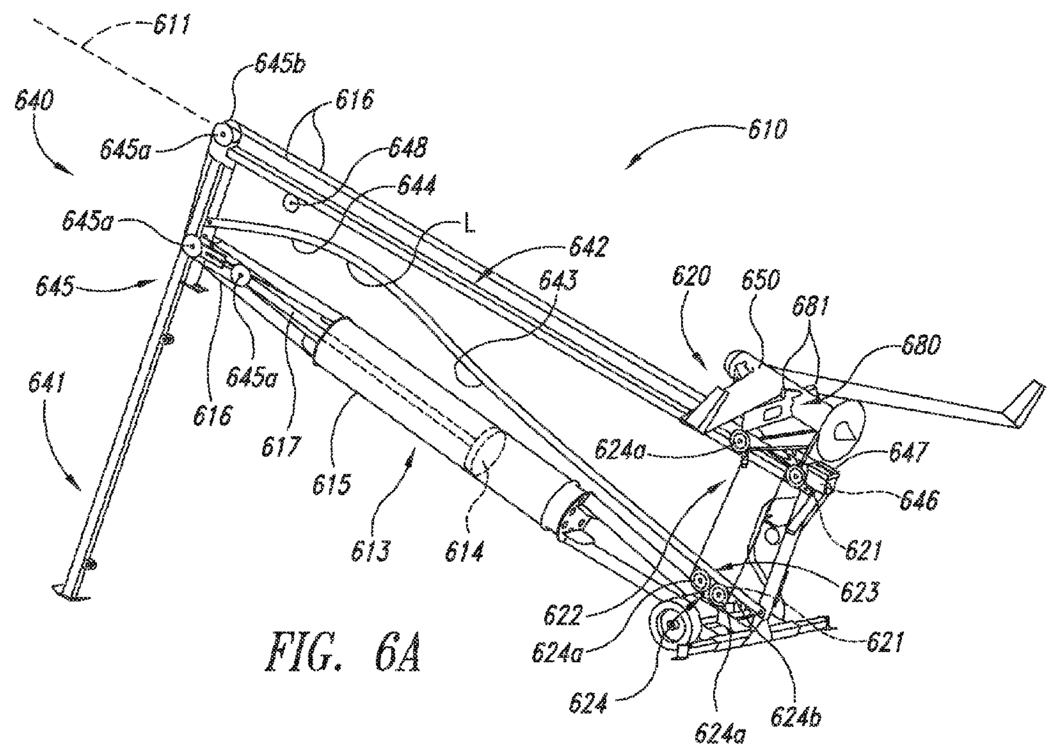
534

FIG. 5B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645a
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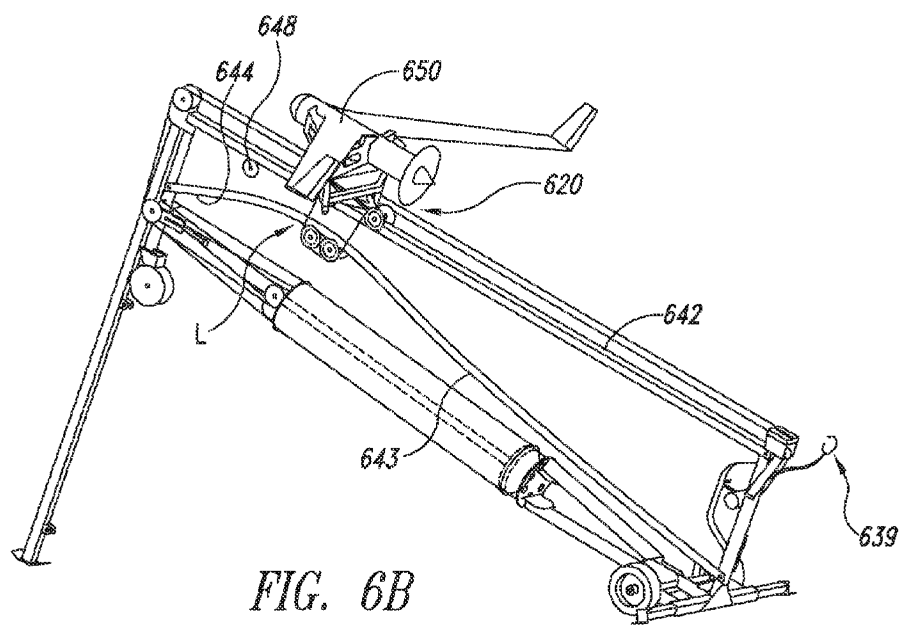
624a
624
624a
624b

FIG. 6A


648
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620
L
642
643
639

FIG. 6B

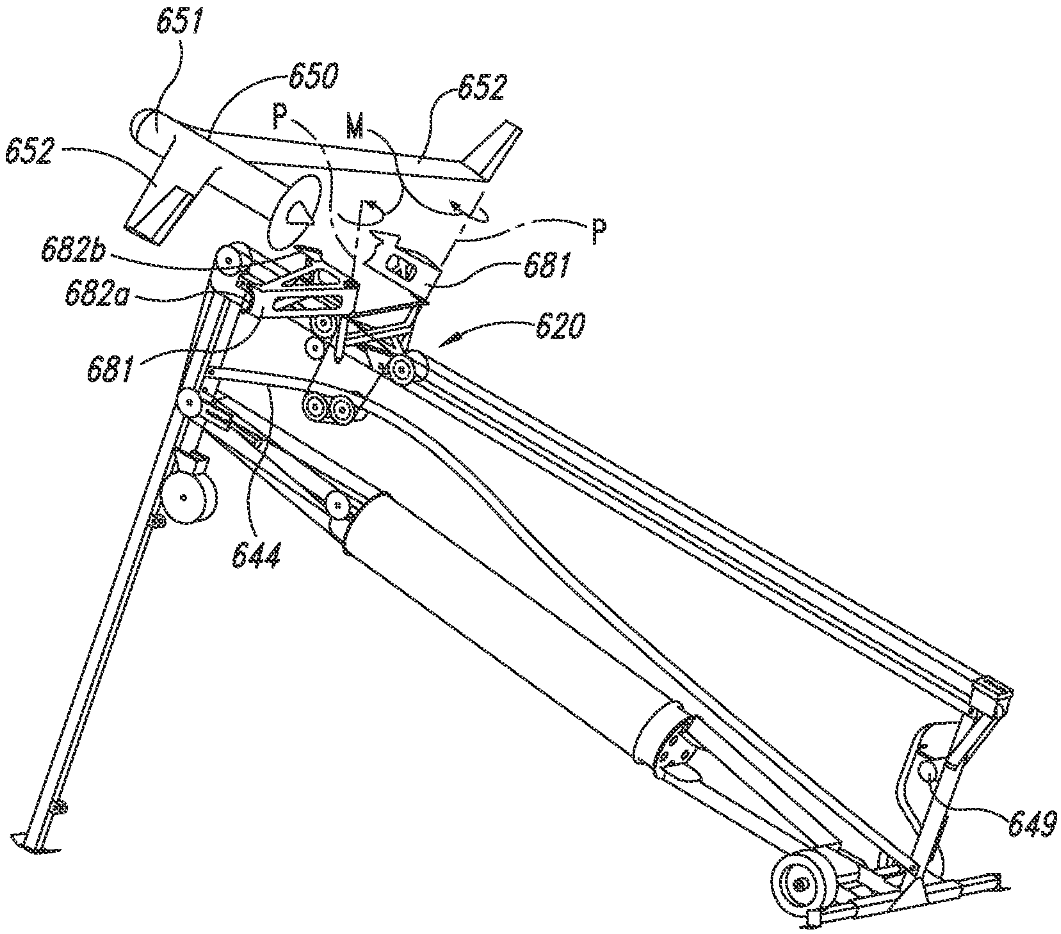

FIG. 6C

CONTROLLED RANGE AND PAYLOAD FOR UNMANNED VEHICLES, AND ASSOCIATED SYSTEMS AND METHODS

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application is a continuation of International Patent Application No. PCT/US12/65360, filed Nov. 15, 2012, entitled CONTROLLED RANGE AND PAYLOAD FOR UNMANNED VEHICLES, AND ASSOCIATED SYSTEMS AND METHODS, which claims the benefit of U.S. Provisional Patent Application No. 61/560,234, filed Nov. 15, 2011, entitled CONTROLLED RANGE AND PAYLOAD FOR UNMANNED VEHICLES, AND ASSOCIATED SYSTEMS AND METHODS, each of which is incorporated by reference in its entirety. To the extent the foregoing application or any other material incorporated herein by reference conflict with the present disclosure, the present disclosure controls.

BACKGROUND

Unmanned systems (e.g., unmanned aerial or aircraft systems, unmanned ground systems, unmanned underwater systems) provide a low-cost and low-risk alternative to a variety of reconnaissance-type tasks performed by manned systems. Unmanned aircraft systems, for example, are used by TV news stations, by the film/television industry, the oil industry, for maritime traffic monitoring, border/shore patrol, civil disaster surveillance, drug enforcement activities, monitoring fleets of fish (e.g., tuna), etc. Law enforcement agencies use manned helicopters and airplanes as an integral part of their operations, but unmanned aircraft systems are starting to be used in a growing number of places. The uses for aviation equipment in law enforcement that can be filled by unmanned aerial systems include, for example:

Photographic uses,
Surveillance uses,
Routine patrol/support,
Fugitive searches,
Search and Rescue,
Pilot Training,
Drug Location/Interdiction,
SWAT operations, and
Firefighting/Support.

Table 1 provides statistics related to the use of aviation units by large law enforcement agencies with one hundred or more full time officers in the United States.

TABLE 1

Aviation Law Enforcement Statistics		
Number of aviation units, US		2010
Rotary - median $/flt.hr.	$168 (Maintenance)	$45 (Fuel)
Fixed - median $/flt.hr.	$54 (Maintenance)	$74 (Fuel)
Unmanned		$1.79/hour

Unmanned systems can include a Global Positioning System (GPS) receiver to obtain adequate near real time position data to know where the system is, and calculate attitude with feedback information from solid-state rate gyros. Unmanned aerial systems capable of, for example, automated take-off/launch, flight via programmed way-points, and snag-type recovery have been developed that reduce the cost to own and operate when compared to human-operated aircraft (e.g., single-pilot fixed and rotor aircraft). Unmanned vehicles that are covered by the United States Munitions List (USML) are subject to export controls administered by the U.S. Department of State under the Arms Export Control Act and the International Traffic in Arms Regulations (ITAR) defined at 22 C.F.R. §§120-130. For example, the Missile Technology Control Regime ("MTCR") (See 22 C.F.R. §121.16) defines two categories of unmanned air vehicles subject to State Department Control, each category subject to different export controls. "MTCR Category I" vehicles are those vehicles that 1) are capable of at least 300 km of autonomous flight and navigation and 2) can carry a payload of at least 500 kg. "MTCR Category II" vehicles are those vehicles that either 1) are capable of at least 300 km of autonomous flight and navigation or 2) can carry a payload of at least 500 kg. (See 22 C.F.R. §121.16 (2011).) Commodities subject to export controls administered by other agencies (e.g., the U.S. Department of Commerce), such as unmanned air vehicles that are incapable of autonomous flight and navigation for 300 km or more and cannot carry a payload of 500 kg or more, are subject to less stringent export requirements.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram illustrating a control station configured in accordance with an embodiment of the disclosure.

FIG. **2** is a block diagram illustrating subsystems of an unmanned aerial vehicle configured in accordance with an embodiment of the disclosure.

FIG. **3** is a block diagram showing some of the components incorporated in associated computing systems in accordance with an embodiment of the disclosure.

FIG. **4** is a flow diagram illustrating the processing of an "operate vehicle module" configured in accordance with particular embodiments of the disclosure.

FIGS. **5**A-**5**B illustrate overall views of apparatuses and methods for capturing unmanned aircraft in accordance with an embodiment of the disclosure.

FIGS. **6**A-**6**C illustrate an arrangement for launching an unmanned aircraft in accordance with an embodiment of the disclosure.

DETAILED DESCRIPTION

The presently disclosed technology is directed generally to unmanned vehicle systems and methods configured to satisfy certain restrictions. For example, the systems and methods can satisfy Commerce Department jurisdiction requirements without falling within the purview of State Department control. Through limited range of operation, limited payload types (e.g., surveillance equipment, munitions, insecticides or other materials for agricultural crops) and capabilities, and tamper-proof or tamper-resistant features, embodiments of the unmanned vehicle system are designed to fall within the purview and under control a first set of export control regulations or requirements, such as Export Administration Regulations ("EAR") overseen by the U.S. Commerce Department, and not within the purview and under control of a second set of export control regulations or requirements, such as MTCR, ITAR, and other State Department control thresholds. Disclosed techniques in accordance with particular embodiments provide protection against repurposing a vehicle as a weapons delivery device and repurposing a commercial vehicle for military or other operations by, for example, modifying operation of the vehicle (e.g., preventing vehicle systems from executing, preventing the vehicle from launching, preventing the vehicle's engine from starting) in response to detecting these conditions. Representative techniques can also provide protection against in-flight handoff between ground controlling authorities, eavesdropping of available data streams, and so on by, for example, restricting use of commands for performing these functions. Although this disclosure discloses particular embodiments in the context of Category II vehicles by way of example, one skilled in the art will recognize that the disclosed techniques may be applied to Category I vehicles in addition to other vehicles or commodities that may be subject to varying sets of requirements.

I. System Design and Capabilities

In some embodiments, the unmanned vehicle has a low payload capability of 3.3 lbs., (1.5 Kg), a diameter of 7 inches, a length of 42 inches, a wingspan of 10 feet, an empty weight of 26 lbs, and a gross takeoff weight of 40 lbs. Furthermore, the unmanned vehicle's design and capabilities are based on its airframe structure electronics systems and software architecture, which includes trusted computing technologies, and are described in further detail below.

A. Airframe Structure

In certain embodiments, the aircraft structure, which comprises the fuselage, main wing box, wing skin sandwich panels, winglets, fuel tank, and internal brackets, is fabricated using, for example, low cost carbon fiber/epoxy materials, fiberglass, aluminum, or molded plastics based on considerations of size, weight, power, cost, etc. and hard-tool molding commercial techniques. Such techniques have been used in, for example, bicycle frame, snow-sport and water-sport equipment manufacturing.

B. Command and Control System and Software

1. Command and Control System

In certain embodiments, the electronic hardware and software of the unmanned vehicle are configured to limit range (distance from designated point, such as a point of origin or launch location), but not necessarily endurance (total distance traveled during a flight). For example, the range can be limited to 60 nautical miles from the operator control station (e.g., ground control base station or mobile control base station) using a radio transmitter and antenna gain combination that limits the maximum physical range of communication for the provided radio link on the aircraft to the control station antenna. Flight operation limits can be achieved through the physical limits of radio frequency command and control wireless data links coupled with software commands that prevent waypoint entry beyond the radial distance of 60 nautical miles. For example, aircraft mission management software can be configured to compare control station GPS location to aircraft GPS location to maintain radio-link margin distance at all times. In the case of a lost data or communication link, the aircraft can alter course to regain the lost data or communication link with a control station. If link interruption continues, the aircraft can return to the last known GPS position of the control station to execute flight termination or emergency landing procedures. In this embodiment, travel of the unmanned vehicle beyond 60 nautical miles causes the auto pilot to steer the unmanned vehicle toward the control station GPS location to secure communication. The software may also be configured to limit the range of the unmanned vehicle or return to base at or below the 299 km distance from a launch location to meet MTCR requirements.

a. Navigation System

In some embodiments, to limit the operation of the unmanned vehicle, the unmanned vehicle is not equipped with a magnetic compass or accelerometers to estimate current altitude, speed, and direction. Instead, the unmanned vehicle can be equipped with a rudimentary navigation system. Without adequate GPS data, the unmanned vehicle cannot maintain a known navigation solution and will attempt to return to the control station or terminate travel based on one or more emergency procedure protocols known to those of ordinary skill in the art. For example, in the case of lost communications and/or lost GPS connectivity, the unmanned vehicle can deploy speed-reducing devices (e.g., parachutes or parafoils) and/or airbags and execute a spin-stall maneuver, causing the aircraft to tumble as slowly as possible to the ground. The unmanned vehicle's navigation protocol and emergency procedures are designed to prevent flight beyond the 60 nautical mile range of the Command and Control system. The unmanned vehicle may typically fly over uninhabited terrain at altitudes below 5,000 feet above the ground, thereby reducing the probability of human injury. The unmanned vehicle can be configured to tumble out of the sky using automatic auto rotation and/or automatic chute deployment in the case of lost communications and/or lost GPS connectivity.

In other embodiments, a collection of multiple control stations are available for communication with the unmanned vehicle system. For example, environment conditions (e.g., obstructions to line of sight) and communication systems may prevent the unmanned vehicle system from communicating with control stations beyond a certain distance, such as 60 nautical miles. In these embodiments, control stations and the unmanned vehicle system can perform a handoff procedure as the unmanned vehicle system approaches a specified distance (e.g., 60 nautical miles) from the control station with which the unmanned vehicle system is communicating to another control station so that the unmanned vehicle system can maintain control station connectivity and take advantage of a greater permissible range, such as 299 km from a launch location. The handoff procedure may be based on, for example, the type of vehicle and control station involved, the speed and/or direction of the vehicle and/or control station, the launch location or target of the vehicle, and so on. In this manner, the range of the unmanned vehicle can approach the "299 km from launch location" limit discussed above. However, embodiments of the system will prevent the aircraft from flying beyond the "299 km from launch location" limit discussed above. Furthermore, the aircraft can be configured to set a transponder to squawk an emergency code if the aircraft is approaching the edge of a navigation restriction zone or is within a predetermined distance (e.g., ten feet, 2000 feet, or one mile) from the edge.

In some embodiments, the unmanned vehicle system is configured to prevent flight beyond 60 nautical miles from the control station (e.g., ground control station) and/or 299 km from a launch location at least in part by:

- establishing and confirming location of the Control Station,
- maintaining an autopilot navigation solution without a GPS solution and switching to an Emergency Response Procedure, such as changing course to "dead reckon" toward the control station, maintaining level flight until a flight termination timer expires, executing a spin-stall maneuver to slowly descend from the sky, or establishing a GPS-based navigation solution,
- limiting the Command & Control Data Link RF communication between the aircraft radio transmitter and the associated send/receive antenna for the control station. In the event that communication is lost, the unmanned vehicle will attempt to navigate toward the last known GPS coordinate location of the control station to achieve

connection. If connection is not re-established, the unmanned vehicle will automatically navigate back to a predefined GPS location within 3 nautical miles of the control station for emergency landing.

Hard coded data entry configured to:

control emergency landing location to within, for example, 3 nautical miles of the control station,

prevent "hand-off" to alternate control stations, and

prevent way-point entry beyond a 60 nautical mile radius of the GPS coordinates for the control station.

b. Control Station and Unmanned Vehicle

In some embodiments, the control station and unmanned vehicle comprise computers, video monitors, hobby-market controllers for radio controlled hobby vehicles, keyboards, track-ball mouse, power cables and connectors and associated software.

In some embodiments, the control station and unmanned vehicle utilize Trusted Computing Group technologies modeled after implementations developed under the NSA High Assurance Platform (HAP) Program (see http://www.nsa.gov/ia/programs/h_a_p/index.shtml). The unmanned vehicle can use Trusted Platform Module (TPM) security chips, such as those provided by Infineon Technologies AG, that attest to or confirm the identity of the control station and the aircraft computer's identity and further confirm the integrity of the software running on each. Furthermore, computers within the unmanned vehicle system can use, for example, a National Institute of Standards and Technology (NIST) verified Trusted Operating System utilizing Trusted Boot to measure and attest to the boot measurements (e.g., system configuration measurements and diagnostics made at boot time) when appropriate. Remote confirmation verifies software state on client and remote machines. Trusted Computing technologies confirm that the unmanned vehicle is operating as expected based on its design (e.g., only authorized software is running on the vehicle) to ensure that the unmanned vehicle system remains compliant with Commerce Department export control requirements.

Trusted Computing technologies allow the unmanned vehicle to verify the integrity of sub-system components relative to initial configuration information. For example, at boot-time or during operation, a trusted component of the unmanned vehicle can verify that the unmanned vehicle is configured as originally designed by querying the various components for their identification and current configuration information. In this manner, the unmanned vehicle can ensure that it is equipped with components that do not render the unmanned vehicle subject to State Department export control. For example, system devices (avionics, radios, transponder, integrated flight controller, ground control station, etc.) are configured to include a software module and/or a hardware module that can publish an identification of that device and can certify identifications from some other device. In other words, one cannot, for example, swap in military mission components subject to ITAR control without causing system failures and rendering the system inoperable because the swapped-in components will have different identifications than the components of the vehicle in its initial configuration and the vehicle will not be permitted to, for example, operate, launch, accept input commands, transmit data, etc. Accordingly, an unmanned vehicle constructed and equipped to comply with Commerce Department export control requirements can be rendered inoperable after modification. In some embodiments, the unmanned vehicle may send a communication to a ground control station or satellite in response to determining that its configuration has changed.

In some embodiments, the unmanned vehicle includes a commercial Advanced Encryption Standard (AES)-256 Encrypted data interface in the onboard electronics and all data links between the unmanned vehicle and the control station. Encrypted data protocols will allow operators to maintain configuration control and limit device connection with specific encryption keys controlled by a central authority.

c. Tampering Prevention

In some embodiments, the hardware and software of the unmanned vehicle system are designed to prevent and/or detect tampering and provide security to the system. Trusted Platform Module (TPM) technology to be used in the unmanned vehicle system (e.g., Infineon Technologies, TPM Chip SLB9635T1.2, ECCN 5A992, TPM Professional Package (Software), ECCN 5D002) is controlled by the Commerce Department. In some embodiments, the unmanned vehicle may send a communication to a ground control station or satellite in response to detecting tampering. Design elements include, for example:

An Avionics Module containing: a) the commercial GPS receiver (e.g., Novetel OEMV-2-L1L2 GPS-ECCN No. 7A994); b) an Auto Pilot computer; and c) a regulated power conditioning system. These components can be factory sealed in the Avionics Module to prevent tampering. Data communication to and from the Avionics Module requires matching encryption keys to function. The avionics are factory—programmed using specific compiled code and Trusted Platform Module encryption techniques.

The Avionics Module is capable of factory-only programming and encryption key configuration. Updates to the software are limited to factory only upgrades of the Avionics Module.

For an unmanned aircraft, a tail-less design prevents over-flight weight or aircraft length modifications due to the physical limitation of flight envelope (Bernoulli principle). Without proper updates to the autopilot, stable flight is typically impossible within 30 seconds to 2 minutes. The time elapsed between stable and non-stable flight will depend on localized atmospherics, how much integration error the aircraft attitude algorithm has accumulated at the time the GPS is turned off, and the actual maneuver the aircraft is performing at the moment the GPS is turned off. For example, navigation direction is lost immediately when the aircraft does not have an on-board compass and GPS provides the only reference to Earth.

Sensors for the unmanned vehicle may include, for example, EAR99 (i.e., subject to Commerce Department export control) Electro-optical sensors to a commercial Sony Handycam®, LongWave Infrared Sensors, such as the Goodrich Aerospace Short Wave Infrared (SWIR).

2. Software

In some embodiments, the software of the unmanned vehicle system is written using C++ industry standard commercial language and development methodology. A modular system architecture allows feature sets of the vehicle control or control station software to be removed before compiling at the factory. Removal of features sets for the software assures the system operation is limited to the desired feature set. The feature set specific to the unmanned vehicle will be modules that are left out or added in when code is compiled and no source code or variable settings/switches will be available to the user. Moreover, human-readable characters may be removed from the code using, for example, a pre-parser.

Further, the code may be subjected to obfuscation techniques or programs (See, e.g., www.preemptive.com/products/dotfuscator/overview).

In some embodiments, delivered unmanned vehicle hardware does not include programmable devices. Software and hardware upgrades to the unmanned vehicle are accomplished by delivering new hardware from the factory. Software and hardware features are limited to factory delivered configuration through the use of Trusted Computing technologies.

The control station hardware includes commercial off-the-shelf work stations and laptops using, for example, the MICROSOFT WINDOWS® operating system, which is recognized by industry as a trusted operating system allowing complete implementation of the Trusted Computing strategy applied to the unmanned vehicle system.

3. Representative Design Features:

Table 2 below identifies representative design features for several subsystems of an aircraft system configured in accordance with embodiments of the present technology.

TABLE 2

	Navigation:
Range Restriction - ROM Chip	Prevent vehicle from flying outside of a Latitude/Longitude box and prevent user from modifying the Latitude/Longitude box by, for example, burning the Latitude/Longitude box into a ROM chip.
Range Restriction - Expanding Box	Prevent vehicle from flying outside of an expandable Latitude/Longitude box and prevent user from modifying the Latitude/Longitude box beyond a certain size.
Reduced Navigation Accuracy	Limit the accuracy of the navigation system.
Flight Termination on High Speed	Disable navigation system if vehicle exceeds a predetermined speed.
Limited Speed	Prevent indicated airspeed from exceeding a defined threshold.
Server-Validated Flight Plans	Software validates flight commands (flight plans, orbits, and recovery definitions) through a home server. The data is sent to the server, if it passes a given set of criteria it is encrypted with a Private Key and returned, requiring decryption with, for example, a public key.
Approved Flight Box	A combination of the Latitude/Longitude box restriction and the Public/Private Key challenge and response.
Time Limited Approvals (Expiration)	A combination of any of the Pub/Private key schemes, but the response has a time limit encoded into it. After the time limit expires, it will no longer be accepted.
Minimum Height Above Terrain	Software will not command flight less than a predetermined altitude above the ground level (e.g., 200 ft) as reported by Digital Terrain Elevation Data (DTED).
Flight Termination on Engine Out	Command a flight termination at current location if engine is not running.
Flight Termination on Low Altitude	A combination of the DTED restriction and the engine out flight termination.
Homecoming -- Near Launch Location	Prevent a change to the home coming route if the terminal point is more than a predetermined distance from the launch location (e.g., 50 nautical miles).
	COMMUNICATION:
Unique Radios	Use radios which are not compatible with radios used in a vehicle subject to ITAR control (or other regulations).
	PAYLOADS:
Payload Weight Restrictions	Prevent operation if mass and center of gravity change.
Video to Fly	Prevent operation if proper video signal is not detected because, for example, a video recorder has been removed.
	DECODING/DATA ASSURANCE:
Potting Simplified Avionics	The entire avionics unit is converted to single board and then potted, so as to make it impossible to add/remove/decode/modify any parts to unit.
Anti-Tamper -- Avionics	Any attempt to disassemble a section of the vehicle breaks it. Frangible connectors.
Anti-tamper -- Elec Discharge	Any attempt to disassemble a section of the vehicle breaks it. Charged capacitors that discharge into ICs if not opened correctly.
No Payload -- Foam Fill	Empty spaces in the vehicle are filled with unremovable foam/goo (so there is no place to add explosives).
Removed Screens	Screens deemed unnecessary are hidden.
Single Programming -- All	Prevent reprogramming of executables/param files in the field (e.g., burn once NVRAM).
	HARDWARE/SYSTEM INTEGRITY:
Proprietary Connectors	Use proprietary (or difficult-to-find/acquire) connectors to make it difficult to add/swap part.
Anti-Tamper -- Unreadable FLASH	Use hardware that prevents user from reading NVRAM/FLASH data (e.g., MPC-555).

C. General Electronics

In some embodiments, electronics used in the unmanned vehicle system include those derived from U.S. industrial and automotive grade components. For example, an auto-pilot system of the unmanned vehicle may include the Motorola/Freescale 555 processor, a widely used microprocessor in the automotive industry.

1. Circuit Cards

Circuit cards of the unmanned vehicle system can be designed by using IPC standard design and manufacturing standards commonly applied by the U.S. industry.

2. Propulsion System

The propulsion system of the unmanned vehicle can be based on publicly-available hobby aircraft 2-stroke technology (e.g., available 3W-Modellmotoren GmbH (3W Modern Motors) of Rodermark, Germany), commercially-available electric motor systems, commercially-available battery and/or fuel cell technologies, etc.

3. Generator

The electrical power system (e.g., the generator) of the unmanned vehicle can include, for example, a brushless electric motor, such as a Kollmorgen industrial brushless electric motor (EAR99) available from Kollmorgen of Radford, Va. or a Kollmorgen authorized distributor.

II. Export Control Analysis

MTCR & ITAR

The disclosed unmanned vehicle is designed with limited capability so that it will not meet ITAR-control threshold criteria (e.g., range equal to or greater than 300 km), thereby not reaching the minimum threshold for State Department export control, thereby falling within the purview of and under control of the U.S. Commerce Department export control regulations.

As described in Section I, specific safeguards have been put in place to protect concerns of National Security and U.S. government military technologies. In particular embodiments, such safeguards, which were described in more detail in Section I, include:

- Range Limited to less than 300 Km—The software and hardware will limit flight range to less than 300 Km from point of origin.
- Trusted Computing Technologies—Tamper-proof and/or tamper-resistant technologies (endorsed by NIST) to maintain the as-delivered configuration of the unmanned vehicle and control station.
- Commerce Controlled Components—Components of the unmanned vehicle and control station are traced to EAR control requirements (Commerce Depart export control).
- Aircraft Limited Payload Capacity—The design and configuration of the aircraft limit payload capacity to less than 2 kilograms in particular embodiments.

One feature of embodiments of the present technology is that by constructing the unmanned vehicle without ITAR-controlled components and military capability, the unmanned vehicle will not require compliance with the ITAR controls for items covered under Category VIII of the U.S. Munitions List. Rather, the unmanned vehicle is designed to be controlled under the Commerce Control List (CCL), such as Export Control Classification Number (ECCN) 9A012, which covers non-military "unmanned aerial vehicle" (UAV) with Missile Technology (MT) and National Security (NS) reasons for control. An advantage of this feature is that it can expand commercial use of the vehicle without creating compliance issues with national security regulations. Many of the techniques used to implement this feature are directly contrary to features designed into conventional vehicles and in particular, conventional aircraft. For example, typical conventional aircraft are designed to maximize payload capacity and/or range while embodiments of the present technology are designed to deliberately limit either or both of the foregoing technical features and/or other technical features.

The computing devices on which the disclosed techniques may be implemented can include a central processing unit, memory, input devices (e.g., keyboard and pointing devices), output devices (e.g., display devices), and storage devices (e.g., disk drives). The memory and storage devices are computer-readable storage media that may be encoded with computer-executable instructions that implement the technology, which means a computer-readable storage medium that stores the instructions. In addition, the instructions, data structures, and message structures may be transmitted via a computer-readable transmission medium, such as a signal on a communications link. Thus, "computer-readable media" includes both computer-readable storage media for storing and computer-readable transmission media for transmitting. Additionally, data used by the facility may be encrypted. Various communications links may be used, such as the Internet, a local area network, a wide area network, a point-to-point dial-up connection, a cell phone network, wireless networks, and so on.

The disclosed technology may be described in the general context of computer-executable instructions, such as program modules, executed by one or more computers or other devices. Generally, program modules include routines, programs, objects, components, data structures, and so on that perform particular tasks or implement particular abstract data types. Typically, the functionality of the program modules may be combined or distributed as desired in various embodiments, including cloud-based implementations.

Many embodiments of the technology described herein may take the form of computer-executable instructions, including routines executed by a programmable computer. Those skilled in the relevant art will appreciate that aspects of the technology can be practiced on computer systems other than those shown and described herein. Embodiments of the technology may be implemented in and used with various operating environments that include personal computers, server computers, handheld or laptop devices, multiprocessor systems, microprocessor-based systems, programmable consumer electronics, digital cameras, network PCs, minicomputers, mainframe computers, computing environments that include any of the above systems or devices, and so on. Moreover, the technology can be embodied in a special-purpose computer or data processor that is specifically programmed, configured or constructed to perform one or more of the computer-executable instructions described herein. Accordingly, the terms "computer" or "system" as generally used herein refer to any data processor and can include Internet appliances and hand-held devices (including palm-top computers, wearable computers, cellular or mobile phones, multi-processor systems, processor-based or programmable consumer electronics, network computers, mini computers and the like). Information handled by these computers can be presented at any suitable display medium, including a CRT display, LCD, LED display, OLED display, and so on.

The technology can also be practiced in distributed environments, where tasks or modules are performed by remote processing devices linked through a communications network. In a distributed computing environment, program modules or subroutines may be located in local and remote memory storage devices. Aspects of the technology described herein may be stored or distributed on computer-readable media, including magnetic or optically readable or removable computer disks. Furthermore, aspects of the technology may be distributed electronically over networks. Data structures and transmissions of data particular to aspects of the technology are also encompassed within the scope of the technology.

FIG. **1** is a block diagram illustrating a control station configured in accordance with particular embodiments. In this example, the control station includes a control station subsystem **110** communicatively-coupled to an antenna interface subsystem **120** and a control GPS interface **130**. The control station subsystem **110** includes a video/data exploitation computer, a video antenna switch, an uninterruptible power supply (UPS), a trusted platform module, and an interface computer comprising one or more display screen(s), a keyboard interface, and a multifunction interface. The antenna interface subsystem **120**, which is communicatively coupled to a command control and payload control antenna **125**, includes an antenna control interface, a command/control transmitter/receiver, a video receiver, an antenna pointing control interface, and a power conditioning module. The command control and payload control antenna **125** includes frequency feed(s) and antenna pointing actuator(s). The control GPS interface **130** includes a GPS receiver, a GPS antenna interface, and a subsystem and control interface, and is communicatively coupled to a 2-channel GPS antenna **135**.

FIG. **2** is a block diagram illustrating subsystems an unmanned aerial vehicle configured in accordance with particular embodiments. In this example, the unmanned aerial vehicle includes an avionics subsystem **210** communicatively coupled to a left wing subsystem **220**, a right wing subsystem **230**, a payload subsystem **240**, and a propulsion subsystem **250**. The avionics subsystem **210** includes a GPS receiver and antenna, a data bus interface, a vehicle/subsystem control interface, a trusted platform module, and a mission computer/autopilot comprising airspeed sensors and rate gyros. The left wing subsystem **220** includes a command/control transmitter/receiver, a video transmitter, and control surface actuators. The right wing subsystem **230** includes a video transmitter, and control surface actuators. The payload subsystem **240** includes a payload/turret computer comprising rate gyros and turret axis drives, includes a sensor package comprising a focal plane and a lens assembly, and includes a trusted platform module. The propulsion subsystem **250** includes an engine management module, a generator and related interface, a throttle actuator, and a trusted platform module.

FIG. **3** is a block diagram showing some of the components incorporated in associated computing systems in some embodiments. Computer system **300** comprises one or more central processing units ("CPUs") **301** for executing computer programs; a computer memory **302** for storing programs and data while they are being used; a persistent storage device **303**, such as a hard drive for persistently storing programs and data; a computer-readable media drive **304**, such as a CD-ROM drive, for reading programs and data stored on a computer-readable medium; and a network connection **305** for connecting the computer system to other computer systems, such as via the Internet. While computer systems configured as described above are suitable used to support the operation of the disclosed technology, those skilled in the art will appreciate that the techniques may be implemented using devices of various types and configurations. Moreover, communications to and from the CPU and on data buses and lines can be encrypted to protect against snooping of internal data.

FIG. **4** is a flow diagram illustrating the processing of an "operate vehicle module" configured in accordance with particular embodiments of the disclosed technology. The module is invoked to perform vehicle operations based on an initial specification for a vehicle and the current configuration of the vehicle and its installed components. In block **405**, the module receives an initial specification for the vehicle. The initial specification may include a list of all components installed on the vehicle and their state or configuration at the time of installation or delivery. For each installed component, the specification can include an indication of whether the component must be present to perform a particular operation. The initial specification may be encrypted and can be installed by the vehicle manufacturer or another party e.g., an explicitly authorized party. In block **410**, the module receives a request to operate the vehicle, such as a request to change the speed of the vehicle, a request to modify a planned route for the vehicle (e.g., add or remove a waypoint from a flight plan), a request to change the direction of travel of the vehicle, and/or other requests. In block **415**, the module identifies those components that must be present for the request to be granted by, for example, analyzing the initial specification. In block **420**, the module loops through each of the identified components to determine whether they are present and properly configured. In decision block **425**, if the component has already been selected then processing continues at block **430**, else the module continues at decision block **435**. In decision block **435**, if the selected component is present, then the module continues at block **440**, else the module continues at block **455**. In block **440**, the module retrieves the current configuration information for the selected component. In decision block **445**, if the current configuration information for the selected component is different from the configuration information specified in the initial specification, then the module loops back to block **420** to select the next component, else the module continues at decision block **450**. In decision block **450**, if the change is acceptable then the module loops back to block **420** to select the next component, else the module continues at block **455**. For example, if the initial specification indicates that an acceptable payload is 1.4 kg+/−0.2 kg and the payload has changed from 1.3 kg to 1.5 kg, the module will determine this change to be acceptable. In this manner, the module can determine whether a current configuration for a vehicle is consistent with an initial configuration of the vehicle in determining whether to grant or deny a request. In block **430**, the module grants the request, thereby allowing the requested operation to occur and then completes processing. In block **455**, the module denies the request and then completes processing. In some cases, the module may perform additional actions when denying a request, such as sending out an emergency signal, sending a notification to a ground control station or another vehicle, safely rendering the vehicle inoperable, and so on.

FIGS. **5A-5B** illustrate overall views of representative apparatuses and methods for capturing unmanned aircraft in accordance with embodiments of the disclosure. Representative embodiments of aircraft launch and capture techniques are also disclosed in U.S. patent application Ser. No. 11/603,810, filed Nov. 21, 2006, entitled METHODS AND APPARATUSES FOR LAUNCHING UNMANNED AIRCRAFT, INCLUDING RELEASABLY GRIPPING AIRCRAFT DURING LAUNCH AND BREAKING SUBSEQUENT GRIP MOTION (now U.S. Pat. No. 7,712,702) and U.S. patent application Ser. No. 13/483,330, filed May 30, 2012, entitled LINE CAPTURE DEVICES FOR UNMANNED AIRCRAFT, AND ASSOCIATED SYSTEMS AND METHODS, each of which is herein incorporated by reference in its entirety. Beginning with FIG. **5A**, a representative unmanned aircraft **510** can be captured by an aircraft handling system **500** positioned on a support platform **501**. In one embodiment, the support platform **501** can include a boat, ship, or other water vessel **502**. In other embodiments, the support platform **501** can include other structures, including a building, a truck or other land vehicle, or an airborne vehicle, such as a balloon. In many of these embodiments, the aircraft handling system **500** can be configured solely to retrieve the aircraft **510** or, in particular embodiments, it can be configured to both launch and retrieve the aircraft **510**. The aircraft **510** can include a fuselage **511** and wings **513** (or a blended wing/fuselage), and is propelled by a propulsion system **512** (e.g., a piston-driven propeller).

Referring now to FIG. **5**B, the aircraft handling system **500** can include a recovery system **530** integrated with a launch system **570**. In one aspect of this embodiment, the recovery system **530** can include an extendable boom **531** having a plurality of segments **532**. The boom **531** can be mounted on a rotatable base **536** or turret for ease of positioning. The segments **532** are initially stowed in a nested or telescoping arrangement and are then deployed to extend outwardly as shown in FIG. **5**B. In other embodiments, the extendable boom **531** can have other arrangements, such as a scissors arrangement, a parallel linkage arrangement or a knuckle boom arrangement. In any of these embodiments, the extendable boom **531** can include a recovery line **533** extended by gravity or other forces. In one embodiment, the recovery line **533** can include 0.25 inch diameter polyester rope, and in other embodiments, the recovery line **533** can include other materials and/or can have other dimensions (e.g., a diameter of 0.3125 inch). In any of these embodiments, a spring or weight **534** at the end of the recovery line **533** can provide tension in the recovery line **533**. The aircraft handling system **500** can also include a retrieval line **535** connected to the weight **534** to aid in retrieving and controlling the motion of the weight **534** after the aircraft recovery operation has been completed. In another embodiment, a different recovery line **533***a* (shown in dashed lines) can be suspended from one portion of the boom **531** and can attach to another point on the boom **531**, in lieu of the recovery line **533** and the weight **534**.

In one aspect of this embodiment, the end of the extendable boom **531** can be positioned at an elevation E above the local surface (e.g., the water shown in FIG. **5**B), and a distance D away from the nearest vertical structure projecting from the local surface. In one aspect of this embodiment, the elevation E can be about 15 meters and the distance D can be about 10 meters. In other embodiments, E and D can have other values, depending upon the particular installation. For example, in one particular embodiment, the elevation E can be about 17 meters when the boom **531** is extended, and about 4 meters when the boom **531** is retracted. The distance D can be about 8 meters when the boom **531** is extended, and about 4 meters when the boom **531** is retracted. In a further particular aspect of this embodiment, the boom **531** can be configured to carry both a vertical load and a lateral load via the recovery line. For example, in one embodiment, the boom **531** can be configured to capture an aircraft **510** having a weight of about 30 pounds, and can be configured to withstand a side load of about 400 pounds, corresponding to the force of the impact between the aircraft **510** and the recovery line **533** with appropriate factors of safety.

FIG. **6**A illustrates a launch system **610** having a launch guide **640** and a carriage **620** that together accelerate and guide an aircraft **650** along an initial flight path **611** at the outset of a flight. The launch guide **640** can include a support structure **641** carrying a first or upper launch member **642** (e.g., a track) and a second or lower launch member **643**, both of which are generally aligned with the initial flight path **611**. The support structure **641** can be mounted to a vehicle (e.g., a trailer or a boat) or to a fixed platform (e.g., a building). Portions of the first launch member **642** and the second launch member **643** can be non-parallel to each other (e.g., they can converge in a direction aligned with the initial flight path **611**) to accelerate the carriage **620**, as described below.

The carriage **620** can include a gripper **680** having a pair of gripper arms **681** that releasably carry the aircraft **650**. The carriage **620** can also include a first or upper portion **622** and a second or lower portion **623**, each of which has rollers **621** (shown in hidden lines in FIG. **6**A). The rollers **621** can guide the carriage **620** along the launch members **642**, **643** while the carriage portions **622**, **623** are driven toward each other. Accordingly, normal forces applied to the rollers **621** can drive the rollers **621** against the launch members **642**, **643**, drive the carriage portions **622**, **623** together, and drive the carriage **620** forward, thereby accelerating the aircraft **650** to flight speed.

An actuator **613** can be linked to the carriage **620** to provide the squeezing force that drives the carriage portions **622**, **623** toward each other and drives the carriage **620** along the launch guide **640**. Many actuators **613** that are configured to release energy fast enough to launch the aircraft **650** also have a spring-like behavior. Accordingly, the actuators **613** tend to exert large forces at the beginning of a power stroke and smaller forces as the power stroke progresses and the carriage **620** moves along the launch guide **640**. An embodiment of the system **610** shown in FIG. **6**A can compensate for this spring-like behavior by having a relative angle between the first launch member **642** and the second launch member **643** that becomes progressively steeper in the launch direction. In one example, the force provided by the actuator **613** can decrease from 6000 lbs to 3000 lbs as the carriage **620** accelerates. Over the same distance, the relative slope between the first launch member **642** and the second launch member **643** can change from 6:1 to 3:1. Accordingly, the resulting thrust imparted to the carriage **620** and the aircraft **650** can remain at least approximately constant.

At or near a launch point L, the carriage **620** reaches the launch speed of the aircraft **650**. The first launch member **642** and the second launch member **643** can diverge (instead of converge) forward of the launch point L to form a braking ramp **644**. At the braking ramp **644**, the carriage **620** rapidly decelerates to release the aircraft **650**. The carriage **620** then stops and returns to a rest position at least proximate to or coincident with the launch position L.

In one embodiment, the actuator **613** includes a piston **614** that moves within a cylinder **615**. The piston **614** is attached to a flexible, elongated transmission element **616** (e.g., a rope or cable) via a piston rod **617**. The transmission element **616** can pass through a series of guide pulleys **645** (carried by the launch guide **640**) and carriage pulleys **624** (carried by the carriage **620**). The guide pulleys **645** can include first guide pulleys **645***a* on a first side of the support structure **641**, and corresponding second guide pulleys **645***b* on a second (opposite) side of the support structure **641**. The carriage pulleys **624** can also include first carriage pulleys **624***a* on a first side of the carriage **620** and second pulleys **624***b* on a second (opposite) side of the carriage **620**. One or more equalizing pulleys **646**, located in a housing **647** can be positioned between (a) the first guide pulleys **645***a* and the first carriage pulleys **624***a* on the first side of the support structure **641**, and (b) the second guide pulleys **645***b* and the second carriage pulleys **624***b* on the second side of the support structure **641**.

In operation, one end of the transmission element **616** can be attached to the first side of the support structure **641**, laced through the first pulleys **645***a*, **624***a*, around the equalizing pulley(s) **646**, and then through the second pulleys **645***b*, **624***b*. The opposite end of the transmission element **616** can be attached to the second side of the support structure **641**.

The equalizing pulley(s) **646** can (a) guide the transmission element **616** from the first side of the support structure **641** to the second side of the support structure **641**, and (b) equalize the tension in the transmission element **616** on the first side of the support structure **641** with that on the second side of the support structure **641**.

When the transmission element **616** is tensioned, it squeezes the carriage portions **622**, **623** together, forcing the carriage **620** along the converging launch members **642**, **643**. The carriage pulleys **624** and the rollers **621** (which can be coaxial with the carriage pulleys **624**) are secured to the carriage **620** so that the carriage **620** rides freely along the initial flight path **611** of the aircraft **650** as the carriage portions **622**, **623** move together.

FIG. **6**B illustrates the launch of the carriage **620** in accordance with an embodiment of the disclosure. The carriage **620** is held in place prior to launch by a trigger device **639**, e.g., a restraining shackle. When the trigger device **639** is released, the carriage **620** accelerates along the launch members **642**, **643**, moving from a first launch carriage location to a second launch carriage location (e.g., to the launch point L). At the launch point L, the carriage **620** achieves its maximum velocity and begins to decelerate by rolling along the braking ramp **644**. In this embodiment, one or more arresting pulleys **648** can be positioned along the braking ramp **644** to intercept the transmission element **616** and further decelerate the carriage **620**.

As shown in FIG. **6**C, once the carriage **620** begins to decelerate along the braking ramp **644**, the aircraft **650** is released by the gripper arms **681**. Each gripper arm **681** can include a forward contact portion **682***a* and an aft contact portion **682***b* configured to releasably engage a fuselage **651** of the aircraft **650**. Accordingly, each contact portion **682** can have a curved shape so as to conform to the curved shape of the fuselage **651**. In other embodiments, the gripper arms **681** can engage different portions of the aircraft **650** (e.g., the wings **652**). Each gripper arm **681** can be pivotably coupled to the carriage **620** to rotate about a pivot axis P. The gripper arms **681** can pivot about the pivot axes P to slightly over-center positions when engaged with the aircraft **650**. Accordingly, the gripper arms **681** can securely grip the fuselage **651** and resist ambient windloads, gravity, propeller thrust (e.g., the maximum thrust provided to the aircraft **650**), and other external transitory loads as the carriage **620** accelerates. In one aspect of this embodiment, each pivot axis P is canted outwardly away from the vertical. As described in greater detail below, this arrangement can prevent interference between the gripper arms **681** and the aircraft **650** as the aircraft **650** is launched.

At least a portion of the mass of the gripper arms **681** can be eccentric relative to the first axis P. As a result, when the carriage **620** decelerates, the forward momentum of the gripper arms **681** causes them to fling open by pivoting about the pivot axis P, as indicated by arrows M. The forward momentum of the gripper arms **681** can accordingly overcome the over-center action described above. As the gripper arms **681** begin to open, the contact portions **682***a*, **682***b* begin to disengage from the aircraft **650**. In a particular aspect of this embodiment, the gripper arms **681** pivot downwardly and away from the aircraft **650**.

From the foregoing, it will be appreciated that specific embodiments of the technology have been described herein for purposes of illustration, but that various modifications may be made without deviating from the disclosure. For example, the unmanned vehicle system can include additional components or features, and/or different combinations of the components or features described herein. While particular embodiments of the technology were described above in the context of ITAR, MTCR, and EAR regulations, other embodiments using generally similar technology can be used in the context of other regulations. Such regulations may vary from one jurisdiction (e.g., national or regional jurisdictions) to another. Additionally, while advantages associated with certain embodiments of the new technology have been described in the context of those embodiments, other embodiments may also exhibit such advantages, and not all embodiments need necessarily exhibit such advantages to fall within the scope of the technology. Accordingly, the disclosure and associated technology can encompass other embodiments not expressly shown or described herein.

We claim:

1. A method, performed by a computing system of an unmanned aerial vehicle, for ensuring that the unmanned aerial vehicle complies with specified export control requirements throughout the operation of the unmanned aerial vehicle, the method comprising:

storing an indication of an initial specification of the unmanned aerial vehicle, the initial specification of the unmanned aerial vehicle specifying initial configuration information and an identification for each of a plurality of tamper-resistant trusted components of the unmanned aerial vehicle, wherein the initial configuration of the unmanned aerial vehicle is in compliance with the specified export control requirements and wherein at least one of the trusted components is configured to ensure that the range of the unmanned aerial vehicle does not exceed a predetermined distance;

receiving a request to operate the unmanned aerial vehicle;

in response to receiving the request to operate the unmanned aerial vehicle, for each of the plurality of trusted components of the unmanned aerial vehicle,

querying the trusted component of the unmanned aerial vehicle for current configuration information, wherein communication with the trusted component of the unmanned aerial vehicle is encrypted,

receiving an indication that the trusted component of the unmanned aerial vehicle is not present within the unmanned aerial vehicle or that the configuration of the trusted component of the unmanned aerial vehicle has been modified since the initial specification was stored, and

in response to receiving the indication that the trusted component of the unmanned aerial vehicle is not present within the unmanned aerial vehicle or that the configuration of the trusted component of the unmanned aerial vehicle has been modified since the initial specification was stored, modifying the operation of the unmanned aerial vehicle;

receiving an indication that the unmanned aerial vehicle is at least a predetermined distance from a launch location or that communication between the unmanned aerial vehicle and a control station has been lost; and

in response to receiving the indication that the unmanned aerial vehicle is at least the predetermined distance from the launch location or that communication between the unmanned aerial vehicle and the control station has been lost, modifying a path of the unmanned aerial vehicle.

2. The method of claim **1** wherein at least one of the trusted components of the unmanned aerial vehicle is configured to ensure that a payload of the unmanned aerial vehicle cannot operate when the payload exceeds a predetermined weight.

3. The method of claim 1, further comprising:

receiving an indication that a speed of the unmanned aerial vehicle is in excess of a predetermined speed threshold; and

in response to receiving the indication that the speed of the unmanned aerial vehicle is in excess of the predetermined speed threshold, disabling a navigation system of the unmanned aerial vehicle.

4. The method of claim 1 wherein at least one of the trusted components of the unmanned aerial vehicle is configured to ensure that an altitude of the unmanned aerial vehicle exceeds a predetermined altitude threshold while the unmanned aerial vehicle is not taking off and not landing.

5. The method of claim 1 wherein modifying the operation of the unmanned aerial vehicle comprises disabling a launch of the unmanned aerial vehicle.

6. The method of claim 1 wherein modifying the operation of the unmanned aerial vehicle comprises executing a spin-stall maneuver.

7. The method of claim 1 wherein modifying the operation of the unmanned aerial vehicle comprises disabling a navigation system of the unmanned aerial vehicle.

8. An unmanned vehicle comprising:

a memory configured to store initial configuration information for each of a plurality of tamper-proof trusted components of the unmanned aerial vehicle having an initial configuration that is in compliance with specified export control requirements; and

a system verification component configured to, for each of the trusted components,

query the trusted component for current configuration information,

receive the current configuration information,

receive an indication that the current configuration information is different from the initial configuration information, and

disable the unmanned aerial vehicle in response to receiving an indication that the current configuration information is different from the initial configuration information.

9. The unmanned vehicle of claim 8 wherein at least one of the trusted components is configured to ensure that a range of the vehicle does not exceed a predetermined distance.

10. A computer-readable storage medium storing instructions that, if executed by a computing system, cause the computing system to perform operations comprising:

storing an indication of an initial specification of a vehicle that, at the time of an initial configuration, is in compliance with specified control requirements;

receiving a request to operate the vehicle; and

in response to receiving the request to operate the vehicle, for each of a plurality of trusted components of the vehicle,

querying the trusted component of the vehicle for current configuration information, wherein communication with the trusted component of the vehicle is encrypted,

receiving an indication that the trusted component of the vehicle is not present within the vehicle or that the configuration of the trusted component of the vehicle has been modified since the initial specification was stored, and

in response to receiving the indication that the trusted component of the vehicle is not present within the vehicle or that the configuration of the trusted component of the vehicle has been modified since the initial specification was stored, denying the request to operate the vehicle.

11. The computer-readable storage medium of claim 10 wherein at least one of the trusted components is configured to ensure that a range of the vehicle does not exceed a predetermined distance.

12. The computer-readable storage medium of claim 10, herein the operations further comprise:

in response to receiving the request to operate the vehicle, for each of the plurality of the trusted components of the vehicle,

receiving a command from a control station,

in response to receiving the command from the control station,

determining that the control station is not a trusted control station, and

ignoring the received command in response to determining that the control station is not a trusted control station, and

receiving an indication that the vehicle is at least a predetermined distance from a launch location, and

in response to receiving the indication that the vehicle is at least the predetermined distance from the launch location, modifying a path of the vehicle.

13. The computer-readable storage medium of claim 10, wherein the operations further comprise:

receiving a plurality of points, each point having an associated latitude and longitude;

identifying an area defined by the received plurality of points; and

preventing the vehicle from traveling outside of the area defined by the received plurality of points.

14. The computer-readable storage medium of claim 13, wherein the operations further comprise:

receiving an indication that the vehicle is within a predetermined distance from an edge of the area defined by the received plurality of points; and

in response to receiving the indication that the vehicle is within the predetermined distance from the edge of the area defined by the received plurality of points, broadcasting an emergency code.

15. The computer-readable storage medium of claim 14, wherein at least a first trusted component of the plurality of trusted components of the vehicle is a software module and wherein at least a second trusted component of the plurality of trusted components of the vehicle is a hardware module.

16. A method, performed by a computing system, for ensuring that an unmanned aerial vehicle complies with specified export control requirements throughout the operation of the unmanned aerial vehicle, the method comprising:

for each of a plurality of the export control requirements,

determining a threshold value associated with the export control requirement, and

installing a component on the unmanned aerial vehicle configured to ensure that the unmanned aerial vehicle cannot be operated when an attribute of the unmanned aerial vehicle violates the threshold value associated with the export control requirement.

17. The method of claim 16 wherein a first export control requirement has an associated threshold range value and wherein installing a component for the first export control requirement comprises installing a component configured to ensure that the unmanned aerial vehicle cannot be operated when the distance of the unmanned aerial vehicle from a launch point exceeds the threshold range value.

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