Blast energy absorption system is capable of being integrated into the structure of a vehicle having removable, interchangeable, and configurable components adaptable to configure the vehicle for varying mission threats. The blast energy absorption system has a plurality of independent energy absorbing systems including one or more in combination of the following: a floor structure, a housing, cross beam members, adjustable energy absorbing containers, and an understructure. Each component may be an independent reactant system. The integral relationship between the above mentioned components forms a system that absorbs and distributes blast energy to minimize energy transfer to the occupants of the vehicle. Blast energy absorption system is capable of many configurations depending on the threat level of a mission.
BLAST ENERGY ABSORPTION SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. Provisional Application Ser. No. 61/108,167, filed Oct. 24, 2008, which is hereby incorporated herein by reference in its entirety for all purposes.

BACKGROUND

[0002] Military vehicles are exposed to many threat levels depending on mission deployment. High forces caused by blasts from mines or other ordinance result in high occupant accelerations thereby increasing the risk of harm to the occupants.

SUMMARY

[0003] Blast energy absorption system dimensioned to be integrated into the structure of a vehicle, and in particular multiple, removable, interchangeable, and configurable components adaptable to configure the vehicle for varying mission threats are disclosed.

[0004] One embodiment of a blast energy absorption system comprises: at least first and second floor structures, wherein each floor structure is dimensioned for integration in a longitudinal-horizontal plane of a vehicle; and a housing disposed between at least first and second floor structures, wherein the housing comprises at least first and second vertical members, wherein a body portion of the first vertical member is connected to a first side of the first floor structure, and wherein a body portion of the second vertical member is connected to a first side of the second floor structure, and wherein each of the floor structures and the housing is configured to absorb blast energy by dampening blast loads along at least one of horizontal-longitudinal plane, longitudinal-vertical plane, and horizontal-vertical plane.

[0005] In one embodiment, the system includes an understructure disposed underneath the at least first and second floor structures and the housing, wherein a first side of the understructure is connected to a second side of the first floor structure, wherein a second side of the understructure is connected to a second side of the second floor structure, wherein a first body portion of the understructure is connected to one end of the first vertical member, and wherein a second body portion of the understructure is connected to one end of the second vertical member, and wherein the first floor structure, the first vertical member, and the understructure are configured to form a first compartment, wherein the second floor structure, the second vertical member, and the understructure are configured to form a second compartment, wherein the housing and the understructure are configured to form a third compartment, and wherein each of the compartments is configured to absorb blast energy by dampening blast loads along a portion of at least one of the at least first and second floor structures, the least first and second vertical members, the housing, and the understructure.

[0006] In one embodiment, the system includes at least one cross beam member horizontally arranged on top of the understructure, wherein the at least one cross beam member is housed within the third compartment, and wherein the at least one cross beam member is configured to absorb blast energy by dampening blast loads along a horizontal direction.

[0007] In one embodiment, the system includes at least one of longitudinal and vertical blast energy absorbing members housed within the third compartment, wherein the at least one longitudinal and vertical blast energy absorbing members is configured to absorb blast energy by dampening blast loads along at least one of longitudinal and vertical directions.

[0008] In one embodiment, the system includes at least one adjustable energy absorbing container disposed within each of the first and the second compartments, wherein the at least one adjustable energy absorbing container is configured to absorb blast energy by dampening blast loads along at least one of horizontal, longitudinal, and vertical directions.

[0009] In one embodiment, the system includes at least one of interior and exterior support structures housed within each of the first and second compartments, wherein the at least one of interior and exterior support structures is configured to absorb blast energy by dampening blast loads along at least one of the at least one of interior and exterior support structures.

[0010] In one embodiment, the system includes at least one crush element disposed within the at least one adjustable energy absorbing container, wherein the at least one crush element is configured to absorb blast energy by dampening blast loads along the at least one of horizontal-longitudinal plane, longitudinal-vertical plane, and horizontal-vertical plane.

[0011] One embodiment of a blast energy absorption system comprises at least first and second floor structures, wherein each floor structure is dimensioned for integration in a longitudinal-horizontal plane of a vehicle; a housing disposed between the at least first and second floor structures, wherein the housing comprises at least first and second vertical members, and wherein a body portion of the first vertical member is connected to a first side of the first floor structure, and wherein a body portion of the second vertical member is connected to a first side of the second floor structure; and an understructure disposed underneath the at least first and second floor structures and the housing, wherein a first side of the understructure is connected to a second side of the first floor structure, wherein a second side of the understructure is connected to a second side of the second floor structure, wherein a first body portion of the understructure is connected to one end of the first vertical member, and wherein a second body portion of the understructure is connected to one end of the second vertical member, and wherein the floor structure, the first vertical member, and the understructure are configured to form a first compartment, wherein the second floor structure, the second vertical member, and the understructure are configured to form a second compartment, wherein the housing and the understructure are configured to form a third compartment, and wherein each of the compartments is configured to absorb blast energy by dampening blast loads along a portion of at least one of the at least first and second floor structures, the at least first and second vertical members, the housing, and the understructure.

[0012] In one embodiment, the system includes at least one cross beam member horizontally arranged on top of the understructure, wherein the at least one cross beam member is housed within the third compartment, and wherein the at least one cross beam member is configured to absorb blast energy by dampening blast loads along a horizontal direction.

[0013] In one embodiment, the system includes at least one adjustable energy absorbing container disposed within each of the first and the second compartments, wherein the at least
one adjustable energy absorbing container is configured to absorb blast energy by dampening blast loads along at least one of horizontal, longitudinal, and vertical directions.

[0014] In one embodiment, the system includes at least one of longitudinal and vertical blast energy absorbing members housed within the third compartment, wherein the at least one of longitudinal and vertical blast energy absorbing members is configured to absorb blast energy by dampening blast loads along at least one of longitudinal and vertical directions.

[0015] In one embodiment, the system includes at least one adjustable energy absorbing container disposed within each of the first and the second compartments, wherein the at least one adjustable energy absorbing container is configured to absorb blast energy by dampening blast loads along at least one of horizontal, longitudinal, and vertical directions.

[0016] In one embodiment, the system includes at least one of interior and exterior support structures housed within each of the first and second compartments, wherein the at least one of interior and exterior support structures is configured to absorb blast energy by dampening blast loads along at least one of the at least one of interior and exterior support structures.

[0017] In one embodiment, the system includes at least one crush element disposed within the at least one adjustable energy absorbing container, wherein the at least one crush element is configured to absorb blast energy by dampening blast loads along at least one of horizontal-longitudinal plane, longitudinal-vertical plane, and horizontal-vertical plane.

[0018] One embodiment of a blast energy absorption system comprises: at least first and second floor structures, wherein each floor structure is dimensioned for integration in a longitudinal-horizontal plane of a vehicle; a housing disposed between the at least first and second floor structures, wherein the housing comprises at least first and second vertical members, and wherein a body portion of the first vertical member is connected to a first side of the first floor structure, and wherein a body portion of the second vertical member is connected to a first side of the second floor structure; an understructure disposed underneath the at least first and second floor structures and the housing, wherein a first side of the understructure is connected to a second side of the first floor structure, wherein a second side of the understructure is connected to a second side of the second floor structure, wherein a first body portion of the understructure is connected to one end of the first vertical member, and wherein a second body portion of the understructure is connected to one end of the second vertical member; and wherein the first floor structure, the first vertical member, and the understructure are configured to form a first compartment, wherein the second floor structure, the second vertical member, and the understructure are configured to form a second compartment, wherein the housing and the understructure are configured to form a third compartment, and wherein each of the compartments is configured to absorb blast energy by dampening blast loads along a portion of at least one of the at least first and second floor structures, the at least first and second vertical members, the housing, and the understructure; and at least one cross beam member horizontally arranged on top of the understructure, wherein the at least one cross beam member is housed within the third compartment, and wherein the at least one cross beam member is configured to absorb blast energy by dampening blast loads along a horizontal direction.

[0019] In one embodiment, the system includes at least one of longitudinal and vertical blast energy absorbing members housed within the third compartment, wherein the at least one of longitudinal and vertical blast energy absorbing members is configured to absorb blast energy by dampening blast loads along at least one of longitudinal and vertical directions.

[0020] In one embodiment, the system includes at least one adjustable energy absorbing container disposed within each of the first and the second compartments, wherein the at least one adjustable energy absorbing container is configured to absorb blast energy by dampening blast loads along at least one of horizontal, longitudinal, and vertical directions.

[0021] In one embodiment, the system includes at least one of interior and exterior support structures housed within each of the first and second compartments, wherein the at least one of interior and exterior support structures is configured to absorb blast energy by dampening blast loads along at least one of the at least one of interior and exterior support structures.

[0022] In one embodiment, the system includes at least one crush element disposed within the at least one adjustable energy absorbing container, wherein the at least one crush element is configured to absorb blast energy by dampening blast loads along at least one of horizontal-longitudinal plane, longitudinal-vertical plane, and horizontal-vertical plane.

[0023] Other variations, embodiments and features of the present disclosure will become evident from the following detailed description, drawings and claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] FIGS. 1A and 1B are perspective and cross-section views, respectively, of one embodiment of the present disclosure;

[0025] FIGS. 2A and 2B are perspective top and bottom views, respectively, of the embodiment of FIGS. 1A and 1B integrated into a vehicle;

[0026] FIGS. 3A and 3B are perspective top and bottom views, respectively, of an understructure of the embodiment of FIGS. 1A and 1B;

[0027] FIGS. 4A-4J are perspective and exploded views of various embodiments of an adjustable energy absorbing container;

[0028] FIGS. 5A and 5B are top and side views, respectively, of various embodiments of alternative crush element retention devices;

[0029] FIGS. 6A and 6B are top views of alternative crush element retention devices sized to retain different sized crush elements;

[0030] FIG. 7 illustrates side views of alternative crush element retention devices integral with different sized crush elements;

[0031] FIGS. 8A-8D are illustrations of an alternative embodiment of an adjustable energy absorbing containers engagement feature;

[0032] FIGS. 9A-9C are perspective views of an alternative embodiment of a horizontal retention device in engaged and disengaged position respectively;

[0033] FIGS. 10A and 10B are perspective views of an alternative embodiment of a horizontal retention device in engaged and disengaged position respectively;

[0034] FIG. 11 is a perspective view of one embodiment of the crush elements installed into an interior support structure;

[0035] FIG. 12A-C are perspective views of an alternative embodiment of a crush element retention sleeve; and
FIGS. 1A and 1B are perspective and cross-section views, respectively, of a blast energy absorption system 2 according to one embodiment of the present disclosure. In this embodiment, the blast energy absorption system 2 includes a housing 6 coupled to two floor structures 4 on opposing sides of the housing 6. Although two floor structures 4 are shown, there can be more or fewer floor structures 4 in the blast energy absorption system 2. In one embodiment, the housing 6 may be disposed between the two floor structures 4.

In this embodiment, the floor structures 4 and the housing 6 are configured to be integrated in a substantially longitudinal-horizontal (x-y) plane as defined by the axes shown. In one instance, the blast energy absorption system 2 may be dimensioned for integration in a longitudinal-horizontal (x-y) plane of a vehicle.

FIGS. 2A and 2B are perspective top and bottom views, respectively, of an embodiment of a blast energy absorption system 2 being integrated into a floor of a vehicle 100 including the likes of jeeps, sedans, cars, tanks and military vehicles, among others. In one embodiment, the floor structures 4 may be dimensioned for integration into the floor of the vehicle 100. In another embodiment, the housing 6 may be dimensioned for integration into the floor of the vehicle 100. In other embodiments, these and other components may be integrated into the floor of the vehicle 100 and will become more apparent in subsequent figures and discussion. In one embodiment, all the components of the blast energy absorption system 2 may be dimensioned for integration into the chassis and/or frame of the vehicle 100. In some instances, all the components may be integrated directly or indirectly into the vehicle 100. For example, the components may be connected by semi-permanent fastening techniques or re-attachable fastening techniques. In other examples, the components may be removable either for repair or for varying the level of occupant protection, among others (e.g., weight limitation).

Returning now to FIGS. 1A and 1B, in one embodiment, the housing 6 has a substantially three-sided (e.g., u-shape) box-like structure with horizontal members 48 connected to vertical members 46 on opposing ends 48A of the horizontal member 48. In this instance, a body portion of the vertical members 46 may be connected to one end of a floor structure 4, while a similar body portion of the vertical member 46 may be connected to one end of the floor structure 4 on an opposite side of the housing 6. In one embodiment, the three-sided box-like structure tapers along a longitudinal (x) direction of the housing 6 as best shown in FIG. 1A. In another embodiment, the three-sided box-like structure may extend throughout the entire length of the housing 6 along the longitudinal (x) direction (not shown). In some embodiments, each of the floor structures 4 and the housing 6 is capable of providing load transfer in at least one of horizontal-longitudinal (y-x) plane, longitudinal-vertical (x-z) plane, or horizontal-vertical (y-z) plane for dampening blast loads.

As used herein, “blast load” and the like means a blast event external to a vehicle. In some embodiments, blast load includes any forces external to a vehicle including the likes of bullets, bombs, explosives, grenades, missiles, artillery, fires, among others. In other embodiments, each of the components of the blast energy absorption system 2 is capable of dissipating blast energy from the blast loads along at least one direction and/or one plane.

In one embodiment, at least one longitudinal blast energy absorption member 50A may be disposed within the housing 6 to supplement the blast energy absorbing capability of the housing 6. In one example, the longitudinal blast energy absorption member 50A is disposed within the housing 6 along a substantially longitudinal (x) direction. For example, the longitudinal blast energy absorbing member 50A may dampen blast loads along a portion of at least one of horizontal-longitudinal (y-x) or vertical-longitudinal (z-x) planes. In some instances, the longitudinal blast energy absorbing member 50A may dampen blast loads along a substantially longitudinal (x) direction.

In one embodiment, at least one vertical blast energy absorbing member 503 may be disposed within the housing 6 to supplement the blast energy absorbing capability of the housing 6. In one instance, the vertical blast energy absorbing member 503 is disposed within the housing 6 along a substantially vertical (z) direction. For example, the vertical blast energy absorbing member 503 may dampen blast loads along a portion of at least one of longitudinal-vertical (x-z) or horizontal-vertical (y-z) planes. In some instances, the vertical blast energy absorbing member 503 may dampen blast loads along a substantially vertical (z) direction.

In one embodiment, at least one cross member 8 may be disposed within the housing 6 to supplement the blast energy absorbing capability of the housing 6. In one instance, the cross member 8 is disposed within the housing 6 along a substantially horizontal (y) direction. For example, the cross member 8 may dampen blast loads along a portion of at least one of longitudinal-horizontal (x-y) or vertical-horizontal (z-y) planes. In some instances, the cross member 8 may dampenblast loads along a substantially horizontal (y) direction.

In one embodiment, the blast energy absorption system 2 includes an understructure 10 disposed underneath the floor structures 4 and the housing 6. In some instances, the understructure 10 may be integrated into an undercarriage of a vehicle 100. In other instances, the understructure 10 may be disposed about an exterior portion of a vehicle 100.

FIGS. 3A and 3B are perspective top and bottom views, respectively, of an understructure 10 according to an embodiment of FIGS. 1A and 1B. In one embodiment, the understructure 10 of an armored vehicle includes a bottom plate 12 and two cover plates 14 of armor. The number of and general shapes of the bottom plate 12 and the cover plates 14 may vary depending on the vehicle and type of mission. As such, the illustrations herein are for illustration purposes only and are not intended to limit the claimed disclosure.

In one embodiment, the bottom plate 12 may be connected to two cover plates 14 on opposing sides of the bottom plate 12. In one example, one end of a cover plate 14 may be connected to an end of the floor structure 4 via through holes 60 sized to receive threaded bolts 70 for engaging with
through holes 72 of the floor structure 4 (best shown in FIG. 1B). In this example, an opposite end of the cover plate 14 may be coupled to an end of the bottom plate 12 via an overlapping arrangement (best shown in FIG. 1B and corresponding inset). In this instance, the bottom plate 12 and the cover plate 14 may be arranged in an overlapping relationship 20 along a mating edge 22 that substantially eliminates any gaps between the mating parts 12, 14 and improves the blast integrity by reducing any blast air infiltration leak paths into the vehicle.

[0048] In one embodiment of the overlapping arrangement 20, an end of the bottom plate 12 may include a lip 24 having a cutout 26 with a depth D being approximately the thickness T of the cover plate 14. In this instance, the cutout 26 may have a length L sufficient such that the gap G is less than length L during operational mission conditions. In some instances, the cutout plate 14 may be completely received within the cutout 26 without any gap G and with the depth D being approximately the thickness T. In some embodiments, additional fasteners may be utilized (e.g., nuts, bolts) to ensure that the bottom plate 12 and the cover plate 14 are securely fastened to each other. In other embodiments, there need not be any overlapping arrangement 20 and the cover plate 14 may be secured to the bottom plate 12 via fasteners (e.g., nuts, bolts) or the plates 14, 12 may be an integrated unit (e.g., welding, single aluminum sheet formed by bending).

[0049] In one embodiment, the bottom plate 12 of the blast energy absorption system 2 can be a sandwiched structure having outer skins 16A, 16B and a core 18 (best shown in FIGS. 1B and 3A). In this instance, the outer skins 16A and 16B can be made of a metallic material (e.g., steel, aluminum) or a composite structure (e.g., plastic, thermoplastic, polymer). Likewise, the core 18 can be made of a metallic material (e.g., steel, aluminum), composite structure (e.g., plastic, thermoplastic, polymer), or foam (e.g., metal, plastic). In some embodiments, the cover plates 14 may also include through holes 68 sized to receive threaded bolts 70 for engaging with through holes 72 of the floor structures 4 and with through holes 74 disposed about the exterior support structures 28 (best shown in FIG. 3B). In one instance, the two cover plates 14 may be first attached followed by the bottom plate 12 to complete installation of the blast energy absorption system 2.

[0050] In one embodiment, the portion of the bottom plate 12, while coupled to a portion of the cover plate 14, may also be connected to a portion of the vertical member 46 via through holes 64 sized to receive a threaded bolt 62 for engaging with through holes 66 of the housing 6.

[0051] In one embodiment, the floor structure 4, the vertical member 46, and the understructure 10 are capable of forming a side compartment 91. In another embodiment, the housing 6 and the understructure 10 are capable of forming a central compartment 93. In these embodiments, the compartments 91, 93 are capable of absorbing blast energy by dampening blast loads along a portion of at least one of the floor structures 4, the vertical members 46, the housing 6 and the understructure 10. In some instances, at least one longitudinal blast energy absorbing member 50A, 50B may be housed within the central compartment 93, along with at least one cross member 8.

[0052] In some embodiments, at least one of the floor structures 4, the housing 6, the understructure 10, the longitudinal blast energy absorbing members 50A, the vertical blast energy absorbing members 50B, and the cross members 8, is capable of providing load transfer in at least one of longitudinal (x) direction, horizontal (y) direction or vertical (z) direction to dampen blast loads. In other embodiments, at least one of the floor structures 4, the housing 6, the understructure 10, the longitudinal blast energy absorbing members 50A, the vertical blast energy absorbing members 50B, and the cross members 8, is capable of providing load transfer in at least one of horizontal-longitudinal (y-x) plane, longitudinal-vertical (x-z) plane, or horizontal-vertical (y-z) plane for dampening blast loads.

[0053] In some embodiments, at least one of the compartments 91, 93 is capable of providing load transfer in at least one of longitudinal (x) direction, horizontal (y) direction or vertical (z) direction to dampen blast loads. In other embodiments, at least one of the compartments 91, 93 is capable of providing load transfer in at least one of horizontal-longitudinal (y-x) plane, longitudinal-vertical (x-z) plane, or horizontal-vertical (y-z) plane for dampening blast loads.

[0054] Although the understructure 10 has been described as having multiple members (e.g., bottom plate 12 and two cover plates 14), in one embodiment, the understructure 10 may be provided as an integrated, singular member (e.g., welding separate components, bending an aluminum sheet or plate).

[0055] Continuing with FIGS. 1A and 1B, at least one cross beam member 8 may be horizontally arranged on top of the understructure 10 and housed within the central compartment 93. In one instance, a bottom portion of the cross beam member 8 may include an aperture 66 while an adjacent end of the bottom plate 12 of the understructure 10 may include a corresponding aperture 64. In these instances, the apertures 66, 64 may be similarly sized and threaded. Accordingly, the apertures 66, 64 may be capable of receiving a bolt 62 for securing attaching the cross beam member 8 to a portion of the understructure 10. In this embodiment, the cross beam member 8 is configured to absorb blast energy by dampening blast loads at least along a horizontal direction, among others.

[0056] In one embodiment, the cross beam member 8 may be coupled to the housing 6 via a cross beam member attachment member 52. For example, one end 54 of the cross beam member attachment member 52 may include through holes 56 while an adjacent end of the cross beam member 8 may include corresponding through holes 58. In these instances, the through holes 56, 58 may be similarly sized and threaded. Accordingly, each of the through holes 56, 58 may be capable of receiving a bolt 60 for securely attaching the cross beam member 8 to a portion of the housing 6. An opposite end of the cross beam member attachment member 52 may be fastened to the vertical member 46 in a similar fashion. In other embodiments, the opposite end of the cross beam member attachment member 52 may be permanently fastened to a portion of the vertical member 46 via welding, among other bonding techniques. In one embodiment, the number of cross beam members 8 attached to the housing 6 at any given time may depend on the mission threat.

[0057] Continuing with FIGS. 1A and 1B, one embodiment of the blast energy absorption system 2 includes at least two floor structures 4 and a central housing 6 for a minimal or no mission threat. In addition, the two floor structures 4 and the central housing 6 may function as integral components of a vehicle 100 (see FIGS. 2A and 2B). In one embodiment, the housing 6 may act as a center hub interconnecting a plurality of independent reactant systems (e.g., cross beam members 8, adjustable energy absorbing containers 9, understructure 10) on one side of the vehicle 100 to corresponding independent
reactant systems 8, 9, 10 on the other side of the vehicle 100. In another embodiment, the housing 6 is capable of intercon-necting a plurality of independent reactant systems to the vehicle 100. In these instances, the housing 6 can be any suitable configuration and formed of any suitable material (e.g., aluminum, steel, composite). Additional details about the adjustable energy absorbing container 9 will become more apparent during subsequent figures and discussion.

[0058] FIGS. 4A-4J are perspective and exploded views of various embodiments of an adjustable energy absorbing con-tainer 9 for a blast energy absorption system 2. In one embodiment, the adjustable energy absorbing containers 9 includes an exterior support structure 28 (e.g., angle brackets), an interior support structure 30, and one or more crush elements 32, which will be discussed in more detail below. In one embodiment, each component may be an independent reaction-tant system. The integral relationship between the above mentioned components may form a system that is capable of absorbing and distributing blast energy to minimize energy transfer to occupants of a vehicle. In some embodiments, the blast energy absorption system 2 is capable of many configurations depending on the threat level of a mission.

[0059] For example, in one embodiment, a blast energy absorption system 2 includes at least two floor structures 4, the housing 6 and the understructure 10 for high mission threats levels. In one embodiment, a blast energy absorption system 2 includes at least two floor structures 4, the housing 6, the understructure 10 and at least one cross beam members 8 for higher mission threats. In one embodiment, a blast energy absorption system 2 includes at least two floor structures 4, the housing 6, the understructure 10, exterior support structure 28 and interior support structure 30 for higher mission threats. Additional details about the exterior support structure 28 and the interior support structure 30 will become more apparent in subsequent figures and discussion. In one embodiment, a blast energy absorption system 2 includes at least two floor structures 4, the housing 6, the understructure 10, at least one cross beam members 8, exterior support structure 28 and interior support structure 30 for higher mission threats. In one embodiment, a blast energy absorption system 2 includes at least two floor structures 4, the housing 6, the understructure 10, at least one cross beam members 8, exterior support structure 28, interior support structure 30 and one or more crush elements 32 for yet a higher mission threats. Additional details about the one or more crush elements 32 will become more apparent in subsequent figures and discussion.

[0060] Returning now to FIGS. 1A and 1B, the adjustable energy absorbing container 9 can include an exterior support structure 28 (e.g., angle brackets), interior support structure 30, and crush elements 32. In one example, the exterior support structure 28, the interior support structure 30, and the crush elements 32 are capable of forming a triangular box-like structure. In one embodiment, the interior support structure 30 can be an extrusion or forging having an outer frame 38 and energy absorbing members 40 interiorly connected to the outer frame 38 to form collapsible cavities 42. In one instance, the outer frame 38 may be substantially planar extending along at least a portion of the horizontal-longitudinal (y-x) and/or longitudinal-vertical (x-z) planes. In some instances, the outer frame 38 may be substantially adjacent the understructure 10 and runs along the length of the outer cover plates 14. In one embodiment, a side 44 of the outer frame 38 adjacent the cover plate 14 may include at least one aperture 34 for forming at least one cavity 36, wherein the aperture 34 and the cavity 36 are both sized to receive and retain crush elements 32. The crush elements may be retained in the apertures 34 and cavities 36 by semi-permanent and/or re-attachable fastening techniques. These and other embodiments of the crush elements 32 will be described in more detail below.

[0061] In one embodiment, the adjustable energy absorbing container 9 may be connected to a portion of the floor structure 4 via one or more bolts 74. For example, an upper portion of the exterior support structure 28 of the adjustable energy absorbing container 9 may include through holes 78 while an adjacent portion of the floor structure 4 may include corresponding through holes 76. In some instances, the through holes 78, 76 may be similarly sized and threaded. In other instances, the through holes 76 may be counter-sunk and the through holes 78 may be threaded to correspond. Accordingly, each of the through holes 78, 76 may be capable of receiving a bolt 74 for securely attaching the adjustable energy absorbing container 9 to a portion of the floor structure 4.

[0062] In one embodiment, the adjustable energy absorbing containers 9, having three-dimensional box-like structures, may be disposed within each of the side compartments 91. In some embodiments, the adjustable energy absorbing containers 9 are capable of providing load transfer in at least one of longitudinal (x) direction, horizontal (y) direction or vertical (z) direction to dampen blast loads. In other embodiments, the adjustable energy absorbing containers 9 are capable of providing load transfer in at least one of horizontal-longitudinal (y-x) plane, longitudinal-vertical (x-z) plane, or horizontal-vertical (y-z) plane for dampening blast loads.

[0063] As can be understood from the above embodiments, any combination of cross beam members 8, adjustable crush containers 9 (e.g., exterior support structure 28, interior support structure 30, and crush elements 32), and the understructure 10, may be removed to reduce the weight of the vehicle and still maintain the required blast integrity to assure the safety of the occupants. In some embodiments, each component is designed to plastically deform (e.g., buckle, bend) to absorb energy from a bomb or mine blast and not to fragment into small pieces that become projectiles. In one embodiment, the energy that is not dissipated by these components may be dissipated by the floor structures 4 and/or the housing 6 with minimal or reduced plastic deformation.

[0064] Returning now to FIGS. 4A-4J, in one embodiment, the adjustable energy absorbing container 9 may be slidably attached to the bottom surface of the floor structure 4 as best shown in FIG. 4A. In one embodiment, the adjustable energy absorbing container 9 includes a casing 80 that encases the exterior support structure 28, the interior support structure 30, and the crush elements 32. The enclosure of the casing 80 may facilitate the installation of the adjustable energy absorbing container 9 from an exterior portion of the vehicle 100 without having to gain entry into the vehicle 100 to remove attachment features including the likes of nuts and bolts, among others. The ability to change external armorment configuration may allow for a change in armor while soldiers are on-board a vehicle 100 waiting or otherwise readying the vehicle 100 (e.g., replenishing ammunition, ordinances, supplies) for the next mission without interference by the ground crew changing the armor (e.g., adjustable energy absorbing containers 9).
In some embodiments, the casing 80 may include a series of handles 82, 84 to facilitate the handling and installation of the casing 80 onto a vehicle 100 (best shown in FIGS. 4C-4D and 4G-4I). Handles 82, 84 may be located on an edge 86 or a side 88 of the casing 80. Depending on the size of the adjustable energy absorbing containers 9A, 9B, smaller adjustable energy absorbing container 9B may be picked up and carried by one installer while larger adjustable energy absorbing container 9A may need to be picked up and carried by two or more installers either because of weight or length. In some instances, multiple small adjustable energy absorbing containers 9 may be installed simultaneously as best shown in FIGS. 4I and 4L. Although the figures illustrate only one handle 84 per side 88, it is contemplated that more than one handle 84 may be coupled to the sides 88 of the adjustable energy absorbing container 9. Likewise, there may be more or fewer handles 82 on the edge 86 as necessary for purposes of installation and/or maintenance.

In one embodiment, the casing 80 includes a top surface 96 that opens for the installation and removal of the crush elements 32 as best illustrated in FIG. 4A. In another embodiment, the top surface 96 allows for access to exterior support structures 28 and interior support structures 30 for routine maintenance and/or repairs. In some embodiments, ground crew members need not change the entire adjustable energy absorbing container 9 but instead may change out crush elements 32, exterior support structures 28, or interior support structures 30, among others as necessary. In other words, any components within the casing 80 of the adjustable energy absorbing container 9 may be module-like and may be maintained and/or repaired using external access without interior access to the vehicle 100.

In one embodiment, the top surface 96 may be movable attached or connected to a back surface 158 along a back edge 162 or at least one side 88 along a side edge 164 as best illustrated in FIGS. 4A and 4C. In one embodiment, the attachment between the top surface 96 and the back surface 158 or the sides 88 can be a solid connection or joint where the top surface 96 and the back surface 158 or the sides 88 are a monolithic or single piece of material that is bent approximately 90 degrees to form the substantially 90 degree orientation of the top surface 96 to the back surface 158 or the sides 88. In some instances, there can be sufficient spring-back in the solid joint making it capable of opening and closing several times without fatiguing the joint and without a device such as a conventional hinge.

In one embodiment, the top surface 96 may be attached to the back surface 158 and the sides 88 via hinges (not shown). In another embodiment, the top surface 96 can include a rotatable latch 160 having an extension 166 that contacts an inner leading edge 89 of a lower surface 168 for temporarily securing the top surface 96 to the lower surface 168. For instance, the rotatable latch 160 is capable of securing the top surface 96 to the leading edge 86 and the inner leading edge 89. In some instances, the leading edge 86 of the lower surface 168 may be integrated with a bottom side 152 of the adjustable energy absorbing container 9. In one instance, a clockwise rotation of the latch 160 would release the top surface 96 from the lower surface 168. In another instance, a counter-clockwise rotation would secure the top surface 96 to the lower surface 168. In other instances, different angles of rotation and/or amount of rotation may be made to secure and/or release the top surface 96 from the lower surface 168.

In one embodiment, recessed hand grips 90 may be located on a bottom side 152 of the adjustable energy absorbing container 9 as best illustrated in FIGS. 4D-4F. In one example, the recessed hand grips 90 may be covered by spring-loaded flappers 154 that may substantially cover and seal the interior of the recessed hand grips 90 from environmental dirt and debris. In another example, the spring-loaded flappers 154 may streamline the bottom surface 152 for improved aerodynamic performance. In these instances, the spring-loaded flappers 154 may be actuated to allow handling of the adjustable energy absorbing containers 9 using the recessed hand grips 90 as best illustrated in FIGS. 4E-4F.

In one embodiment, the casing 80 may be coupled to the floor structure 4 via engaging members 92 and cooperating engagement features 94 as best illustrated in FIG. 4A. In this embodiment, the engagement may be that of a dovetail or dovetail joint. For instance, the engaging member 92 may be a dovetail joint received within the cooperating engagement feature 94 such as a dovetail slot. In this instance, the engagement members 92 are disposed about a top surface 96 of the adjustable energy absorbing container 9 while the cooperating engagement features 94 are disposed about a bottom surface 98 of the floor structure 4. In one embodiment, the dovetail joint 92 and the dovetail slot 94 may be slidably engaged. In another embodiment, the geometries of the dovetail joints 92 may be slightly smaller in size than the dovetail slots 94 to facilitate ease of installation and removal. In some embodiments, the engagement features may be sufficient as to prevent the adjustable energy absorbing container 9 from significant vertical, horizontal and/or longitudinal movements under operational mission conditions.

In one embodiment, the coefficient of friction between engaging member mating surface 95A and the cooperating engagement feature mating surface 95B may be low enough to facilitate ease of sliding the dovetail joint 92 in and out of the dovetail slot 94. In another embodiment, the reduced coefficient of friction may minimize or mitigate binding of the adjustable energy absorbing container 9 to the floor structure 4 during removal and/or installation. In some embodiments, the engagement features are capable of enabling installation of the adjustable energy absorbing container 9 from the exterior of the vehicle 100 without the need to enter the occupant compartment.

In operation, now turning to FIGS. 4E-4I, an adjustable energy absorbing container 9 can be lifted for installation onto a vehicle by a single person. In FIGS. 4E and 4F, the person places fingers onto spring loaded flappers 154 and slightly pushes inward displacing the spring loaded flappers 154 into the recesses 90 in order to hold and balance the adjustable energy absorbing container 9. In FIGS. 4F-4H, the person can use his or her forearms to steady and distribute the load of the adjustable energy absorbing container 9 while picking up, as well as transportation. In FIGS. 4I and 4J, the person transports the adjustable energy absorbing container 9 (shown only as blast energy absorption system 2 for convenience) to the vehicle 100 and positions the adjustable energy absorbing container 9 for horizontal installation (y-direction relative to vehicle orientation) onto the vehicle 100.

Once the adjustable energy absorbing containers 9 are installed onto the vehicle 100, retention devices may be actuated. Retention devices can be any suitable mechanical, electrical, electromechanical, or magnetic devices capable of holding the adjustable energy absorbing container 9 in place.
when longitudinal, horizontal or vertical loads are induced onto the vehicle 100 due to events such as hard cornering or serpentine maneuvers to avoid enemy assault. Retention devices may also be helpful during the installation process to hold the adjustable energy absorbing container 9 in place during the installation of other components of the blast energy absorption system 2 (e.g., cover plates 14). In this instance, the cover plates 14 may further strengthen and secure the adjustable energy absorbing container 9. In some embodiments, retention devices may also facilitate the installation process by holding the adjustable energy absorbing container 9 steady on un-level surfaces or while the vehicle 100 is in motion.

[0074] One type of retention device is shown in FIG. 4A. As shown, the casing 80 of the adjustable energy absorbing container 9 can include vertically-oriented retention devices 102 situated about portions of the top surface 96. The retention devices 102 may be received by corresponding engagement recesses 104 disposed about an edge of the floor structure 4 for inhibiting movement of the casing 80 in at least one of horizontal, longitudinal or vertical direction when the vehicle 100 is in operation or when the vehicle 100 is parked on an uneven surface. In one embodiment, the retention device 102 can be a pivotal pin operably attached to the handles 82, whereby the retention device 102 may be rotated 90 degrees by rotating the handle 82 by 90 degrees. In other embodiments, the amount of rotation to the handle 82 may cause the retention device 102 to be rotated accordingly.

[0075] In one embodiment, the casing 80 can include horizontally-oriented cooperating retention devices 106 extending through the housing 6 as best illustrated in FIGS. 4B and 9A-9C. The cooperating retention devices 106 and the horizontal retention devices 108 may be installed in the casing 80 as shown. In other embodiments, the horizontal retention devices 108 may be installed on the longitudinal or vertical blast energy absorbing members 50A, 503 within the housing 6.

[0076] FIGS. 9A-9C illustrate the cooperating retention device 106 engaging and disengaging the horizontal retention devices 108. FIGS. 9A and 9C shows the devices 106, 108 in an engaged or locked position while FIG. 9B shows the devices 106, 108 in a disengaged or unlocked position. In one embodiment, the horizontally-oriented cooperating retention device 106 may include a pin 110 at one end 112 of a longitudinal member 114, while an opposing end 116 of the longitudinal member 114 may be operably connected to a handle 82. In one embodiment, the horizontal retention device 108 can be a slot having width and length being slightly larger than the width and length of the pin 110. In operation, the pin 110 may be aligned with the slot 108 and inserted there-through as best illustrated in FIG. 9B. Once the pin 110 has cleared the slot 108, the handle 82 may be rotated 90 degrees to rotate the pin 110 such that the pin 110 makes contact with an interior housing wall 170. To engage or lock the adjustable energy absorbing container 9 to the casing 80 and/or the blast energy absorbing members 50 of the housing 6 (e.g., retain the adjustable energy absorbing container 9 within side compartments 91), the cooperating retention device 106 may be situated at a first horizontal position (9 o'clock position) or a second horizontal position (3 o'clock position) relative to the slot 108 as best illustrated in FIGS. 9A and 9C, respectively. To disengage or unlock, the cooperating retention device 106 may be rotated to a vertical position (12 o'clock position) as best illustrated in FIG. 9B. In some embodiments, the rotation of the cooperating retention device 106 may be carried out with or without the use of handle 82.

[0077] In one embodiment, a retractive pin mechanism 190 may be used for horizontally retaining the adjustable energy absorbing container 9 as best illustrated in FIGS. 10A (engaged position) and 10B (disengaged position). In this embodiment, the retractive pin mechanism 190 includes a pin 192 operably connected to a handle 82, which may be pivotally coupled to a leading edge 86 of the adjustable energy absorbing container 9. The pin 192 may be received into and through a hole 194 disposed adjacent the leading edge 86. In the engaged position (FIG. 10A), the pin 192 extends beyond an upper surface 196 of the leading edge 86 and may be received into a hole or recess similar to the corresponding engagement recess 104 of the floor structure 4 as shown in FIG. 4A. In one instance, the spring 198 may be disposed between a washer unit 200 and a stopper unit 202. In this instance, the washer unit 200 may be pressed into the hole 194 and flush with an upper surface 196 while the stopper unit 202 may be fixedly connected to the pin 192. In another embodiment, the spring 198 may also be connected at each of its ends to the washer 200 and the stopper unit 202 such that as the handle 82 is rotated downward (FIG. 10A), the spring 198 stretches in response to the movement of the handle 82.

[0078] In operation, when the handle 82 is rotated downward (FIG. 10A), the spring 198 is stretched, and the pin 192 retracts into the hole 194 (FIG. 10B) until the pin 192 is at least clear of a hole or recess similar to the corresponding engagement recess 104 of the floor structure 4 thereby clearing any obstacles (e.g., pin/hole interaction) from the horizontal path of an adjustable energy absorbing container 9 as it is installed and/or uninstalled from the vehicle 100. When the handle 82 is released, the spring 198 compresses to its original displacement, the handle 82 rotates upward (FIG. 10A), and the pin 194 extends into a hole or recess similar to the corresponding engagement recess 104 of the floor structure 4 for securing the adjustable energy absorbing container 9 to the vehicle 100.

[0079] Another engagement feature according to the present disclosure includes vertical retention devices such as a hook latch 172 and a locking block 174 as best illustrated in FIGS. 8A and 8B. In one embodiment, the hook latch 172 may be rotatably connected to the side 88 of the casing 80 by a stationary pin 176. A spring 178 may be attached to a pin 179, which is connected to the hook latch 172, and can bias the rotating hook latch 172 relative to the stationary pin 176 such that as a head 180 of the hook latch 172 contacts a side surface 181 of a locking block 174 connected to the floor structure 4, the hook latch 172 deflects or rotates counter-clockwise (or clockwise) until the head 180 vertically clears a top surface 182 of the locking block 174. Once the head 180 clears the top surface 182, spring 178 urges the hook latch 172 clockwise (or counter-clockwise) to receive a portion 184 of the locking block 174 into a hook recess 186.

[0080] In one embodiment, the hook latch 172 can also include a release arm 188 to release the hook latch 172 from the locking block 174. By asserting a spring counter force F1, F2 onto the release arm 188, the hook latch 172 rotates counter-clockwise (or clockwise) until the head 180 horizontally clears the top surface 182 of the locking block 174, thereby removing the vertical restraint allowing the adjustable energy absorbing container 9 to freely move downward. Actuation of the release arm 188 can be manual by applying a downward force F1 or a horizontal force F2. For example,
the manual actuation can be carried out by a linkage mechanism (not shown) or a person's thumb (not shown). In other embodiments, the actuation of the release arm 188 may also be carried out by electronic circuits (not shown).

In operation, the adjustable energy absorbing containers 9 may be horizontally installed (y-direction) onto a vehicle 100 as discussed above (FIGS. 4E-4I). In some embodiments, the adjustable energy absorbing containers 9 may be vertically installed (z-direction) onto a vehicle 100 as shown in FIGS. 8C and 8D. In this instance, a user (not shown) may position the adjustable energy absorbing container 9C below the floor structure 4, followed by bringing the adjustable energy absorbing container 9C vertically in the direction of arrows V for engaging the hook latch 172 with the locking block 174. In some instances, the spring force of the spring 178 may be sufficient not to require the horizontal retention devices 106, 108 as discussed above. In some cases, the horizontal retention devices 106, 108 as described herein may be necessary for installing the adjustable energy absorbing containers 9A, 9B, 9C to the floor structures 4.

FIG. 11 illustrates a perspective view of an interior support structure 30 containing at least one crush element 32. Although hexagonal in appearance, the crush element 32 can take on other polygonal shapes and sizes. In one embodiment, the crush element 32 may be loosely housed within a hole 34 of the interior support structure 30. In another embodiment, the crush element 32 may be semi-permanently fastened to the interior support structure 30. In one embodiment, the crush element 32 may be coupled to the interior support structure 30 via re-attachable fastening techniques. Regarding the re-attachable fastening techniques, minimal interference fit or press fit may be required for purposes of maintaining the crush element 32 in place. In these instances, the larger the interference fit, the higher the force is required to insert and remove the crush element 32.

In one embodiment, each of the exterior support structure 28, the interior support structure 30, and the crush element 32 may be disposed within each of the side compartments 91. In some embodiments, at least one crush element 32 may be housed or disposed within the adjustable energy absorbing container 9, which can be housed within the side compartment 91. In one embodiment, at least one crush element 32 may be housed or disposed within the interior support structure 30.

In some embodiments, each of the exterior support structure 28, the interior support structure 30, and the crush element 32, is capable of providing load transfer in at least one of longitudinal (x) direction, horizontal (y) direction or vertical (z) direction to dampen blast loads. In other embodiments, each of the exterior support structure 28, the interior support structure 30, and the crush element 32, is capable of providing load transfer in at least one of horizontal-longitudinal (y-x) plane, longitudinal-vertical (x-z) plane, or horizontal-vertical (y-z) plane for dampening blast loads.

In one embodiment, the exterior support structure 28 is configured to absorb blast load or blast energy by dampening blast loads along the exterior support structure 28. In one embodiment, the interior support structure 30 is configured to absorb blast load or blast energy by dampening blast loads along the interior support structure 30. In one embodiment, the crush element 32 is configured to absorb blast load or blast energy by dampening blast loads along the crush element 32. In other words, each of the exterior support structure 28, the interior support structure 30, and the crush element 32, is capable of collapsing on itself to absorb or resist the blast energy from the blast loads thereby minimizing physical harm to the occupants within the vehicle.

In one embodiment, the crush element 32 may be circular in shape with an outer diameter greater than the diameter of the hole 34. In this embodiment, the contact surface area of the crush element in relation to the hole 34 may be determined by the perimeter of the hole 34. Other possible shapes are oval, oblong, elliptical, or any other shapes with two or more contact points. In these examples, the use of a polygonal-shaped crush element 32 reduces the contact surface area to two or more contact points with less contact surface area than the perimeter of a hole 34. The sides of a polygon may determine the number of contact points between the crush element 32 and the hole 34. Another factor in determining the force to insert and remove a polygon-shaped crush element 32 is the interference fit between the diameter of the hole 34 and an outer diameter 204 of the polygon-shaped crush element 34. Any polygon is acceptable including but not limited to a plane (2 points of contact), triangle (3 points of contact), quadrilateral (4 points of contact), pentagon (5 points of contact), hexagon (6 points of contact), and up to a number of sides (n points of contact).

FIGS. 5A and 5B are top and side views, respectively, of various embodiments of alternative crush element retention devices 31 for retaining the crush element 32 within a hole 34 of the exterior support structure 28. In some embodiments, crush element retention device 31 may also be used for retaining the crush element 32 within a hole 34 of the interior support structure 30. In one embodiment, the crush element retention device 31 can be an insert 118 made of resilient material (e.g., silicone, rubber, polymer) having a plurality of fingers 120. In one embodiment, the fingers 120 are capable of deflecting outward and contacting an outer surface 122 of the crush elements 32 (see FIG. 11B) to create frictional loads that may center and retain the crush element 32 within the hole 34 of the interior support structure 30. Position A is the shape of the crush element retention device 31 before the crush element 32 is inserted within the insert 118. Position B is the shape of the crush element retention device 31 after the crush element 32 is inserted within the insert 118. In this instance, the crush element 32 will lead to a deformation of the crush element retention device 31. As the fingers 120 are deflected outward, the crush element 32 is being retained and secured to the interior support structure 30 by the crush element retention device 31.

FIGS. 6A and 6B illustrate examples of inserts 118 for use with the holes 34 of the interior support structure 30 having a diameter 124 (see FIG. 5B). In these instances, each of the inserts 126, 128, 130 may have the same outer diameter OD relative to the diameter 124 of the hole 34. However, the inserts 126, 128, 130 may have different inner diameters ID sized for the outer diameters OD of different crush elements 32 (see FIG. 1B). In other words, the outer diameter OD of the inserts 118 of the crush element retention device 31 may match the diameter 124 of the hole 34, but the inner diameter ID of the inserts 118 of the crush element retention device 31 may be adjusted as needed for housing different shapes and sizes of crush elements 32.

FIG. 6B illustrates another set of inserts 132, 134, 136 that can be configured with resilient, deformable material (e.g., rubber, polymer, silicone) having inner diameters ID being smaller than the diameter of the holes 34. In some embodiments, the inner diameters ID are also smaller than the
outer diameter OD of the crush element 32 in forming an interference fit. In these embodiments, the interference fit can be sufficient for centering and retaining the crush element 32 within the hole 34. In addition, the interference fit may also ease the removal of the crush element retention device 31 from the crush element 32.

[0090] FIG. 7 illustrates side views of alternative crush element retention devices 31 integrated with different sized crush elements 32. As shown, each insert within the set of inserts 138, 140, 142 includes a resilient sleeve 144 capable of being integrated, respectively, with crush elements 146, 148, 150 in forming a single, integral member. As shown, each crush member retention device 31 may be received within the diameter of the hole 34, and may be integrable with crush elements 146, 148, 150 having different sizes. In other embodiments, the crush member retention device 31 may be customized to fit different shapes and sizes for accommodat ing the size of the hole 34 and the crush element 32. Furthermore, the crush member retention device 31 may also be integrated with a sleeve 144.

[0091] FIGS. 12A-12C are perspective views of an alternative embodiment of a crush element retention system having a retention sleeve 206 with a tapered inner diameter 1D. In these embodiments, the opening inner diameter 208 of the crush element 32 may be greater than the outer diameter 210 of the crush element 32. In some instances, the inner diameter 212 at a bottom end 214 of the retention sleeve 206 may be less than the outer diameter 210 of the crush element 32. In operation, as the crush element 32 enters the crush element retention sleeve 206 and makes contact with the inner diameter 1D of the retention sleeve 206. In these instances, because the inner diameter ID of the retention sleeve 206 is tapered, the crush element 32 is capable of being received by the inner diameter ID of the retention sleeve 206 until the outer diameter 210 of the crush element 32 exceeds that of the inner diameter ID of the retention sleeve 206. When the outer diameter of the crush element 32 exceeds that of the inner diameter ID of the retention sleeve, the crush element 32 can no longer travel down the inner 215 of the retention sleeve 206. Accordingly, the tapering can be designed to retain crush elements 32 having different outer diameter OD 210 without being required to have matched retainers for each crush element 32.

[0092] FIGS. 13A and 13B are cross-section views of a crush retention system having a crush element 32 installed into an interior support structure 30 using another alternative crush element retention device 31. In one embodiment, the crush retention system includes a spring clamp 216 that deflects outward when a crush element 32 with an outer diameter OD 210 is greater than the relaxed diameter 218 (solid lines in FIG. 13A) of the spring clamp 216 that is insert therein. In one embodiment, the spring clamp 216 may have a maximum deflection diameter 220 (dotted lines in FIG. 13A) that may not be exceeded to assure the spring clamp 216 substantial returns to its relaxed position.

[0093] In operation, the blast energy absorption system 2 may deform to absorb the blast energy. For example, the understructure 10 and cross beam members 8 (if any) may bend and buckle inward. In another example, the interior support structure 30 may buckle. In some instances, the crush elements 32 (if any) may be crushed. In other instances, the exterior support structure 28 may bend and buckle inward. In some embodiments, longitudinal energy absorbing members 50 (if any) may buckle. In one embodiment, the floor structure 4 and the housing 6 may dampen the remaining energy with little or no plastic deformation.

[0094] In one embodiment, all the components described above may be integrated into the chassis and/or frame of the vehicle 100 as shown in FIGS. 2A and 2B either directly (e.g., floor structures 4, housing 6) or indirectly (e.g., cross beam members 8, adjustable energy absorbing containers 9, understructure 10), and may either be connected by semi-permanent fastening techniques (e.g., welding or adhesive) or by replaceable fastening techniques (e.g., screws, nuts/bolts), whereby the components are all contemplated as being capable of being removable either for repair or for varying the level of occupant protection.

[0095] Though dovetails/dovetail slots and hooks/latches are illustrated, any acceptable devices are contemplated with the scope of the disclosure and not intended, to limit the disclosure to any one configuration.

[0096] While there has been described herein the principles of the disclosure, it is to be understood to those skilled in the art that this description is made only by way of example and not as a limitation to the scope of the disclosure. Accordingly, it is intended to cover all modifications of the disclosure which fall within the true spirit and scope of the disclosure. And although the disclosure has been described in detail with reference to several embodiments, additional variations and modifications exist within the scope and spirit of the disclosure as described and defined in the following claims.

What is claimed is:

1. A system comprising:
   at least first and second floor structures, wherein each floor structure is dimensioned for integration in a longitudinal-horizontal plane of a vehicle; and
   a housing disposed between the at least first and second floor structures, wherein the housing comprises at least first and second vertical members, wherein a body portion of the first vertical member is connected to a first side of the first floor structure, and wherein a body portion of the second vertical member is connected to a first side of the second floor structure; and
   wherein each of the floor structures and the housing is configured to absorb blast energy by dampening blast loads along at least one of horizontal-longitudinal plane, longitudinal vertical plane, and horizontal-vertical plane.

2. The system of claim 1, further comprising:
   an understructure disposed underneath the at least first and second floor structures and the housing, wherein a first side of the understructure is connected to a second side of the first floor structure, wherein a second side of the understructure is connected to a second side of the second floor structure, wherein a first body portion of the understructure is connected to one end of the first vertical member, and wherein a second body portion of the understructure is connected to one end of the second vertical member; and
   wherein the first floor structure, the first vertical member, and the understructure are configured to form a first compartment, wherein the second floor structure, the second vertical member, and the understructure are configured to form a second compartment, wherein the housing and the understructure are configured to form a third compartment, and wherein each of the compartments is configured to absorb blast energy by dampening blast loads along a portion of at least one of the at
least first and second floor structures, the at least first and second vertical members, the housing, and the understructure.

3. The system of claim 2, further comprising:
   at least one cross beam member horizontally arranged on top of the understructure, wherein the at least one cross beam member is housed within the third compartment, and wherein the at least one cross beam member is configured to absorb blast energy by dampening blast loads along a horizontal direction.

4. The system of claim 2, further comprising:
   at least one of longitudinal and vertical blast energy absorbing members housed within the third compartment, wherein the at least one of longitudinal and vertical blast energy absorbing members is configured to absorb blast energy by dampening blast loads along at least one of longitudinal and vertical directions.

5. The system of claim 3, further comprising:
   at least one adjustable energy absorbing container disposed within each of the first and the second compartments, wherein the at least one adjustable energy absorbing container is configured to absorb blast energy by dampening blast loads along at least one of horizontal, longitudinal, and vertical directions.

6. The system of claim 5, further comprising:
   at least one of interior and exterior support structures housed within each of the first and second compartments, wherein the at least one of interior and exterior support structures is configured to absorb blast energy by dampening blast loads along at least one of horizontal-longitudinal plane, longitudinal-vertical plane, and horizontal-vertical plane.

8. A system comprising:
   at least first and second floor structures, wherein each floor structure is dimensioned for integration in a longitudinal-horizontal plane of a vehicle;
   a housing disposed between the at least first and second floor structures, wherein the housing comprises at least first and second vertical members, and wherein a body portion of the first vertical member is connected to a first side of the first floor structure, and wherein a body portion of the second vertical member is connected to a first side of the second floor structure; and an understructure disposed underneath the at least first and second floor structures and the housing, wherein a first side of the understructure is connected to a second side of the first floor structure, wherein a second side of the understructure is connected to a second side of the second floor structure, wherein a first body portion of the understructure is connected to one end of the first vertical member, and wherein a second body portion of the understructure is connected to one end of the second vertical member; and wherein the first floor structure, the first vertical member, and the understructure are configured to form a first compartment, wherein the second floor structure, the second vertical member, and the understructure are configured to form a second compartment, wherein the housing and the understructure are configured to form a third compartment, and wherein each of the compartments is configured to absorb blast energy by dampening blast loads along a portion of at least one of the at least first and second floor structures, the at least first and second vertical members, the housing, and the understructure.

9. The system of claim 8, further comprising:
   at least one cross beam member horizontally arranged on top of the understructure, wherein the at least one cross beam member is housed within the third compartment, and wherein the at least one cross beam member is configured to absorb blast energy by dampening blast loads along a horizontal direction.

10. The system of claim 9, further comprising:
    at least one adjustable energy absorbing container disposed within each of the first and the second compartments, wherein the at least one adjustable energy absorbing container is configured to absorb blast energy by dampening blast loads along at least one of horizontal, longitudinal, and vertical directions.

11. The system of claim 8, further comprising:
    at least one of longitudinal and vertical blast energy absorbing members housed within the third compartment, wherein the at least one of longitudinal and vertical blast energy absorbing members is configured to absorb blast energy by dampening blast loads along at least one of longitudinal and vertical directions.

12. The system of claim 11, further comprising:
    at least one adjustable energy absorbing container disposed within each of the first and the second compartments, wherein the at least one adjustable energy absorbing container is configured to absorb blast energy by dampening blast loads along at least one of horizontal, longitudinal, and vertical directions.

13. The system of claim 9, further comprising:
    at least one of interior and exterior support structures housed within each of the first and second compartments, wherein the at least one of interior and exterior support structures is configured to absorb blast energy by dampening blast loads along at least one of the at least one of interior and exterior support structures.

14. The system of claim 9, further comprising:
    at least one crush element disposed within the at least one adjustable energy absorbing container, wherein the at least one crush element is configured to absorb blast energy by dampening blast loads along at least one of horizontal-longitudinal plane, longitudinal-vertical plane, and horizontal-vertical plane.

15. A system comprising:
    at least first and second floor structures, wherein each floor structure is dimensioned for integration in a longitudinal-horizontal plane of a vehicle;
    a housing disposed between the at least first and second floor structures, wherein the housing comprises at least first and second vertical members, and wherein a body portion of the first vertical member is connected to a first side of the first floor structure, and wherein a body portion of the second vertical member is connected to a first side of the second floor structure; and an understructure disposed underneath the at least first and second floor structures and the housing, wherein a first side of the understructure is connected to a second side of the first floor structure, wherein a second side of the understructure is connected to a second side of the second floor structure, wherein the at least first and second floor structures and the housing, wherein a first side of the understructure is connected to a second side of the first floor structure, wherein a second side of the
understructure is connected to a second side of the second floor structure, wherein a first body portion of the understructure is connected to one end of the first vertical member, and wherein a second body portion of the understructure is connected to one end of the second vertical member; and

wherein the first floor structure, the first vertical member, and the understructure are configured to form a first compartment, wherein the second floor structure, the second vertical member, and the understructure are configured to form a second compartment, wherein the housing and the understructure are configured to form a third compartment, and wherein each of the compartments is configured to absorb blast energy by dampening blast loads along a portion of at least one of the at least first and second floor structures, the at least first and second vertical members, the housing, and the understructure; and

at least one cross beam member horizontally arranged on top of the understructure, wherein the at least one cross beam member is housed within the third compartment, and wherein the at least one cross beam member is configured to absorb blast energy by dampening blast loads along a horizontal direction.

16. The system of claim 15, further comprising:

at least one of longitudinal and vertical blast energy absorbing members housed within the third compartment, wherein the at least one of longitudinal and vertical blast energy absorbing members is configured to absorb blast energy by dampening blast loads along at least one of longitudinal and vertical directions.

17. The system of claim 16, further comprising:

at least one adjustable energy absorbing container disposed within each of the first and the second compartments, wherein the at least one adjustable energy absorbing container is configured to absorb blast energy by dampening blast loads along at least one of horizontal, longitudinal, and vertical directions.

18. The system of claim 17, further comprising:

at least one of interior and exterior support structures housed within each of the first and second compartments, wherein the at least one of interior and exterior support structures is configured to absorb blast energy by dampening blast loads along at least one of the at least one of interior and exterior support structures.

19. The system of claim 18, further comprising:

at least one crush element disposed within the at least one adjustable energy absorbing container, wherein the at least one crush element is configured to absorb blast energy by dampening blast loads along at least one of horizontal-longitudinal plane, longitudinal-vertical plane, and horizontal-vertical plane.

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