

Case Study of IED Incident in Cauca, Colombia – A Review of the Blast Threats and Protection Provided to the EOD Technician

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Abstract. In June 2022, an Explosives Technician of the Colombia Dirección Central de Policía Judicial e Inteligencia (DIJIN) responded to a suspect Improvised Explosive Device (IED) mounted on a motorcycle, in Cauca, Suarez, Colombia. The local unit of the Policía, responsible for responding to explosives incidents arrived at the scene to investigate. The explosives technician conducted a search and render safe procedure of the suspect device. After a canine unit and a robot could not definitively confirm an explosive device, the decision was made to conduct a manual approach of the motorcycle with suspect device using a Med-Eng EOD 9 bomb suit. During the course of procedures, the IED detonated. The ensuing blast posed a fatal threat that was mitigated by the bomb suit the technician was using. He was launched several meters away and suffered non life-threatening injuries to the extremities. This paper is a case study that analyses the four blast threats (overpressure, fragmentation, impact, heat) related to the particular device and circumstances. Through a detailed analysis of the Explosive Ordnance Disposal (EOD) suit including a numerical simulation, one can ascertain the protection provided across the entire body and some inherent limitations. Injury outcome is compared with expectations based on the blast conditions that confronted the victim. Lessons learned from the response and outcome of this specific incident can be beneficial in mitigating injury risk to EOD technicians responding to similar situations.

1. DESCRIPTION OF THE EVENT AND OUTCOME

According to Cardash [1], motorcycle VBIEDs (Vehicle-Borne Improvised Explosive Devices) have become a favoured tactic, technique, and procedure (TTP) employed by FARC (Fuerzas Armadas Revolucionarias de Colombia) dissidents in recent years, particularly in Colombia's Cauca department. Historically, these attacks involved motorcycles carrying large explosive devices, often targeting police stations and government buildings. However, Cardash highlights a recent shift toward smaller explosive payloads aimed at moving police vehicles or officers, including bomb disposal technicians responding to investigate these motorcycles. The present study includes a comprehensive analysis of the four main threats posed by the blast in that specific incident and a focus on how the bomb suit effectively protected the bomb technician exposed to the explosion. Details included in the study were informed by an interview with the bomb technician involved in the incident, as well as by direct examination of the bomb suit he was wearing at the time of the explosion.

1.1 The blast event

On the morning of June 16, 2022, in Suárez, located in Colombia's Cauca region, a local bomb technician was dispatched to investigate a suspected explosive device possibly attached to a motorcycle parked near the rear garage door of the Suárez police station (Figure 1). This incident followed two similar cases in the preceding weeks in the same area, both of which had turned out to be hoaxes. Despite this precedent, the bomb technician approached the situation with appropriate caution.

During the initial assessment, a canine unit was deployed to inspect the area; however, no suspicious indicators were detected. Next, a small EOD robot was sent to examine the motorcycle, but it could not confirm the presence of an explosive device (Figure 2). Wearing the Med-Eng EOD 9 bomb suit ensemble, the bomb technician proceeded with a manual approach to determine whether there was indeed a suspect device located beneath the motorcycle seat. While attempting to dislodge a possible suspected package wrapped in fabric and appearing stuck under the seat, the technician braced his left foot against the motorcycle and pulled on the package. At 9:17 AM, the suspected IED detonated while the technician was in this position (Figure 3, centre). The force of the blast propelled the technician approximately three meters from the motorcycle.

The entire event, up to the moment of the explosion, was captured on video by bystanders and later retrieved online. No visual records exist of the aftermath, except for photos provided by Colombian authorities. The photo on the right of Figure 3 identifies the approximate landing location of the technician, marked by where the bomb suit and helmet were left after first responders rescued

and evacuated the injured operator. Figure 3 also illustrates the severe damage sustained by the motorcycle, as well as minor damage to the garage door and surrounding area.

A forensic report from the Colombian authorities (DIJIN), later provided to Med-Eng, revealed that the IED contained approximately 2 kg of explosives. According to the DIJIN official technical report, the explosive was identified as a high explosive, although its exact composition could not be determined at the time of investigation. It was remotely detonated using a radio frequency device modified from a vehicle alarm system, enabling activation from a distance of up to 400 meters. From the videos and photos, it is estimated that the bomb technician's chest was located at a standoff of approximately 80 cm from the IED at the time of the explosion.



Figure 1. Photos from the area where the blast even took place, extracted from Google Maps (©2025 Google, Image ©2025 Maxar Technologies).



Figure 2. Pre-explosion images. Left: The suspected motorcycle VBIED positioned near the garage door. Centre: The bomb technician being suited up by an assistant. Right: The technician advancing toward the scene for manual inspection. All images courtesy of Colombia's DIJIN



Figure 3. Left and Centre: Still images extracted from a video of the incident obtained from the Internet, capturing the moment of the explosion. In the centre image, the technician's left foot is resting against the motorcycle while handling the explosive package with no standoff. Right: A post-incident photograph of the scene, showing the aftermath after first responders had removed the injured technician from the bomb suit. The image on the right is provided courtesy of Colombia's DIJIN

1.2 The medical outcome

Following the blast, the bomb technician sustained various injuries, including the amputation of his left forefoot, which had been in direct contact with the motorcycle (and underlying explosive), and a fracture of his left tibia. Since he was holding the fabric wrapping the explosive at the moment of detonation, both of his hands were injured, with the right hand being more severely affected, including multiple finger fractures. He also suffered minor burn injuries to his forearms due to flames propagating up the bomb suit sleeves.

Notably, the technician did not sustain any penetrating wounds, blast overpressure injuries (including to the ears), or head trauma. He remained conscious and alert upon arrival at the hospital. Figure 4 shows photos of the technician taken a few days after the incident, highlighting his primary injuries.



Figure 4. Photos from a Colombian news report showing the injuries sustained by the technician a few days after the incident

1.3 Personal Protective Equipment after the blast

Due to the bomb technician's close proximity to the blast source, the left side of the bomb suit trousers sustained significant fragmentation damage, particularly in the lower exterior portion. This damage exposed the soft armour aramid layers and shattered the shin plate. In contrast, the right side of the trousers, positioned slightly farther from the blast, experienced only minor fragmentation damage. Importantly, no fragments fully penetrated the stack of materials comprising the trousers worn on either leg. See images on Figure 5.



Figure 5. Photos of the bomb suit and helmet after the blast

Similarly, the upper portion of the bomb suit jacket, which directly faced the blast, exhibited concentrated fragmentation damage. Although fragments penetrated the soft armour and some of the rigid armour at the chest and groin levels, none managed to breach the innermost protective layers, thereby ensuring the wearer's safety. Some deformation of the rigid protective plates was observed. The rear portions of the trousers and jacket, which were shielded from the blast, remained largely unaffected. While the left sleeve was removed by medical personnel to facilitate the victim's evacuation, the remaining sleeve showed no significant damage.

Regarding the helmet, a single fragment penetrated the surface of the outer acrylic layer of the visor but failed to breach the innermost polycarbonate layer. The visor primarily exhibited cosmetic fragmentation damage, and the rubber trim housing the LED lights was dislodged during the blast. Despite this, the retention system remained fully functional, and the helmet shell sustained no penetrations. Figure 5 presents photos of the bomb suit ensemble, highlighting the damaged areas.

2. ANALYSIS OF THE MAIN BLAST THREATS

2.1 Primary blast threat: overpressure

An estimation of survivability based on blast overpressure can be derived from the work of Van der Voort et al. [2], which updated the original survivability curves developed by Bowen et al. [3]. These curves, referred to here as the "NATO curves", presented in terms of peak overpressure and positive phase duration (Figure 6), estimate the probability of survival for an unprotected individual. Similarly, Figure 7, inspired from previous work [4] translates these survivability predictions into a format based on explosive charge and standoff distance, using free-field blast calculations. For the current scenario—2 kg of TNT detonated at an approximate standoff distance of 80 cm—the corresponding data points are marked on both figures. The predicted survivability level (<1%) highlights the unfavourable outcome expected for an unprotected individual *not* wearing a bomb suit.

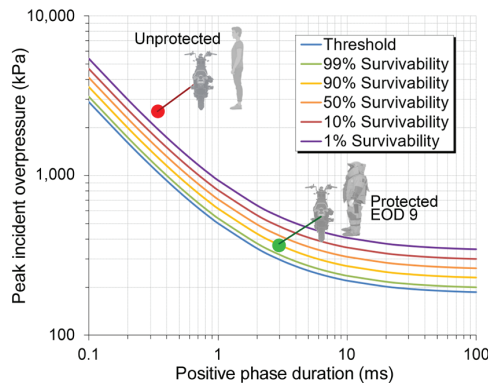


Figure 6. NATO blast injury prediction curves [2] along with data points corresponding to the motorcycle VBIED scenario

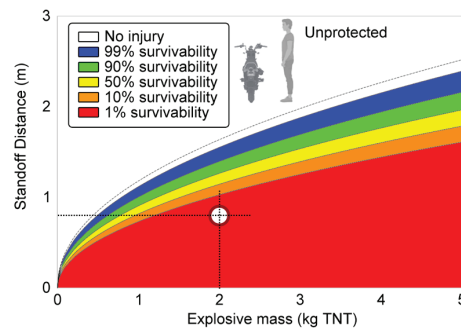


Figure 7. NATO curves expressed in terms of explosive charge mass and standoff distance, with the motorcycle VBIED scenario data point for an unprotected scenario

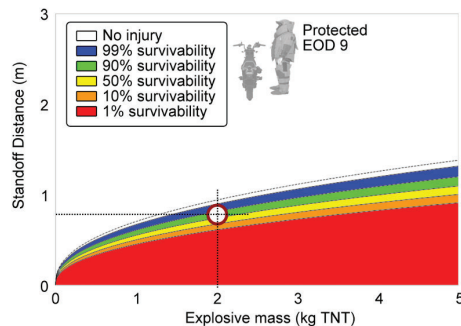


Figure 8. NATO blast injury curves from Figure 7 modified to account for the protection provided by the EOD 9 bomb suit. Data shown for the motorcycle VBIED scenario

Figure 8 presents the NATO injury curves, adjusted to reflect the protective capabilities of the EOD 9 bomb suit (assuming a conservative 85% reduction in overpressure and a fourfold increase in positive phase duration, see [5]). Based on Figure 8, the bomb technician was predicted to have a 90% chance of survival from the blast overpressure threat alone, consistent with the actual survival outcome of this incident. However, it is important to note that the charts in Figures 6 to 8 are intended as general guidance for free-field blasts, and do not provide definitive or fully validated injury predictions.

The threshold for eardrum perforation is as low as 35 kPa. At 100 kPa, there is a 50% probability of perforation, increasing to 95% at 200 kPa [6]. Figure 9 illustrates the potential for eardrum perforation based on these thresholds, shown in terms of explosive charge mass and standoff. Figure 10 presents the same data for an individual wearing the EOD 9 Helmet, which provides a conservative 90% reduction in overpressure at the ear. In the current scenario, the unprotected probability of eardrum perforation exceeds 95%, while the helmet reduces it to 50%. Notably, the bomb technician did not sustain any ear injuries during this incident.

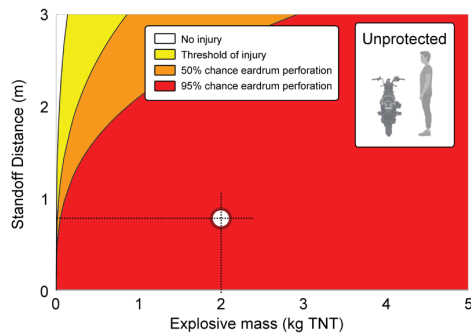


Figure 9. Ear overpressure injury chart (unprotected case)

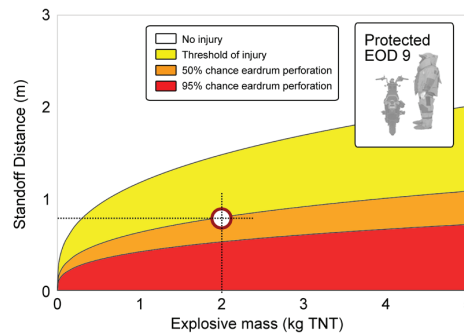


Figure 10. Ear overpressure injury chart (protected case – EOD 9 Helmet)

2.2 Secondary blast threat: fragmentation

Cardash [1] observed that adding fragmentation to small motorcycle VBIEDs significantly enhances their impact and effective range, effectively offsetting the limitations of smaller explosive payloads typically used in targeted attacks. For the incident under study, however, Colombian authorities did not provide specific details regarding the fragmentation threat posed by the IED itself. Nevertheless, even in the absence of engineered fragmentation, the motorcycle itself can act as a source of secondary fragmentation upon detonation, generating debris of varying sizes capable of causing severe penetrating injuries in the absence of proper protective measures.

The images in Figure 5 highlight the significant fragmentation and peppering damage sustained by the bomb suit due to the blast. This resulted in considerable cosmetic damage, along with a few penetrations through the suit's outermost layers and protective plates. For instance, Figure 11 illustrates fragmentation damage to the groin protective plates. However, none of the fragments fully penetrated the innermost composite rigid layer. Similarly, only one fragment damaged the helmet visor without completely penetrating its material layers. The bomb suit ensemble thus provided essential fragmentation protection, effectively preventing fragment penetration to critical areas.

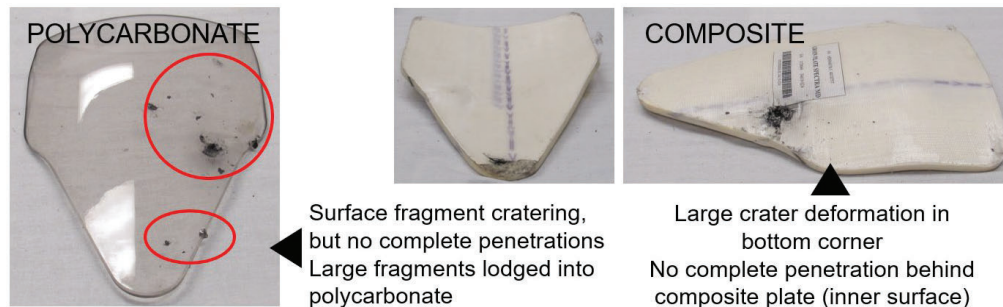


Figure 11. Photos of the innermost groin protective layer showing no complete penetration. No complete penetrations were observed anywhere on the bomb suit

2.3 Tertiary blast threat: impact

Blast exposure can cause rapid head acceleration, leading to back-and-forth brain movement within the skull, which is a potential “impact” mechanism for blast-related brain injury. Although the Head Injury Criterion (HIC, [7]) has not been specifically validated for blast scenarios, it can still be used to correlate head acceleration measurements with the likelihood of brain injury through applying correlations to the Abbreviated Injury Scale [8]. Leveraging HIC, Dionne et al. [9] developed predictive tools that relate AIS injury levels to explosive charge and standoff distance for free-field blasts, based on data from multiple blast tests using instrumented mannequins. Figure 12 illustrates the chart developed for the EOD 9 bomb suit, showing the data point corresponding to the motorcycle VBIED incident under study. The chart predicts “no injury,” consistent with the medical report provided by Colombian authorities, which noted no brain injuries, or concussion symptoms. Furthermore, the technician was reportedly able to converse shortly after the incident. These findings suggest that the EOD 9 Helmet provided effective protection, preventing brain injury in this case.

Beyond the direct impact of the blast wave on the head, the technician's head could have also impacted the ground as the body was propelled by the blast force. To explore this further, an LS Dyna (Ansys Inc., Canonsburg, PA) computer simulation was performed to model the technician's motion following the blast, inspired from earlier work [10]. A Hybrid III model was adapted to account for the additional mass of the bomb suit. The mannequin was positioned at the representative distance and in a posture similar to that of the technician during the motorcycle VBIED incident and subjected to a 2 kg TNT explosion. The simulation results (see Figure 13) were successfully validated against the technician's final landing position. While the figure includes the motorcycle for reference, it was not part of the simulation itself. The simulation suggests that the technician's head may have impacted the ground, potentially with a frontal impact. However, it must be noted once again that no head injuries were reported for the technician following the incident, based on the helmet protection provided.

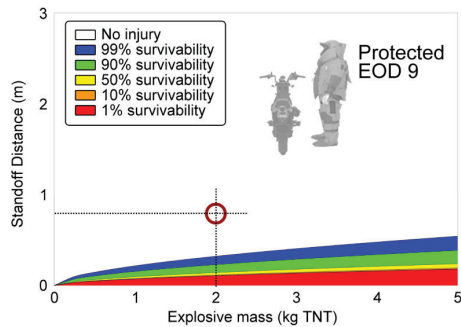


Figure 12. Blast induced traumatic brain injury chart for the EOD 9 protected case, from [9]

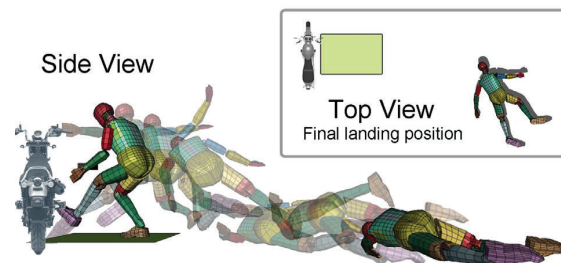


Figure 13. LS Dyna simulation of the blast event using a Hybrid III mannequin whose weight was adjusted to account for the weight of the bomb suit

2.4 Quaternary blast threat: heat (fireball)

When an explosive detonates, it generates a fireball composed of extremely high-temperature gases. Although this intense thermal hazard only persists for a few milliseconds, it can cause severe burns to unprotected skin if an individual is within the fireball's radius. Figure 14 illustrates the estimated size of the fireball in free-field experiments as a function of the explosive charge, based on high-speed video analysis of blast events [11]. For the 2 kg high explosive charge used in this motorcycle VBIED incident, the graph suggests that the bomb technician—whose foot was in contact with the motorcycle and whose chest was approximately 80 cm from the explosive centre—would have been positioned within the fireball.

Despite the protection provided by the bomb suit, the technician sustained burn injuries to the forearms (Figure 15) due to the fireball entering through the uncinched sleeve openings around the hands. This occurred because the arms were directly facing the IED at the moment of detonation. Medical documentation provided by DJIN classified these injuries as second-degree (superficial partial-thickness) burns, specifically affecting the anterior and lateral aspects of the right forearm. It is important to note that bomb technicians prefer to work with their bare hands during render-safe procedures, which leaves them vulnerable to such risks. Although the burn damage to the technician's forearms was not extensive, it underscores the inherent dangers faced in such situations. Some clues of burning damage were also visible on the bomb suit itself, visible on the photos from Figure 5. The

sleeves feature an adjustable strap that permits tightening of the opening at the wrist and minimizing flame ingress; this feature was not used by the bomb technician in this incident.

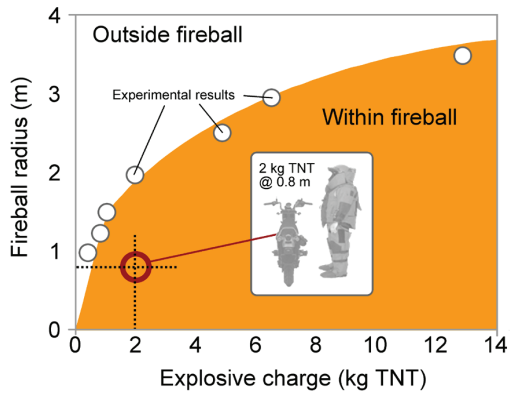


Figure 14. Estimated fireball size as a function of the explosive charge, indicating that the bomb technician was within the radius of the fireball [11]



Figure 15. Second degree burn injuries suffered by the technician on the forearms

3. DISCUSSION

Incidents involving bomb technicians are rare due to their expertise, the remote tools they use, as well as the sensitive nature of information related to such events, which is often guarded by authorities to prevent its misuse by terrorists or perpetrators. When such information is available, it is frequently limited, incomplete, or ambiguous. However, the incident discussed in this case study provided a wealth of data, making it particularly valuable for analysis. The availability of bystander video footage captured the technician's movements and exact posture just before the explosion, offering critical insights into standoff distance and positioning at the time of detonation. Additionally, the Colombian authorities (DIJIN) shared extensive materials, including original medical and forensic reports, as well as the damaged bomb suit and helmet for direct inspection. A meeting with the injured technician in Colombia a few months after the event (see Figure 16) provided additional information for the study, allowing for a comprehensive reconstruction of the events.



Figure 16. Injured bomb technician (right) in November 2022 (5 months after the explosion)

This incident highlights the importance of studying bomb suit protection under such severe threat conditions. The blast involved was lethal to an unprotected individual and posed a significant risk even to a technician wearing a bomb suit, resulting in serious injuries despite the suit's protective capabilities. This case study analysed the four primary blast threats—overpressure, fragmentation, impact, and heat—and evaluated the performance of the bomb suit using numerical simulations and forensic analysis. A comparison between the injury outcomes and the expected effects of the blast provided valuable insights into the protective capacity of the bomb suit and its limitations. Lessons learned from this incident are crucial for improving the safety of EOD technicians and mitigating injury risks in similar high-threat scenarios. Furthermore, the findings underscore the life-saving potential of bomb suits while providing a realistic understanding of their limitations as well as the injuries that may still occur under extreme conditions.

Acknowledgments

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