

TARGET LOCATING AND ENGAGING SYSTEM

FIELD OF THE INVENTION

[0001] The present invention generally relates to a method and system for locating and engaging targets using an aerial vehicle, an aerial vehicle tracking system, a target locating system and a target engagement system.

BACKGROUND TO THE INVENTION

[0002] One of the current techniques for locating, identifying and engaging hostile forces in an urban warfare involves the use of helicopter gunships flying in the sky with Line Of Sight (LOS) weapons or Non-Line-Of-Sight (NLOS) missiles to engage targets that are hiding in difficult to reach locations. However, the capability of helicopter gunship is limited in that they cannot be flown safely in narrow and cramped surroundings. This is especially true in urban environments where the hostile forces are in close proximity and could be waiting in ambush.

[0003] Unmanned Aerial Vehicle (UAV) with Global Positioning System (GPS) and other sensors can be used to locate hostile forces hiding in the aforementioned environments. However GPS signals can be jammed or could otherwise be unavailable at the time of the engagement with the hostile forces. GPS that is used to determine the absolute position of the UAV flying in an urban environment can also have poor satellite coverage and can suffer inaccuracy due to cloudy weather or the surrounding tall buildings especially when the GPS is used without DGPS (Differential GPS) or WAAS (Wide Area Augmentation System).

1
2 **[0004]** The absolute location of an UAV can also be determined by a surveying
3 instrument or a laser distance sensor by placing the crosshair of the instrument or sensor onto
4 the flying UAV which can be at a distance away. However, in the time of tension, the
5 operator of the surveying instrument or the laser distance sensor may not be able to
6 accurately place the crosshair of the sensor onto the flying UAV within milli-seconds when
7 the ground operator of the UAV locates the target through a distance sensor, a digital
8 compass, an inclinometer; and identifies the target with a camera or electro-optics which are
9 mounted on the UAV. If this takes place, erroneous data would be obtained and a wrong
10 target position would be determined by a computer using triangulation algorithm.
11

12 SUMMARY OF THE INVENTION

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14 **[0005]** In accordance with the first aspect, a method and a system of locating and
15 engaging a target having an engagement zone and a target location comprises generating a
16 target location of the target using a target locating system, and using a target engagement
17 system to control a target destruction system. The target engagement system delivers a
18 projectile to the target based on the target location determined by computer through
19 triangulation. Further, the computer of the target engagement system checks an aerial vehicle
20 position of an aerial vehicle with the engagement zone of the target, and if the aerial vehicle
21 position is within the engagement zone of the target, then the target engagement system
22 disables the target destruction system to allow the aerial vehicle to be maneuvered safely
23 outside the engagement zone before the target is engaged.
24

1 **[0006]** From the foregoing disclosure and the following more detailed description of
2 various preferred embodiments, it will be apparent to those skilled in the art that the present
3 invention provides a significant advance in the technology of tracking and engaging targets
4 especially in an urban environment. Particularly significant in this regard is the potential that
5 the invention affords for providing a high quality target tracking and engaging system.
6 Additional features and advantages of various preferred embodiments will be better
7 understood in view of the detailed description provided below.

8 9 **BRIEF DESCRIPTION OF THE DRAWINGS**

10 **[0007]** Fig. 1 shows a target locating and engaging system in a preferred embodiment,
11 showing the use of triangulation to determine the locations of the target and the aerial vehicle.

12
13 **[0008]** Fig. 2 is a flowchart that shows generally the steps in the preferred
14 embodiment of the invention wherein the aerial vehicle tracking system has two or more 3
15 dimensional video cameras.

16
17 **[0009]** Fig. 3 is a flowchart that shows generally the steps in another preferred
18 embodiment of the invention wherein the aerial vehicle tracking system has a video tracking
19 camera and a laser distance sensor.

20
21 **[0010]** Fig. 4 is a flowchart that shows generally the steps in another preferred
22 embodiment of the invention wherein the aerial vehicle tracking system has a millimeter
23 wave radar with a 3D radar scanning mechanism.

24

[0011] It should be understood that the appended drawings are not necessarily to scale, presenting a somewhat simplified representation of various preferred features illustrative of the basic principles of the invention. The specific design features of the method and system for tracking and engaging targets as disclosed herein, including, by way of example, the specific dimensions of the method and system for tracking and engaging targets, will be determined in part by the particular intended application and use environment. Certain features of the illustrated embodiments have been enlarged or emphasized relative to others to help provide clear understanding. In particular, thin features may be thickened, for example, for clarity of illustration. All references to direction and position, unless otherwise indicated, refer to the orientation illustrated in the drawings.

DETAILED DESCRIPTION OF CERTAIN PREFERRED EMBODIMENTS

[0012] It will be apparent to those skilled in the art, that is, to those who have knowledge or experience in this area of technology, that many uses and design variations are possible for locating and engaging targets and are disclosed herein. The following detailed discussion of various alternatives and preferred features and embodiments will illustrate the general principles of the invention with reference to a method and system suitable for locating and engaging targets. Other embodiments suitable for other applications will be apparent to those skilled in the art given the benefit of this disclosure.

[0013] The invention disclosed herein is an improved method and system for target locating and engaging comprising an aerial vehicle 101, an aerial vehicle tracking system, a target locating system and a target engagement system. Fig. 1 shows various parts of the invention. Aerial vehicle 101 is equipped with a smart laser distance sensor 104, a video

1 camera or electro-optics 105 and a video transmitter 106. The aerial vehicle 101 or the smart
2 laser distance sensor 104 can also have an inclinometer or a MEMS accelerometer, a digital
3 compass and an encoder. The aerial vehicle 101 also has an aerial vehicle data up and down
4 link 107 to allow the smart laser distance sensor 104 and the video camera or electro-optics
5 105 to be controlled from the ground, and to provide the vector indicating the coordinate of
6 the target 103 with respect to the smart laser distance sensor 104, or an integral video and
7 data link and a radar reflector. The radar reflector enhances the reflected radar signal from the
8 aerial vehicle 101 especially to avoid confusion in locating the aerial vehicle 101 due to low
9 signal to noise ratio especially in an urban environment. The video camera or electro-optics
10 105 on the aerial vehicle 101 preferably has infrared, night vision, image and/or thermal
11 intensifying capabilities with or without the assistance of infrared illuminator to search and
12 identify targets in poor light conditions or to work effectively in night operation.

13
14 **[0014]** Since the aerial vehicle 101, which is preferably a VTOL (Vertical Take Off
15 and Landing) UAV (Unmanned Aerial Vehicle) has high maneuverability, the VTOL UAV is
16 effectively the gimbals for the video camera or electro-optics 105 and the smart laser distance
17 sensor 104. The aerial vehicle 101 can be manned by an external pilot on the ground or is
18 programmed to operate autonomously. The aerial vehicle 101 can also have audio capturing
19 and amplification capabilities.

20
21 **[0015]** The aerial vehicle tracking system can be installed on a vehicle 102 preferably
22 an armored fighting vehicle. The aerial vehicle tracking system preferably can comprise:
23 (i)(a) two or more 3-dimensional aerial vehicle tracking video cameras or electro-optics

108. The 3-dimensional aerial vehicle tracking video cameras are separated by a large baseline This is to improve the accuracy and to build up a precise three dimensional image of the aerial vehicle for tracking.; and

(b) a pan-tilt device 109 and joystick control 112 for an operator on the ground to place the crosshair of the cameras or electro-optics 108 onto the aerial vehicle 101 before the video tracking software is initiated by the operator for aerial vehicle tracking; and

(c) a computer 111 with 3 dimensional video tracking algorithm installed; and

(d) an up and down data link 115 and video link 114 transferring data and video between the aerial vehicle 101 and the vehicle 102; and

(e) a video display of the target 103 in the monitor 113 for target 103 searching and identification purposes; and

(f) an external pilot 118 on the ground maneuvering the aerial vehicle 101 for searching and identification of a target 103, and to maneuver the aerial vehicle 101 to a safe zone when subjected to sniper fire; and

(g) an infrared illuminator 116 which is manually controlled by an operator to enhance the visibility of the aerial vehicle 101 in poor light conditions and at night;

or

(ii)(a) a video tracking camera or electro-optics 105 installed in vehicle 102; and

(b) a smart laser distance sensor with an inclinometer, and a digital compass 110, and

(c) both (a) and (b) are mounted on a pan-tilt device 109 with joystick control 112 for an operator on the ground to place the crosshair of the camera or electro-optics 105 onto the aerial vehicle 101 before the video tracking software installed in the computer 111 is initiated for aerial vehicle tracking; and

(d) an up and down data link 115 and video link 114 between the aerial vehicle 101 and the vehicle 102; and

(e) a video display of the target 103 in the computer 111 monitor 113 for target 103 searching and identification purposes; and

(f) an external pilot 118 on the ground maneuvering the aerial vehicle 101 for searching and identification of a target 103, and to maneuver the aerial vehicle 101 to a safe zone when subjected to sniper fire; and

(g) an infrared illuminator 116 which is manually controlled by an operator to enhance the visibility of the aerial vehicle 101 in poor light conditions and at night;

or

(iii) (a) a Millimeter Wave Radar with a 3 Dimensional radar scanning mechanism;

and a 3D aerial vehicle tracking algorithm loaded in the computer 111; and

(b) the aerial vehicle 101 carries a radar reflector to enhance the signal; and

(c) the aerial vehicle tracking system also can have a digital compass 110 and an inclinometer;

and

(d) an up and down data link 115 and video link 114 between the aerial vehicle 101 and the vehicle 102; and

(e) a video display of the target 103 in the computer 111 monitor 113 for target 103 searching and identification purposes; and

(f) an external pilot 118 on the ground maneuvering the aerial vehicle 101 for searching and identification of a target 103, and to maneuver the aerial vehicle 101 to a safe zone when subjected to sniper fire; and

(g) an infrared illuminator 116 which is manually controlled by an operator to enhance the visibility of the aerial vehicle 101 in poor light conditions and at night.

1 **[0016]** The target locating system is mounted in a vehicle 102 preferably in an
2 armored fighting vehicle. The purpose of the target locating system is to calculate the
3 position (i.e. the distance, elevation and azimuth) of the target 103 from the vehicle 102.
4

5 **[0017]** The target engaging system comprises of a computer system 111 and a target
6 destruction system 117 which is mounted on a pan-tilt device preferably with a feedback
7 control to improve the accuracy of the target engaging system. The computer system 111 can
8 be loaded with a target locating and engaging algorithm to direct the target destruction system
9 117 to aim at the target 103 through the pan-tilt device for the elimination of the target 103.
10

11 **[0018]** The target destruction system 117 is preferably an air burst grenade launcher
12 mounted on a pan-tilt device, or a missile mounted on a pan tilt device. The target destruction
13 system 117 has single or multiple projectiles. The projectiles can be an air burst grenades or
14 other form of airburst projectiles that can destroy the target 103 even when it is hiding behind
15 a parapet or behind a window or a structure on an upper floor of a building. The target
16 engagement system and the target destruction system 117 are preferably installed as part of
17 the vehicle 102 which is preferably an armored fighting vehicle.
18

19 **[0019]** Fig 2 is a flowchart that shows generally the steps in the preferred
20 embodiment of the invention. Referring to step 201 in Fig 2, an external pilot 118 flies the
21 aerial vehicle 101 to a desired site to seek out target 103. In this preferred embodiment, the
22 aerial vehicle tracking system comprises two or more 3-dimensional aerial vehicle tracking
23 cameras or electro-optics 108. The 3-dimensional aerial vehicle tracking cameras 108 or
24 electro-optics 108 are spaced at a predetermined distance called a baseline and are mounted
25 on a pan-tilt device 109 with pan and tilt sensors (i.e. an encoder for pan measurement and an

inclinometer for tilt measurement) and a digital compass 110 to measure the azimuth from a specific reference direction such as magnetic North or true North, and the inclination with respect to the horizontal plane of the aerial vehicle tracking system. Referring back to Fig 1, the distance L_1 between the aerial vehicle tracking system and the aerial vehicle 101 is measured using triangulation of the 3-dimensional aerial vehicle tracking cameras or electro-optics 108. If the aerial vehicle tracking system comprises 3-dimensional aerial vehicle tracking video cameras, to achieve a larger baseline, the electro-optics 108 can be mounted in more than one vehicle 102 and can have one or more computers.

[0020] Referring to step 202 in Fig 2, in order to initiate the tracking of the aerial vehicle 101, an operator in the vehicle 102, preferably an armored fighting vehicle, maneuvers the pan-tilt device 109 which carries the 3 dimensional aerial vehicle tracking cameras or electro-optics 108, so as to place the aerial vehicle 101 within the field of view of the three-dimensional aerial vehicle tracking cameras or electro-optics 108. The operator then places the image of the aerial vehicle 101 onto the cross hair of the three-dimensional aerial vehicle tracking cameras and displays the image on the monitor 113 of a computer system 111.

[0021] At step 203 of Fig 2, the operator then activates the tracking software in the computer system 111 of the aerial vehicle tracking system and the 3 dimensional aerial vehicle tracking cameras or electro-optics 108 on the pan-tilt device 109 track the aerial vehicle 101 automatically.

[0022] At step 204 in Fig 2, the three-dimensional aerial vehicle tracking cameras or electro-optics 108 on the aerial vehicle 101 is used to locate and identify the target 103. The

external pilot 118 can use a remote control to maneuver the aerial vehicle 101 and use the aerial vehicle 101 as the gimbals for the video camera 105 and the smart laser distance sensor 104. The aerial vehicle 101 could also be autonomous and may be maneuvered to follow the preset commands for specific way points to cover a predetermined search area. Optionally, in poor light conditions or at night, the aerial vehicle tracking system may use an infrared illuminator 116 on the ground to illuminate the search area around target 103 and/or the aerial vehicle 101 to assist in searching of the target. The video image of the target 103 is down linked to the operator in the vehicle 102 and displayed on the monitor 113 of a computer 111.

[0023] Referring to step 205 in Fig 2, when the target 103 is located and identified via the video camera 105 in the aerial vehicle 101, the position of the target 103 with respect to the aerial vehicle 101 (L_2 , β_2 θ_2) is determined and transmitted through the downlink to the vehicle 102.

[0024] Now referring back to Fig 1, the position of the target 103 with respect to a position in space of the aerial vehicle 101 comprises the distance or line L_2 that extends from the target 103 to the aerial vehicle 101; a elevation angle β_2 which is the angle between L_2 and a horizontal plane of the aerial vehicle 101; and an azimuth θ_2 , an angle that is measured in the horizontal plane of the aerial vehicle 101 and is the angle between a reference direction such as the magnetic north or the true north and the direction of R_2 of the target 103. The reference direction of the azimuth of the aerial vehicle 101 can extend in a northward direction or in any other direction. θ_2 is the angle from the reference direction of the aerial vehicle 101, and the intersection of the vertical plane containing the target 103 and the horizontal plane of the aerial vehicle 101.

The following equations are applied in the computation of the position of the target 103 with respect to the position of the aerial vehicle:

$$R_2 = L_2 \cos \theta_2; \text{ and} \quad \text{Equation 1}$$

$$H_2 = L_2 \sin \theta_2 \quad \text{Equation 2}$$

Where R_2 is the horizontal component of distance L_2 ; and H_2 is the vertical component of distance L_2 . The distance L_2 can be measured using the smart laser distance sensor 104 on the aerial vehicle 101. The tilt angle β_2 can be measured using an inclinometer or a MEMS accelerometer. The azimuth θ_2 can be measured using a digital compass 110.

[0025] At step 206 in Fig 2, if hostile forces engage the aerial vehicle 101 while the aerial vehicle 101 is searching and locating the hostile forces, the aerial vehicle 101 can evade their attack by flying out of the line of fire, and still be able to determine the position of the target 103 from its new position even when the new position of the aerial vehicle 101 is behind a tree. The smart laser distance sensor 104 in the aerial vehicle 101 does this by a three point height routine, by measuring the horizontal distance R_2 from the smart laser distance sensor 104, even through a gap in the tree to a point in the vertical surface on the building or structure where target 103 or the hostile forces are located at.

[0026] The smart laser distance sensor 104 is able to do this because it has two modes. In mode 1, which is when the aerial vehicle 101 has line of sight with the target 103, the smart laser distance sensor 104 would provide the hypotenuse L_2 and θ_2 to the computer 111 in the target locating system. In this case, when the aerial vehicle 101 is behind an object such as a tree to avoid fire, a signal is sent by the operator in the vehicle 102 to the smart laser distance sensor 104, activating mode 2 of the laser measurement which measures the horizontal distance R_2 from the smart laser distance sensor 104 to a point on the vertical

surface of the building or structure where target 103 or the hostile forces are located at. After measuring the horizontal distance R_2 , the aerial vehicle 101 is then maneuvered so that the smart laser distance sensor 104 is pointed towards the target 103. The angle β_2 between the target 103 with respect to the horizontal plane of aerial vehicle 101 is then measured with the smart laser distance sensor 104. The distance L_2 of the target 103 from the aerial vehicle 101 can then be calculated using COSINE equation. The digital compass on the aerial vehicle 101 or in the smart laser distance sensor 104 will then provide the azimuth θ_2 .

[0027] At step 207 in Fig 2, measurements of L_2 , θ_2 and β_2 are sent wirelessly via the aerial vehicle data up and down links 107 to a data link 115 of the target locating system mounted in a vehicle 102 on the ground. At the same time, the video captured by the video camera 105 or electro-optics on the aerial vehicle 101 is transmitted wirelessly via a video transmitter 106 to the target image receiver 114 of the aerial vehicle tracking system and displays the image in the monitor 113 of the computer system 111.

[0028] Again referring to Fig 1, the following equations are applied in the process of triangulation to determine the position of the aerial vehicle 101 with respect to the position of the aerial vehicle tracking system (L_1 , θ_1 and β_1).

$$R_1 = L_1 \cos \beta_1; \text{ and} \quad \text{Equation 3}$$

$$H_1 = L_1 \sin \beta_1 \quad \text{Equation 4}$$

Where R_1 is the horizontal component of distance L_1 ; and H_1 is the vertical component of distance L_1 . At step 208 in Fig 2, the distance L_1 is measured using the 3-dimensional aerial vehicle tracking cameras or electro-optics 108. The angle of elevation β_1 can be measured using an encoder installed at the tilt motor of the pan-tilt device or a MEMS inclinometer mounted on the pan-tilt device, and the azimuth θ_1 can be measured using a digital compass.

[0029] At step 209 in Fig 2, the position of the aerial vehicle 101 with respect to the position of the aerial vehicle tracking system (L_1 , θ_1 and β_1) are captured by the data link and fed real time to the computer 111 of the target locating system.

[0030] Referring to step 210 in Fig. 2, the target locating system uses L_2 , β_2 , θ_2 and L_1 , β_1 , θ_1 to compute the location (H_3 , R_3 , L_3 , β_3 , θ_3) of the target 103 with respect to the aerial vehicle tracking system. The location of the target 103 with respect to the aerial vehicle tracking system is known as the target location. Referring to Fig 1, the computation of the location of the target 103 with respect to the aerial vehicle locating system is based on the following equations.

$$H_3 = H_1 + H_2 \quad \text{Equation 5}$$

$$R_3 = \sqrt{[(R_1)^2 + (R_2)^2 - 2(R_1)(R_2)\cos(180^\circ - \theta_1 - \theta_2)]} \quad \text{Equation 6}$$

$$L_3 = \sqrt{[(H_3)^2 + (R_3)^2]} \quad \text{Equation 7}$$

$$\theta_3 = \cos^{-1} [(R_1 \cos \theta_1 + R_2 \cos \theta_2) / R_3] \quad \text{Equation 8}$$

$$\beta_3 = \tan^{-1} (H_3 / R_3) \quad \text{Equation 9}$$

[0031] Referring to step 211 in Fig. 2, after the target locating system has computed the location (H_3 , R_3 , L_3 , β_3 , θ_3) of the target 103 with respect to the aerial vehicle tracking system, this data is fed real time to preferably a feed back control target engaging system which then directs a target destruction system 117 in the direction of the target 103. The target engagement system and the target destruction system 117 are preferably installed as part of the vehicle 102.

[0032] Referring to step 212 in Fig. 2, if the aerial vehicle 101 is within the engagement zone of the target 103, the software of the target engaging system would disable

1 the target destruction system 117 preventing it from firing any rounds as long as the aerial
2 vehicle 101 is within the engagement zone of the target 103. The engagement zone of the
3 target 103 corresponds to the volume defined by the burst radius of a projectile at the target,
4 optionally enlarged by a safety factor. In such case, the external pilot 118 will be notified by
5 the computer 111 and he shall maneuver the aerial vehicle 101 out of the engagement zone.
6 When the aerial vehicle 101 is safely outside the engagement zone, the computer 111 shall
7 enable the destruction system 117 waiting for the operator to activate the destruction system
8 117 and to fire at the target 103.

9
10 **[0033]** Referring to step 213 in Fig. 2, an operator activates the target destruction
11 system to destroy the target 103.

12
13 **[0034]** Fig 3 is a flowchart that shows generally the steps in another preferred
14 embodiment of the invention. In this embodiment, the aerial vehicle tracking system has a
15 single video camera and a smart laser distance sensor. In this embodiment, a smart laser
16 distance sensor 104 is mounted with the single video camera on a pan-tilt device 109 to track
17 the aerial vehicle 101 instead of a pair of three-dimensional area vehicle tracking cameras as
18 discussed in Fig. 2. The laser distance sensor measures the distance L_1 between the aerial
19 vehicle 101 and the aerial vehicle tracking system. The pan-tilt device 109 has pan and tilt
20 sensors and a digital compass for the measurement of tilt angle β_1 and azimuth θ_1 respectively.

21
22 **[0035]** Referring to step 302 in Fig. 3, in order to initiate the tracking of the aerial
23 vehicle 101 in this embodiment, an operator in the vehicle 102 maneuvers the single video
24 tracking camera or electro-optics and the laser distance sensor; using the joystick 112 to
25 capture the image of the flying aerial vehicle 101 into the designated field view of the video

tracking camera(s). An infrared illuminator 116 on the ground may also be used to illuminate the area around the aerial vehicle 101 to help the single video camera and the smart laser distance sensor of the aerial vehicle tracking system to track the aerial vehicle 101. In this embodiment, the distance L_1 is measured using the laser distance sensor of the single video camera or electro-optics system.

[0036] Since the aerial vehicle 101 is a relatively small target when it is at a distance from the aerial vehicle tracking system, it would be difficult to maintain the laser distance sensor mounted on the pan-tilt device 109 on the moving aerial vehicle 101 manually without the video tracking camera and the video tracking software. The video tracking camera is programmed to zoom in on the aerial vehicle 101 and the cross hair of the laser distance sensor is programmed to be placed inside the zoomed image of the aerial vehicle 101. The use of the single video tracking camera with the tracking software mitigates the probability of tracking error as image tracking algorithms are used to autonomously maintain the aerial vehicle 101 within the view of the video tracking camera.

[0037] Fig 4 is a flowchart that shows generally the steps in another preferred embodiment of the invention. In this embodiment, the aerial vehicle tracking system has a Millimeter Wave Radar with a 3D radar scanning mechanism which is very effective when the aerial vehicle tracking system is used in rain or inclement weather, where there is smoke and fire and when the sun is behind the aerial vehicle 101; to measure the position (L_1, β_1, θ_1) of the aerial vehicle 101 with respect to the aerial vehicle tracking system on the ground. wherein the radar aerial vehicle tracking is advantageous when the video tracking system is ineffective in certain circumstances. This embodiment with the use of radar technology is

1 advantageous when the aerial vehicle tracking system is used in rain or inclement weather,
2 where there is smoke and fire and when the sun is behind the aerial vehicle 101.

3
4 **[0038]** Referring to step 402 in Fig. 4, in order to initiate the tracking of the aerial
5 vehicle 101, an operator in the vehicle 102 starts the radar scanning for the aerial vehicle 101,
6 to display the location of the radar reflector mounted in the aerial vehicle 101, in the monitor
7 113 of the computer system 111. L_1 is measured by the radar.

8
9 **[0039]** The aforementioned invention is not restricted to military applications but can
10 also be applied to other applications such as fire fighting and rescue operations. In addition to
11 the aerial vehicle tracking system embodiments described above, it will also be readily
12 apparent to the person skilled in the art, given the benefit of this disclosure that the aerial
13 vehicle tracking system can comprise combinations of the 3 embodiments discussed above.
14 This is to cater for deployment of the system in different circumstances and environment such
15 as the need to operate the system when raining, when there is smoke and/or fire, or when the
16 sun is behind the aerial vehicle 101 or there is space constraints which does not allow 3
17 dimensional video cameras because it requires a large baseline. The target locating and
18 engaging system also has the advantage when the GPS (Global Position System) cannot be
19 used because the GPS signal could be jammed in time of tension.

20
21 **[0040]** From the foregoing disclosure and detailed description of certain preferred
22 embodiments, it will be apparent that various modifications, additions and other alternative
23 embodiments are possible without departing from the true scope and spirit of the invention.
24 The embodiments discussed were chosen and described to provide the best illustration of the
25 principles of the invention and its practical application to thereby enable one of ordinary skill

1 in the art to use the invention in various embodiments and with various modifications as are
2 suited to the particular use contemplated. All such modifications and variations are within the
3 scope of the invention as determined by the appended claims when interpreted in accordance
4 with the breadth to which they are fairly, legally, and equitably entitled.

5

CLAIMS

1. A method of locating and engaging a target having an engagement zone comprising, in combination, the steps of:

generating a target location of the target using a target locating system; and

using a target engagement system to control a target destruction system, wherein the target engagement system delivers at least one projectile to the target based on the target location; and

wherein the target engagement system checks an aerial vehicle position of an aerial vehicle against the engagement zone of the target, and if the aerial vehicle position is within the engagement zone of the target, then the target engagement system disables the target destruction system until the aerial vehicle is maneuvered to a safe location outside the engagement zone and the target can then be subsequently destroyed or eliminated.

2. The method of claim 1 further comprising an aerial vehicle tracking system and a vehicle, wherein the aerial vehicle tracking system comprises tracking software and the aerial vehicle tracking system is mounted on the vehicle.

3. The method of claim 2 wherein the aerial vehicle tracking system comprises two three-dimensional aerial vehicle tracking cameras having a field of view with each three-dimensional aerial vehicle tracking camera having a crosshair; wherein after the aerial vehicle is placed within the field of view and the image of the aerial vehicle is placed onto the crosshairs of the three-dimensional aerial vehicle tracking cameras, the tracking software is activated.

1 4. The method of claim 2 wherein the aerial vehicle tracking system comprises a
2 video camera having a field of view and a crosshair, a digital compass, an inclinometer and a
3 laser distance sensor;

4 wherein after the aerial vehicle is within the field of view of the video camera
5 and the image of the aerial vehicle is on the crosshair of the video camera, the tracking
6 software is activated.

7
8 5. The method of claim 2 wherein the aerial vehicle tracking system comprises a
9 radar having a field of view and the aerial vehicle comprises a radar reflector enhancing a
10 reflected radar signal from the aerial vehicle to avoid confusion in locating the aerial vehicle
11 due to low signal to noise ratio especially in an urban environment;

12 wherein after the aerial vehicle is placed within the field of view of the radar, and
13 the signal from the radar reflector is received by the radar, the tracking software is activated.

14
15 6. The method of any one of claims 2 to 5 wherein the aerial vehicle comprises one
16 of an infrared video camera, electro-optics, and a 3D video tracking camera having image and
17 thermal intensifying capabilities, and a smart laser distance sensor;

18 and the vehicle comprises at least one infrared illuminator to help tracking of
19 aerial vehicle and searching and identifying targets in poor light conditions and at night .

20
21 7. The method of any one of claims 1 to 6 wherein the target locating system uses
22 triangulation to generate the target location.

23
24 8. The method of any one of claims 1 to 7 wherein the target location is generated
25 using a three point height routine when the aerial vehicle is engaged by hostile forces.

1
2 9. The method of claim 8 wherein the three point height routine comprises using
3 Cosine equation and other mathematical functions.

4
5 10. The method of claim 8 wherein the three point height routine comprises using
6 Sine equation and other mathematical functions.

7
8 11. The method of claim 8 wherein the three point height routine comprises using
9 Tangent equation and other mathematical functions.

10
11 12. A target locating and engaging system comprising, in combination:
12 a target having an engagement zone;
13 a target location of a target generated using a target locating system; and
14 a target engagement system which controls a target destruction system, wherein
15 the target engagement system delivers at least one projectile to the target based on the target
16 location;

17 wherein the target engagement system checks an aerial vehicle position of an
18 aerial vehicle against the engagement zone of the target, and if the location of the aerial
19 vehicle position is within the engagement zone of the target, then the target engagement
20 system disables the target destruction system until the aerial vehicle is maneuvered to a safe
21 location before the target destruction system is enabled automatically by a computer to allow
22 the operator to activate the destruction system to destroy or eliminate the hostile targets.

23

1 13. The target locating and engaging system of claim 12 further comprising an aerial
2 vehicle tracking system and a vehicle, wherein a computer of the aerial vehicle tracking
3 system comprises tracking software is mounted in the vehicle.

4
5 14. The target locating and engaging system of claim 13 wherein the aerial vehicle
6 tracking system comprises two three-dimensional aerial vehicle tracking cameras which are
7 separated to enhance accuracy and having a field of view with each three-dimensional aerial
8 vehicle tracking camera having a crosshair; wherein after the aerial vehicle is placed within
9 the field of view and the image of the aerial vehicle is placed onto the crosshairs of the three-
10 dimensional aerial vehicle tracking cameras, the tracking software is activated.

11
12 15. The target locating and engaging system of claim 13 wherein the aerial vehicle
13 tracking system comprises a video camera having a field of view and a crosshair, an
14 inclinometer, a digital compass and a laser distance sensor, and after the aerial vehicle is
15 within the field of view of the video camera and the image of the aerial vehicle is on the
16 crosshair of the video camera, the tracking software is activated.

17
18 16. The target locating and engaging system of claim 13 wherein the aerial vehicle
19 tracking system comprises a radar having a field of view and the aerial vehicle comprises a
20 radar reflector enhancing a radar signal to noise ratio;

21 wherein after the aerial vehicle is placed within the field of view of the radar, and
22 the signal from the radar reflector is received by the radar, the tracking software is activated.

23
24 17. The target locating and engaging system of any one of claims 13 to 16 wherein
25 the aerial vehicle comprises an infrared video camera having one of an image intensifying

1 capability, thermal intensifying capability and both, and a smart laser distance sensor, and the
2 vehicle comprises at least one infrared illuminator to assist tracking of aerial vehicle and to
3 assist searching and identifying targets in poor light conditions and at night.

4
5 18. The target locating and engaging system of any one of claims 12 to 17 wherein
6 the target locating system uses triangulation to generate the target location.

7
8 19. The target locating and engaging system of any one of claims 12 to 18 wherein
9 the target location is generated using a three point height routine

10
11 20. The target locating and engaging system of claim 19 wherein the three point
12 height routine comprises using Cosine equation and other mathematical functions.

13
14 21. The target locating and engaging system of claim 19 wherein the three point
15 height routine comprises using Sine equation and other mathematical functions.

16
17 22. The target locating and engaging system of claim 19 wherein the three point
18 height routine comprises using Tangent equation and other mathematical functions.