Human Lethality From A Suicide Bomber Bus Event

by Brad Lauritsen, P.E.

The simulated suicide bomber event took place on November 13th, 2007, in San Bernardino, California at a range used by the San Bernardino Bomb Squad. Applied Research Associates (ARA) was invited by the Orange County Sheriff's Department to participate in the Golden Guardian exercise to gather scientific data from this simulated suicide bomber on a city bus and provide preliminary injury predictions. ARA's data collection effort for this test was sponsored by the Technical Support Working Group (TSWG), and was undertaken as the first step in the development of a prediction tool to evaluate and prioritize victims (inside and outside the bus), define extended damage radius to buildings and equipment, and define expected response requirements for law enforcement and first responders after an attack from a suicide bomber on a bus.

The bus was a retired 1980 GMC city transportation bus, with 4 abreast seating for the first ¾ of the bus and open bench seating around the rear of the bus. The bus was completely intact and had been drained of all fluids. Fiberglass mannequins were placed both inside and outside the bus to represent passengers and bystanders. The mannequins inside the bus were filled with water. The suicide bomber mannequin was standing in the aisle in the center of the bus and was also filled with water. The suicide bomb device was built in a vest and contained dynamite in both the front and back. Nails and screws were placed in the lower pouch of the vest, also in the front and back.

Figure 1. MARS Probe

Instrumentation used in the testing included two high-speed digital video cameras, three free-field (outside of the bus) pressure gauges, and two Ironman Blast Dummy instrumentation systems. The pressure gauges used outside the bus are called MARS (Measure Airblast Remote Station) Probes (Figure 1). These are high-speed blast/acoustic, semi-hardened, measuring systems developed by ARA and customized for specific remote applications.

Figure 2. Iron Man with Silicone Head

Two Ironman systems (Figure 2, Figure 3) were used as human surrogates. Ironman is designed to have the equivalent height, mass distribution, and general body shape factor as a 50th percentile human male in order to measure environmental loads on the human body. Both Ironman systems had articulating arms and legs so they could be seated in the bus and give them more realistic reactions to the blast.

Each Ironman typically has four pressure gauges installed in the thorax: one on the front, one on the back, and one on each side. For this test, no gauge was used on the back. Miniature data acquisition systems (miniDAS), developed by ARA, are installed in each Ironman to record the pressures and the data is stored on a flash card.

Figure 3. Iron Man with Camera Inside Head

One Ironman was placed in the back seat of the bus, and the other closer to the middle, near the bomb. The Ironman in the rear had a camera in its head to capture video of the event (Figure 3). The Ironman closer to the bomb, seated just in front of the rear door, had a silicone rubber head that acted as a tissue surrogate for assessing fragment injuries. (Figure 2).

Pressure gauges (MARS probes) were placed outside the bus at distances of 10, 16 and 23 ft (~3, 5, and 7 meters) from the bomber (Figure 4). The outside mannequins were placed at the same radial distance from the charge as the pressure gauges. Distance markers were placed at 10-foot (3-meter) intervals to estimate debris speed from the video footage.

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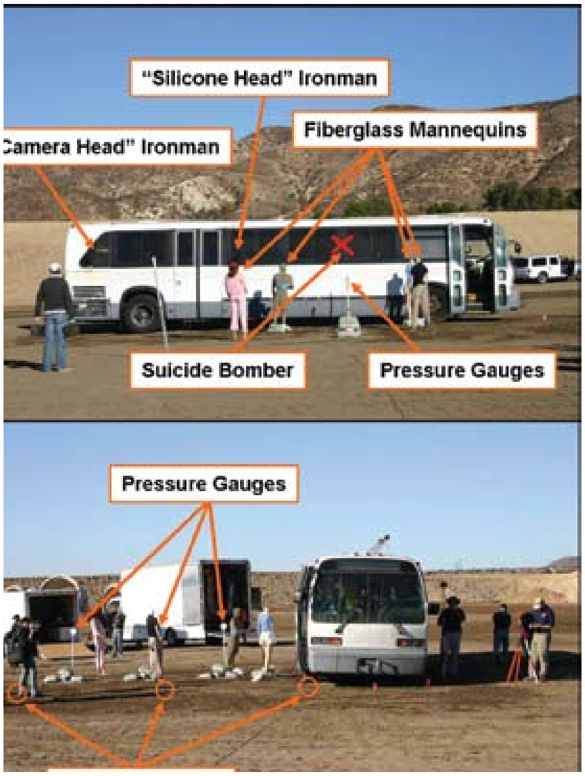

Figure 4. Bus Exterior Before Explosion

Figure 5 shows the bus after the explosion. All of the windows were blown out, as well as the windshield. The roof was bulged outward, but did not depart the bus. Large pieces of the exterior side panels came off, and the front door was completely removed. Inside the bus, the ceiling collapsed and the walls were completely ripped off (Figure 6). All of the material from the seats had been torn away by the blast, leaving only the metal frames. The floor was blown downward, and severely buckled. The blast did not displace the bus from its original position.

Figure 5. Bus Exterior After Explosion

Figure 6. Before and After Photos of Bus Interior

After the test, the Ironman systems were removed and examined for signs of potential injury. It was apparent that they had both been struck by numerous fragments, from both the bus and the nails in the device. The silicone head Ironman had a large gouge in his lower abdomen from a nail, and also a large cut in the top of his head. He also had numerous small fragments embedded in his head. The camera head Ironman also had numerous chips and scratches on his chest and legs. The fiberglass mannequins outside the bus were also examined and they all exhibited some signs of injury, mostly by small fiberglass and metal fragments from the bus.

The pressure data from the Ironman dummies and the MARS probes, and the fragment impact data were input into various computer codes to provide specific injury predictions. Figure 7 shows a graphical summary of the level of injuries the passengers of the bus might have sustained based on the data gathered by the two Ironman systems. The fireball was contained inside the bus, so there was also a chance of burn injury for any passenger in the bus. However, because of budget limitations, instrumentation to measure burns on Ironman could not be fielded. Therefore, based solely on overpressure, those passengers within the inner ring have over a 90% chance of severe injury to the lungs from the blast. The passengers located at the ends of the bus have a 64% chance of injury to the lungs from the blast. Further, there is a high risk for all passengers of fragment penetration injuries and impact injuries from the debris and bus structure.

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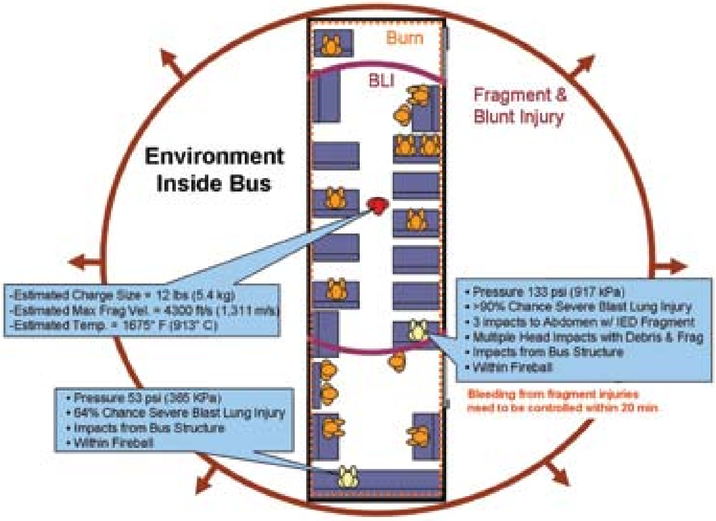

Figure 7. Summary of Injury Predictions Inside the Bus

Outside the bus, the overpressure levels are low enough that lung injury from the blast is not a concern, and the chances of any permanent hearing loss are extremely low. The dangers outside the bus are impact injuries and penetrating injuries from the debris and structure from the bus traveling at very high speeds up to 500 mph (804.6 km/hr) (Figure 8). Since the fireball was contained within the bus, there is also very little chance of sustaining burn injuries outside the bus.

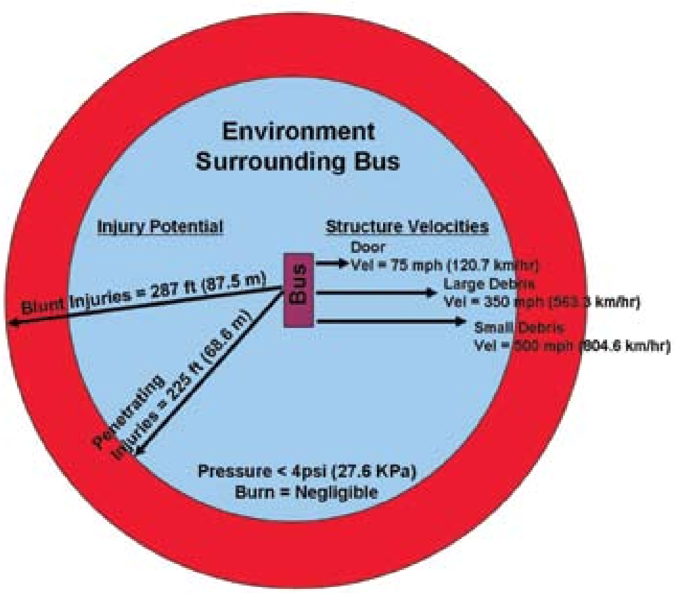

Figure 8. Summary of Injury Predictions Outside the Bus

In conclusion, analysis of the data from this simulated suicide bomber in a bus event provided valuable insight to injuries that might be sustained during a suicide bombing event on a bus. Based on the pressures it recorded, the Ironman closest to the bomber had a 90% chance of severe damage to the lungs. The Ironman located in the back of the bus had a 64% chance of severe damage to the lungs. All passengers inside the bus have some risk for burn injuries, but the level risk can not be determined because no burn data was recorded. There is also a high risk for all passengers of penetration injuries from bomb fragments traveling up to 4,300 ft/s (1,311 m/s) and impact injuries from the debris and bus structure.

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Further, more extensive testing must be performed to gather more data on suicide bomb environments. This data can be used to develop vital tools that can be used to help first responders be prepared for a suicide bomb event allowing them to improve triage, delivery of care, and utilization of resources. Using the data gathered from these tests, ARA can create a quick-reference tool to be used on scene to assess victim's injuries in the form of a Blast Injury Reference Card that provides guidelines for external signs and symptoms that first responders must look for in order to assess their possible blast-related injuries. This will allow the first responders to evaluate, treat, and expedite victims based on signs and symptoms. The cards will also provide guidelines for a search radius to look for victims with specific injuries. This radius may extend into nearby buildings. These cards would be applicable to other blast events as well.

Brad Lauritsen is a licensed professional engineer with a Master's Degree in Mechanical Engineering. He specializes in counterterrorism research and testing at the Advanced Technology Office in ARA's Rocky Mountain Division. He recently finished work on the Explosive Breaching Characterization Handbook, which is also sponsored by the Technical Support Working Group (TSWG).