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Harding et al.

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(54) **AUTONOMOUS MISSION PROFILE PLANNING**

(75) Inventors: **William V. Harding**, Arlington, TX (US); **Arlin W. Gant**, Arlington, TX (US); **Douglas R. Zimmerer**, Flower Mound, TX (US)

(73) Assignee: **Lockheed Martin Corporation**, Bethesda, MD (US)

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(51) **Int. Cl.**[7] **F41G 7/00**

(52) **U.S. Cl.** **244/3.15**; 244/3.1; 244/3.11; 342/62; 342/195; 89/1.11

(58) **Field of Search** 342/61, 62, 63, 342/64, 65, 175, 195; 244/3.1, 3.11, 3.12–3.22; 89/1.11

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U.S. patent application Ser. No. 09/847,224, *Autonomous Mission Profile Planning*, filed May 2, 2001, in the name of William V. Harding.

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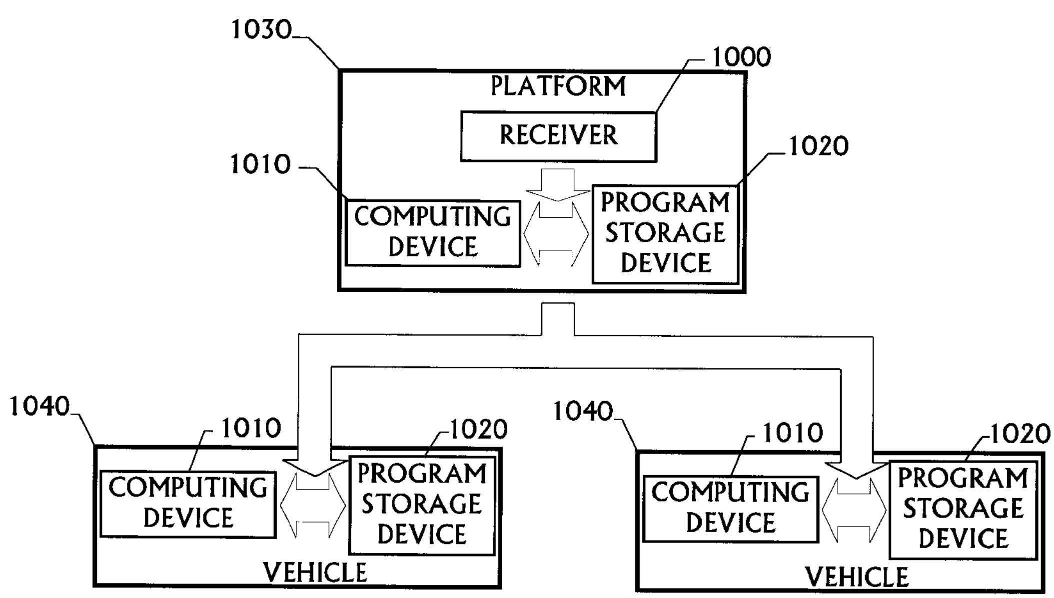
Primary Examiner—Bernarr E. Gregory
(74) *Attorney, Agent, or Firm*—Williams, Morgan & Amerson, P.C.

(57) **ABSTRACT**

The present invention, in its various aspects and embodiments, includes a method for planning a mission profile in real time. The method comprises ascertaining a plurality of target information (including a target location, a target velocity, and a target location error) and autonomously determining a pattern from the ascertained target information. In one particular embodiment, the autonomous determination includes projecting along a target axis a distance of the target location error to establish two intersections of the target axis with the target location error; projecting perpendicularly left and right from the intersections to determine a pair of possible start point pairs; selecting the possible start point pair including a closest single start point; selecting the farthest start point of the selected start point pair; identifying an adjusted start point; mirroring the adjusted start point to obtain an adjusted start point pair; and laying out the front-end and back-end traces from the adjusted start point pair.

71 Claims, 12 Drawing Sheets



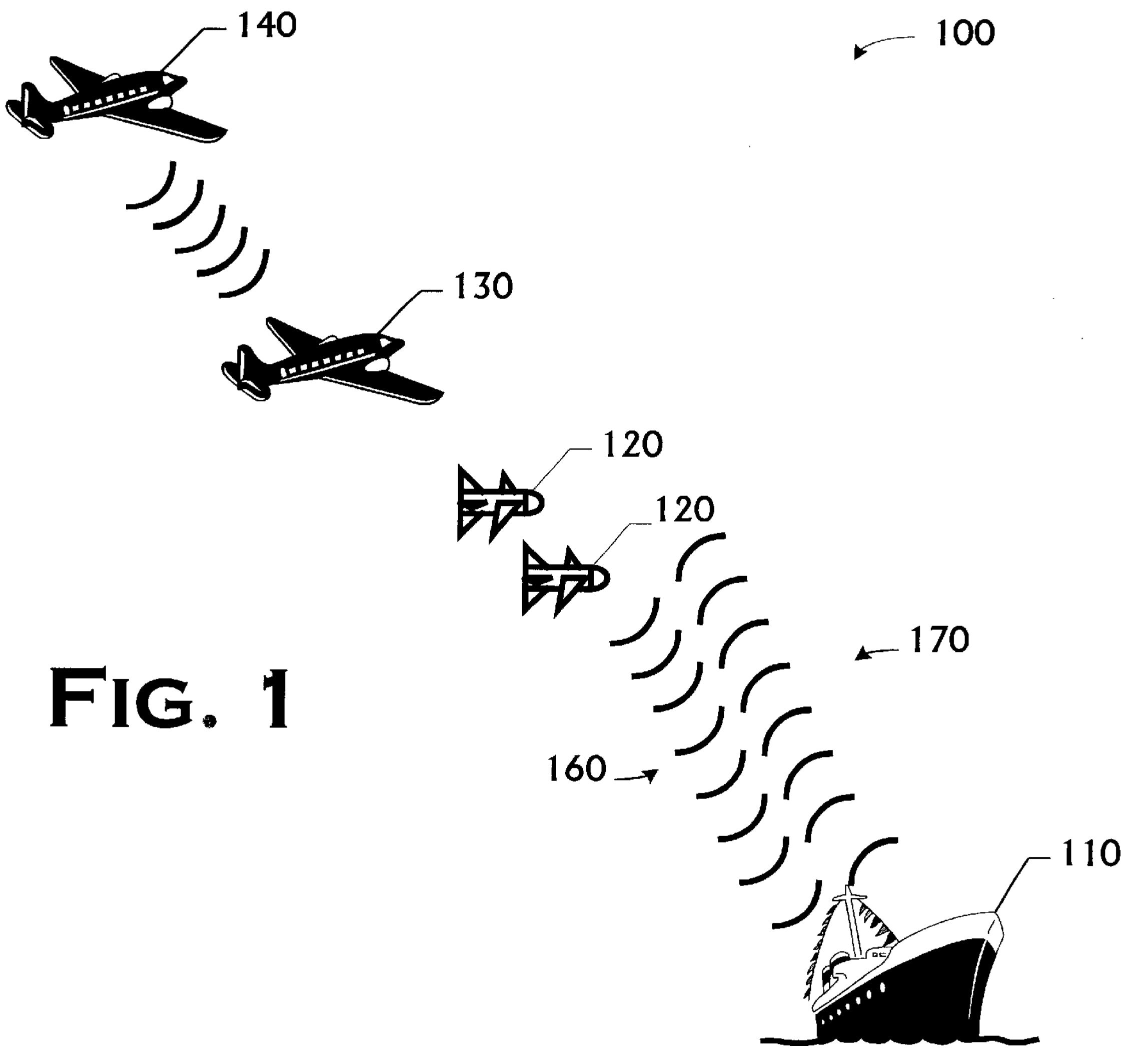

140
100
130
120
120
170
160
110

FIG. 1

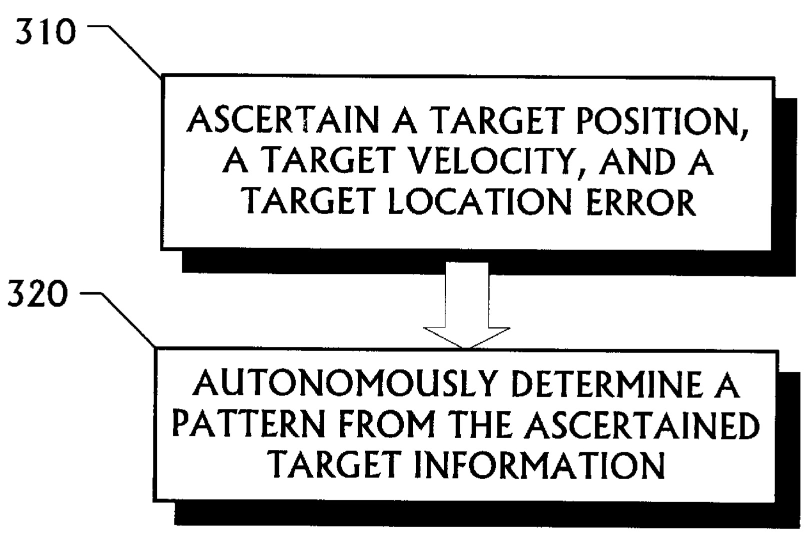

310
ASCERTAIN A TARGET POSITION, A TARGET VELOCITY, AND A TARGET LOCATION ERROR
320
AUTONOMOUSLY DETERMINE A PATTERN FROM THE ASCERTAINED TARGET INFORMATION

FIG. 3

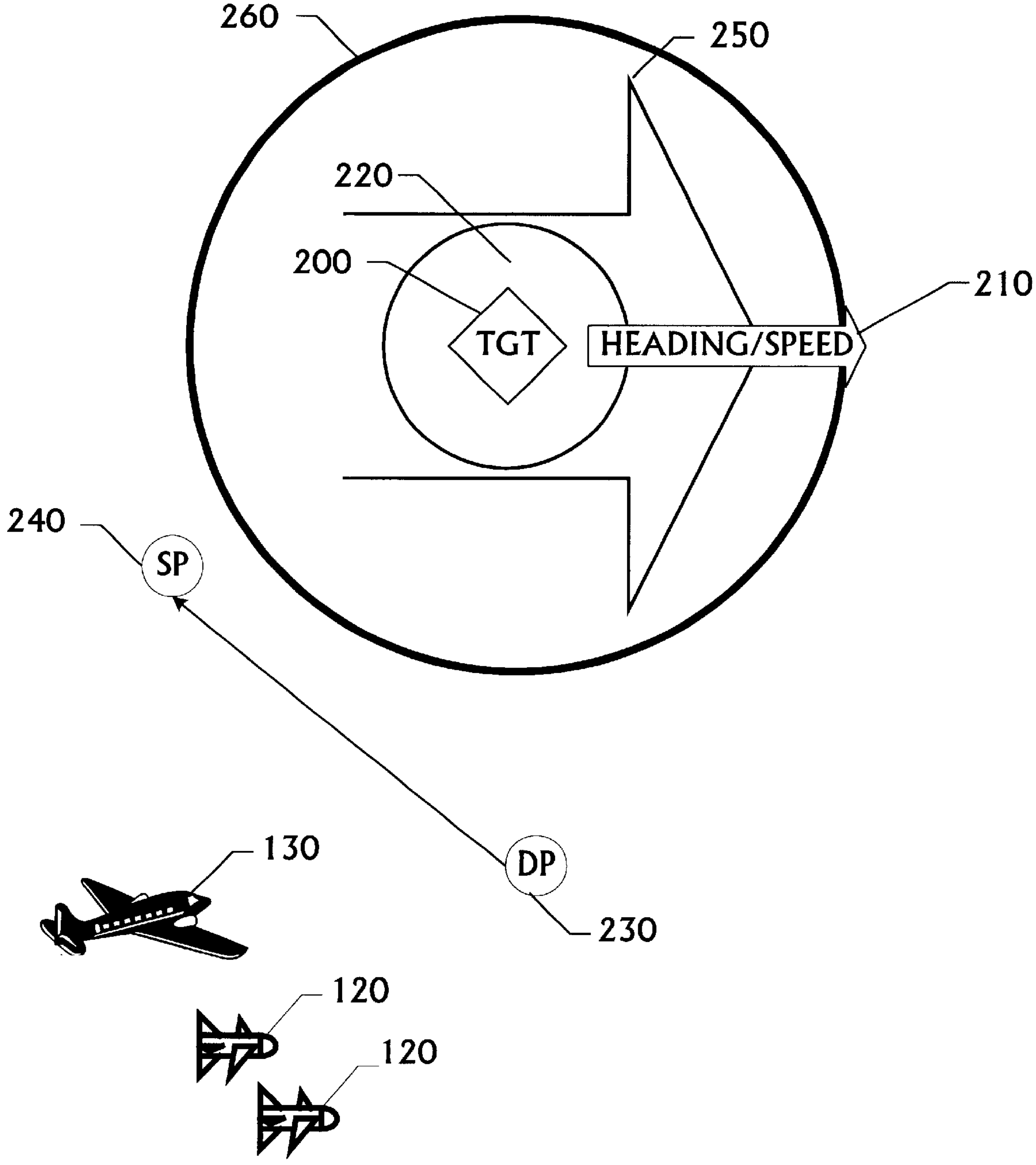


FIG. 2

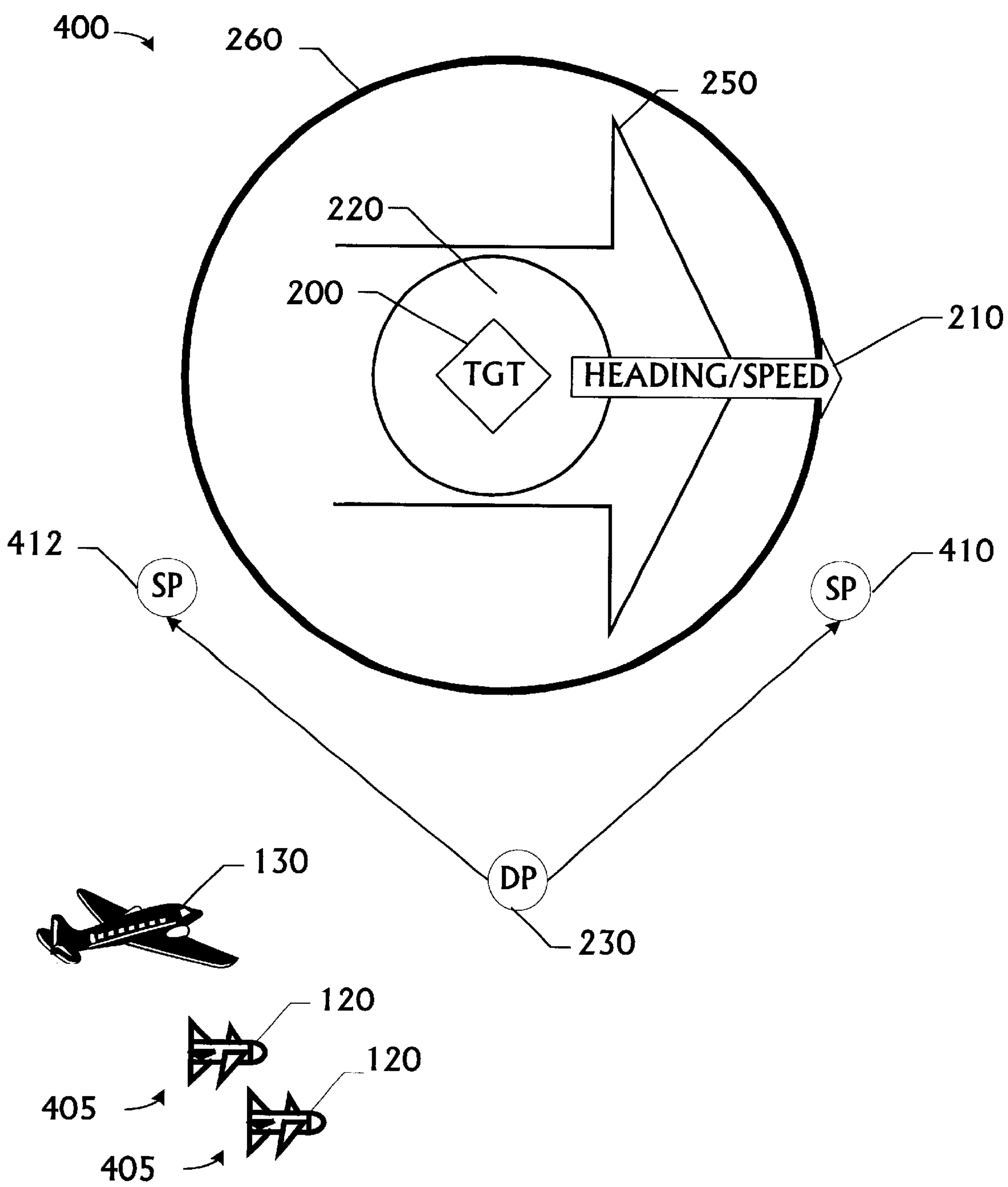

400
260
250
220
200
TGT
HEADING/SPEED
210
412
SP
SP
410
DP
130
230
120
120
405
405

FIG. 4A

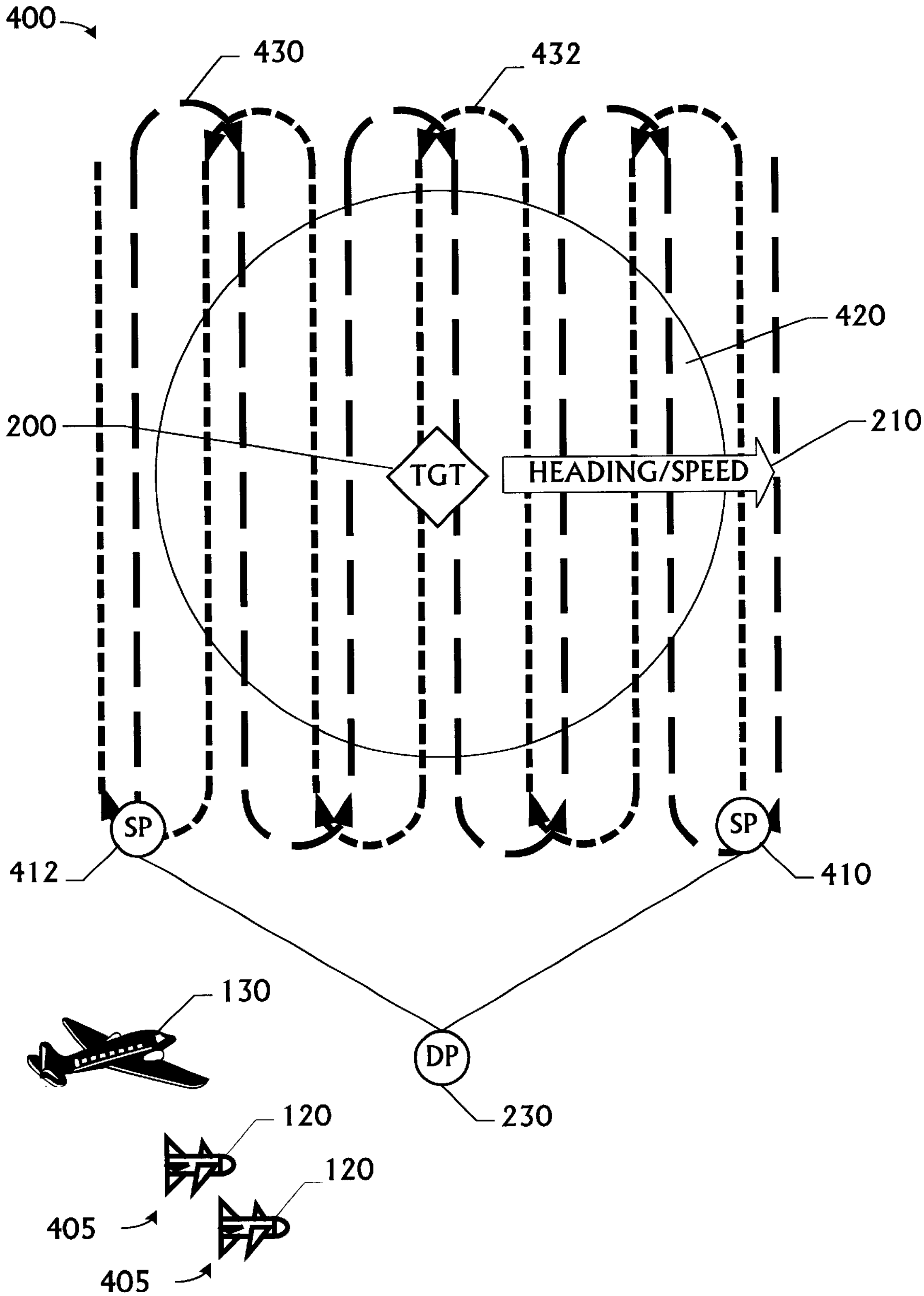

400
430
432
420
200
TGT
HEADING/SPEED
210
SP
SP
412
410
130
DP
230
120
120
405
405

FIG. 4B

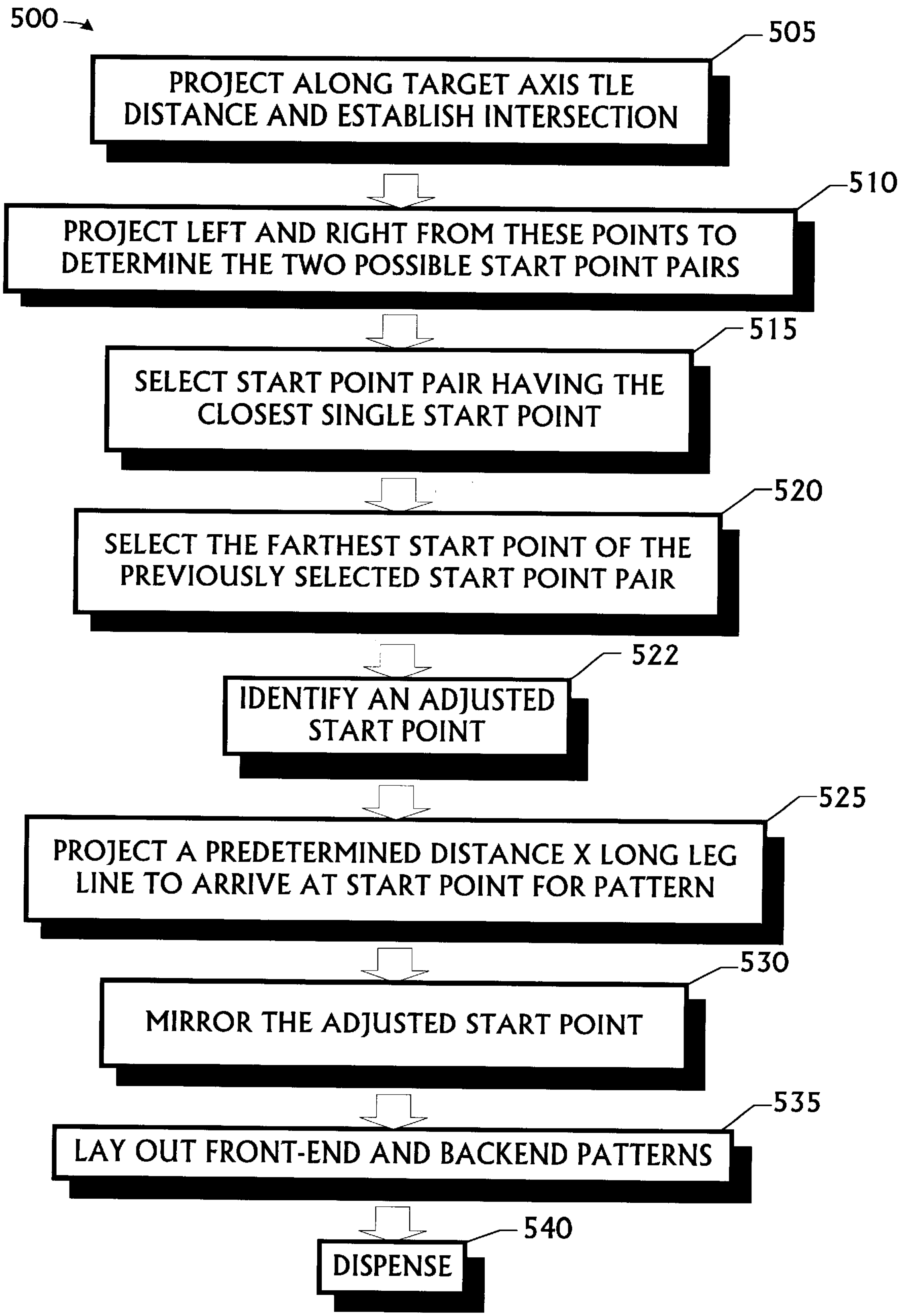

500
505
PROJECT ALONG TARGET AXIS TLE DISTANCE AND ESTABLISH INTERSECTION
510
PROJECT LEFT AND RIGHT FROM THESE POINTS TO DETERMINE THE TWO POSSIBLE START POINT PAIRS
515
SELECT START POINT PAIR HAVING THE CLOSEST SINGLE START POINT
520
SELECT THE FARTHEST START POINT OF THE PREVIOUSLY SELECTED START POINT PAIR
522
IDENTIFY AN ADJUSTED START POINT
525
PROJECT A PREDETERMINED DISTANCE X LONG LEG LINE TO ARRIVE AT START POINT FOR PATTERN
530
MIRROR THE ADJUSTED START POINT
535
LAY OUT FRONT-END AND BACKEND PATTERNS
540
DISPENSE

FIG. 5

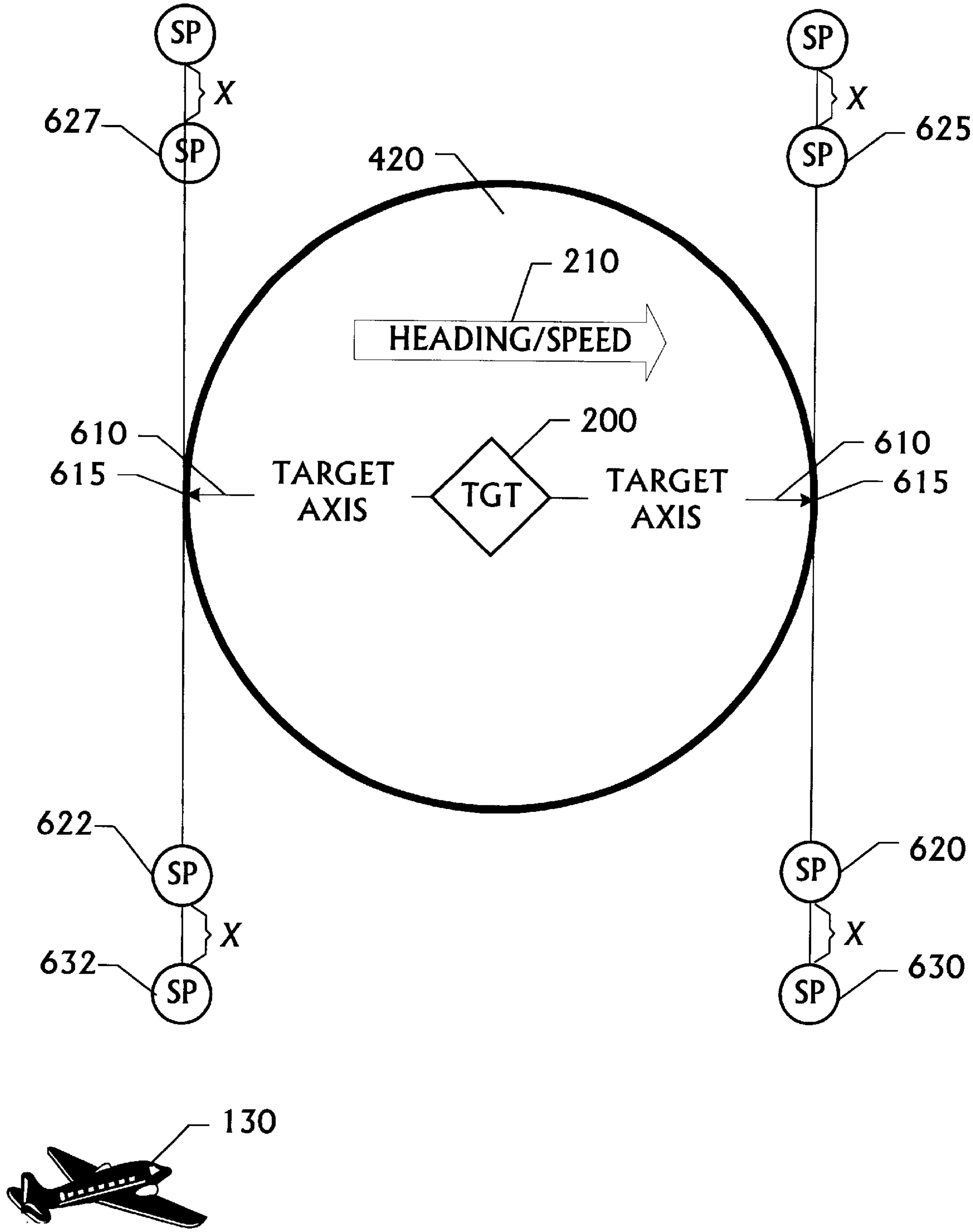

SP
X
627
SP
SP
X
625
SP
420
210
HEADING/SPEED
200
610
615
TARGET AXIS
TGT
TARGET AXIS
610
615
622
SP
X
632
SP
620
SP
X
630
SP
130

FIG. 6

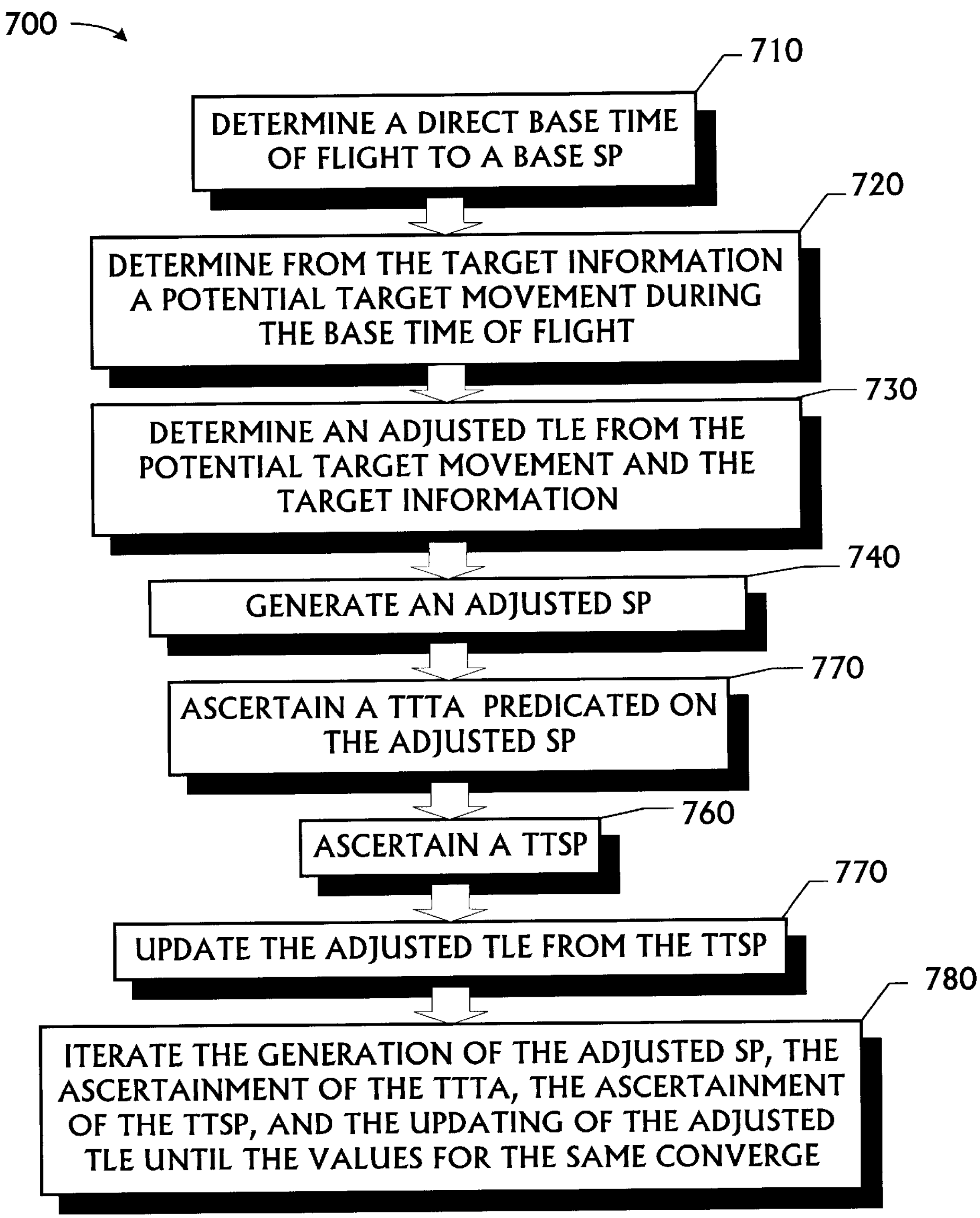

700
710
DETERMINE A DIRECT BASE TIME OF FLIGHT TO A BASE SP
720
DETERMINE FROM THE TARGET INFORMATION A POTENTIAL TARGET MOVEMENT DURING THE BASE TIME OF FLIGHT
730
DETERMINE AN ADJUSTED TLE FROM THE POTENTIAL TARGET MOVEMENT AND THE TARGET INFORMATION
740
GENERATE AN ADJUSTED SP
770
ASCERTAIN A TTTA PREDICATED ON THE ADJUSTED SP
760
ASCERTAIN A TTSP
770
UPDATE THE ADJUSTED TLE FROM THE TTSP
780
ITERATE THE GENERATION OF THE ADJUSTED SP, THE ASCERTAINMENT OF THE TTTA, THE ASCERTAINMENT OF THE TTSP, AND THE UPDATING OF THE ADJUSTED TLE UNTIL THE VALUES FOR THE SAME CONVERGE

FIG. 7

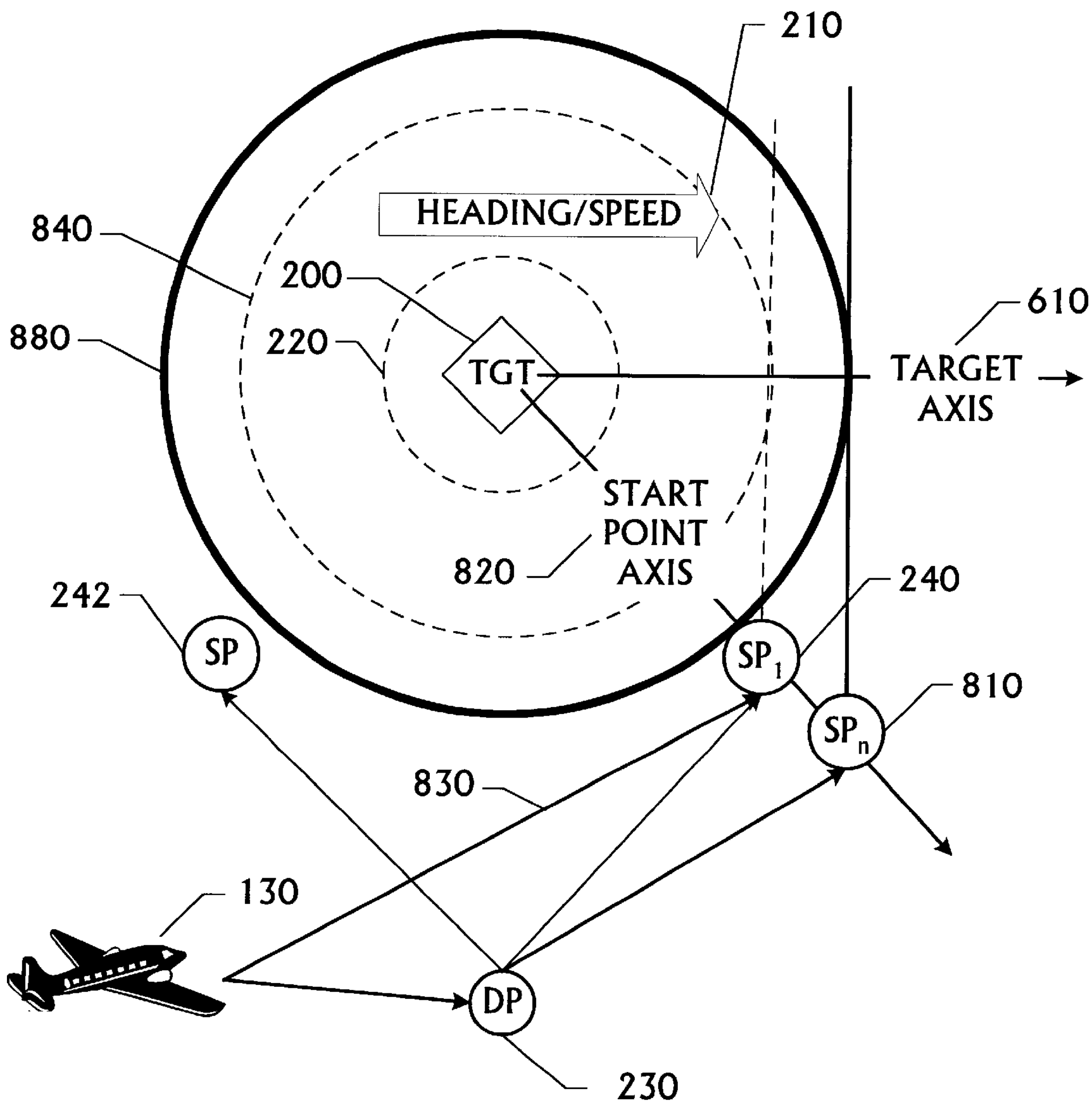

210
HEADING/SPEED
840
200
610
880
220
TGT
TARGET AXIS
START POINT AXIS
820
240
242
SP
SP_1
810
SP_n
830
130
DP
230

FIG. 8

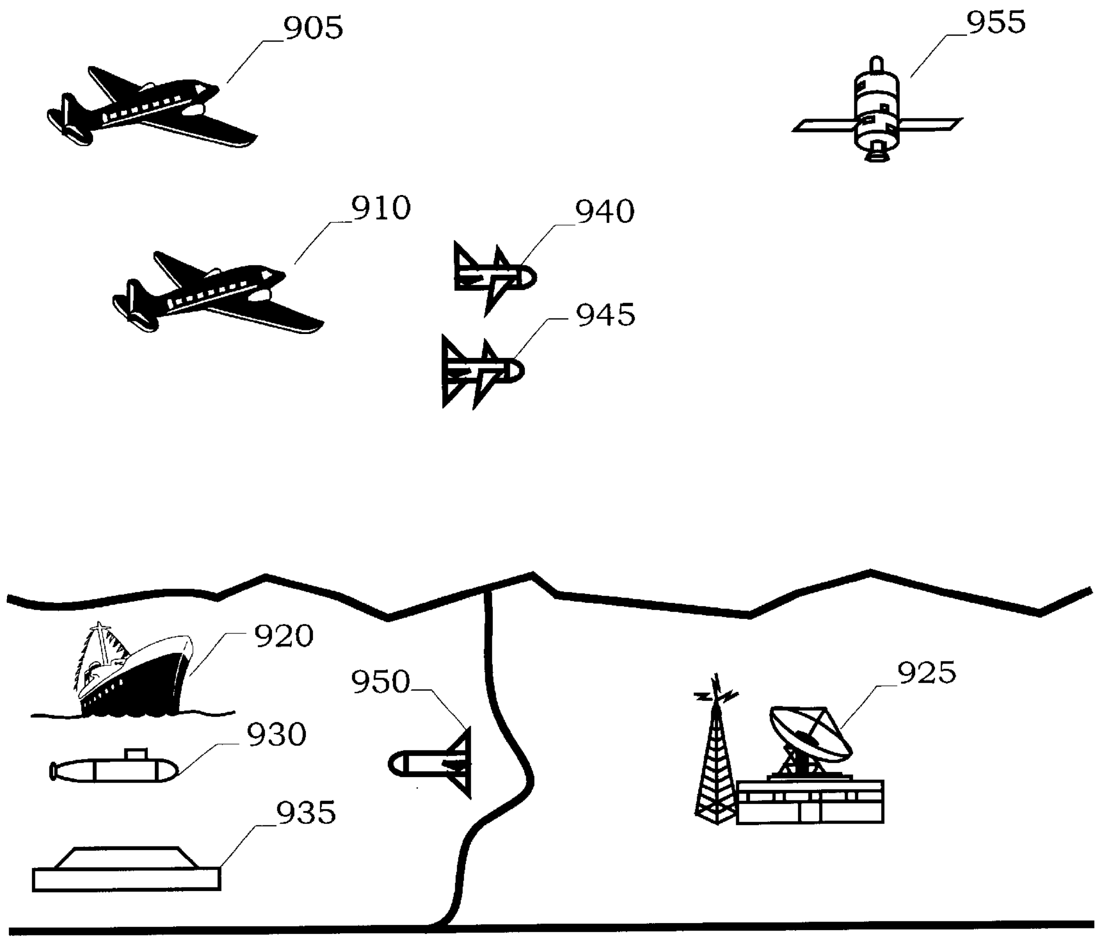


FIG. 9

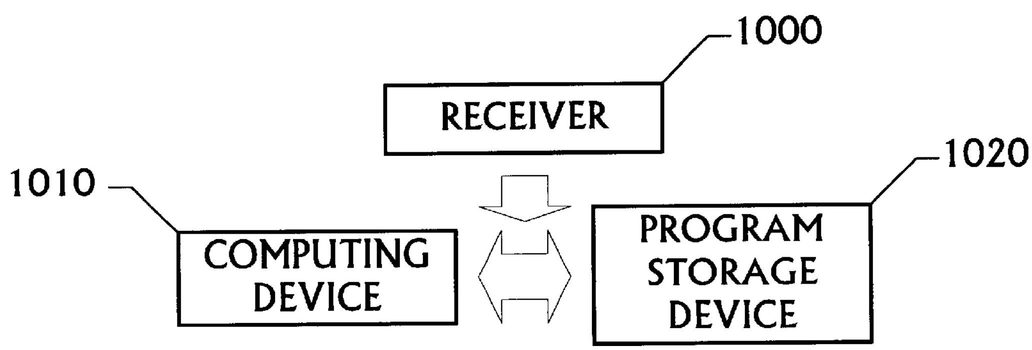


FIG. 10A

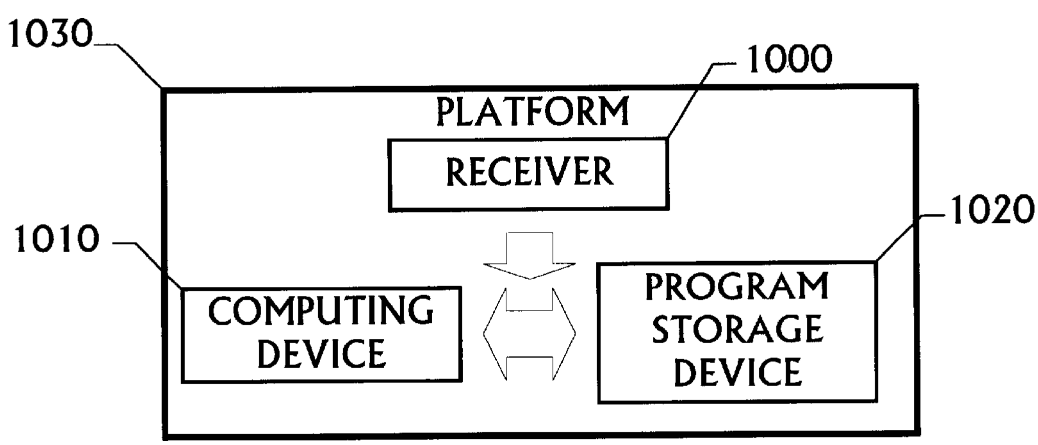


FIG. 10B

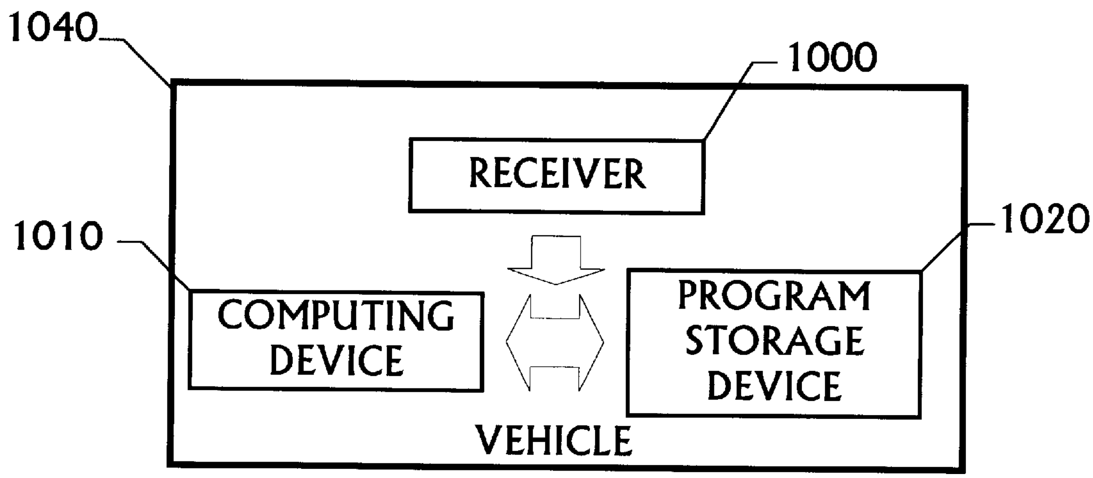


FIG. 10C

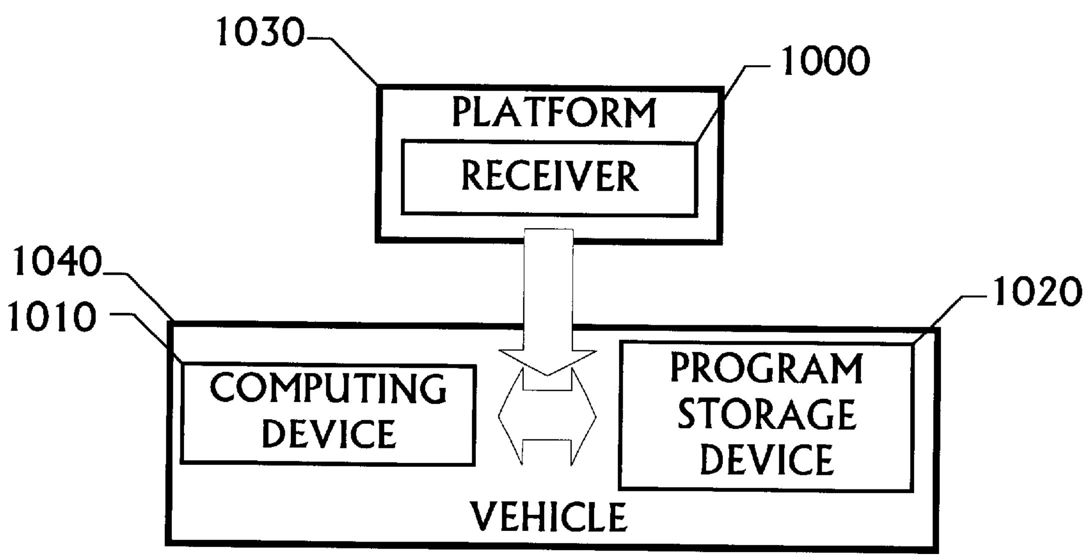


FIG. 10D

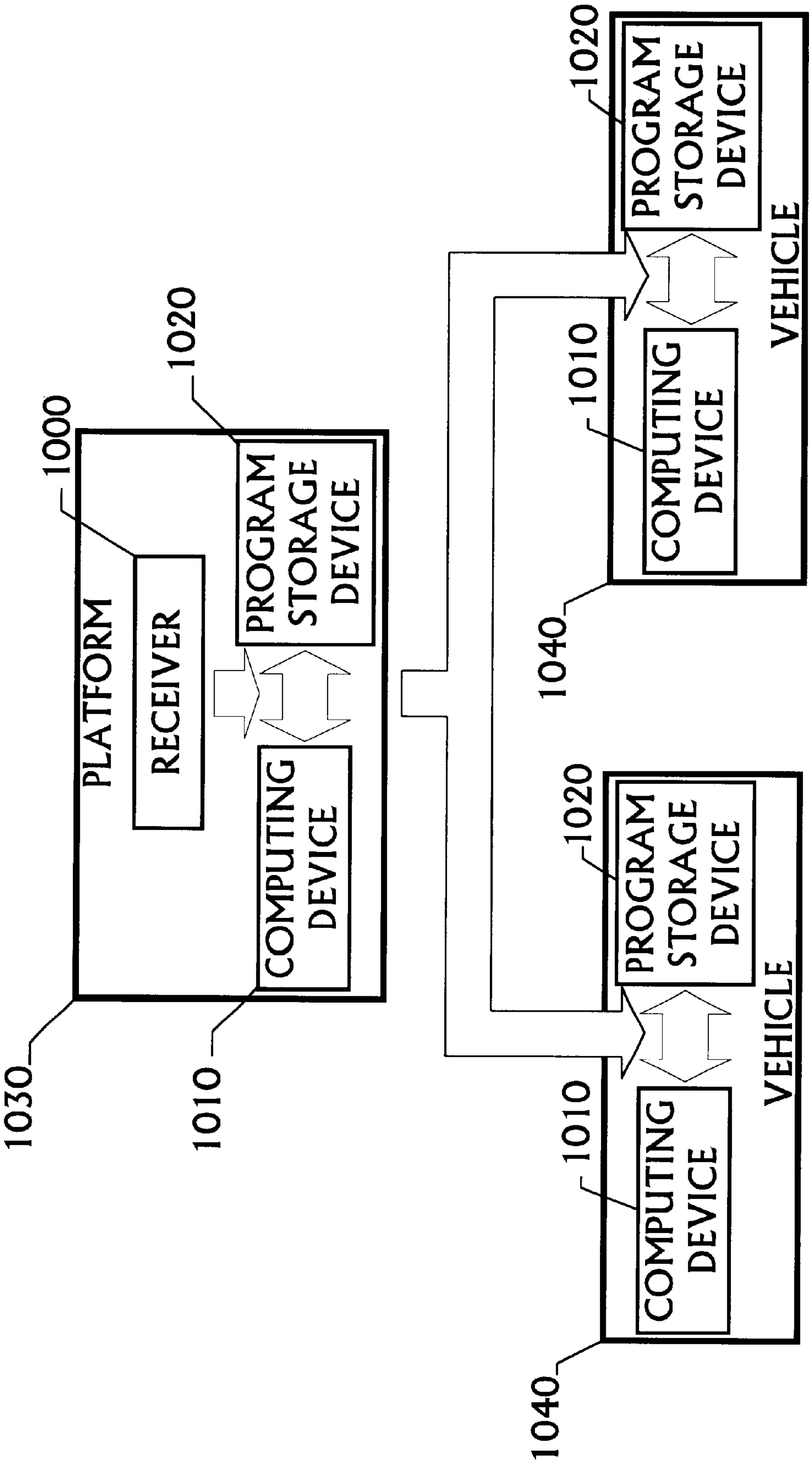

PLATFORM
RECEIVER
PROGRAM STORAGE DEVICE
COMPUTING DEVICE
1000
1020
1030
1010
VEHICLE
PROGRAM STORAGE DEVICE
COMPUTING DEVICE
1020
1010
1040
VEHICLE
PROGRAM STORAGE DEVICE
COMPUTING DEVICE
1020
1010
1040

FIG. 11

AUTONOMOUS MISSION PROFILE PLANNING

The present invention is related to the invention disclosed and claimed in co-pending application Ser. No. 09/847,224, entitled "Autonomous Mission Profile Planning," filed on an even date herewith in the name of William V. Harding, and commonly assigned herewith.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention pertains to mission profiles for weapons and reconnaissance systems, and, more particularly, to a method and apparatus for autonomous mission profile planning.

2. Description of the Related Art

The power and sophistication of modern weapons and reconnaissance systems have increased tremendously in recent years. One attribute of these systems manifesting this increase is mobility. Modern systems move much faster and much further than ever before. While battlefield conditions have never been static, the rate at which battlefield conditions change has correspondingly increased dramatically.

This fluidity in battlefield conditions emphasizes the need for flexibility in the deployment of weapons and reconnaissance systems. Weapons systems, reconnaissance systems, and other agents of military force are traditionally deployed according to a "mission profile." Mission planners gather intelligence about expected battlefield conditions pertaining to a particular military objective and then develop a mission profile by which the military objective may be accomplished. The mission profile is typically based upon numerous assumptions including, but not limited to, the expected performance of the deployed weapons system, the environmental conditions in which the deployment occurs, the expected performance of opposing weapons systems, and expected tactical responses of the enemy.

The fluidity in battlefield conditions, however, sometimes obsoletes one or more assumptions on which the mission profile is developed. For instance, the weapons system may not perform as expected; the weather may be worse than expected; an opposing weapons system may be deployed much more effectively than expected, or the enemy might do something unexpected. The theory of military tactics and strategy actually holds, in fact, that one can actually expect one or more developments of this kind to be encountered in any operation. The classic theorist Karl von Clausewitz referred to this as "the fog of war," i.e., the uncertainty arising from unexpected developments that will undoubtedly occur.

Some assumptions are more tenuous than others, and mission profiles typically contemplate alternative formulations predicated on the most probable contingencies beforehand. However, sometimes the changed conditions are so unexpected, are so critical, or are of such a degree that the mission profile as a whole becomes untenable. In such circumstances, the mission typically is either aborted or otherwise fails in its military objective.

Consider, for example, the pursuit of SCUD missile launchers by forces under United Nations ("UN") control ("UN forces") during the conflict against Iraq sometimes referred to as the "Persian Gulf War." UN forces would detect a SCUD missile launch as it occurred or shortly thereafter, and would dispatch military aircraft to destroy the launchers. UN forces enjoyed reconnaissance capabilities superior to any ever previously deployed, absolute air superiority, and the highest performance aircraft ever known. Still, UN forces never destroyed, or even damaged, a single SCUD missile launcher.

The launchers were very mobile, and Iraqi forces would begin moving them immediately upon launching their missiles. By the time UN aircraft reached the area in which they expected to find the launchers, the Iraqis had secreted them away so they could not be found. UN mission planners simply were unable to develop a mission profile capable of overcoming the capabilities of the Iraqi weapons system. The essential assumption on which the mission was planned, i.e., that the UN aircraft could arrive before the Iraqis hid the launchers, was untenable.

Consequently, as battlefield conditions become more fluid, greater emphasis is placed on flexibility in weapons and reconnaissance system deployments. A more flexible deployment permits the mission planners to contemplate a wider range of possible contingencies. All other things being equal, the more contingencies that can be accounted for beforehand the more likely the mission can be successfully completed.

The recent emphasis on "standoff" weapons and reconnaissance drones has exacerbated these considerations. Standoff weapons are weapons deployed against a target from a distance at which military personnel are relatively safe from retaliatory action. A classic example of a standoff weapon is a cruise missile, which can be launched at a target from several hundred miles away with great accuracy. Because of the distance, the personnel launching the cruise missile typically worry little about retaliation from even an otherwise dangerous target. Similarly, a reconnaissance drone may be programmed with a mission profile and launched. The reconnaissance drone then executes the mission and returns or signals information back to a central location. Either way, personnel remain behind in relative safety.

Unfortunately, standoff weapons and reconnaissance systems are not very "smart" and consequently not very flexible. Consider the cruise missile, for example. A cruise missile is programmed with a target's location and then launched. While the cruise missile can arrive at the programmed location with great accuracy, it will miss the target if the target has moved from that location. The mission planner has few options because the weapons system is not very flexible. A change in battlefield conditions (i.e., changed target location) cannot be contemplated in the mission profile because the weapons system does not have the capability. At the same time, the distance over which the cruise missile has to travel increases the probability because of the time it takes to fly the distance.

Mission profile planning is performed manually. An "analyst" sits down with some target information about a target. The target information may include the target's location and, if the target is mobile, information such as the target speed, target heading, target location error ("TLE"), and age of the information. If target information other than the target location is missing, values may be assumed. Planning the mission profile is relative if the target is stationary. However, if the target is mobile, the analyst must develop a profile under which the weapon system or reconnaissance can locate the target. This includes developing a search pattern that thoroughly covers the area in which the target may be (defined by the TLE) in an efficient manner. This can be a relatively time consuming process.

Thus, another significant problem encountered for some weapons systems and, less frequently, some reconnaissance systems is the stress of battlefield conditions. Consider a standoff weapon launched from an aircraft; for example, an air to ground missile. Although the pilot might not need to worry about retaliation from the target, the launch might occur in enemy territory over which the pilot may be subject to hostile anti-aircraft fire. The pilot may receive information about a target that may have some error in it or will have some error by the time the weapon is dispensed. A pilot under fire has neither the time nor the inclination to calculate, i.e., promulgate a new or more accurate mission profile before launching the weapon.

The present invention is directed to resolving, or at least reducing, one or all of the problems mentioned above.

SUMMARY OF THE INVENTION

The present invention, in its various aspects and embodiments, includes a method for planning a mission profile in real time. The method comprises ascertaining a plurality of target information (including a target location, a target velocity, and a target location error) and autonomously determining a pattern from the ascertained target information. In one particular embodiment, the autonomous determination includes projecting along a target axis a distance of the target location error to establish two intersections of the target axis with the target location error; projecting perpendicularly left and right from the intersections to determine a pair of possible start point pairs; selecting the possible start point pair including a closest single start point; selecting the farthest start point of the selected start point pair; identifying an adjusted start point; mirroring the adjusted start point to obtain an adjusted start point pair; and laying out the front-end and back-end traces from the adjusted start point pair.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention may be understood by reference to the following description taken in conjunction with the accompanying drawings, in which like reference numerals identify like elements, and in which:

FIG. **1** depicts one particular embodiment of a mission scenario in which the present invention may be employed;

FIG. **2** illustrates some concepts regarding a mission profile relevant to the present invention;

FIG. **3** charts one particular embodiment of a method practiced in accordance with the present invention;

FIG. **4**A and FIG. **4**B conceptually illustrate a pattern from a mission profile developed in accordance with one particular embodiment of the present invention;

FIG. **5** illustrates one particular implementation of a method for determining the pattern in FIG. **4**A and FIG. **4**B;

FIG. **6** conceptually illustrates intermediate steps in determining the pattern in FIG. **4**A and FIG. **4**B in accordance with the implementation of FIG. **5**;

FIG. **7** charts one particular technique for determining the adjusted start points from which the pattern in FIG. **4**A and FIG. **4**B is begun;

FIG. **8** conceptually illustrates the technique of FIG. **7**;

FIG. **9** conceptually illustrates various mission scenarios with which the invention may be implemented;

FIG. **10**A to FIG. **10**D illustrate various, alternative hardware implementations of the present invention; and

FIG. **11** illustrates one particular hardware implementation for the embodiment illustrated from FIG. **4**A to FIG. **8**.

While the invention is susceptible to various modifications and alternative forms, specific embodiments thereof have been shown by way of example in the drawings and are herein described in detail. It should be understood, however, that the description herein of specific embodiments is not intended to limit the invention to the particular forms disclosed, but on the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the invention as defined by the appended claims.

DETAILED DESCRIPTION OF THE INVENTION

Illustrative embodiments of the invention are described below. In the interest of clarity, not all features of an actual implementation are described in this specification. It will of course be appreciated that in the development of any such actual embodiment, numerous implementation-specific decisions must be made to achieve the developers' specific goals, such as compliance with system-related and business-related constraints, which will vary from one implementation to another. Moreover, it will be appreciated that such a development effort, even if complex and time-consuming, would be a routine undertaking for those of ordinary skill in the art having the benefit of this disclosure.

The invention includes a method for developing a mission profile in real time. The method may be used to promulgate an original mission profile or an updated mission profile, or both, depending on the implementation. In general, the method includes:

ascertaining a plurality of target information including a target location, a target velocity, and a target location error; and

autonomously determining a pattern from the ascertained information.

The term "autonomous," as used herein, means under programmed control without human intervention. As will become apparent from the discussion below, the invention admits wide variation in implementation.

Turning now to the drawings, FIG. **1** conceptually illustrates one particular mission scenario **100** in which the invention may be employed. The mission scenario implements a method for autonomously planning a mission profile practiced in accordance with the present invention. In this particular scenario **100**, the objective is to destroy the target **110** with one or more flying submunitions **120**. The submunitions **120** may be flown in one or more formations, depending upon the implementation. Note, however, that the invention is not so limited. For instance, an objective in an alternative embodiment might be to locate and identify the target **110**. Other alternative embodiments are disclosed below. Still other variations within the scope of the claims appended hereto will become apparent to those skilled in the art having the benefit of this disclosure.

The submunitions **120** are dispensed from an aircraft **130**. In the illustrated embodiment, the aircraft **130** receives the target information from an airborne surveillance platform **140**, such as an Airborne Warning and Control System ("AWACS") or Joint Surveillance Target Attack Radar System ("JSTARS") aircraft. More technically, the airborne surveillance platform **140** transmits an electromagnetic signal **160** to the aircraft **130** containing the target information. Thus, in this manner, the target information is "ascertained" in this particular embodiment.

The aircraft **130** includes a computing device (not shown) programmed to determine a pattern for the submunitions **120** to use in searching for and locating the target **110** in accordance with the present invention. The computing device will typically be a sophisticated processor (e.g., a high performance microprocessor or digital signal processor) embedded in the aircraft **130**'s weapons systems. In one particular implementation, the submunitions **120** are preprogrammed with an original mission profile. Consequently, the aircraft **130** determines an "updated" or "modified" mission profile from the target information. However, the aircraft **130** may alternatively promulgate an original mission profile.

The submunitions **120** are then dispensed by the aircraft **130** in accordance with the mission profile. In some implementations, the submunitions **120** may be dispensed prior to the determination of the pattern. The submunitions **120** begin searching on the pattern determined as part of the mission profile. The submunitions **120** transmit electromagnetic signals **160** while flying on the pattern. The signals **160** are reflected by objects such as the target **110**. The submunitions **120** analyze the reflected signals **170** to determine whether the object reflecting them is the target **110**. This is known as "target recognition," and the submunitions **120** are said to employ an automatic target recognition system ("ATR System"). In some implementations, the reflected signals **170** or data extracted from them is relayed to another location, target recognition is performed off the submunitions **120**, and the results of the target recognition transmitted to the submunitions **120**.

In one particular embodiment, the submunitions **120** are equipped with a "seeker head" (not shown) that employs laser RADAR, or laser ranging and detecting s ("LADAR") signals for the signals **150**, **160**. The basic structure and operation of this seeker head is disclosed in the following references:

U.S. Pat. No. 5,285,461, entitled "Improved Laser RADAR Transceiver," issued Feb. 5, 1994, to Loral Vought Systems Corporation (now Lockheed Martin Corporation) as assignee of the inventors Nicholas J. Krasustsky and Lewis G. Minor;

U.S. Pat. No. 5,224,109, entitled "Laser RADAR Transceiver," issued Jun. 29, 1993, to LTV Missiles and Electronics Group (now Lockheed Martin Corporation) as assignee of the inventors Nicholas J. Krasustsky and Lewis G. Minor; and

U.S. Pat. No. 5,200,606, entitled "Laser RADAR Scanning System," issued Apr. 6, 1993, to LTV Missiles and Electronics Group (now Lockheed Martin Corporation) as assignee of the inventors Nicholas J. Krasustsky, Lewis G. Minor, and Edward M. Flowers.

One particular implementation of this seeker disclosed in U.S. application Ser. No. 09/263,411, entitled "Dual Mode Semi-Active Laser/Laser Radar Seeker," filed Mar. 5, 1999, now U.S. Pat. No. 6,262,800, in the name of the inventor Lewis G. Minor, now commonly assigned herewith to Lockheed Martin Corporation, is capable of switching between "active" and "semi-active" modes. In another implementation, the seeker head scans using a technique disclosed in U.S. Pat. No. 5,898,483, entitled "Method for Increasing LADAR Resolution," issued Apr. 27, 1999, to Lockheed Martin Corporation as assignee of the inventor Edward Max Flowers.

One advantage of using LADAR signals **160**, **170** is that they provide three-dimensional data. This is particularly advantageous in recognizing and acquiring the target **110**. One implementation of the present invention may employ an automatic target recognition ("ATR") system disclosed in U.S. Pat. No. 5,893,085, entitled "Dynamic Fuzzy Logic Process for Identifying Objects in Three-Dimensional Data," issued Apr. 6, 1999, to Lockheed Martin Corporation as assignee of the inventor Ronald W. Phillips. In the particular mission scenario **100**, the target **110** is then destroyed, or at least attacked, once recognized and acquired.

However, the invention is not limited to these particular implementations. For instance:

- any suitable seeking apparatus known to the art may be employed;
- signals other than LADAR signals, including those that yield only two-dimensional data, may be used; and
- any suitable target recognition system known to the art may be employed. Indeed, many aspects of the present invention will be implementation specific.

One factor influencing many aspects of a given implementation is the environment in which the invention is deployed. The mission scenario **100** in FIG. **1** is an air-to-ground scenario. As used herein, "air-to-ground" shall encompass delivery from the air to a target on the surface of a body of water. However, in alternative embodiments, mission scenarios might be air-to-air or ground-to-ground, or even partially or completely underwater. For instance, in alternative embodiments, the invention might include:

- a submarine launching a submersible vehicle (such as a torpedo) programmed to seek out and destroy an underwater or surface target;
- a submarine or a submerged weapons barge launching a missile or reconnaissance drone programmed to seek out a target;
- an aircraft (e.g., the aircraft **130**) dispensing a reconnaissance drone programmed to seek out a target;
- a ground-based facility launching a missile or a reconnaissance drone programmed to seek out a target; or
- a satellite or other space-based platform launching a missile programmed to seek out a target.

Thus, the aircraft **130** may more generically be described as a "platform" from which the submunitions **120** are dispensed. Similarly, the submunitions **120** might more generically be referred to as a "vehicle" dispensed by the "platform." The present invention therefore includes, in a general sense, a platform from which a vehicle is dispensed to implement a mission profile promulgated in accordance with the present invention. The more general terms "platform" and "vehicle" shall hereafter be used in describing the aircraft **130** and the submunitions **120**, respectively.

The invention also admits wide variation in the manner in which the target information is ascertained. Some implementation will simply assume values for one or more of the TLE, target heading, and target speed. In one implementation in which this information is received, as in the scenario **100**, the platform may receive the information from a variety of sources. For instance, the information may be received from or relayed by a satellite, or received from a ground-based facility, or from a submersible such as a submarine.

Returning to FIG. **1**, and now referring to both FIG. **2** and FIG. **3**, the mission scenario **100** begins by ascertaining a plurality of target information, namely a position **200**, velocity **210**, and location error **220**, all conceptually illustrated in FIG. **2**, of the target **110**, as set forth in the box **310** of FIG. **3**. These parameters will be referred to as the "initial target location," "target velocity," and "base TLE," respectively. The target location **200** defines a pattern area **250** and a threat approach limit **260**. The threat approach limit **260** is the boundary beyond which a dispense of the vehicles **120** would compromise the platform **130**, e.g., a radar volume within which the platform **130** might be detected. Some embodiments of the present invention might be limited such that the vehicles **120** may only be dispensed from beyond the target approach limit **260**. However, the invention is not so limited in all its embodiments, and some embodiments may omit any consideration of the threat approach limit **260**.

Note that the velocity **310** of the target **110** is represented as the heading and speed of the target **110** in the illustrated embodiment. As will be appreciated by those skilled in the art having the benefit of this disclosure, the altitude/depth of the target **110** and/or vehicles **120** influences the "footprint" of the search. For instance, higher altitudes for the vehicles **120** yield a larger footprint, i.e., more area is searched at any given time, and permits a wider separation between legs of the search pattern. However, higher altitudes reduce the resolution of the returned data, making target identification more difficult. The altitude/depth of the vehicles **120** and the target **110** is not otherwise significant in promulgating the mission profile.

The target information is "ascertained" in the illustrated embodiment prior to launching the vehicles **120**. The vehicles **120** are programmed with a predetermined mission profile that includes the target information and a preliminary pattern predicated on that information. The preliminary mission profile defines the dispense point ("DP") **230** at which the vehicles **120** are dispensed and one or more start points ("SPs") **240** at which the vehicles **120** are to start executing the pattern in accordance with the preliminary mission profile. The altitude/depth for the vehicles **120** is, in this particular embodiment, a part of the preliminary mission profile. In this embodiment, the method of the invention is actually used to update, or replan, the preliminary mission profile. However, in alternative embodiments, the vehicles **120** may be loaded aboard the platform **130** without a preliminary mission profile. In this scenario, the target information may be transmitted to the platform **130** from which a mission profile may be originally promulgated. Furthermore, in various alternative embodiments, the target information may be ascertained before or after the vehicles **120** are dispensed, depending on the implementation.

The mission scenario **100** then autonomously determines a pattern from the ascertained target information, as set forth in the box **320** of FIG. **3**. As mentioned above, in the illustrated embodiment, the vehicles **120** are loaded with a preprogrammed mission profile that defines a base pattern such that the pattern determined in the box **320** is an "updated" or "modified" pattern. However, in alternative embodiments, this pattern might be an originally determined pattern.

One particular embodiment **400** is illustrated in FIG. **4A** and FIG. **4B**. In this particular implementation **400**, this autonomous determination is performed in accordance with the method **500** in FIG. **5**, which is graphically illustrated in FIG. **6**. This particular embodiment employs two formations **405** of vehicles **120**, each formation **405** including at least one vehicle **120**. The formations **405** are sequentially dispensed at the dispense point **230**. One formation **405** then proceeds to the start point **410** and the other formation proceeds to the start point **412** in accordance with the promulgated mission profile.

Referring now to FIG. **5** and FIG. **6**, the method **500** begins by projecting along a target axis **610** the TLE distance to establish the intersections **615** between the target axis **610** and the TLE **420**, as set forth in the box **505**. Note that the target axis is defined by the heading (symbolized by the arrow **210**) of the target and the target's location **200**. This projection establishes the perpendicular orientation of the pattern relative to the target's heading **210**, which tends to improve performance. Thus, it is desirable to ascertain a true heading **210** instead of assuming one. Note, however, that assuming the heading does not prevent implementation of the present invention, but merely affects the orientation of the pattern relative to the target's heading. Similarly, knowing the target's speed is also desirable, as it permits a smaller TLE **420**, but a target speed may be assumed and reflected in a larger magnitude for the TLE **420**.

The method **500** then proceeds by projecting perpendicularly left and right from each of the intersections **615** to identify two start point pairs **620**, **622** and **625**, **627**, as set forth in the box **510**. The projections are of such a length that the start points **620**, **622** and **625**, **627** are at least as great as the TLE distance. The TLE distance was determined in establishing the intersections **615**.

The method **500** then selects the start point pair **620**, **622** and **625**, **627** having the single closest start point **620**, **622**, **625**, **627**, to the platform **130**, as is set forth in the box **515**. In the illustrated in embodiment, the single closest start point is **622**, and so the start point pair **620**, **622** is selected. The method then selects the start point **620**, **622** of the previously selected start point pair **620**, **622** that is farthest from the platform **130**, as set forth in the box **520**. In the illustrated embodiment, the start point **620** is selected.

Once selected, the start point **620** becomes the "base start point" for the "TLE **15** iteration", described in greater detail below, by which an adjusted start point is identified, as set forth in the box **522**. The "TLE iteration" is disclosed relative to FIG. **7** below. Note, however, in implementations in which a preliminary mission profile is being replanned, one of the preprogrammed start points may be identified as the "base start point" for use in identifying the adjusted start point. Thus, not all embodiments will employ the acts set forth in boxes **505**–**520**.

FIG. **7** charts one particular technique for determining the adjusted start points **410**, **412** from which the pattern in FIG. **4B** is begun. The method of FIG. **7** is graphically illustrated in FIG. **8**. Referring now to FIG. **8**, the technique, in general terms, involves iteratively determining a series of adjusted start points **810** along a start point axis **820** based on adjusted times of flight and adjusted TLEs. Note that only one adjusted start point **810** is illustrated for the sake of clarity. Eventually, successive values for the adjusted start points **810**, times of flight, and adjusted TLEs will converge. The difference that will indicate convergence will be implementation specific. In one particular implementation, the adjusted TLEs are said to have converged when the difference in two successive values differs by less than 0.1 m. Once the convergence occurs, the adjusted start point **810** is mirrored and the serpentine traces **420**, **430** (shown in FIG. **4B**) can be plotted.

More precisely, the method **700** begins by first calculating a time of flight direct from the platform **130** to the base start point **240**, as represented by the arrow **830** and as set forth in the box **710**. The direct time of flight **830** is then used to determine target movement from the target location **200**, as set forth in the box **720**, resulting in an adjusted TLE **840**, as set forth in the box **730**. An adjusted start point **810** is then determined from the adjusted TLE **840**, as set forth in the box **740**. Next, the method **700** calculates a total time of flight to the target axis **610** ("TTTA") based on the adjusted start point **810** and the total time of flight to the adjusted start point **810** ("TTSP") based from the dispense point **230**, as set forth in the boxes **750**, **760**. Then method **700** then updates the adjusted TLE **840** to obtain an updated adjusted TLE **860**, as set forth in the box **770**.

If the values have converged, as described above, the process of obtaining the adjusted start point **810** is finished.

Otherwise, boxes **740–770** are iterated until they do. Convergence is determined by comparing the updated adjusted TLE **860** to the previously adjusted TLE **860** or, in the first iteration, the TLE **220**. If the difference exceeds a predetermined threshold, then they have not converged and the iteration begins. If the difference is within the threshold, then the values are said to have converged.

The adjusted start point **810** in FIG. **8** typically corresponds to the start point **410** in FIG. **4**A and FIG. **4**B. Note that some embodiments might employ a vehicle that performs "blind turns" between the legs of a trace, i.e., turns during which the vehicle cannot scan the TLE **420**. In these embodiments, the adjusted start point **810** should be adjusted yet again to ensure full coverage of the TLE **420**. More particularly, the adjusted start point **810** should be moved along the leg line an amount equal to the turning radius of the vehicle. Returning now to FIG. **5** and FIG. **6**, assume that the start point **620** has been adjusted and now corresponds to the adjusted start point **810**. The method **500**, in this particular embodiment, next projects a distance X along the leg line to find an ultimate start point **630**, as set forth in the box **525**. Note that this penultimate adjustment may be performed even in embodiments that do not employ vehicles that perform blind turns to better ensure full coverage of the TLE **420**. The method **500** then mirrors the start point **630** to obtain the start point **632**, which will correspond to the start point **412** in FIG. **4**A and FIG. **4**B, as set forth in the box **530**.

The method **500** then lays out the front-end and back-end patterns, i.e., the serpentine traces **430**, **432** in FIG. **4**B, as set forth in the box **535**. This typically involves determining the leg length, any necessary turn radius, and the leg separation. This may be done in conventional fashion once the adjusted start points **410**, **412** have been determined in accordance with the present invention. The leg separation is determined by the altitude/depth of the vehicles **120**. This factor is preplanned in this particular embodiment, as are the number of vehicles **120** in each formation **405**, the separation between the vehicles **120** in the formations **405**. The number of legs is obtained by dividing the adjusted TLE by the leg separation. The leg length is the diameter of the adjusted TLE plus twice the blind turn distance on each end of each leg.

In the illustrated embodiment, the method **500** concludes by dispensing a first formation **405** and a second formation **405**, as set forth in the box **540**. The formations **405** are dispensed from the platform **130** at the dispense point **230** in accordance with the mission profile. In the illustrated embodiment, the dispense altitude is defined in the preliminary mission profile. The release parameters, including the release azimuth, release distance, release altitude, descent angle and descent speed are also preplanned, but may be collected in real time at the platform **130** at the dispense point **230** immediately prior to releasing the vehicles **120**. This data, along with the age of the data, may be displayed to the operator of the platform **130**, e.g., on a heads-up display.

The platform **130** is shown dispensing two vehicles **120**, each vehicle **120** constituting a formation **405** of one. Various implementations of this particular embodiment may employ formations **405** of varying numbers. One particular implementation employs two formations **405** of four vehicles **120** for what is known as a "flight of eight." However, various implementations may use varying numbers of vehicles **120** in each formation. Some implementations may employ, for example, four vehicles **120** in one formation and two vehicles **120** in a second formation. Once dispensed, the formations **405** then implement the pattern, i.e., begin following the serpentine traces **430**, **432**. Where the formations **405** comprise more than a single vehicle, the formations **405** are centered on the traces **430**, **432**.

Some aspects of the present invention are software implemented. Some portions of the detailed descriptions herein are consequently presented in terms of a software implemented process involving symbolic representations of operations on data bits within a memory in a computing system or a computing device. These descriptions and representations are the means used by those in the art to most effectively convey the substance of their work to others skilled in the art. The process and operation require physical manipulations of physical quantities. Usually, though not necessarily, these quantities take the form of electrical, magnetic, or optical signals capable of being stored, transferred, combined, compared, and otherwise manipulated. It has proven convenient at times, principally for reasons of common usage, to refer to these signals as bits, values, elements, symbols, characters, terms, numbers, or the like.

It should be borne in mind, however, that all of these and similar terms are to be associated with the appropriate physical quantities and are merely convenient labels applied to these quantities. Unless specifically stated or otherwise as may be apparent, throughout the present disclosure, these descriptions refer to the action and processes of an electronic device, that manipulates and transforms data represented as physical (electronic, magnetic, or optical) quantities within some electronic device's storage into other data similarly represented as physical quantities within the storage, or in transmission or display devices. Exemplary of the terms denoting such a description are, without limitation, the terms "processing," "computing," "calculating," "determining," "displaying," and the like.

Note also that the software implemented aspects of the invention are typically encoded on some form of program storage medium or implemented over some type of transmission medium. The program storage medium may be magnetic (e.g., a floppy disk or a hard drive) or optical (e.g., a compact disk read only memory, or "CD ROM"), and may be read only or random access. Similarly, the transmission medium may be twisted wire pairs, coaxial cable, optical fiber, or some other suitable transmission medium known to the art. The invention is not limited by these aspects of any given implementation.

FIG. **9** illustrates some of the variations that may be found in various implementations of the present invention. The target may be:

- airborne, e.g., the aircraft **905**, **910**, or the satellite **915**;
- surface based, e.g., the ship **920** or the ground facility **925**; or
- submerged underwater, e.g., the submarine **930** or the submerged weapons barge **935**.

The nature and expected identity of the target will strongly influence the nature of the vehicle, as will the goal of the mission. For instance:

- if the goal is simply to locate and/or identify the target, the vehicle(s) may be implemented using reconnaissance drones such as the drone **940**;
- if the target is to be destroyed, then the vehicle may be implemented using a guided weapon **945**, such as a flying submunition or a cruise missile, if the target is airborne or surface based,
- if the target is to be destroyed, then the vehicle may be implemented using a guided weapon such as the

SONAR-equipped submersible vehicle (such as a torpedo) **950** if the target is submerged.

Similarly, the dispensing platform may be:

airborne, e.g., the aircraft **905**, **910**, or the satellite **915**;

surface based, e.g., the ship **920** or the ground facility **925**; or

submerged underwater, e.g., the submarine **930** or the submerged weapons barge **935**.

Still other variations in the nature of the target, vehicle, and dispensing platform may become apparent to those skilled in the art and are included within scope and spirit of the invention.

Other aspects of the invention are similarly subject to variation. Other than the target location, the target information may be ascertained by observation or assumed at some value. The target location information must be observed or otherwise determined and cannot be assumed. The vehicle may directly ascertain the target information itself, or receive it from, for example, any one or more of the aircraft **905**, **910**, satellite **915**, ship **920**, ground facility **925**, submarine **930**, submerged weapons barge **935**, or the satellite **955**. Furthermore, the target information may be ascertained either before or after the vehicle is dispensed, depending on the implementation. Again, still other variations in the nature of the target, vehicle, and dispensing platform may become apparent to those skilled in the art and are included within scope and spirit of the invention.

Thus, note the flexibility with which various embodiments might implement the hardware. Referring now to FIG. **10**A, generally speaking, the hardware comprises a receiver **1000** by which the target information, or at least the target location, may be received; a computing device **1010**, and a program storage device **1020**. The program storage device **1020** is encoded with instructions that, when executed by the computing device **1010**, perform the method **500** of FIG. **5**, using the target information received via the receiver **1000** or estimated as discussed above. However, the receiver **1000**, computing device **1010**, and the program storage device **1020** may all comprise a portion of a platform **1030**, as shown in FIG. **10**B, a portion of a vehicle **1040** as shown in FIG. **10**C, or distributed across the platform **1030** and the vehicle **1040**, as shown in FIG. **10**D.

FIG. **11** illustrates one particular hardware implementation of the embodiment shown in FIG. **4**A to FIG. **8**. The platform **1030** includes a receiver **1000**, a computing device **1010**, and a program storage device **1020**. Each vehicle **1040** includes a computing device **1010** and a program storage device **1020**. In operation, the platform **1030** receives the target information, including at least the target location, via the receiver **1000**. The computing device **1010** invokes the software encoded on the program storage device **1020** to autonomously determine a pattern in accordance with method **500** of FIG. **5**. Once the pattern is autonomously determined, it is downloaded to the vehicles **1040** via their respective computing devices **1010** and stored into their respective program storage devices **1020**. More particularly, the parameters for the front-end trace are downloaded to one vehicle **1040** and the parameters for the back-end trace are downloaded to the other vehicle **1040**. The platform **1000** then dispenses the vehicles **1040** which then fly to their respective start points and implement their assigned traces—one the back-end trace and one the front-end trace.

This concludes the detailed description. The following references are hereby incorporated by reference for all purposes as if set forth herein verbatim:

U.S. application Ser. No. 09/847,224, entitled "Autonomous Mission Profile Planning," filed on an even date herewith in the name of William V. Harding, and commonly assigned herewith.

U.S. application Ser. No. 09/263,411, entitled "Dual Mode Semi-Active Laser/Laser Radar Seeker," filed Mar. 5, 1999, now U.S. Pat. No. 6,262,800, in the name of the inventor Lewis G. Minor, now assigned to Lockheed Martin Corporation;

U.S. Pat. No. 5,893,085, entitled "Dynamic Fuzzy Logic Process for Identifying Objects in Three-Dimensional Data," issued Apr. 6, 1999, to Lockheed Martin Corporation as assignee of the inventor Ronald W. Phillips;

U.S. Pat. No. 5,898,483, entitled "Method for Increasing LADAR Resolution," issued Apr. 27, 1999, to Lockheed Martin Corporation as assignee of the inventor Edward Max Flowers;

U.S. Pat. No. 5,285,461, entitled "Improved Laser RADAR Transceiver," issued Feb. 5, 1994, to Loral Vought Systems Corporation (now Lockheed Martin Corporation) as assignee of the inventors Nicholas J. Krasustsky and Lewis G. Minor;

U.S. Pat. No. 5,224,109, entitled "Laser RADAR Transceiver," issued Jun. 29, 1993, to LTV Missiles and Electronics Group (now Lockheed Martin Corporation) as assignee of the inventors Nicholas J. Krasustsky and Lewis G. Minor; and

U.S. Pat. No. 5,200,606, entitled "Laser RADAR Scanning System," issued Apr. 6, 1993, to LTV Missiles and Electronics Group (now Lockheed Martin Corporation) as assignee of the inventors Nicholas J. Krasustsky, Lewis G. Minor, and Edward M. Flowers.

The particular embodiments disclosed above are illustrative only, as the invention may be modified and practiced in different but equivalent manners apparent to those skilled in the art having the benefit of the teachings herein. Furthermore, no limitations are intended to the details of construction or design herein shown, other than as described in the claims below. It is therefore evident that the particular embodiments disclosed above may be altered or modified and all such variations are considered within the scope and spirit of the invention. Accordingly, the protection sought herein is as set forth in the claims below.

What is claimed:

1. A method for planning a mission profile in real time, comprising:

ascertaining a plurality of target information, including a target location, a target velocity, and a target location error; and

autonomously determining a pattern from the ascertained target information.

2. The method of claim **1**, wherein ascertaining the target information includes assuming a value for at least one of the target velocity and the target location error.

3. The method of claim **1**, wherein ascertaining the plurality of target information includes ascertaining a target location that places the target in the air, on the surface, or submerged underwater.

4. The method of claim **1**, wherein ascertaining the plurality of target information includes receiving at least one of the target location, target velocity, and target location error in a transmission.

5. The method of claim **1**, further comprising:

dispensing at least a first formation including at least one vehicle; and

implementing the pattern with the vehicle.

6. The method of claim 5, wherein ascertaining the target information includes:

acquiring the target information at a platform from which the first formation is dispensed;

receiving at least the target location from a platform other than the platform from which the first formation is dispensed; or

acquiring the target information aboard the vehicle.

7. The method of claim 5, wherein dispensing the first formation includes:

launching the first formation from an airborne platform; or

launching the first formation from a surface-based platform; or

launching the first formation from an underwater platform.

8. The method of claim 5, wherein the vehicle includes a vehicle selected from the group consisting of a submersible vehicle, a reconnaissance drone, a flying submunition, a cruise missile, and a smart bomb.

9. The method of claim 1, wherein autonomously determining the pattern from the ascertained target information includes autonomously determining a serpentine pattern.

10. The method of claim 1, wherein autonomously determining the pattern from the ascertained target information includes:

projecting along a target axis a distance of the target location error to establish two intersections of the target axis with the target location error;

projecting perpendicularly left and right from the intersections to determine a pair of possible start point pairs;

selecting the possible start point pair including a closest single start point;

selecting the farthest start point of the selected start point pair;

identifying an adjusted start point;

mirroring the adjusted start point to obtain an adjusted start point pair; and

laying out the front-end and back-end traces from the adjusted start point pair.

11. The method of claim 10, wherein identifying an adjusted start point includes:

determining a base time of flight to a base start point;

determining from the target information a potential target movement during the base time of flight;

determining an adjusted target location error from the potential target movement and the target information;

generating an adjusted start point;

ascertaining a total time of flight to a target axis predicated on the adjusted start point;

ascertaining a total time of flight to the adjusted start point;

updating the adjusted target location error from the total time of flight to the adjusted start point; and

iterating the generation of the adjusted start point, the ascertainment of the total time of flight to the target axis, the ascertainment of the total time of flight to the adjusted start point, and the updating of the adjusted target location error until the value for the same converge.

12. The method of claim 11, further comprising adjusting the adjusted start point pair by a predetermined distance along a leg of each of the front-end and back-end traces.

13. The method of claim 10, further comprising:

dispensing a first and a second formation, each of the first and second formations including at least one vehicle, at the dispense point defined by the preplanned mission profile; and

implementing the pattern with the first and second formations, the first formation implementing the pattern at a first one of the first or second start point pairs and the second formation implementing the pattern at a second one of the first or second start point pairs.

14. The method of claim 1, further comprising identifying the target.

15. The method of claim 14, wherein identifying the target includes employing an automatic target recognition system.

16. The method of claim 14, further comprising attacking the target.

17. A method for planning a mission profile in real time, comprising:

ascertaining a plurality of target information, including a target location, a target velocity, and a target location error; and

autonomously determining a pattern including a front-end trace and a back-end trace from the ascertained target information, including:

projecting along a target axis a distance of the target location error to establish two intersections of the target axis with the target location error;

projecting perpendicularly left and right from the intersections to determine a pair of possible start point pairs;

selecting the possible start point pair including a closest single start point;

selecting the farthest start point of the selected start point pair;

identifying an adjusted start point;

mirroring the adjusted start point to obtain an adjusted start point pair; and

laying out the front-end and back-end traces from the adjusted start point pair.

18. The method of claim 17, wherein ascertaining the target information includes assuming a value for at least one of the target velocity and the target location error.

19. The method of claim 17, wherein ascertaining the plurality of target information includes ascertaining a target location that places the target in the air, on the surface, or submerged underwater.

20. The method of claim 17, wherein ascertaining the plurality of target information includes receiving at least one of the target location, target velocity, and target location error in a transmission.

21. The method of claim 17, further comprising:

dispensing at least a first formation including at least one vehicle; and

implementing the pattern with the vehicle.

22. The method of claim 21, wherein ascertaining the target information includes:

acquiring the target information at a platform from which the first formation is dispensed;

receiving at least the target location from a platform other than the platform from which the first formation is dispensed; or

acquiring the target information aboard the vehicle.

23. The method of claim 21, wherein dispensing the first formation includes:

launching the first formation from an airborne platform; or launching the first formation from a surface-based platform; or

launching the first formation from an underwater platform.

24. The method of claim **21**, wherein the vehicle includes a vehicle selected from the group consisting of a submersible vehicle, a reconnaissance drone, a flying submunition, a cruise missile, and a smart bomb.

25. The method of claim **17**, wherein autonomously determining the pattern from the ascertained target information includes autonomously determining a serpentine pattern.

26. The method of claim **17**, wherein identifying an adjusted start point includes:

determining a base time of flight to a base start point;

determining from the target information a potential target movement during the base time of flight;

determining an adjusted target location error from the potential target movement and the target information;

generating an adjusted start point;

ascertaining a total time of flight to a target axis predicated on the adjusted start point;

ascertaining a total time of flight to the adjusted start point;

updating the adjusted target location error from the total time of flight to the adjusted start point; and

iterating the generation of the adjusted start point, the ascertainment of the total time of flight to the target axis, the ascertainment of the total time of flight to the adjusted start point, and the updating of the adjusted target location error until the value for the same converge.

27. The method of claim **26**, further comprising adjusting the adjusted start point pair by a predetermined distance along a leg of each of the front-end and back-end patterns.

28. The method of claim **17**, further comprising:

dispensing a first and a second formation, each of the first and second formations including at least one vehicle, at the dispense point defined by the preplanned mission profile; and

implementing the pattern with the first and second formations, the first formation implementing the pattern at a first one of the first or second start point pairs and the second formation implementing the pattern at a second one of the first or second start point pairs.

29. The method of claim **17**, further comprising identifying the target.

30. The method of claim **29**, wherein identifying the target includes employing an automatic target recognition system.

31. The method of claim **29**, further comprising attacking the target.

32. An apparatus for use in planning a mission profile in real time, comprising:

a receiver capable of receiving a plurality of target information, the target information including a target location;

a computing device; and

a program storage device encoded with instructions that, when executed by the computing device, perform a method for autonomously determining a pattern from the target information.

33. The apparatus of claim **32**, wherein the method for autonomously determining the pattern from the target information includes assuming a value for at least one of a target velocity and a target location error.

34. The apparatus of claim **32**, wherein the receiver, the computing device, and the program storage device are distributed across a platform and a vehicle.

35. The apparatus of claim **34**, wherein the platform is an airborne platform, a surface platform, or a submerged platform.

36. The apparatus of claim **34**, wherein the vehicle includes a vehicle selected from the group consisting of a submersible vehicle, a reconnaissance drone, a flying submunition, a cruise missile, and a smart bomb.

37. The apparatus of claim **32**, wherein the receiver, the computing device, and the program storage device comprise a portion of a platform.

38. The apparatus of claim **37**, wherein the platform is an airborne platform, a surface platform, or a submerged platform.

39. The apparatus of claim **32**, wherein the receiver, the computing device, and the program storage device comprise a portion of a vehicle.

40. The apparatus of claim **39**, wherein the vehicle includes a vehicle selected from the group consisting of a submersible vehicle, a reconnaissance drone, a flying submunition, a cruise missile, and a smart bomb.

41. The apparatus of claim **32**, wherein the method for autonomously determining the pattern from the ascertained target information includes autonomously determining a serpentine pattern.

42. The apparatus of claim **32**, wherein the method for autonomously determining the pattern includes:

projecting along a target axis a distance of the target location error to establish two intersections of the target axis with the target location error;

projecting perpendicularly left and right from the intersections to determine a pair of possible start point pairs;

selecting the possible start point pair including a closest single start point;

selecting the farthest start point of the selected start point pair;

identifying an adjusted start point;

mirroring the adjusted start point to obtain an adjusted start point pair; and

laying out the front-end and back-end traces from the adjusted start point pair.

43. The apparatus of claim **42**, wherein identifying an adjusted start point in the method for determining the pattern includes:

determining a base time of flight to a base start point;

determining from the target information a potential target movement during the base time of flight;

determining an adjusted target location error from the potential target movement and the target information;

generating an adjusted start point;

ascertaining a total time of flight to a target axis predicated on the adjusted start point;

ascertaining a total time of flight to the adjusted start point;

updating the adjusted target location error from the total time of flight to the adjusted start point; and

iterating the generation of the adjusted start point, the ascertainment of the total time of flight to the target axis, the ascertainment of the total time of flight to the adjusted start point, and the updating of the adjusted target location error until the value for the same converge.

44. The apparatus of claim 43, wherein the method for autonomously determining the pattern further comprises adjusting the adjusted start point pair by a predetermined distance along a leg of each of the front-end and back-end traces.

45. The apparatus of claim 32, further comprising an automatic target recognition system.

46. The apparatus of claim 45, wherein the method for autonomously determining the pattern further comprises identifying the target.

47. An apparatus for planning a mission profile in real time, comprising:

a receiver capable of receiving a plurality of target information, the target information including a target location;

a computing device; and

a program storage device encoded with instructions that, when executed by the computing device, perform a method for autonomously determining a pattern including a front-end trace and a back-end trace from the ascertained target information, the method including:

projecting along a target axis a distance of the target location error to establish two intersections of the target axis with the target location error;

projecting perpendicularly left and right from the intersections to determine a pair of possible start point pairs;

selecting the possible start point pair including a closest single start point;

selecting the farthest start point of the selected start point pair;

identifying an adjusted start point;

mirroring the adjusted start point to obtain an adjusted start point pair; and

laying out the front-end and back-end traces from the adjusted start point pair.

48. The apparatus of claim 47, wherein the method for autonomously determining the pattern from the target information includes assuming a value for at least one of a target velocity and a target location error.

49. The apparatus of claim 47, wherein the receiver, the computing device, and the program storage device are distributed across a platform and a vehicle.

50. The apparatus of claim 49, wherein the platform is an airborne platform, a surface platform, or a submerged platform.

51. The apparatus of claim 49, wherein the vehicle includes a vehicle selected from the group consisting of a submersible vehicle, a reconnaissance drone, a flying submunition, a cruise missile, and a smart bomb.

52. The apparatus of claim 47, wherein the receiver, the computing device, and the program storage device comprise a portion of a platform.

53. The apparatus of claim 52, wherein the platform is an airborne platform, a surface platform, or a submerged platform.

54. The apparatus of claim 47, wherein the receiver, the computing device, and the program storage device comprise a portion of a vehicle.

55. The apparatus of claim 54, wherein the vehicle includes a vehicle selected from the group consisting of a submersible vehicle, a reconnaissance drone, a flying submunition, a cruise missile, and a smart bomb.

56. The apparatus of claim 47, wherein the method for autonomously determining the pattern from the ascertained target information includes autonomously determining a serpentine pattern.

57. The apparatus of claim 47, wherein identifying an adjusted start point in the method for determining the pattern includes:

determining a base time of flight to a base start point;

determining from the target information a potential target movement during the base time of flight;

determining an adjusted target location error from the potential target movement and the target information;

generating an adjusted start point;

ascertaining a total time of flight to a target axis predicated on the adjusted start point;

ascertaining a total time of flight to the adjusted start point;

updating the adjusted target location error from the total time of flight to the adjusted start point; and

iterating the generation of the adjusted start point, the ascertainment of the total time of flight to the target axis, the ascertainment of the total time of flight to the adjusted start point, and the updating of the adjusted target location error until the value for the same converge.

58. The apparatus of claim 57, wherein the method for autonomously determining the pattern further comprises adjusting the adjusted start point pair by a predetermined distance along a leg of each of the front-end and back-end traces.

59. The apparatus of claim 47, further comprising an automatic target recognition system.

60. The apparatus of claim 59, wherein the method for autonomously determining the pattern further comprises identifying the target.

61. An apparatus capable of planning a mission profile in real time, comprising:

a platform, including

a receiver capable of receiving a plurality of target information, the target information including a target location;

a first computing device; and

a first program storage device encoded with instructions that, when executed by the computing device, perform a method for autonomously determining a pattern including a front-end trace and a back-end trace from the ascertained target information, the method including:

projecting along a target axis a distance of the target location error to establish two intersections of the target axis with the target location error;

projecting perpendicularly left and right from the intersections to determine a pair of possible start point pairs;

selecting the possible start point pair including a closest single start point;

selecting the farthest start point of the selected start point pair;

identifying an adjusted start point;

mirroring the adjusted start point to obtain an adjusted start point pair; and

laying out the front-end and back-end traces from the adjusted start point pair;

a first vehicle, including:

a second program storage device capable of being encoded with the pattern by the first computing device; and

a second computing device capable of implementing the pattern encoded on the second program storage device through control of the vehicle; and a second vehicle, including:

a third program storage device capable of being encoded with the pattern by the first computing device; and

a third computing device capable of implementing the pattern encoded on the third program storage device through control of the vehicle.

62. The apparatus of claim **61**, wherein the method for autonomously determining the pattern from the target information includes assuming a value for at least one of a target velocity and a target location error.

63. The apparatus of claim **61**, wherein the platform is an airborne platform, a surface platform, or a submerged platform.

64. The apparatus of claim **61**, wherein the first and second vehicles include a vehicle selected from the group consisting of a submersible vehicle, a reconnaissance drone, a flying submunition, a cruise missile, and a smart bomb.

65. The apparatus of claim **61**, wherein the method for autonomously determining the pattern from the ascertained target information includes autonomously determining a serpentine pattern.

66. The apparatus of claim **61**, wherein identifying an adjusted start point in the method for determining the pattern includes:

determining a base time of flight to a base start point;

determining from the target information a potential target movement during the base time of flight;

determining an adjusted target location error from the potential target movement and the target information;

generating an adjusted start point;

ascertaining a total time of flight to a target axis predicated on the adjusted start point;

ascertaining a total time of flight to the adjusted start point;

updating the adjusted target location error from the total time of flight to the adjusted start point; and

iterating the generation of the adjusted start point, the ascertainment of the total time of flight to the target axis, the ascertainment of the total time of flight to the adjusted start point, and the updating of the adjusted target location error until the value for the same converge.

67. The apparatus of claim **66**, wherein the method for autonomously determining the pattern further comprises adjusting the adjusted start point pair by a predetermined distance along a leg of each of the front-end and back-end traces.

68. The apparatus of claim **61**, further comprising an automatic target recognition system.

69. The apparatus of claim **68**, wherein the method for autonomously determining the pattern further comprises identifying the target.

70. An apparatus for planning a mission profile in real time, comprising:

means for ascertaining a plurality of target information, including a target location, a target velocity, and a target location error; and

means for autonomously determining a pattern from the ascertained target information.

71. An apparatus for planning a mission profile in real time, comprising:

means for ascertaining a plurality of target information, including a target location, a target velocity, and a target location error; and

means for autonomously determining a pattern including a front-end trace and a back-end trace from the ascertained target information, including:

means for projecting along a target axis a distance of the target location error to establish two intersections of the target axis with the target location error;

means for projecting perpendicularly left and right from the intersections to determine a pair of possible start point pairs;

means for selecting the possible start point pair including a closest single start point;

means for selecting the farthest start point of the selected start point pair;

means for identifying an adjusted start point;

means for mirroring the adjusted start point to obtain an adjusted start point pair; and

means for laying out the front-end and back-end traces from the adjusted start point pair.

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