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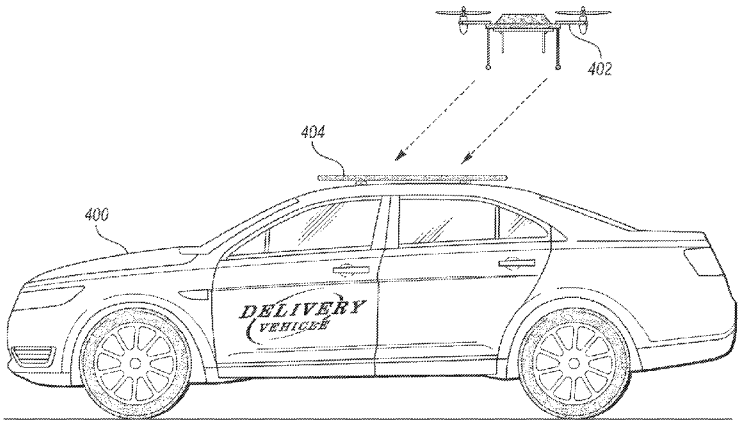



FIG. 4

(57) Abstract: A delivery system includes a processor programmed to construct a route so as to include predefined segments traveled by carriers configured to taxi the vehicle and charge a battery thereof such that a state of charge of the battery remains above a target for a duration of the route, and forward the route to the vehicle.

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# TAXI OF UNMANNED AERIAL VEHICLES DURING PACKAGE DELIVERY

## TECHNICAL FIELD

**[0001]** The present disclosure relates to the use of unmanned aerial vehicles in package delivery systems.

## BACKGROUND

**[0002]** Carriers provide transportation of packages or parcels between locations throughout the world. Shipment of a package may require hand delivery or pickup. Such hand delivery or pickup, however, may be inefficient or impractical depending on retrieval and delivery locations.

## SUMMARY

**[0003]** A delivery system may include a processor programmed to construct a route to include predefined segments traveled by carriers configured to taxi a vehicle. The processor may construct the route in response to a request for a route to a destination. The processor may be programmed to charge a battery of an unmanned aerial vehicle such that a state of charge of the battery remains above a target for the duration of the route. The route may be forwarded to the vehicle.

**[0004]** The processor may be programmed to construct the route such that an inflight portion of a travel time therefor is minimized. The processor may be programmed to construct the route such that the travel time therefor is less than a specified travel time. The processor may be programmed to receive the predefined segments.

**[0005]** The unmanned aerial vehicle, as stated above, may be a drone. The route may include a pickup location and delivery location. The pickup or delivery location may be at least one of the carriers. The carriers may be military vehicles.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0006]** Figure 1 is a map depicting potential routes for a UAV to taxi on carriers;

**[0007]** Figure 2 is a flow chart of an algorithm for constructing a list of potential routes;

**[0008]** Figures 3A-3D are flow charts of an algorithm for delivering a package using a UAV; and

**[0009]** Figure 4 is a depiction of a interaction between a UAV and a carrier.

## DETAILED DESCRIPTION

**[0010]** Embodiments of the present disclosure are described herein. It is to be understood, however, that the disclosed embodiments are merely examples and other embodiments may take various and alternative forms. The figures are not necessarily to scale; some features could be exaggerated or minimized to show details of particular components. Therefore, specific structural and functional details disclosed herein are not to be interpreted as limiting, but merely as a representative basis for teaching one skilled in the art to variously employ the present invention. As those of ordinary skill in the art will understand, various features illustrated and described with reference to any one of the figures may be combined with features illustrated in one or more other figures to produce embodiments that are not explicitly illustrated or described. The combinations of features illustrated provide representative embodiments for typical applications. Various combinations and modifications of the features consistent with the teachings of this disclosure, however, could be desired for particular applications or implementations.

**[0011]** Carriers are used to deliver packages throughout the world. Common carriers may include UPS, FedEx, or government affiliated organizations. Transport vehicles of common carriers may be organized with routes that include segments to deliver packages on the route. Packages may be transported through a web of segments. These routes may be analyzed to find the best possible route or group of routes to deliver a package. The routes may be current or anticipated. These routes may include poor delivery metrics due to drop-off and pickup exchanges that hinder the timely

delivery of packages because transport vehicles or carriers are required to stop and wait for loading and unloading.

**[0012]** Contract carriers may include for-hire parcel services. A for-hire service may deliver packages to a specific location based on an immediate need. For example, a transplant organ may need to be transported between hospitals from the donor to recipient. For-hire services may be cost inefficient due to the limited economy of scale related to delivering one package at a time. These private carriers may also include military vehicles. A supply truck or forward vehicle may transport supplies to forward positions in order to provide food, ammunition, or inessential items.

**[0013]** Another type of carrier may include common vehicles self-availed to deliver packages. For example, these carriers may be notified or sign up to be notified of immediate delivery needs. As "for-hire carrier organizational system" for packages, these carriers may be identified by historically determined routes or proximity to retrieval and delivery locations. For instance, a person who travels to a work location every weekday morning may be identified as a candidate to carry packages between locations. Each of the carriers and routes may have segments or portions that comprise the route.

**[0014]** UAVs may be coupled to carriers to deliver packages. A UAV may attach to a carrier to deliver packages without requiring driver assistance to place a package in a delivery area. A delivery service may have a license to place a docking station on a carrier, allowing UAVs to come and go as necessary. A driver on a delivery route may also direct a UAV to deliver a package from the delivery vehicle or carrier. A UAV may also include or be connected to a processor programmed to identify delivery locations based on navigational data, such as GPS, to autonomously deliver the package. For instance, a drone may be configured to recognize packages on the delivery vehicle or carrier. The UAV may recognize the location of the vehicle being proximate to the delivery location. The UAV may retrieve the package from the carrier's storage and deliver the package. This package delivery system may be analyzed by a computer or server system in communication with the drone or delivery vehicle. The server may analyze and preplan packages prepared and ready for delivery on a given day by recognizing the delivery date and location of the package. The server may organize packages on the delivery vehicle. The server may determine an optimal delivery route for the carrier

by analyzing transit times between each of the package delivery locations to minimize route length or time to complete the route.

**[0015]** Each carrier may be fitted with a charging and docking station configured to charge at least one UAV. The docking station may be configured to taxi the UAV on the carrier until the UAV decides to eject. The docking system may have articulating hooks or actuated locks to hold the UAV in place during taxi. The charging system may be configured to directly or wirelessly charge the UAV. The charging system may be configured to recharge a UAV employing other propulsion methods. For instance, the charging station could be configured to recharge or refill a UAV operating on gas, diesel, or hydrogen.

**[0016]** The UAV or drone may be autonomous or remotely directed. A server, processor, or controller may provide aerial navigation commands to a drone to establish flight paths and delivery methods. The drone may be configured to create its own path based on waypoints dictated by a central server. The drone may be configured to create its own path based on a retrieval and delivery location sent from a server. The UAV may also be controlled remotely by someone at a central control center or a person within the carrier. The carrier may be fitted to include a control mechanism and communication systems to control multiple UAVs.

**[0017]** A server, processor, or controller in communication with the UAV or on the UAV itself may be configured to construct, orchestrate, compose, fabricate, engineer, create, design, erect, establish, fashion, forge, form, formulate, manufacture, produce, set up, or shape a delivery route based on multiple carriers to retrieve and deliver a package. The route construction may include a compilation of all routes near and between the retrieval and delivery locations. Near and between may mean a 50-mile wide strip between the retrieval and delivery locations and a 50-mile radius surrounding the retrieval and delivery locations. For instance, a package delivery may be requested between a warehouse in City A, and a house in City B. City B may be Southeast from the warehouse. A processor may identify all routes between and surrounding the cities. A processor may designate those routes as useful by analyzing all of the routes leaving or projected to leave City A having a direction within 45° of a direct heading to City B. If City B is Southeast (45°) of the warehouse, the processor would identify all routes having segments within a radius of City A having an azimuthal direction of travel between 90° and 180° the direction of travel from the retrieval

location. If no routes are found within the strip, the size of the strip may be increased to obtain more routes. If too many routes are found, the strip may be decreased to better routes. The processor may analyze each route's endpoints to determine the segment length. For instance, should the route end outside of the strip, the processor may limit the segment to stay within the bounds of the strip. The processor may continue to build or construct the route using this method, by adding additional segments, until the route is near enough the delivery location for the UAV to deliver the package. The route may also ensure that the UAV has enough energy to return to a carrier after delivery for storage or charging. The UAVs may reside at a warehouse or on carriers until the next delivery request is received.

**[0018]** Routes may include a present heading, route data derived from a navigation system, anticipated route data based on a driving record, or other routes derived by the process. The processor may also be configured to recognize when the route, as anticipated, has deviated from a general direction of travel a specified angle from the delivery location. When the processor has determined that the angle of the carrier's route has deviated from the delivery location, the processor may perform another search for routes having segments within a radius of the segment endpoint and heading in a direction to the delivery location.

**[0019]** The UAV may not reside on the carrier for the entire of the trip, and multiple UAVs may be used to perform the package delivery. One UAV may be used for the first portion of the trip, and another UAV may be used for a second portion of the trip. The processor may be configured to determine the best use of the UAVs to ensure limited down time. For instance, if a UAV is on a route requiring the UAV to taxi on a carrier for an extended period of time, e.g., greater than five hours, the processor may determine that two UAVs should be used. The first UAV would be used to deliver the package on the carrier or for the first portion of the route. The second UAV would be used to deliver the package to the residence or for the second portion of the route.

**[0020]** The route may be constructed based on an estimated state of charge ("SOC") of the UAV. For example, a threshold level for a UAV may be set at 25% SOC. The route may be constructed to ensure that the threshold level is not exceeded, meaning the SOC remains above 25%. A route may be constructed to maximize the usage of carrier taxiing in relation to the inflight time. For instance, if two routes can provide delivery of a package, the server or processor may be

configured to select the route with the least flight time for the UAV. The server or processor may have a maximum threshold for overall package delivery time in relation to the inflight time. For instance, if one of the routes having lower inflight time has a delivery time twice as long as the longer inflight route, the processor may choose the longer inflight time having a shorter trip duration. The processor may also determine that UAV is not the best method for delivery due to a travel time longer than a specified travel time. The system may alert operations that the package does not have a delivery time meeting the specified travel time threshold.

**[0021]** Route construction may take into account the timing of each route to prevent delays. A UAV may have an intended route that uses Carrier A and Carrier B. The route of Carrier A and Carrier B intersect or are near enough to allow a UAV to move the package between the two carriers at a Point A. Unfortunately, both carriers do not arrive near Point A at the same time. Carrier A leaves at 10:00 AM and expects to arrive at Point A by 10:30 AM. Carrier B leaves at 1:00 PM and expects to arrive at Point A by 1:15 PM. The route construction system is able to notice these timing issues and delays. The system may choose a different route if the delays are too substantial (e.g., five hours). The processor may construct the route with a delay where the UAV maintains a constant hovering pattern, resting pattern on the ground, or transports the package closer to the pickup point. The processor may be able to take into account other timing based factors (e.g., weather, traffic, etc.). The processor may derive a statistical analysis to determine the likelihood of intersection between routes and the probability of delay. Using these factors, the processor may select a preferred route based on the delays, overall length, inflight time, etc. The processor may choose to reduce delays and flight time at the expense of overall length. The processor may choose to reduce delays at the expense of flight time. UAVs may be further configured to prevent collisions with other UAVs. For example, if a carrier is fitted with a docking station capable of carrying multiple UAVs, the UAVs may be configured with proximity or awareness sensors to reduce collisions.

**[0022]** Referring now to Figure 1, a route 100 is constructed for delivery of a package. For visualization purposes this route is shown on a map. As is known in the art, the route may be constructed as a sequence of locations or data points and times. Point A 102 is a retrieval location. Point B 104 is a delivery location. A plurality of routes 106, 108, 110 driven by carriers are shown. The carriers may have already begun traveling on routes 106, 108, 110 or anticipate traveling on the routes 106, 108, 110. The routes 106, 108, 110 may include intended or anticipated travel times at

waypoints along the route. For instance, the carrier on route 106 may intend to arrive at the intersection between 106 and 108 at 10:30 AM. The carrier on route 108 may intend to arrive at the intersection between 106 and 108 at 1:30 PM. In this fashion, a processor may construct a route to allow a UAV to deliver a package from Point A 102 to Point B 104. The route for the UAV may include disembarking the carrier on route 106 at flight 116 and traveling with the carrier on route 108 on route 112. The processor may choose this route instead of the route using segments of route 106 and route 110 because of similar inflight times at flights 116, 118 and shorter overall travel route for the combination of segments from route 106 and segments from route 108. The processor may construct the route for the UAV including segments of route 106, 110 if the delay time at the intersection of route 106 and route 108 is too long (e.g., five hours).

**[0023]** Referring now to Figure 2, an algorithm 200 for determining a route is depicted. The algorithm 200 starts at step 202. At step 204 a package transportation request is received by the server, processor, controller, carrier, or UAV. At 206, the server, processor, or controller determines locations of UAVs and carriers. Locations may be anticipated or current. At step 208, carrier routes, as anticipated or known, are received. At step 210, a list or relational database of potential routes is constructed including segments of the available routes anticipated or known by the carriers. The list may include expected delay times, intersection times, inflight times, and route duration. At step 212, a preferred route may be determined. At step 214, the route may be sent to applicable UAVs and carriers. At step 216, the route may be updated depending on deviations by the carriers to particular routes, mechanical issues with the carriers or UAVs, and another iteration of the algorithm 200 may be performed if the route is updated.

**[0024]** Referring now to Figures 3A-3D, an expanded algorithm 300 for delivering a package is depicted. In step 304, a processor may determine whether a single UAV can deliver the package from the retrieval site. In step 306, the single UAV delivers the package. In step 308, an enhanced package delivery method is started. In step 310, a broadcast may be established to locate local vehicles subscribed as carriers. In step 312, vehicles heading in the desired direction may be identified. In step 314, higher priority packages requiring delivery may demand that a carrier changes course to meet the delivery demands. In step 316, vehicles willing to deviate may be selected to meet delivery demands. In step 318 vehicles that meet desired attributes may be used to transfer the package. In step 320, flight to the subscribed carrier may be started. In step 322, the

UAV may dock on the carrier to begin taxiing. In step 324, the UAV may recharge in step 326; communicate with the carrier in step 328; download updates in step 330; supply needed information in step 332 to the vehicle human machine interface to notify drivers or passengers of attachment and to maintain route; and request a return to a storage location in step 334. In step 336, if the carrier is still on track the UAV may maintain position 340 on the dock or perform a transfer, in step 338 to a different vehicle. In step 342, if the carrier is not on course, as determined in step 336, the UAV or server may send a message to the carrier to return to the route. In step 344, the UAV or server may remind the carrier of the intended route. In step 346 the driver may provide indication as to whether the constructed route will be followed. In step 348, the vehicle may remain docked unless, as determined in step 346, the driver chooses not to follow the route. In step 350, if the driver of the vehicle will not return to desired path, as determined in step 346, another carrier may be located for taxiing. In step 352 and step 354, a loop continues until a carrier is available in the correct direction. In step 356, the UAV may undock from the current carrier, and switches to the new carrier.

**[0025]** If the UAV is within the next carrier or destination, as determined in step 338, the UAV may begin the undock procedure in step 358. In step 360 the UAV may proceed to the next carrier or segment. In step 362, if the destination type is another carrier, the process repeats as shown in step 364. If it is determined in step 362 that the destination is a delivery, the UAV, in step 366, may fly to the destination and deliver the payload. In step 368, the UAV begins the return to home procedure. Header 370 starts the return home procedure. In step 372, local subscribed carriers may be found to allow docking of the UAV. In step 374, the processor or server may determine whether any carriers are headed in the proper direction. The UAV may wait until a carrier is available for taxiing in step 376. In step 378 the UAV may find a carrier that has the lowest taxiing charge for transport. In step 380 the UAV beings flight to subscribed carrier. In step 382 the UAV docks on the carrier and charges itself. In step 384 the UAV may continue to hop until it has reached a storage location or home base. The process ends in step 386.

**[0026]** Now referring to Figure 4, a UAV taxiing system is shown. The carrier 400, includes a docking station 404 for UAV 402. The carrier 400 may be a common vehicle, common carrier, contract carrier, or other type of vehicle. The docking station 404 may be located on the roof of the carrier. The docking station 404 may also be on a separate trailer of the carrier 400. The docking station 404 may include wired or wireless electrical connections to the carrier 400 to allow

recharging of UAV 402 batteries. The docking process of the UAV may be optimized such that the UAV 402 can dock and undock with the carrier 400 while the carrier 400 is in motion. The UAV 402 may begin communicating with the carrier 400 upon approach to determine direction and speed. As is known in the art, V2X communications may be used to facilitate a docking process. The UAV 402 may use this procedure to determine vehicle speed, direction, and intended route. The UAV 402 may notify the carrier 400 via a human machine interface or mobile device once the docking process has completed. The carrier 400, UAV 402, or docking station 404 may be configured to communicate off-board with a server (not shown). The server may be configured to retain delivery information as a database or other repository.

**[0027]** The processes, methods, or algorithms disclosed herein may be deliverable to or implemented by a processing device, controller, or computer, which may include any existing programmable electronic control unit or dedicated electronic control unit. Similarly, the processes, methods, or algorithms may be stored as data and instructions executable by a controller or computer in many forms including, but not limited to, information permanently stored on non-writable storage media such as ROM devices and information alterably stored on writeable storage media such as floppy disks, magnetic tapes, CDs, RAM devices, and other magnetic and optical media. The processes, methods, or algorithms may also be implemented in a software executable object. Alternatively, the processes, methods, or algorithms may be embodied in whole or in part using suitable hardware components, such as Application Specific Integrated Circuits (ASICs), Field-Programmable Gate Arrays (FPGAs), state machines, controllers or other hardware components or devices, or a combination of hardware, software and firmware components.

**[0028]** The words used in the specification are words of description rather than limitation, and it is understood that various changes may be made without departing from the spirit and scope of the disclosure. As previously described, the features of various embodiments may be combined to form further embodiments of the invention that may not be explicitly described or illustrated. While various embodiments could have been described as providing advantages or being preferred over other embodiments or prior art implementations with respect to one or more desired characteristics, those of ordinary skill in the art recognize that one or more features or characteristics may be compromised to achieve desired overall system attributes, which depend on the specific application and implementation. These attributes may include, but are not limited to cost, strength, durability,

life cycle cost, marketability, appearance, packaging, size, serviceability, weight, manufacturability, ease of assembly, etc. As such, embodiments described as less desirable than other embodiments or prior art implementations with respect to one or more characteristics are not outside the scope of the disclosure and may be desirable for particular applications.

WHAT IS CLAIMED IS:

1. A delivery system comprising:

a processor programmed to, in response to a request from an unmanned aerial vehicle for a route to a destination, construct the route so as to include predefined segments traveled by carriers configured to taxi the vehicle and charge a battery thereof such that a state of charge of the battery remains above a target for a duration of the route, and to forward the route to the vehicle.

2. The system of claim 1, wherein the processor is further programmed to construct the route such that an inflight portion of a travel time therefor is minimized.

3. The system of claim 2, wherein the processor is further programmed to construct the route such that the travel time therefor is less than a specified travel time.

4. The system of claim 1, wherein the unmanned aerial vehicle is a drone.

5. The system of claim 1, wherein the route defines pickup and delivery locations.

6. The system of claim 5, wherein the pickup location or delivery location is at one of the carriers.

7. The system of the claim 1, wherein the carriers are military vehicles.

8. A system comprising:

a processor programmed to, in response to receiving a route including predefined segments traveled by carriers configured to taxi unmanned aerial vehicles (UAV) and charge batteries thereof, execute commands to direct the UAV along the route such that portions thereof are traversed while docked and charging at one of the carriers to maintain a state of charge associated with the UAV above a target for a duration of the route.

9. The system of claim 8, wherein the processor is further programmed to construct the route such that an inflight portion of a travel time therefor is minimized.

10. The system of claim 9, wherein the processor is further programmed to construct the route such that the travel time therefor is less than a specified travel time.

11. The system of claim 8, wherein the route defines pickup and delivery locations.

12. The system of claim 11, wherein the pickup location or delivery location is at one of the carriers.

13. A method comprising:

by a processor,

in response to a request for a route to a destination, constructing the route so as to include predefined segments traveled by carriers configured to taxi unmanned aerial vehicles such that an inflight travel time associated with the route is less than a target value; and

forwarding the route to an unmanned aerial vehicle.

14. The method of claim 13, wherein the carriers are further configured to charge batteries associated with the unmanned aerial vehicles and wherein the route is constructed so as to include the predefined segments such that a state of charge associated with the unmanned aerial vehicle remains greater than a threshold while traversing the route.

15. The method of claim 13, wherein the route is constructed such that a travel time associated therewith is less than a specified travel time.

16. The method of claim 15, wherein the inflight travel time is defined as a portion of the travel time.

17. The method of claim 13, wherein the route defines pickup and delivery locations.

18. The method of claim 17, wherein the pickup location or delivery location is at one of the carriers.

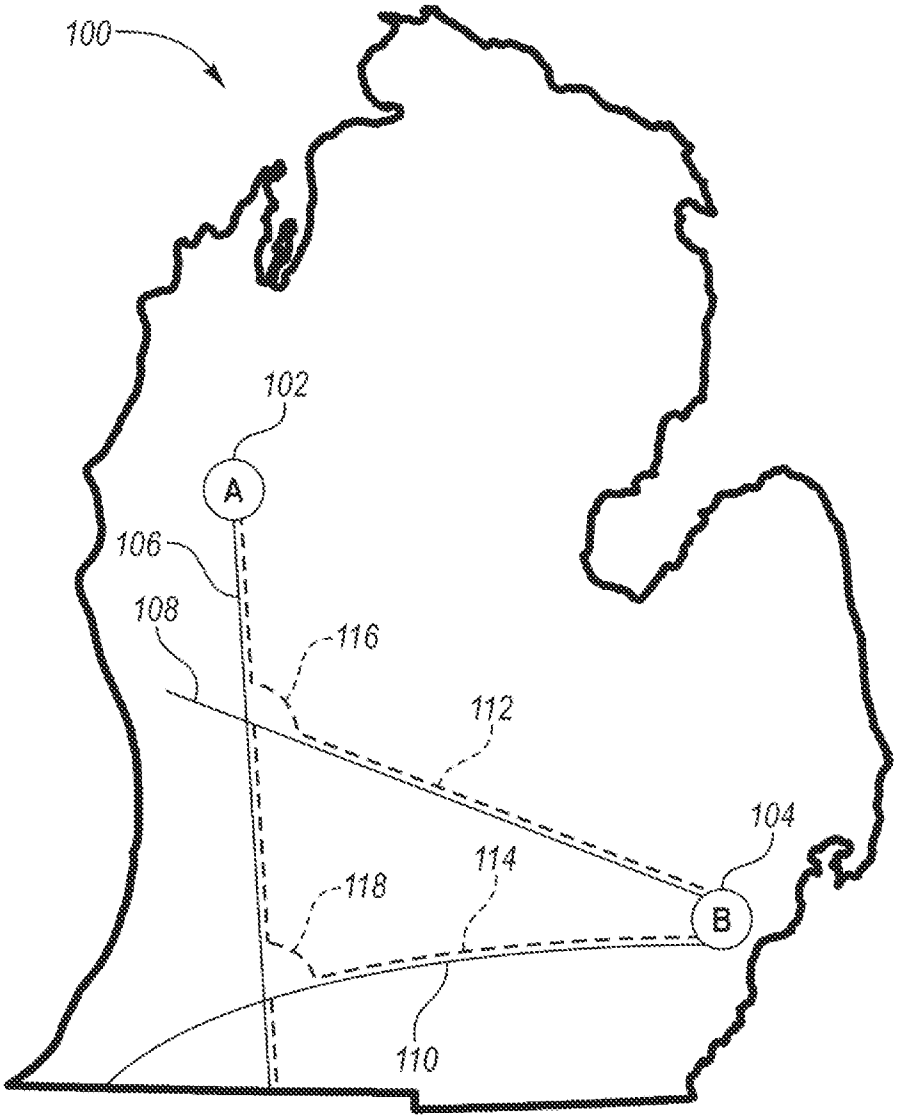



FIG. 1

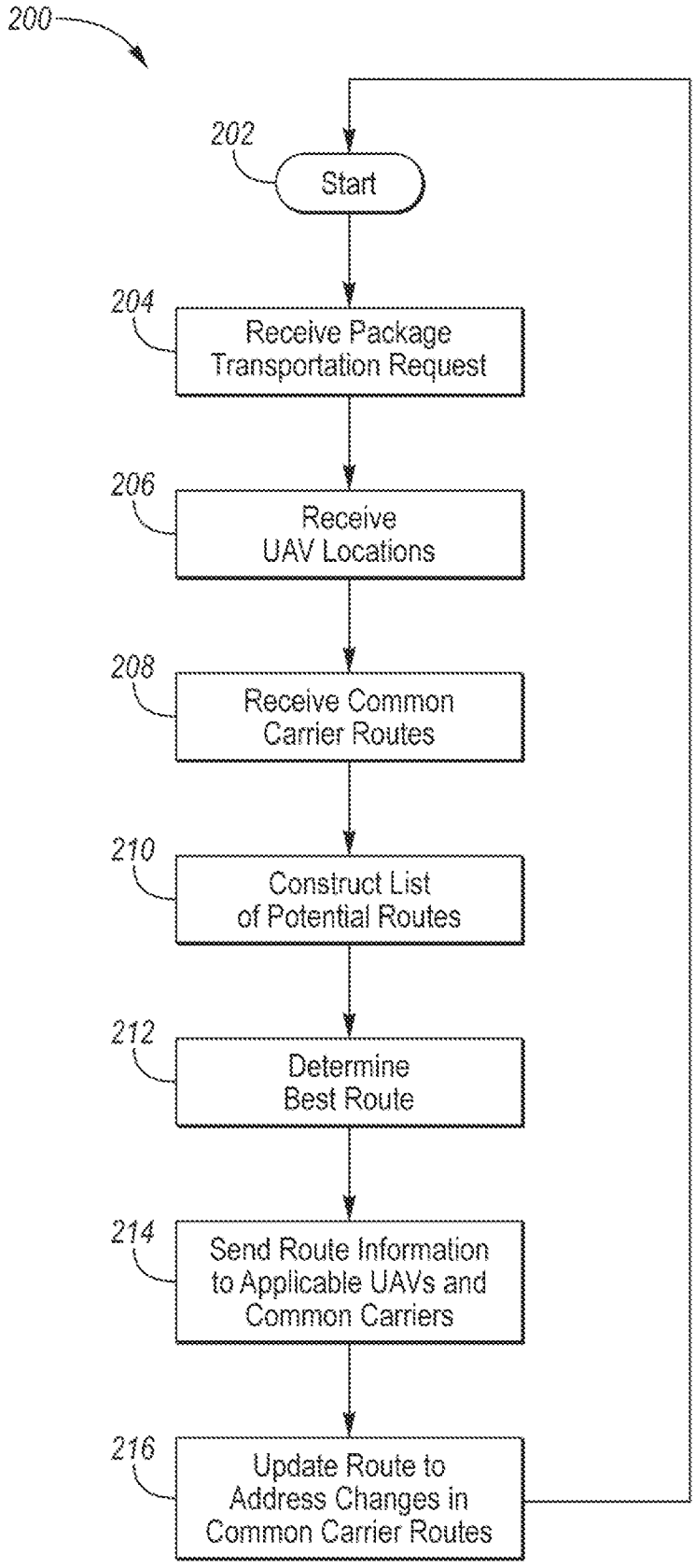

200
202
Start
204
Receive Package Transportation Request
206
Receive UAV Locations
208
Receive Common Carrier Routes
210
Construct List of Potential Routes
212
Determine Best Route
214
Send Route Information to Applicable UAVs and Common Carriers
216
Update Route to Address Changes in Common Carrier Routes

FIG. 2

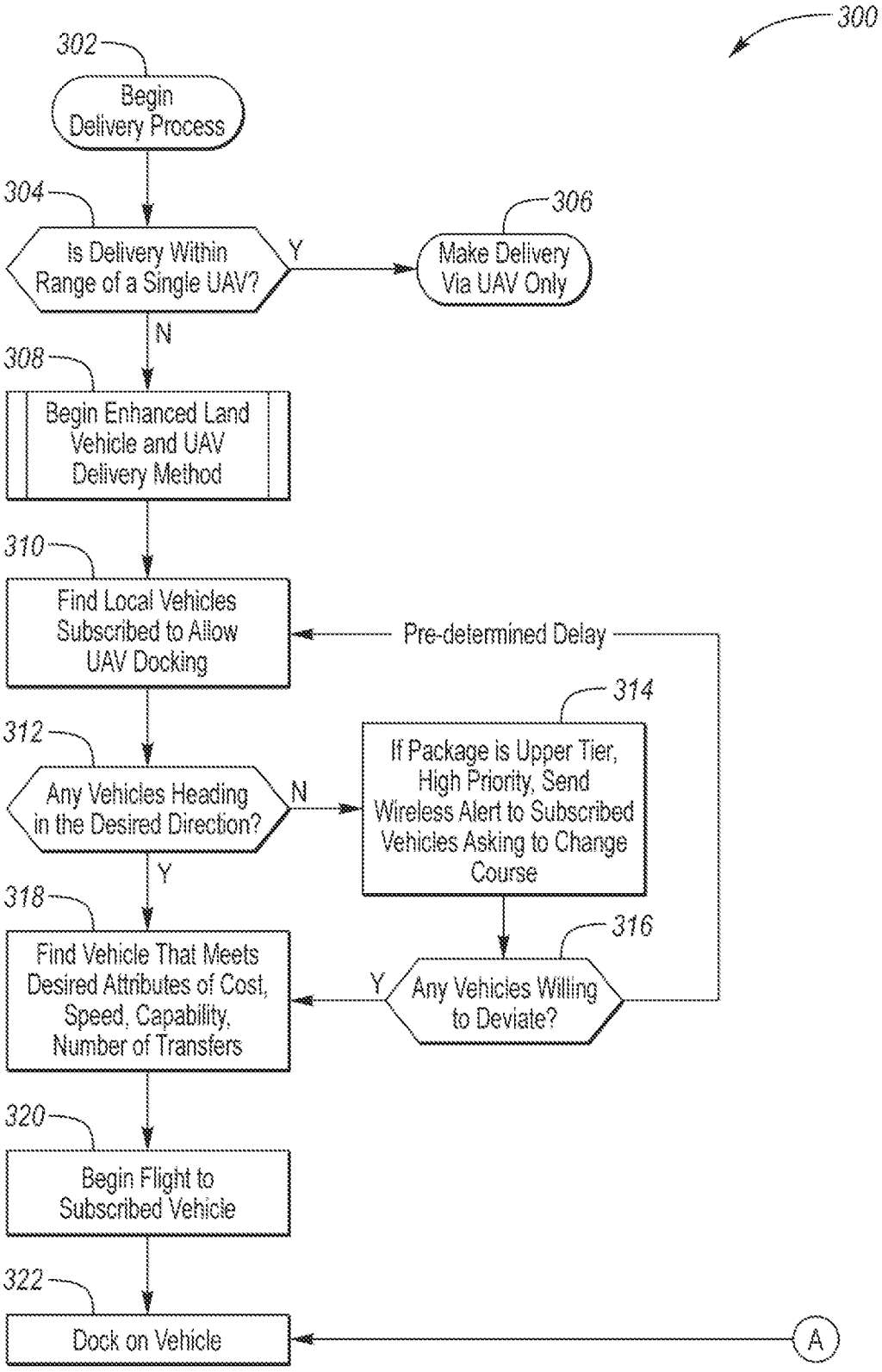

300
302
Begin Delivery Process
304
Is Delivery Within Range of a Single UAV?
Y
306
Make Delivery Via UAV Only
N
308
Begin Enhanced Land Vehicle and UAV Delivery Method
310
Find Local Vehicles Subscribed to Allow UAV Docking
Pre-determined Delay
314
312
Any Vehicles Heading in the Desired Direction?
N
If Package is Upper Tier, High Priority, Send Wireless Alert to Subscribed Vehicles Asking to Change Course
Y
318
316
Find Vehicle That Meets Desired Attributes of Cost, Speed, Capability, Number of Transfers
Y
Any Vehicles Willing to Deviate?
320
Begin Flight to Subscribed Vehicle
322
Dock on Vehicle
A

FIG. 3A

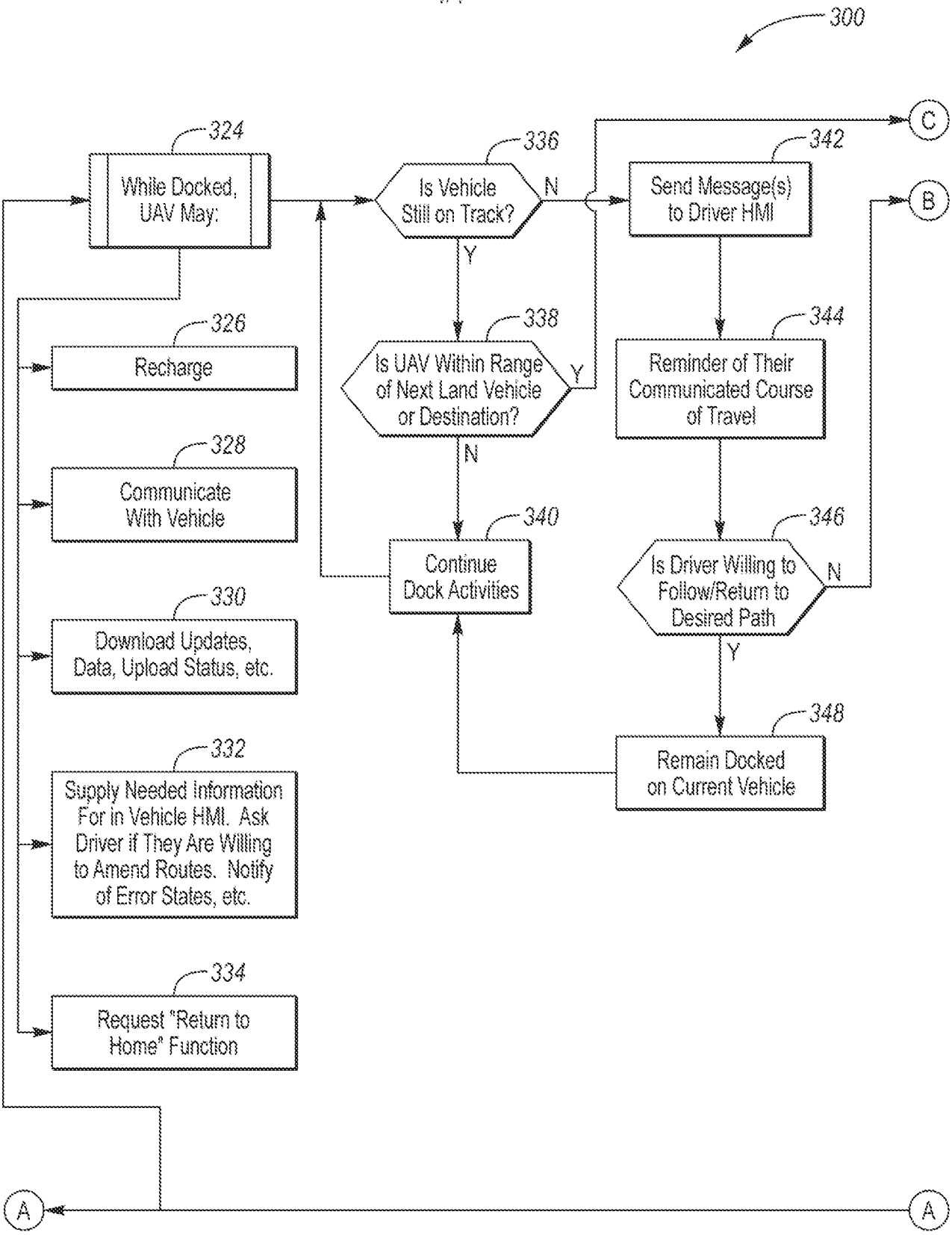

300
324
While Docked, UAV May:
326
Recharge
328
Communicate With Vehicle
330
Download Updates, Data, Upload Status, etc.
332
Supply Needed Information For in Vehicle HMI. Ask Driver if They Are Willing to Amend Routes. Notify of Error States, etc.
334
Request "Return to Home" Function
336
Is Vehicle Still on Track?
N
Y
338
Is UAV Within Range of Next Land Vehicle or Destination?
Y
N
340
Continue Dock Activities
342
Send Message(s) to Driver HMI
344
Reminder of Their Communicated Course of Travel
346
Is Driver Willing to Follow/Return to Desired Path
N
Y
348
Remain Docked on Current Vehicle
A
A
B
C

FIG. 3B

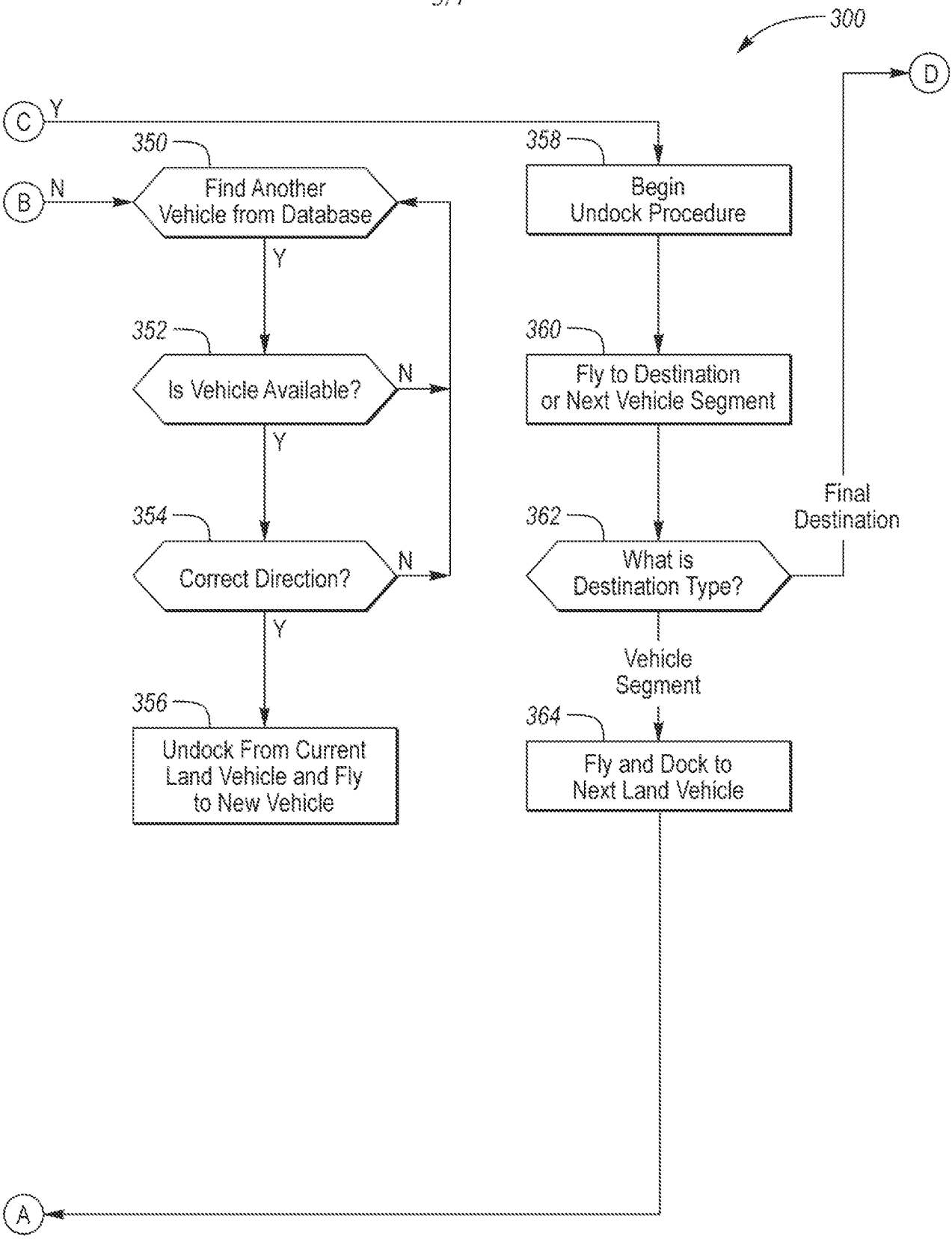

300
C
Y
B
N
350
Find Another Vehicle from Database
Y
352
Is Vehicle Available?
N
Y
354
Correct Direction?
N
Y
356
Undock From Current Land Vehicle and Fly to New Vehicle
358
Begin Undock Procedure
360
Fly to Destination or Next Vehicle Segment
362
What is Destination Type?
Final Destination
D
Vehicle Segment
364
Fly and Dock to Next Land Vehicle
A

FIG. 3C

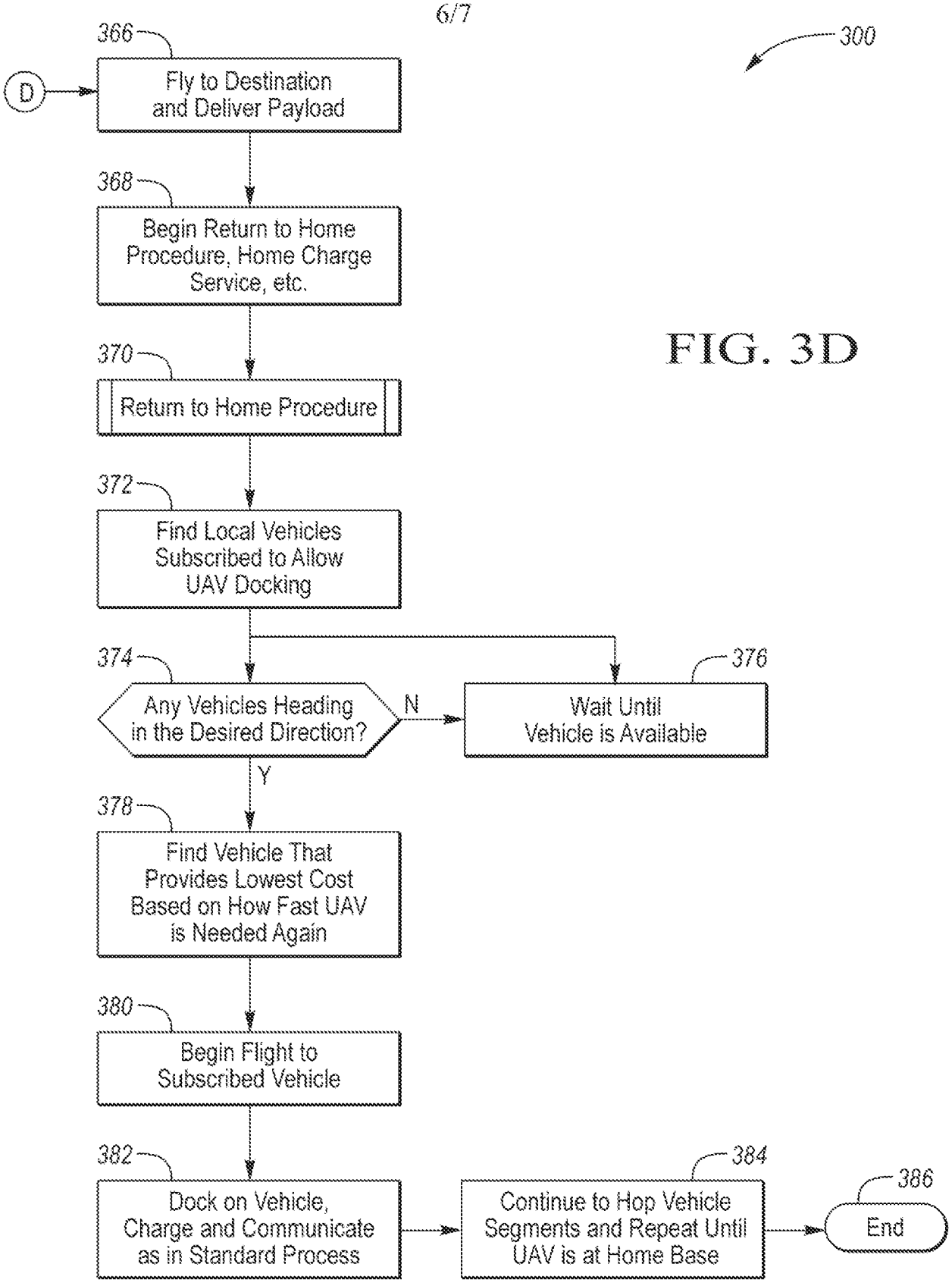

300
366
D
Fly to Destination and Deliver Payload
368
Begin Return to Home Procedure, Home Charge Service, etc.
370
Return to Home Procedure
372
Find Local Vehicles Subscribed to Allow UAV Docking
374
Any Vehicles Heading in the Desired Direction?
N
376
Wait Until Vehicle is Available
Y
378
Find Vehicle That Provides Lowest Cost Based on How Fast UAV is Needed Again
380
Begin Flight to Subscribed Vehicle
382
Dock on Vehicle, Charge and Communicate as in Standard Process
384
Continue to Hop Vehicle Segments and Repeat Until UAV is at Home Base
386
End

FIG. 3D

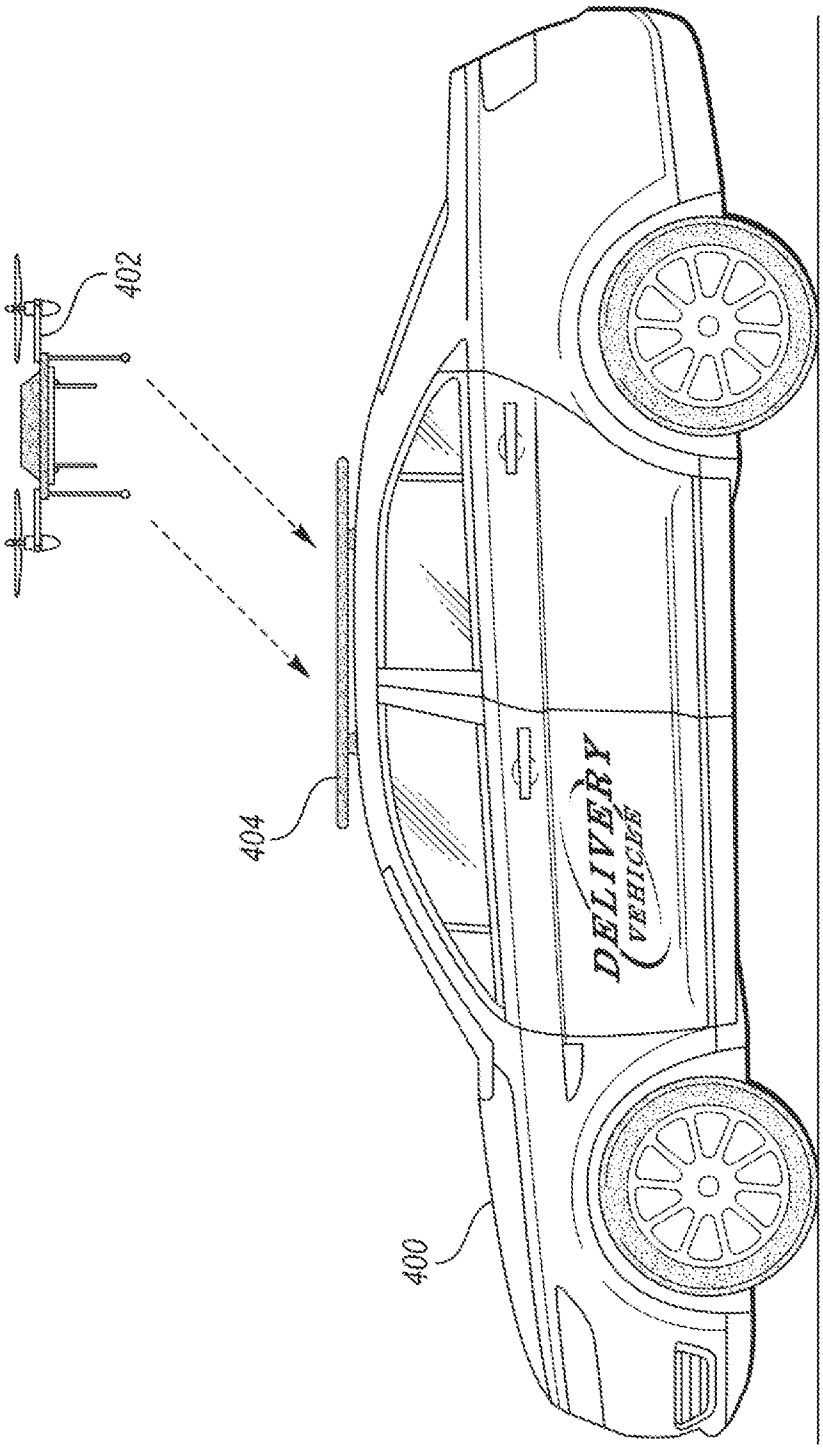



FIG. 4

# INTERNATIONAL SEARCH REPORT

International application No.
PCT/US16/17128

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - B64F 1/04 (2016.01)
CPC - B64F 1/04
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8) Classifications: B64F 1/04, 1/22, 1/00; B64C 39/02 (2016.01); CPC Classifications: B64F 1/04, 1/22, 1/222, 1/00; B64C 39/024; B60R 9/00; Y02T 10/7072, 10/7088, 90/14, 90/16, 90/124, 10/7005

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PatSeer (US, EP, WO, JP, DE, GB, CN, FR, KR, ES, AU, IN, CA, Other Countries (INPADOC), RU, AT, CH, TH, BR, PH); IEEE/IEEEXplore; Google/Google Scholar; IP.com; Keywords: unmanned aerial vehicle, UAV, drone, launch, flight, plan, pattern, carrier, transport, mobile base unit, MBU, deliver, pick up, recharge, dock, battery, location, route, truck, military, status, level, track

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X | US 2015/0353206 A1 (SZ DJI TECHNOLOGY CO., LTD) 10 December 2015; paragraphs [0029], [0031], [0107], [0108], [0113], [0116], [0131], [0159], [0160], [0238], [0242], [0360], [0361] | 1-3, 8-10 |
| Y | | 4-7, 11, 12 |
| Y | US 2014/0254896 A1 (ZHOU, T et al.) 11 September 2014; abstract; paragraph [0116] | 4 |
| Y | US 2012/0152654 A1 (MARCUS, R) 21 June 2012; paragraphs [0030], [0032], [0049], [0054] | 5-7, 11, 12 |
| A | US 2013/0081245 A1 (THE BOEING COMPANY) 4 April 2013; entire document | 1-12 |

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 8 April 2016 (08.04.2016) | 24 JUN 2016 |
| Name and mailing address of the ISA/<br>Mail Stop PCT, Attn: ISA/US, Commissioner for Patents<br>P.O. Box 1450, Alexandria, Virginia 22313-1450<br>Facsimile No. 571-273-8300 | Authorized officer<br>Shane Thomas<br>PCT Helpdesk: 571-272-4300<br>PCT OSP: 571-272-7774 |

Form PCT/ISA/210 (second sheet) (January 2015)

# INTERNATIONAL SEARCH REPORT

International application No.
PCT/US16/17128

**Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)**

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

**Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)**

This International Searching Authority found multiple inventions in this international application, as follows:
Group I: Claims 1-12; Group II: Claims 13-18

-***-Continued within extra sheet-***-

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
1-12

**Remark on Protest**

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

-***-Continued from Box No. III - Observations where unity of inventions is lacking-***-

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fee must be paid.

Group I: Claims 1-12 are directed toward a delivery system comprising charging a battery.
Group II: Claims 13-18 are directed toward a method comprising an inflight travel time.

The inventions listed as Groups I-II do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

The special technical features of Group I include charging a battery thereof such that a state of charge of the battery remains above a target for a duration of the route, which are not present in Group II.

The special technical features of Group II include constructing a route such that an inflight travel time associated with the route is less than a target value, which are not present in Group I.

The common technical feature shared by Groups I-II is in response to a request for a route to a destination, constructing the route so as to include predefined segments traveled by carriers configured to taxi unmanned aerial vehicles (UAV).

However, these common features are previously disclosed by US 2015/0353206 A1 to SZ DJI TECHNOLOGY CO., LTD (hereinafter "DJI"). DJI discloses in response to a request for a route to a destination (UAV location/position and velocity data are provided by the UAV to the companion vehicle which uses the data to generate the commands to control the flight of the UAV (in response to a request from an unmanned aerial vehicle for a route) such as enabling the UAV to land (a route to a destination); paragraphs [0107], [0108], [0242]), constructing the route so as to include predefined segments traveled by carriers configured to taxi UAVs (the UAV can be launched from a moving companion truck (carrier configured to taxi the vehicle) constrained to movement along a predetermined path (predefined segments traveled by carriers), and follows a preset flight pattern while remaining within a threshold distance directly ahead of the moving companion vehicle (construct the route so as to include predefined segments traveled by carriers); [0031], [0131], [0238], [0360], [0361]).

Since the common technical feature is previously disclosed by the DJI reference, this common feature is not special and so Groups I-II lack unity.