

DARPA WHITE PAPER

March 1, 2005

BAA04-31

TECHNICAL AREA: (1) Urban Access, (2) Rapid Stabilization, (3) Asymmetric Warfare Countermeasures, (4) System Architecture and Integration

LEAD ORGANIZATION: Microcube Technology Corporation

TYPE OF BUSINESS: "OTHER SMALL BUSINESS"

TAXPAYER IDN: 77-0382083 also see James K. Bullis, SSN 482-46-1466

WHITE PAPER TITLE: BOMB SURVIVAL CAR

TECHNICAL POINT OF CONTACT: Bullis, James,
ADDRESS: 1155 Pimento Ave., Sunnyvale, CA 94087
TELEPHONE: 408-738-4608,
FAX: 408-738-4074
EMAIL: bullis@msn.com

ADMINISTRATIVE POINT OF CONTACT: Same as above

FUNDS REQUESTED: Phase I, 6 months, \$100,000; Phase II, 12 months, \$300,000

PREPARATION DATE: March 1, 2005

BOMB SURVIVAL CAR

INTRODUCTION

This proposal responds to the plight of the soldier who is sent into dangerous situations without adequate protective equipment. DARPA has also recognized this problem in an existing program announcement that solicits such work repeatedly in that announcement. The call for enhanced mobility with measures that provide effective defense against urban threats is answered by the proposed “bomb car.”

In the bomb car, soldiers ride in single file, yet the vehicle is the width of a jeep. The bomb car height is about twice its width, so soldiers ride at an elevated level. Soldiers get added protection from the greater height, but the main advantage is that space is provided that enables vehicle shaping which greatly enhances armor effectiveness. It also allows sufficient armor carrying structure. This proposal is based on a unique vehicle concept that provides the stability for such an awkward looking configuration in high speed operations. Thus, this vehicle will outpace the adversary, while still providing protection to soldiers.

The proposed concept is compatible with signature control measures.

The bomb car can be made as long as necessary. It can carry a single driver or a squad of soldiers riding in single file. There is flexibility to include various armor systems and weaponry, as needed for different circumstances.

PROPRIETARY

TECHNICAL CONCEPT

It is necessary to protect soldiers from simple roadway bombs or land mines as well as small arms fire, while enabling high speed travel over roads through both rural and urban areas. Adding heavy armor plates to Jeeps and Humvees is not likely to give satisfactory results, since these methods intensify the destructive force of shock waves and lead to yet heavier armor. The result is a significant impact on vehicle weight, which then degrades operating speed and road handling characteristics of the vehicle.

Vehicle shaping is a very important method for minimizing the destructive force of explosions. Where such shaping is made practical, light weight armor can provide a high degree of survivability that cannot be reasonably accomplished otherwise.

Shock wave physics shows that force increases drastically in stagnation regions. These act as energy accumulating regions. Force is integrated in this process, such that it builds to high destructive levels. Shaping to deflect gases at narrow grazing angles prevents the stagnation region. This is all known in the field of armored vehicle design, where sloped panels are arranged where possible.

The “shaped charge” projectile is designed to work against these sloped panels, where large battlefield weapons fire such projectiles. Ultimately, traditional armored vehicles have become very heavy. This is necessary for battlefield operations, but the size and weight of such vehicles make them unsuitable for many military situations.

Such situations include urban warfare and general occupation missions. Large numbers of military vehicles operate in this category. These conventional vehicles need to move rapidly so there are practical limitations on both the weight and shape of protective armor that can be used. The general problem is that armoring leads to a high center of gravity that makes conventional wheeled systems unstable. The vehicle aspect ratio, which is vehicle height divided by its width, is usually designed to be as low as possible, largely in order to keep the center of gravity low.

A serious leap ahead in defensive vehicle design is enabled by a high aspect vehicle concept that is the basis of this proposal. This concept was developed for common transportation purposes, where it enables a personal car that has the efficiency advantages of a motorcycle while providing the safety and comfort of an SUV. Protective structure is provided to enable survival of the driver in a crash with an SUV. An articulated vehicle concept was developed to give such a high aspect ratio vehicle the stability that would obviously be lacking with the ordinary four wheeled automobile arrangement. The result is a “lean” car that is designed to carry a single driver, or driver and passengers in tandem.

PROPRIETARY

PROPRIETARY

The same principles can be applied to enable a protective vehicle that would retain maneuverability and speed of ordinary road vehicles, yet would allow riders the safety of an elevated position, protected by a structure having a shape that is optimized for soldier survivability. The bomb survival concept car is the result.

Not only does this provide protection in ordinary transportation activities, it also enables new tactical possibilities. This protective vehicle can be built in a length to carry a single soldier or in a length to carry a squad riding in single file. The proposed stabilization concept works with arbitrary lengths. For a bomb car carrying a squad, the stabilizer allows an approach to a hostile area where a narrow frontal area is presented. Then, using steerable rear wheels, the carriage can be swung to the side to arrange a broadside attack by the squad. Thus, it is possible to rapidly bring an overwhelming force to a combat situation.

Figure 1 illustrates this concept vehicle in simplified form. Many obvious details are omitted for the sake of presentation. As shown it is a basis for a preliminary design, where all the details including power system, suspension, brakes, and weight distribution are worked out, with sufficient analysis to enable construction of a demonstration vehicle. A diesel-electric system with battery reserve storage is the leading contender among the various possibilities. This would include wheel hub electric motors on some or all of the wheels.

This is an articulated vehicle, having two parts that are tied together by an articulating joint device. One part is the carriage and the other part is the stabilizer. The joint is integrated into these, along with a connecting joint structure. Hinging about the near vertical yaw axis allows the stabilizer to turn relative to the carriage, while hinging about the horizontal pitch axis allows the multi-wheel device to maintain contact with the ground, without resorting to an excessively soft suspension system. A critical feature is a significant offset between the two axes. This offset allows use of weight distribution to counter a pitch tendency, which tends to defeat the primary stabilizing effect. Another useful feature is the tilted yaw axis, which causes the carriage to roll toward the inside of a turn.

PROPRIETARY

PROPRIETARY

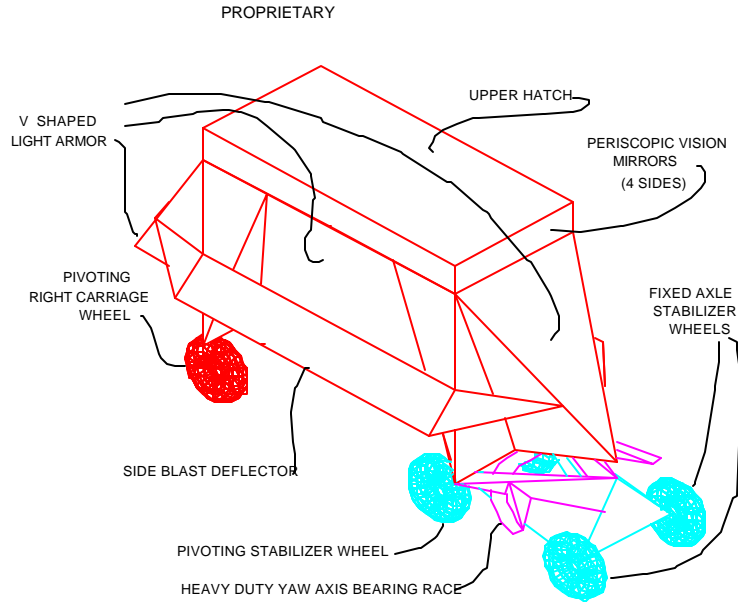


FIGURE 1

PROPRIETARY

This primary stabilizing effect comes about from extending a rear wheel that is on the outside of a turn, so that upward force on that wheel, together with leverage due to position of that wheel, counters torque about the center of gravity caused by radial acceleration forces on the collected wheels. As a first approximation, the upward force is limited by the downward force applied at the pitch axis as a result of the carriage weight and its distribution.

This concept is here illustrated in terms of the bomb survival car, sized for carrying two passengers in tandem. Here the newly available height possibilities are used to enhance the armor effects of light weight metal plate. The illustration shown is a vehicle having a wheel base width about equal to that of a jeep. The overall height of the vehicle is about twice that wheel base width.

PROPRIETARY

PROPRIETARY

Figure 1 shows the key parts mentioned above, along with interesting survivability features. The arrangement is dictated by the need to avoid stagnation regions in a shock wave, with emphasis on those waves that originate close to the vehicle. Thus the primary armoring panels are large, flat surfaces that are formed in a wedge shape that the greatest effectiveness against shock waves from explosions that originate under and closest to the vehicle. Machinery and battery compartments are planned to be below and outside the compartment formed by the wedges. The flat panels would be backed by high strength structure that is thickest in the lower interior regions and then is made thinner to allow for the occupants that ride at elevated positions in the compartment. The armor effectiveness against blasts from further to the side is enhanced by blast deflecting rails on the sides of the vehicle.

Soldier protection from small arms fire is also provided by the large side panels. An all direction viewing capability is provided by a periscopic mirror system such that bullets are allowed to pass through the windows, yet are still over the head of the soldiers. Shielding against flying broken glass would obviously be incorporated in this design.

Stealth operations are enabled by silent operations that are provided for over a reduced time duration based on electrical operation from battery reserves. The design is compatible with other stealth measures including radar signature control. However, these are though not shown in the figures.

The key to effective urban operations seems to be to keep the vehicle light and fast, such that it would not take on battlefield requirements that would lead to vehicles like the "light armored personnel carrier" that weighs 38,000 lbs.

The proposed concept has general purpose, where useful applications could range from a single passenger vehicle to a heavy duty truck. For any given vehicle width, this concept will enable greater height of the center of gravity of the vehicle, without incurring the usual penalty of instability. A variety of new opportunities come about from this approach, which is counter to the usual design efforts that strive to lower the center of gravity.

PROPRIETARY

PROPRIETARY

PROPRIETARY

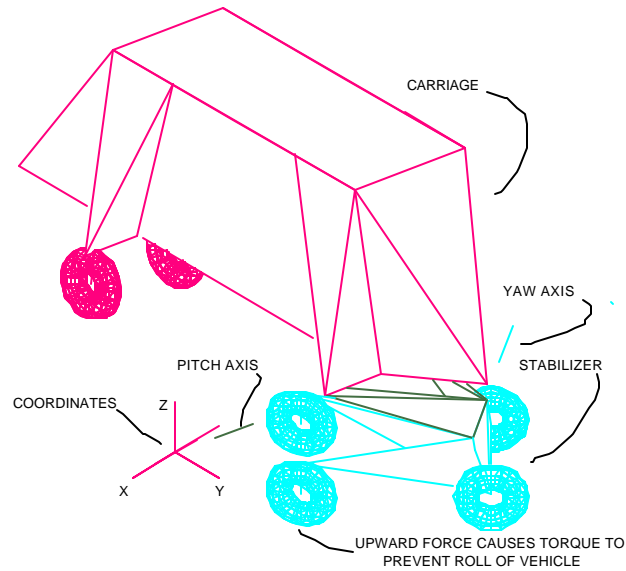


FIGURE 2

PROPRIETARY

The operation of the basic vehicle stabilization system is illustrated in Figure 2. A turning condition is shown, where the effective wheel base is significantly widened to the side where it is needed. The turn is initiated by a steering linkage (not shown) that causes the rear stabilizer wheels to pivot about a vertical axis. A simple tiller arrangement is used to control that linkage. This starts the stabilizer to begin turning such that the front stabilizer wheels go in an intended direction and the carriage follows from the attachment point on the yaw axis hinge. The tilt of the yaw axis causes the pitch axis to tilt, such that the carriage leans into the turn. The yaw tilt angle can be made to vary according to speed, such that tilt angle will increase for higher speed. This will enhance the function of the extended stabilizer wheel, for applications where it is found to be necessary.

PROPRIETARY

PROPRIETARY

By including steerable wheels at the back of the carriage, backing up is made more practical. It also can be used to negotiate very tight turns at lower speeds, which is a particularly important capability for longer variations of this vehicle. It would work like the well known hook and ladder firetrucks known for use in urban circumstances. Use of this steering capability in high speed turning does not appear to be prudent.

The wheel arrangement and steering of the stabilizer is like that of the common forklift truck. The articulating arrangement has some things in common with the common semi-trailer truck, however the offset structure is decidedly different. Also, here the pitch axis is attached to the carriage and the yaw axis is attached to the stabilizer, where this arrangement is the opposite on standard semi-trailer trucks.

Figure 3 shows the carriage, joint structure and stabilizer, separated from each other to aid in visualization of the articulated vehicle concept.

Current thinking is to use wheel hub electric motors with a diesel electric generator and batteries located at low positions in the vehicle. This can be optimized in the urban combat form by arranging an engine and battery compartment that would be separate from passengers. It appears appropriate to not protect these components, such that weight arrangements can be optimized to not operate negatively against the stabilization capabilities. While the stabilization can be designed to handle substantial mass at relatively high positions, it is not without penalty. The ultimate penalty is that the extension distance would become such that available width of roadway to the outside of a turn would be too uncommon a circumstance. This problem is not severe where the driver is adequately trained. The basic steering considerations are similar to those involved in driving a forklift down narrow aisles in a warehouse, as is commonly done.

Optimum design of weight distribution is an important topic from several points of view. Such considerations include tendency of wheels to skid in turning operations where weight at wheels does not cause sufficient holding friction relative to the need for that holding friction to prevent the skid.

From a project point of view, a technology demonstration vehicle can be produced using components that exist in current automobile technology, with augmentation from industrial equipment where that would enable particularly useful features. Even though this is an unconventional form of armor, compared to armor used on battlefield vehicles, it is still expected that optimizing the armor system relative to the range of threats of most concern will require experience based methods and practical materials that would need to come from military sources.

PROPRIETARY

PROPRIETARY

Without benefit of direct experience with armor systems, a starting point would be to form the large flat panels using high strength steel with closely spaced framing, and overlaying this with a heat resistant and abrasive material such as ferro-cement, as is known in the field of ship construction. An outer layer of steel would start a process of spreading out a bullet and the ferro-cement would further dull and disintegrate an armor piercing bullet. This layering system would augment the shaping effects that would help keep bomb generated shock waves from building into extreme destructive forces, where the augmentation would be to isolate hold back heat effects as much as possible.

Operation of the basic stabilized, articulated vehicle concept has been tested as a scale model with a "soap box derby" type model, which can be ridden down a hill. The effect of the offset axes, along with the associated weight distribution was evaluated. The planned steering linkage was also tested. This showed excellent cornering stability with a rider sitting at a high position. It also proved the smooth and stable steering system using a simple tiller steering control, as previously mentioned.

PROPRIETARY

PROPRIETARY

PROPRIETARY

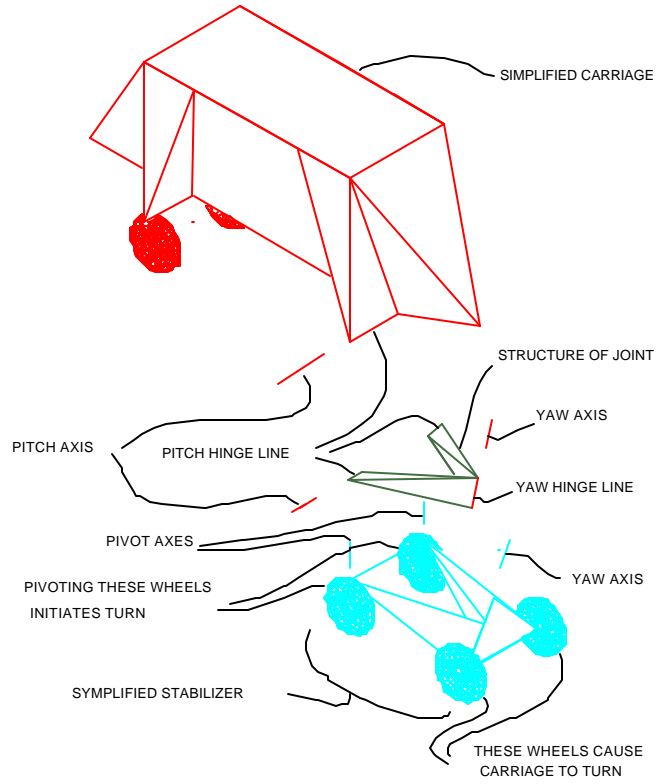


FIGURE 3

PROPRIETARY

PROPRIETARY

CONCLUSION

The proposed bomb survival car is a combination of a new vehicle concept that was developed for daily commuting on American freeways and an armor enhancement concept that is enabled by characteristics of this new vehicle concept. It appears to offer an important new degree of protection to soldiers while enhancing their operational movements in urban conflict settings and offering new tactical operating modes in such settings. Furthermore, the bomb car concept can be applied to a variety of military vehicle types for use in many different scenarios.

A further advantage to the American military is the ability to show prospective recruits that great efforts are being made to support soldiers. It fits well with the commercials that show a well equipped, modern, high technology force.