Title: DEFENSE SYSTEM AND METHOD

Abstract: A system and method of weapons defense is shown and described. The system includes a gun; a threat-detector; a control system; and ammunition capable of transmitting and receiving data. In some embodiments, the threat-detector obtains primary projectile information. The control system determines a preliminary target intercept location from the primary projectile information and orders the gun to fire ammunition at the preliminary target intercept location. Ammunition begins generating secondary projectile information, which is obtained by the threat-detector. Using the secondary projectile information, the preliminary target intercept location is modified to create an improved target intercept.
DEFENSE SYSTEM AND METHOD

[0001] This application is entitled to the benefit of provisional application 60/646,440 filed January 24, 2005 and provisional application 60/670,445 filed April 12, 2005.

Background

(1) Field of the Invention

[0002] The present invention relates generally to the field of defense systems. More particularly, the present invention relates, in one aspect, to improving functionality of defense systems. Still, more particularly, the present invention relates to incorporating devices and methods for improving defensive response and accuracy.

(2) Description of Related Technology

[0003] Using current technology, it is difficult to defend against or intercept small missile fire. For example, military and civilian targets remain vulnerable to attack by rocket propelled grenades (RPGs) and other close-quarter or individually launched missiles or mortars. Generally, the primary defenses against these types of weapons are a vehicle’s or building’s armor or structural integrity. While such a passive defense is undesirable for vehicles and buildings on the ground, it can be fatal for ships at sea or planes in the air, where structural damage can lead to a loss of flotation, lift, control systems or pressurization.

[0004] Others have tried to develop defense systems to counter RPG attacks, and similar attacks. For example, some have tried to fire grouped volleys of bullets at incoming projectiles. Others have tried to track projectiles using infrared and radar and shoot them down with turreted guns. Still others have attempted to develop airbag systems for the exterior of vehicles that inflate prior to missile impact in an attempt to divert or absorb the explosion and accompanying fragmentation. Others still employ
reactive armor on vehicles that explodes on impact in an attempt to counter the explosion of the projectile.

[0005] Others, even still, have attempted to locate a series of defensive projectiles around a vehicle, where each defensive projectile has forward and lateral radar systems. The forward radar system detects incoming missiles, which causes the defense projectile to launch. The lateral radar system causes the defense projectile to detonate in close proximity to the incoming missile in an attempt to destroy it.

[0006] For various reasons these prior attempts have had various short comings, leaving personnel and property subject to damage.

[0007] Defensive responses to larger, conventional, missile attacks have typically been more effective. Using sophisticated interceptor-type missiles, for example like the Patriot Missile, conventional larger missiles can be brought down with some success. These interceptor type missiles may work using any combination of radar, heat-seeking, or laser-guidance technologies. However, even these interceptor type missiles have general problems that can lead to reduced success.

[0008] Current interceptor missile technology is based on a one-shot-at-the-target approach. If the interceptor missile malfunctions or fails to destroy the target, it has failed. Further, as larger missiles become more sophisticated, they employ counter-intercept strategies, for example, multi-stage charges. Current interceptor technology is ill suited to deal with these problems.
Summary

One or more of the abovementioned needs are satisfied by a system and method of weapons defense as shown and described. The system includes a threat-detector, which is preferably a parabolic reflector antenna in communication with a control system. The system also includes a gun in communication with the control system, which is preferably a .50 caliber gun. The gun fires ammunition capable of generating data.

In operation, the threat-detector obtains primary projectile information and relays that information to the control system. The control system determines a preliminary target intercept location from the primary projectile information and orders the gun to fire ammunition at the preliminary target intercept location. The ammunition begins generating secondary projectile information, which is obtained by the threat-detector. Using the secondary projectile information, the preliminary target intercept location is modified to create an improved target intercept.
**Brief Description of the Drawings**

[0011] Figure 1 shows one embodiment of the system of the present invention.

[0012] Figure 2 shows one embodiment of a turret of the present invention.

[0013] Figure 3 shows various views of one embodiment of a bullet of the present invention.

[0014] Figure 4 shows a schematic representation of one embodiment of the control system of the present invention in communication with the radar and with the gun.

[0015] Figure 5 shows a flow chart representation of software executing in one or more processors to achieve functions realized by the present invention.

[0016] Figure 6 shows a schematic representation of a network defense system according to one embodiment of the present invention.
Description of the Preferred Embodiments

[0017] Referring now to the drawings and present disclosure, it will be understood that the text and illustrations are for the purpose of describing a preferred embodiment of the invention and are not intended to limit the invention thereto.

[0018] Figure 1 shows an illustrative embodiment of the weapons defense system 10 of the present invention mounted on a vehicle 12. The vehicle 12 depicted is similar to a military transport car or truck, such as the Military HumV, but the weapons defense system of the present invention may be mounted on other vehicles, such as other boats, planes or helicopters, or may be freestanding, or not mounted at all. Similarly, many may desire to use the present invention on missiles, for example, an interceptor missile for intercepting other missiles, e.g. intercontinental ballistic missiles (ICBMs). Such variations are within the scope of the present invention.

[0019] The system 10 includes primary radar 14 for transmitting and receiving information, control system 16 for receiving information from the primary radar 14 and for processing information, and gun 20 in communication with the control system 16 for firing ammunition capable of sending and receiving data. The system 10 also includes ammunition 22 capable of sending and receiving data.

[0020] The primary radar 14 of the system 10 is a threat-detector, and is, in this embodiment, depicted as a radio-frequency (RF) radar, but those skilled in the art would recognize that any number of devices capable of detecting incoming projectiles would qualify as a threat-detector or as a radar within the scope of the present invention. For example, some may choose to use audio, video, laser or infra red technologies, either in conjunction with RF technologies or separate from RF technologies, all of which would be within the scope of the present invention. For a discussion of laser or infrared tracking technology, for example, see United States Patent No. 5,123,327, *Automatic Turret Tracking Apparatus For A Light Air Defense System*, to Alston et al., the contents of which are hereby incorporated by reference, and United States Patent No. 5,198,607, *Laser Anti-Missile Defense System*, to Livingston et al., the contents of which are
incorporated by reference; and United States Patent No. 5,662,291, Devices For Self Defense Against Missiles, to Sepp et al., the contents of which are also incorporated by reference. Similarly, while the radar depicted is an active radar, passive radars or human operated radars are also with in the scope of the present invention.

In Figure 1, the radar 14 is shown mounted on the top of vehicle 12 through a radar mount 24. The radar includes an antenna 32 and, a transmitter and a receiver, contained in box 34. Others may desire, instead of using both a transmitter and a receiver, to use a transceiver, which would be within the scope of the present invention. The radar mount 24 includes a base 26 and a support arm 30 for supporting the antenna 32. The radar mount 24 includes a motor (not visible) for rotating support arm 30 and thereby rotating antenna 32. While the antenna depicted is a parabolic antenna, others may prefer other antennas. For example, some may prefer strip or lobe antennas for their lower profile, or wider beam. Still some may prefer a narrower beam, with a higher gain, e.g. parabolic reflector antennas, for their increases accuracy and resolution. Still others may prefer other linearly or circularly polarized antennas.

Radar 14 of the present system 10 includes a first transmitter 34 for transmitting signals and a first receiver 34 for receiving signals. Transmitter 34 and receiver 34 are shown as one device, for example, as part of radar 14. Others may, however, prefer to locate either the transmitter or the receiver, or both, elsewhere, for example in the control system. All such configurations would be within the scope of the present invention.

The first transmitter 34 of the radar 14 is capable of transmitting a plurality of signals essentially simultaneously, including signals to be received by the ammunition and signals for projectile detection. Similarly, the first receiver 34 of the radar 14 is capable of receiving a plurality of signals essentially simultaneously, including a plurality of different signals as well as distinguishing between a plurality of similar signals.

For example, radar 14 has the ability to transmit signals 36 for detecting an incoming projectile 40. The signals 36 are transmitted generally away from the vehicle
12, or system 10, or may be transmitted in a specific direction, for example a direction of known threat. When the signals 36 encounter a projectile, signals 42 are reflected off of the projectile back to the receiver 34 of radar 14. Such information may be sent to the control system 16 of the system 10.

[0025] In Figure 1, the control system 16 is located inside of vehicle 12 and is in communication 44 with the radar 14 and in communication 46 with the gun 20. In some embodiments the control system may be considered an onboard fire control computer. In this embodiment, applicants prefer to achieve communication physically, for example through wire connection, yet others, wishing to locate the control center in a different location, for example, off of vehicle 12, may wish to establish communication by other means. For example, in a network of defense systems, others may find it desirable to establish communication with a remote control center wirelessly, for example by satellite or radio. All such configurations and variations are within the scope of the present invention. The structure and function of control system 16 is illustrated by subsequent figures and their respective descriptions.

[0026] Figure 1 also shows the gun 20 of the present invention. The gun 20, as depicted in this embodiment, includes a barrel 50 and rotating turret 52. The turret 52 allows the gun to rotate 360 degrees. The turret also includes a barrel-channel 54 for adjusting the height of the barrel 50. The gun 20 uses, preferably, automatic action, and even more preferably, rapid-fire automatic action, e.g. 500 to 3000 rounds per minute. Essentially any caliber gun could be suitable for the present invention. For example, calibers could include .22, .223, .30-06, .45, or .50; or 7 millimeter, 20 millimeter or 40 millimeter. Applicants prefer .50 caliber guns and ammunition. Additionally, all other medium and large caliber NATO machine gun ammunition would be within the scope of the present invention. Guns from other sources may also be suitable.

[0027] Figure 2 shows one embodiment of the turret 52 of the present invention. The turret 52 includes a body 400 and a helmet 402. Helmet 402 rotates relative to body 400 on a sealed bearing 404, which is driven by a horizontal gear 406. Horizontal gear
406 is driven by horizontal actuator 410. Helmet 402 also houses barrel channel 416 through which barrel 50 travels. Helmet 402 also contains an axle 420 and a vertical actuator 414 for affecting gun positioning.

[0028] Body 400 of turret 402 also contains an alignment shaft 412, horizontal control rings 422, and a second horizontal actuator 424. In some embodiments, some might also find it preferential to include a power source 426, such as an external battery or small internal combustion engine, and a cooling system. Body 400 might also house a computer 432 and an external power and sensor array hook up 434. Additional stabilizer gears 434 and bearings 440 are also shown. Body 400 also contains an ammunition housing 442.

[0029] Some may further desire to use, rather than one gun rotating 360 degrees, more than one gun. For example, some may desire to use two guns rotating approximately 180 degrees, or even two guns, each rotation over 180 degrees to provide some coverage overlap. All such variations are within the scope of the present invention.

[0030] Those skilled in the art will recognize that typically the internal bore of a rifle barrel is rifled to increase accuracy. And, in many embodiments of the present invention, Applicants use a rifled barrel. In certain embodiments, however, Applicants prefer to use a smooth bored rifle, for example, in order to reduce friction on ammunition fired from the rifled barrel and to allow for the firing of ammunition having external components or recesses, such as guidance fins or cavities.

[0031] Figure 3 shows various close-up perspective views of one embodiment of the ammunition 22 of the present invention. Figure 3A shows a cut-away interior view of ammunition 22 of the present invention. The bullet 22 has a front end 56, a rear end 58 an exterior housing 60, and an interior surface 62. Those skilled in the art will recognize that the bullet may be constructed of any variety of materials including, but not limited to, lead, steel, copper or bronze. Similarly, the bullet may be frangible or composed of some matrix, e.g. plastic and copper, which promotes fragmentation. In many embodiments, it may be desirable to use frangible ammunition to create more shrapnel
for intercepting incoming projectiles. Additionally, shrapnel may be created by preloading metal pieces into the ammunition.

[0032] The bullet 22, or a round of ammunition, preferably includes a power source 64. Ideally the power source has a size and weight within the limits of ammunition performance, while at the same is able to adequately power on-board components. See, Fontana et al., *An Ultra Wideband Radar For Micro Air Vehicle Applications*, 2002 IEEE Conference on Ultra Wideband Systems and Technologies, Baltimore, MD (2002), the contents of which are incorporated by reference, for a for a discussion of related topics.

[0033] A variety of power sources can be used to achieve the present invention. For example, the power source may be a battery, and preferably it is a battery activated at firing to prevent premature battery drainage. The power supply could also be a capacitor that is charged with the requisite power upon firing. The power supply could also be scavenged power, for example, from piezo ceramics capable of scavenging power generated by acceleration, deceleration, vibration, or heat. See, for example, United States Patent No. 5,125,104, *Electrical Pulse Generator for Use with Exploding Material*, to Ohkawa, the contents of which are incorporated by reference, for a discussion of generating power through an explosion. Similarly, those skilled in the art may wish to use a hybrid power source for powering the ammunition of the current invention. For example, a piezo ceramic scavenging source could generate power as ammunition is fired down the barrel, which is then used to charge a capacitor or supplement battery power. Still some may wish to use ammunition without an internal power source, which is powered from an external wireless source. All such combinations are within the scope of the present invention.

[0034] The bullet 22 may include a radio-frequency second transmitter and second receiver, shown collectively as 68. Those skilled in the art will recognize that a variety of transmitters and receivers could be used to achieve the present invention. For a general discussion of ammunition transmitters, see for example, United States Patent 5,381,445,
Munitions Cartridge Transmitter, to Hershey et al., the contents of which are incorporated by reference.

[0035] The second transmitter and receiver 68 are in communication with antenna 66. Applicants prefer to use a linearly polarized antenna 66, with the majority of radiation intensity directed rearwardly. Such a configuration will allow for maximum communication between primary radar (not visible in this figure) and ammunition with minimal power use. The antenna should also be configured to allow sufficient directivity in other directions to achieve subsequently described functions of the present invention. In particular, the configuration should have sufficient front-to-back ratio to allow for the detection of incoming projectiles. Some may desire to use relaying technology to create a virtual antenna from various successions of ammunition. Additionally, some may desire to employ synthetic aperture technology and may configure ammunition to maximize results. Those skilled in the art will recognize that the invention may be achieved using other antenna configurations or multiple antennas.

[0036] Antenna 66 serves several functions. Antenna 66 transmits radio waves to encounter and reflect off of incoming projectiles. Signaling to and from other ammunition and off of incoming projectiles will typically be required over only a short distance, yet rearward intensity should not be so great that it does not allow for adequate performance in other aspects of the present invention. As a second receiver, antenna 66 is further capable of receiving radio waves reflected off of projectiles. In addition to projectile detection functions, antenna 66 also serves other communication functions.

[0037] For example, antenna 66, when functioning as the second transmitter, is capable of transmitting to the primary radar. Antenna 66 is further able to transmit information to other ammunition. While functioning as the second receiver, antenna 66 is further capable of receiving radio waves originating from other ammunition.

[0038] Bullet 22 may also include signal-processor 70 located on board 80. Applicants prefer to use a signal-processor 70 capable of performing a variety of functions and, may actually be in the form of multiple separate processors. For example,
signal-processor 70 may be capable of converting the radio waves received by the receiver into projectile information. Others, however, may desire to relay radio waves received by ammunition directly to the control system for information processing or conversion to positional information. Additionally, an accelerometer 74, e.g. a tri-axis accelerometer, may be included in the ammunition, and may be, for example, located on board 80. Others, however, may prefer to use an accelerometer integral with the signal-processor, which would be within the scope of the invention. Accelerometer 74 supplements other information received by signal-processor 70. Any of the variety of micro tri-axis accelerometers may be used to achieve the present invention. For example, the ML8950, manufactured by Oki Electronic Industry Co. Ltd. could be used.

Bullet 22 may also include an explosive 72 that is detonated by a detonator 76. Those skilled in the art will recognize that numerous explosive materials could be used to achieve the present invention, all of which would be within the scope of the present invention. Applicants, however, prefer cyclotrimethylene-trinitramine, commonly known as C-4. Detonators may detonate the ammunition at a predetermined position relative to the projectile, such as anywhere within the proximity of shrapnel expansion. Similarly, a variety of detonators could be used to achieve the present invention. For example, detonator 76 may be a proximity fuse that is activated after a sensor, such as radio frequency sensor as embodied in radio transmitter and receiver 66, detects a projectile. In such instances, the proximity fuse can be set to detonate at distances as small as 24 inches. Detonator 76 may also be activated by a signal received from other ammunition or from the control center. See, United States Patent No. 6,378,435, Variable Target Transition Detection Capabilities and Methods Therefor, to Bai et al, the contents of which are incorporated by reference, for a discussion of projectile fuses and detonators, among other things.

Figure 3B shows an exterior view of bullet 22. The bullet has a front end 56 and a rear end 58. In this embodiment, bullet 22 also includes divisionary lines 82 for
facilitating predictable fragmentation particles. Divisionary lines 82 may be achieved using a variety of techniques and may or may not actually be visible on the surface of the bullet. For example, divisionary lines 82 may be formed by scouring the surface of the bullet or by constructing the bullet using a plastic matrix. Some, however, may desire not to use frangible bullets, and in such situations divisionary lines will be undesirable.

[0042] Bullet 22 may also include a guidance system 84 for guiding the bullet. In this embodiment the guiding system 84 is depicted as fins 84, yet anything capable of affecting air flow around the bullet, such as adjustable recesses may comprise the guidance system. Fins 84 may be constructed using bimetallic material for its ease of adjustability. For example, the configuration of fin 84 may be adjusted by sending current through terminal 86 and up one side 90 of fin 84 and down the other side 92 of fin 84 to terminal 94. Regulation of current may be achieved any number of ways, for example, it may be achieved by the signal-processor or by the control system. Still, some may prefer not to use a guidance system or not to use fins, and such ammunition would still be within the scope of the present invention.

[0043] Figure 3C shows bullet 22 from the rear end 58. Adjusted fins 84 can be seen in this view.

[0044] In operation, for example, signal processor 70 may convert incoming projectile signals into guidance information. Guidance system 84 may then utilize that information to redirect bullet path, for example, redirecting a bullet’s path to impact an incoming projectile. Alternatively, again by way of illustration only, guidance system 84 may redirect a bullet’s path to some point in front of an incoming projectile’s path, thereby enabling the bullet to explode and send out shrapnel to intersect the incoming projectile. Still others may wish to guide guidance system 84 from the control system 16, or through the control system in conjunction with the signal processor 70. All such combinations are within the scope of the present invention.

[0045] Figure 4 shows a schematic representation of one embodiment of a control system 116 of the present invention in communication with primary radar 114 and gun
124. Control system 116 includes a projectile-location processor 120 for calculating the location of the projectile and a gun control 22 for aiming and firing the gun 124. Gun control 122 is in communication 126 with projectile-location processor 120. While projectile-location processor 120 could use a variety of techniques to achieve the present invention, applicants prefer to use a plurality of processors to achieve various functions. A memory with various types of data about primary projectiles and the bullets being fired from gun 50 may be included, shown in part as ballistics table 148.

[0046] Projectile-location processor 120 includes a first sub-processor 130, which is in communication 132 with primary radar 114. First sub-processor 130 processes information 134 on incoming projectiles received from primary radar 114.

[0047] Projectile-location processor 120 also may include a second sub-processor 136, which is in communication 140 with primary radar 114. Second sub-processor 136 processes information 142 from the ammunition sent to the primary radar 114.

[0048] Projectile-location processor 120 also includes a tertiary processor 144 having inputs from information output from the first sub-processor 130 with information output from the second sub-processor 136.

[0049] Using the present invention, for example above described embodiments, primary projectile information may be obtained though any variety of threat-detectors, e.g. radar, audio, video, or infra red threat-detectors. Applicants prefer a radar threat detector, as depicted by block 114 in Figure 4. Primary projectile information may include any information related to projectiles, such as projectile speed, distance to a predetermined location, heading, bearing and height, and may be considered information shown in block 134. Primary projectile information may further include information related to identifying characteristics of the projectile, e.g. projectile height, length, width, heat signature, frequency and fin configuration.

[0050] Using primary projectile information, such as represented by block 134, projectile coordinates and path may be determined, for example, using intercept algorithms known to those of skill in the art. See, for illustrative example, R.W.R.
Darling. Geometrically intrinsic nonlinear recursive filters I: algorithms, preprint (1997), available as No. 494 at http://www.stat.berkeley.edu/tech-reports. First sub-processor 130 may be the site where those algorithms are performed. Using the projectile coordinates and path, a preliminary target intercept may be determined, through sub-processor 130, for example at some point in the path of the incoming projectile. The preliminary target intercept may also be determined based, at least in part, by identifying characteristics of the projectile. For example, if a projectile is identified based on its length or frequency, information relating to that particular projectile may be retrieved from ballistics table 148 and used to supplement the calculation of the preliminary target intercept.

First sub-processor 130 may send preliminary target intercept information to gun control 122. Gun control 122 may convert the preliminary target intercept information into gun positioning information. Gun control 122 may then generate instructions for positioning gun 122 to fire at the preliminary target intercept. For example, gun control 122 may generate both turret motor instructions and barrel height instructions for moving respective parts to respective positions. Others, however, may prefer to use first sub-processor 130 to convert the preliminary target intercept information into gun position information. In such situations, the gun control would be used primarily for orienting the gun.

Firing through gun 124 can begin based on the preliminary target intercept. Once firing beings, ammunition may begin producing secondary information to radar 114. From radar 114, secondary information, represented by block 142, is sent to secondary sub-processor block 136. Secondary information may include projectile speed; ammunition speed; distance to a predetermined location; height; heading; and bearing. Secondary information may further includes obtaining information on identifying characteristics of the projectile, such as length, width, heat signature, and fin configuration, which may be used to facilitate identification of the projectile. Secondary information may also include obtaining hit/miss information, which may be generated by
the bullet upon projectile impact, for example, or may be generated by other ammunition that does not impact the projectile. Secondary information may further include information related to projectile counter measures, such as pre-explosions or flare ignition, or other measures that may be used to evade detection or confuse defense systems.

[0053] The ammunition load cycle may also be altered, for example in some embodiments, all the ammunition is information generating ammunition. Others may desire to alter the load cycle, for example to fire a first round with RF transmitting and receiving capability and a proximity fuse; and the next four rounds of high explosive (HE) proximity fused rounds. In other embodiment, the ammunition load cycle is repeated so that every fifth round has a RF transmitting and receiving sensor.

[0054] Some of the secondary information may be obtained through an ammunition sensor, such as radar, which could be represented by antenna 66, as shown in Figure 3A. Ammunition sensors may also include either front or side sensors or both front and sides sensors, which may be radar, laser, or infrared sensors for example.

[0055] Secondary information obtained may also include information about ammunition, for example it could be information about bullet speed, height or rate. Such information, may be generated by tri-axis accelerometer 74.

[0056] Primary and secondary information may also include various friendly-fire criteria, or criteria designed to prevent or terminate firing or destruct ammunition on route to a friendly target. For example, friendly-fire criteria may include a certain transponder frequency that alerts the current defense system of a friendly target. Additionally, friendly-fire criteria may simply be coordinates, for example coordinates of a fixed location, at which the control system will refuse to fire.

[0057] Secondary information sent to the control system 116 of the present invention may be sent by radio. Some may also prefer to form a virtual antenna for sending information, for example by relaying signals through the line of fired bullets,
back to the control system 116. Such a method may be desirable for example in that it
will reduce the power needed for sending signals.

[0058] Secondary information 142 is sent to second sub-processor 136 of control
system 116. Once there, secondary information is accumulated and sent to tertiary
processor 144, which also contains information sent from primary sub-processor 130.
Steps performed by software designed for use in the present invention, including the
control system 116 are outlined in Figure 5. Once the preliminary target intercept
location has been modified with the secondary projectile information, tertiary processor
144 issues an improved target intercept to gun control 122. Gun control 122 then
positions gun 124 and fires at the improved target intercept. Additionally, in some
embodiments, control system 116 may contain antenna controls, for example for
orienting or adjusting directivity, beam, gain, or intensity.

[0059] Figure 5 shows processing steps which may be performed by embodiments
of the control system of the present invention. In this embodiment, upon starting at block
200, a detection algorithm 202 is illustratively executed. The first step in algorithm 202
is registering sensors and guns of the system, as shown by block 204. Registering can
include detecting the presence or absence of a single or multiple sensors, such as a radar,
and the presence or absence of a single or multiple guns, including their caliber.
Registering can also include registering positional or directional information of the
various registered sensors and guns.

[0060] At step 206 registered sensors begin inputting parameters. Generally,
sensor parameters include primary projectile information, such as, for example, speed;
distance to a predetermined location; heading; bearing; and height or elevation.
Preferably a parameter filter (not shown) operates to filter non-essential data, for
example, avian, pedestrian, or vehicular movement, or additional vector data not useful
for evaluating threats or calculating preliminary target intercept. Sensor parameters may
further include identifying characteristics of the projectile, which may be used to identify
the projectile. For example, identifying characteristics may include projectile height,
length, width, heat signature and fin configuration. If a projectile is identified based on identifying characteristics, pre-stored, specific information relating to that particular projectile may be used to modify the algorithm.

[0061] Sensor parameters may also include other environmental factors useful for evaluating threats and implementing the present invitation. For example, some may wish to input environmental factors such as terrain topography. Even still, sensor parameters may include secondary information or information obtained from other ammunition.

[0062] At step 210, parameters input from step 206 are continuously compared to a predetermined list of parameters in order to detect threats such as incoming projectiles. If this comparison yields a positive result, then intercept algorithm 212 is activated. For example, a comparison rule could simply be: if rate > 600 feet per second, then activate block 212.

[0063] The first step of intercept algorithm 212 is to calculate a preliminary target intercept as depicted by block 214. Block 214 may be achieved numerous ways. For example, the intercept algorithm may initially calculate projectile coordinates based on preliminary projectile information. The intercept algorithm may further calculate a projected path of the projectile based on preliminary projectile information. The intercept algorithm may further access a variable ballistics function table, which contains information about ammunition trajectory and initial velocity and terminal velocity. The variable ballistics function table may further contain gun-relocation information, e.g. information dealing with the time it takes to relocate the gun from one position to the next. The intercept algorithm may then determine, based on the projected path of the projectile, ballistics information, and the gun-relocation time, a point along the projected path to intercept the projectile, or a preliminary target intercept. Similarly, rather than using a gun-relocation table, the intercept algorithm may include a gun-relocation processor for determining gun-relocation times.

[0064] Calculations of a preliminary target intercept may further include analyzing factors for prioritizing preliminary target information. For example, information may
include the number of incoming projectiles, speeds of incoming projectiles; and current position of the gun. Further, if multiple guns are registered, the intercept algorithm may include determining which gun is closer to the projectile or may include determining, for example based on the table of gun-relocation times and the position of registered guns, which gun is in a better position to achieve interception of the incoming projectile.

[0065] Upon calculating a preliminary target intercept, a gun position command is generated and sent to the gun, as illustrated by block 216. The gun control system orients the gun in the proper position. Upon obtaining the proper position, the fire command is sent, as illustrated by block 220.

[0066] Upon firing, ammunition almost immediately begins producing secondary projectile information. Secondary information is then read by the processor, as illustrated by block 222. Block 224 illustrates the modification of preliminary target intercept location with secondary projectile information to create an improved target intercept. While the modification can be achieved by a number of ways, applicants prefer multilayered triangulation. For example, potentially every bullet fired can be used as a reference point for triangulating the exact position of an incoming projectile. Using multilayered triangulation or essentially continuous triangulation, highly accurate projectile position information can be obtained. This information can be used to continuously update and optimize projectile path information and projectile intercept information. Block 226 shows gun gun-reposition output generated based on improved intercept being issued prior to fire command generation.

[0067] Figure 6 shows a network configuration of the present invention designated generally as 300. As shown, the network includes a plurality of threat detectors 302, control systems 304, and guns 306. These are multiplicity of the threat detectors, control systems, and guns described previously. Such a network defense system may be ideal, for example, on a military ship in harbor, or on a building or area in an area at high risk from incoming projectiles, e.g. 666. Ammunition is depicted as a stream of several bullets 310a and as a single bullet 310b. The various guns, control systems, and threat
detectors are all in communication with each other. Communication may be established by a variety of means, such as wire, for some embodiments, e.g. ships and buildings. However, for more mobile networks, for example temporary networks, in may be preferable to use radio communication.

[0068] Networks may be a preferable means of practicing the present invention because they may be able to provide a quicker, more reliable defensive response. In addition, the multilayered triangulation of the present invention may potentially be enhanced depending on the environment.

[0069] The defensive network 300 operates, in part, by establishing a defensive perimeter 312 for each gun. Ideally, each perimeter 312 is determined based on positional information established by control systems. Perimeters may also be established manually.

[0070] Each control center continuously monitors the status of its own gun and threat detector, if applicable. In the event that a control system detects inoperable or less than desired status in either its threat detector or its gun, it alerts another control center, and that control center readjusts its defensive perimeter to compensate. For example, if a control center 304a detects damage to threat detector 302a, it would signal control center 304b to control gun 306a. Similarly, control center 304a may maintain control of its own gun using another threat detector, for example, threat detector 302c to detect threats. If a control center itself is destroyed, it will typically be recognized as off-line, and other control centers in the network will resume the function of the damaged control center. If a control center is damaged, yet fails to register as off-line, additional monitoring will detect deficiencies in the network.

[0071] For example, each control center 304 may periodically, e.g. every second or fraction of a second, test the status of each threat-detector, control system or gun. Controls centers may test for, among other things, operational status and perimeter establishment. Any control center may reestablish the defensive perimeter of each gun as needed based on the testing information. Additionally, ammunition may be able to
reestablish the perimeter of a gun. For example, if threat detector 302a detects projectile
66a and instructs gun 306a to fire, ammunition 310 a may send a signal alerting control
system 304b to reestablish a new perimeter for gun 306b that is directed at perceived
incoming threats, e.g. projectile 666a.

Further, those of skill in the art will recognize that multiple guns in
networks of the present invention may be under the control of a single control center.
Additionally, some may find it desirable, especially in networks, to use guns with
different functional configurations. For example, one gun may be configured for
information gathering and another gun may be configured for interception. The gun
configured for interception, for example, may be smooth bored and designed to fire
volleys of smaller information-generating ammunition at locations to maximize
multilayered triangulation. The gun configured for interception, for example, may have a
rifled barrel designed to fire larger ammunition directly at incoming projectiles.

Certain modifications and improvements will occur to those skilled in the
art upon a reading of the foregoing description. It should be understood that all such
modifications and improvements have been deleted herein for the sake of conciseness and
readability but are properly within the scope of the following claims.
We Claim:

1. In a defense system comprising a gun; a threat-detector; a control system; and ammunition capable of transmitting and receiving data, a method of defending against incoming projectiles comprising:

   - obtaining primary projectile information from the threat-detector;
   - determining a preliminary target intercept location from the primary projectile information;
   - firing ammunition at the preliminary target intercept location;
   - obtaining secondary projectile information from the ammunition; and
   - modifying the preliminary target intercept location with the secondary projectile information obtained from the ammunition to create an improved target intercept.

2. The method of Claim 1, wherein obtaining primary projectile information includes obtaining information selected from the group consisting of projectile speed, distance to a predetermined location, heading, bearing and height.

3. The method of Claim 1, wherein the primary projectile information is used for calculating projectile coordinates.

4. The method of Claim 1, wherein obtaining primary projectile information includes obtaining identifying characteristics of the projectile.

5. The method of Claim 4, wherein identifying characteristics are selected from a group consisting of projectile height, length, width, heat signature and fin configuration.

6. The method of Claim 1, wherein the threat-detector is selected from a group consisting of radar, audio, video, and infra red threat-detectors.
7. The method of Claim 1, wherein determining a preliminary target intercept includes determining based on calculated projectile coordinates.

8. The method of Claim 7, wherein determining includes determining based on an algorithm.

9. The method of Claim 7, wherein determining further includes determining a synthetic aperture.

10. The method of Claim 1, wherein firing is selective, based on a predetermined list of factors including number of incoming projectiles, speeds of incoming projectiles; and current position of the gun.

11. The method of Claim 1, wherein firing is from a first gun and from a second gun.

12. The method of Claim 11, wherein the first gun is substantially configured for information gathering and the second gun is configured substantially configured for projectile interception.

13. The method of Claim 1, wherein obtaining secondary information includes obtaining information selected from the group consisting of projectile speed, distance to a predetermined location, height, heading and bearing.

14. The method of Claim 1, wherein obtaining secondary information includes obtaining hit/miss information.
15. The method of Claim 1, wherein the secondary information includes evaluating projectile counter measures.

16. The method of Claim 1, wherein obtaining secondary information includes obtaining through a sensor mounted on ammunition.

17. The method of Claim 16, wherein obtaining includes obtaining through a radar sensor.

18. The method of Claim 16, wherein obtaining secondary information includes information obtained through ammunition.

19. The method of Claim 18, wherein ammunition information includes information obtained by a tri-axis accelerometer.

20. The method of Claim 1, wherein obtaining is powered by a power supply, selected from the group consisting of batteries, capacitors, power scavengers and hybrid power supplies.

21. The method of Claim 1, wherein obtaining secondary information further includes sending secondary information to the control system.

22. The method of Claim 21, wherein the sending is by radio frequency.

23. The method of Claim 21, wherein sending is amplified by forming a virtual antenna.
24. The method of Claim 1, wherein modifying is achieved by a triangulation process.

25. The method of Claim 24, wherein the triangulation process is a multilayered triangulation process.

26. The method of Claim 1, further including firing ammunition at the improved preliminary target intercept.

27. The method of Claim 26, further including detonating the fired ammunition at a predetermined position relative to the projectile.

28. The method of Claim 27, wherein detonating is triggered by the control system, information sent from other ammunition, or a proximity fuse.

29. The method of Claim 1, wherein obtaining primary and secondary information includes evaluating for friendly-fire criteria.

30. The method of Claim 29, further including canceling on order to fire.

31. In a network defense system comprising two guns; two threat-detectors; a control system; and ammunition capable of transmitting and receiving data, a method of forming a virtual network for defending against incoming projectiles comprising:
   establishing a defensive perimeter for each gun;
   testing the status of each threat-detector; and
   reestablishing the defensive perimeter of each gun as needed based on the testing information.
32. The method of Claim 31, wherein ammunition capable of transmitting data are used to reestablish the defensive perimeter of a gun.

33. A weapons defense system comprising:
   a primary radar for transmitting and receiving;
   a control system for receiving information from the primary radar and for processing information;
   a gun in communication with the control system for firing ammunition; and ammunition capable of sending and receiving data.

34. The system of Claim 33, wherein the primary radar includes a first transmitter for transmitting signals.

35. The system of Claim 33, wherein the signals include signals for detecting projectiles.

36. The system of Claim 34, wherein the signals include detonation signals for ammunition.

37. The system of Claim 33, wherein the primary radar includes a first receiver for receiving information.

38. The system of Claim 37, wherein the first receiver receives and processes signals reflected from an incoming projectile.

39. The system of Claim 37, wherein the first receiver receives signals sent from ammunition.
40. The system of Claim 33, wherein the control system includes:
a projectile-location processor for calculating the location of the projectile; and
a gun control for aiming and firing the gun, wherein the gun control in
communication with the projectile processor.

41. The system of Claim 40, wherein the projectile processor includes:
a first sub-processor for processing information on the projectile originated by the
primary radar;
a secondary sub-processor for processing information received from the
ammunition; and
a tertiary processor for modifying information output from the primary processor
with information output from the secondary processor.

42. The system of Claim 33, wherein the gun has a bore size selected from the
group consisting of .22 caliber, .223 caliber, .30-06 caliber, .45 caliber, .50 caliber, 9
millimeter, and 20 millimeter.

43. The system of Claim 33, wherein a round of ammunition includes a radio-
frequency second transmitter and second receiver.

44. The system of Claim 43, wherein the radio-frequency second transmitter is
configured to transmit radio waves capable of being reflected by projectiles and the
radio-frequency second receiver is configured to receive the radio waves reflected off
projectiles.

45. The system of Claim 44, wherein the ammunition includes a signal-
processor configured to convert the radio waves received by the receiver into projectile
information.
46. The system of Claim 45, wherein the ammunition includes an accelerometer in communication with the signal-processor for supplementing projectile information.

47. The system of Claim 45, wherein the second transmitter is capable of transmitting to the primary radar.

48. The system of Claim 47, wherein the second transmitter is capable of transmitting to other ammunition and the second receiver is capable of receiving radio waves originating from other ammunition.

49. The system of Claim 33, wherein the ammunition includes an explosive and a detonator.

50. The system of Claim 49, wherein the detonator is activated by a signal received from other ammunition.

51. The system of Claim 49, wherein the detonator is activated by a signal received from the control system.

52. The system of Claim 33, wherein the system is located on a vehicle selected from the group consisting of boats, trucks, cars, and planes.

53. Information generating ammunition for aiding in projectile detection in a defense system, the ammunition comprising:

   an exterior housing;

   an antenna located at least partially within the housing and configured to radiate a first signal away from the housing for projectile-detection, and to
radiate a second signal substantially rearwardly toward the defense system;

a transmitter located at least partially within the housing and in communication with the antenna to generate the first signal and the second signal;

a receiver located at least partially within the housing to receive incoming signals;

and

a power source located at least partially within the housing to power the antenna.
START 200

Register Sensor and Gun 204

Input Sensor Parameters 206

Threat Parameter Detected? 210

Yes

Calculate Preliminary Target Intercept 214

Gun Position Output Command 216

Fire Command 220

Process Secondary Information 222

Modify Preliminary Target Intercept to Create Improved Target Intercept 224

Gun Reposition Output 226

FIG. 5