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# Human Behavioral Responses after a Targeted Improvised Explosive Device (IED) Attack at Soft Targets & Crowded Places



Developed for:



Science and  
Technology

Developed by: RTI International

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# Executive Summary

## The Problem

IED-based terrorist attacks pose a persistent threat to the United States and its interests abroad. The threat is particularly acute for soft targets, or open, public spaces that can attract large numbers of people. To a terrorist, soft targets represent an opportunity to stoke public fear and cause mass casualties. Bombings are a strategic method for achieving those goals.

Despite the bombing threat to soft targets and the people who occupy them, relatively little is known about individual and group responses to an IED attack. Without this information, bombing prevention and response procedures cannot account for the real-life behaviors that civilians and emergency personnel demonstrate in the immediate aftermath of an attack.

## The Insights

This project addresses that problem, looking specifically at how people respond after an IED functions. RTI International examined six historical cases to analyze human behavioral responses in the wake of high-profile bombings at soft targets and crowded places.

The research team found that in the minutes following an explosion, people behave in ways that we can predict. Additionally, a person's physical distance from an explosion impacts how much information they receive about the blast and, therefore, how they react. Lastly, individuals' behavior is also conditioned by the amount of time that has passed since the explosion occurred.

The below table presents the study's high-level findings for responses at the individual- and group-level, as well as how event-specific factors may influence response.

 INDIVIDUAL-LEVEL FINDINGS	 GROUP-LEVEL FINDINGS	 EVENT-RELATED FINDINGS
Freezing is the most common initial behavior after an IED functions. Also, if able, most people will flee or evacuate from locations near the explosion as soon as possible.	Crowd dynamics shape the behaviors that are available to individuals and the behaviors in which they are most likely to engage.	The magnitude of an explosion determines how fast, how far, and which behaviors spread.
A person's occupation and training can impact how quickly they respond to an IED functioning and which behaviors they will engage in.	People who came to the soft target in groups will try to reunite with their group before fleeing or evacuating.	Responses to attacks involving multiple IEDs are often different than those employing a single device.
People seek leadership following an explosion; when first responders aren't available, civilians will fill that void.	The distribution of behaviors within a crowd becomes more predictable and streamlined as people get farther away from the explosion and as more time passes.	The physical environment shapes the way an IED functions, the amount of information about the blast that people receive, and their ability to evacuate the area.
Only a relative few will engage in helping behaviors after an IED functions. When they do, they may reduce the number of fatalities, create calm, and facilitate evacuations.		Soft targets hosting events may be better prepared for IED incidents than those that are not.

## THE IMPLICATIONS

*Information from this study can be used to inform both emergency management personnel and civilians about how people tend to respond to soft target attacks and what actions they need to take to mitigate further damage. Understanding human behavioral responses to IED events can specifically impact:*

- **Training for law enforcement, fire and rescue, and emergency medical personnel**
- **Public awareness campaigns for civilians**
- **Soft target space design**
- **Soft target security procedures**

## The Approach

Through the Department of Homeland Security (DHS) Science and Technology Directorate (S&T) and in partnership with the Cybersecurity and Infrastructure Security Agency (CISA), RTI International conducted the Evaluation of Soft Target Security and Prevention project to inform practitioners' understanding of IED attacks against soft targets and other crowded places. The below research question guided the project.

### How do people behave in the seconds and minutes after an IED functions?

To answer this question, the research team used a multi-case study approach to analyze human behavioral responses in the wake of six high-profile bombing attacks that occurred at soft targets and crowded places in the United States and Europe.

The analysis used primary and reliable secondary, open-source materials documenting the human behavioral responses to the identified attacks. The research team then employed qualitative analysis to identify individual- and group-level behaviors following an attack and to construct separate case studies.

To systematize the case review, the research team introduced the concepts of zones and phases. Concentric zones were used to divide the physical space surrounding the IED blast. Timed phases were used to demarcate behavioral changes over a period of interest. Through this framework, the research team not only documented and analyzed the range of responses to an IED but also identified behavioral trends among civilians, first responders, and location personnel.

The results of this research can inform public safety and emergency management procedures. As first responders and soft target managers prepare to respond to an IED attack, they are encouraged to review and train for the range of expected behavioral responses from not only civilians but the responders themselves. This project contributes key knowledge to support that effort.

## The Cases



Atlanta Centennial Olympic Park Bombing (1996)



Madrid 11M Bombings (2004)



London 7/7 Bombings (2005)



Boston Marathon Bombings (2013)



Brussels Bombings (2016)



Manchester Arena Bombing (2017)

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# 1

## Introduction

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### How do humans behave after an explosion at a soft target and crowded place?

Runners closed in on the Boston Marathon finish line as spectators cheered them on and law enforcement surveyed the crowds. Suddenly, there was a loud bang and a plume of smoke. Within seconds of the improvised explosive device (IED) functioning, while a white cloud still hung in the air, law enforcement officers rushed across the street toward the site of the explosion. Civilians within the blast radius—who were not severely injured or dead—pushed to get down the sidewalk, corralled between barricades and buildings. Across the street, hundreds of spectators watched the disaster unfold, frozen in shock. A second blast, nearly two hundred yards away, changed everything. The spectators were jolted into action, and most began to run off. Some decided to stay and help the injured. Law enforcement officers were forced to choose which blast site to approach, while also processing the ongoing risk posed to the crowds and themselves. Photographers recorded video and snapped photos of the aftermath. Thousands fled the several blocks around the explosions as fast as they could.

How people reacted after these explosions on Boylston Street, in the Back Bay neighborhood of Boston, Massachusetts, is known because of video evidence submitted during the trial of one of the bombers. The video, a fixed-point perspective of the marathon finish line, provides some of the clearest evidence publicly available of how humans behave after an IED functions at a soft target and crowded place. This report and its insights are built upon a multi-case study of video and other open-source evidence from the Boston Marathon Bombing and five additional case studies of bombings at soft targets and crowded places.<sup>1</sup> This study's analysis of these six terrorist attacks provides the most systematic examination to date that attempts to answer the question, *How do humans behave after an explosion at a soft target and crowded place?*

### Understanding human behavior is an important part of securing soft targets and crowded places

Soft targets and crowded places (ST-CPs), venues with the capacity to accommodate large numbers of people with relatively little security, are uniquely vulnerable locations, and securing them is a top priority. Reducing the risk of attacks against ST-CPs is not only a primary mission of the Department of Homeland Security (DHS) but vital in ensuring our safety and security. Released in 2023, the Third Quadrennial Homeland Security Review (QHSR) underscores this need in preventing attacks against critical infrastructure, while enhancing the security and resilience of soft targets from terrorist threats.<sup>2</sup> In addition to the QHSR, the FY20-24 DHS Strategic Plan identifies the protection of soft targets as an objective within its goal of countering terrorism and threats to homeland security.<sup>3 4</sup>

In support of these objectives, DHS Science and Technology Directorate (S&T) commissioned RTI International to conduct a study that supports data collection and evidence-based analyses of behaviors after an IED functions. In partnership with the Cybersecurity and Infrastructure Security Agency (CISA), who has produced resource guides and security planning tools specifically for ST-CP, this research study aims to measure and evaluate how humans behave and respond to an IED.<sup>5 6</sup> Understanding the most likely human behaviors in the immediate aftermath of an explosion allows DHS—along with critical infrastructure operators such as location managers, staff, and first responders—to be prepared to act effectively if an attack occurs.

While DHS's National Preparedness Goals identify the mitigation of and response to security threats as two necessary pillars needed to create safe and resilient communities, an empirical understanding of post-attack behaviors is rarely incorporated into emergency response planning.<sup>7</sup> One reason for this is that human behavior during and after terrorist and targeted attacks is an understudied and poorly understood component of soft target security. The outcomes of these research initiatives have the potential to inform trainings and policies that focus on soft targets and crowded places.

## Behavioral responses should be incorporated into soft target security policy and training

There are two main reasons to study human behavior after an explosion at a soft target and crowded place:

- 1 To mitigate the impact of an IED functioning
- 2 To develop training for first responders and people working in and around soft targets

First, soft target security best practices tend to focus on the built environment, security deterrence, and emergency response protocols. This makes sense as stopping targeted attacks is the primary goal of security initiatives. However, if an attack occurs, first responders must also have plans in place to effectively provide care and initiate an investigation. Currently, post-event best practices and policies often fail to incorporate an understanding of how people will respond immediately after an attack. Further casualties may be avoided if first responders and experts in charge of soft target security understand and incorporate human behavioral responses into their emergency response plans.

Second, evidence-based training on this topic should be provided to first responders and even those who work in and around soft targets and crowded places. This training would prepare those who are either on the ground already or showing up minutes after an IED functions. For example, security officers at a site should know that most people who are not wounded will flee of their own accord. Similarly, law enforcement officers approaching a blast site several minutes after the IED functions should know that civilians likely have already begun to offer rudimentary first aid. Such knowledge would not only eliminate false impressions of what to expect during a bombing event but also allow first responders and site personnel to grapple with real-life behavior beyond what might be prescribed in a procedure manual.

## Human behaviors researched through multiple case studies

This report draws from analyses of six case studies of bombings at soft targets and crowded places to offer insight on human behavioral responses following an IED attack. These case studies include two domestic IED attacks in Atlanta, Georgia and Boston, Massachusetts and four international attacks in Madrid, Spain; London, England; Brussels, Belgium; and Manchester, England. The data on human behaviors are

analyzed using a multi-case study approach, a methodology suited to collecting and analyzing information on a rare phenomenon. The case studies were purposefully chosen because they were high-profile, targeted terrorist attacks that exclusively used explosives at soft targets and crowded places. High-profile acts of terrorism are typically well covered by news outlets and result in after-action reports, government reviews, and court transcripts. These documents contain first-hand accounts of human behaviors from victims, eyewitnesses, and first responders. Through these accounts, as well as photographic and video evidence, information about human behaviors can be collected, aggregated, and analyzed. The culmination of the research produced a detailed narrative that describes how humans behave after an explosion.

## Outlining the structure of this report

This report begins with a summary of the results of the analysis on human behaviors before providing appendices that lay out in much greater detail the data and methodology that support the report's narratives and insights. The report does not provide a review of the research literature specific to human behaviors, but instead focuses on the practical, real-world implications of how analyzing observed human behaviors after an IED functions can be used to support operational end users. Specifically, Section 2 provides a brief narrative of what humans do after an IED functions. This narrative is a synopsis of a longer narrative contained later in the report, which breaks down human behaviors across time and place in relation to the bombings. These narratives are the result of the multi-case analysis that systematically collected, examined, and extracted information from detailed documentation on six high-profile bombing attacks.

Section 3 presents insights into human behaviors after an IED functions and the implications of those findings. These insights come directly from the narratives on human behaviors within the six case studies. Significantly, they call out unique and important patterns found across the cases that can be leveraged by first responders, policymakers, and soft target security managers. Next, Section 4 presents background information that helps contextualize the patterns identified through the multi-case analysis. This background defines the behaviors that individuals and groups engage in, as well as delineates the geographic locations and timing that might impact if, when, and where these behaviors are likely to occur. Finally, the extended narrative (Section 5) details human behaviors after an explosion and provides support for the patterns discussed in earlier sections. Additional information about the multi-case study methodology, the individual case studies, and the references can be found in Appendices A, B, and C, respectively.

# 2 A Brief Narrative of Human Behaviors After an Explosion

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How people react to an IED functioning depends on how close they are to the explosion and how much time has passed since the blast occurred. Inside the blast radius, after an IED functions, everyone is immediately and physically impacted – eardrums rupture, vision diminishes, bodies and clothing shred from the blast wave, and shrapnel farther injures people and impacts the environment. Many are killed or grievously injured. Most people freeze. They are confused, concussed, and cannot choose a path forward. Some will impulsively flee if there is space to move and the crowd around them allows it.

Several seconds later, smoke and the smell of burnt metal and flesh hang in the air. As the initial shock wears off, many flee. An equal number remain stunned, unable to decide their next move. The decision is complicated by the presence of the injured – possibly family and friends – crying out for help. Some people are trapped inside buildings or vehicles where escaping could be as risky as staying in place.

After a couple of minutes have passed, almost all people can process what is happening—they are no longer in shock. Some who were stunned now flee in panic, while others evacuate calmly and quietly. Those who remain assist the injured as best they can – offering comfort, staunching open wounds or providing leadership when first responders have not yet arrived. Uninjured helpers approach from outside the blast radius, many of whom have specialty skills or training. Eventually, first responders with formal medical training replace these civilian helpers. The severely injured are stabilized and taken away. Friends and families follow. The helpers, as well as those still frozen or wandering, are examined and given first aid if needed. Law enforcement secure the blast site to start collecting forensic evidence.

Immediately outside of the blast radius, the way people experience and respond to an explosion is different. When an IED functions, nearly everyone in this area will see the flash of light; some may even experience hearing damage. Not everyone can see those killed or injured by the explosion. Many witness the panicked masses rushing from the blast and will flee from the incoming crush of people. A roughly equal number freeze in place. A few may help those around them.

Several seconds after the explosion, fleeing becomes the main behavior. Still, some remain frozen in shock, unable to overcome their paralysis and choose a path forward. A few more begin to help those around them or head towards the explosion to help. Onsite first responders begin to head

toward the blast site to provide aid. If people can find shelter, some will hide. Others gawk, watching and recording the carnage nearby.

By the time a minute or two has passed, most have fled. Those who are left help by providing reassurance, evacuation assistance, first aid, and leadership. Almost no one is still in shock, but those who are will likely receive aid from civilians before the first responders arrive. Anywhere from two to fifteen minutes later, offsite first responders arrive including law enforcement, firefighters, and paramedics. Mandatory evacuations are ordered from areas deemed unsafe or unstable. Where possible, the area immediately outside of the blast site is used for triaging the injured. Ambulances transport the severely wounded to hospitals. First aid, water, and oxygen are distributed. As the crime scene is processed, first responders continue to evacuate the zone and extend the secure perimeter as needed.

Farther away from the explosion, information is limited. Some people hear a noise, others might see a flash. Screams drift in from the distance. Most people do not know what is going on, only that something has happened. Nearly everyone freezes or does not react at all, behaviors driven by limited knowledge of the unfolding events. The few who have more information, or need less information to decide, flee.

After several seconds, more information reaches those farther away from the blast site, typically in the form of people fleeing the explosion. The arrival of this crowd triggers many more to flee for safety. Sometimes this panic results in a stampede, which may lead to crushing and trampling injuries. Onsite first responders and individuals with specialized training who are far away from the explosion will push against the flow of people to reach the blast site. In secluded locations, where people still have limited information about the explosion and little to no contact with those closer to the blast, many may still be frozen or have not reacted at all.

Around a minute after the blast, most people are still fleeing, both those who started farther away from the explosion and those running away from the blast site. People without special training may begin to head toward the explosion to help or gawk. Very few are still in shock or wandering, but those who are will most likely need assistance.

Minutes after the explosion, almost all people have fled or are evacuating with first responders. Some stay to gawk,

## Section 2. A Brief Narrative of Human Behaviors After an Explosion

either because they are curious or uncertain of where to go. Others take pictures and record the aftermath of the explosion and the chaos that ensued. Depending on the physical environment, triage areas may be set up, as well as a perimeter to provide care for the wounded, safety for first responders, and to secure crime scene evidence.

In areas so far from the explosion where people do not know what happened, most continue their normal behaviors for several minutes after the IED functions. They are too far away and have too little information to immediately understand what is happening. Smoke, multiple explosions, or people fleeing from the blast site will slowly and unevenly shift the behaviors of these people. Some will stay in place or go toward the explosion to help or see what has happened. Others will join the fleeing crowds or provide assistance from a safe distance.

These evacuated areas fill with people who fled from locations closer to the explosion. Most people will be calm and head home or to other safe locations. Some who were closer to the blast but fled to these areas may need medical help or assistance finding family or friends. Services may be staged for witnesses, survivors, family members and friends of victims, and those displaced by the explosion. Normal routines resume, albeit with a heightened sense of awareness.



# 3 Insights into Human Behaviors after an Explosion

## Introduction

This section provides insights into human behaviors after an explosion. These insights were developed through a multi-case study analysis that identified patterns across six high-profile bombing events. The insights help to explain why different human behaviors are observed across seemingly similar bombing events and, conversely, why similar behaviors are observed across dissimilar events. Security experts and policymakers can leverage these insights when developing training for first responders and people who work at or near soft targets. Where applicable, they can also be incorporated into soft target security policies and procedures.



## Insights into Individual Characteristics & Human Behaviors

**Freezing is the most common initial behavior after an IED functions, but how long someone freezes and what they do next varies greatly.**

Freezing may occur because individuals are trying to process what has happened, unable to decide what to do, or because the force of the blast has physically stunned them. While frozen, people may seek additional information to help make a choice, such as focusing on the explosion or the behaviors of those around them. Many will transition to a new behavior once they are able to make a decision. A few, however, will remain frozen for a long period of time and may need assistance from other survivors or first responders before shifting to a new behavior.

After an explosion, most people will freeze, if only for a few moments, before transitioning to a new behavior. How long a person freezes depends on their ability to process information about the explosion, identify potential next steps, and then decide. The amount of time it takes to process the situation may be influenced by their level of shock, training for mass casualty events, prior experience, personal motives, and environmental stimuli. All things being equal, the further from the explosion a person is, the longer it takes for information about the blast or stimuli to reach them, and the longer it will take for them to flee. If a person determines there is an ongoing risk of injury, they will likely unfreeze and flee. If

they determine that there is no additional risk to themselves or others, they may decide to evacuate normally or even help or gawk. Stimuli that signal a new or ongoing risk, such as a stampede or a second explosion, will likely trigger a sudden shift to a fleeing behavior. If information can be communicated during the freezing stage that reduces the perceived levels of risk, it may have the capacity to reduce the likelihood of fleeing and increase the likelihood of normal evacuation behaviors.

**If able, most people will flee or evacuate from locations near the explosion as soon as possible.**

Those who immediately flee often are so close to the device that running from the blast is an impulsive response to the dangerous stimuli, not a conscious decision. These people may even be injured from the blast and not know it until later. People who do not impulsively flee from the blast will freeze, at least momentarily, until they can decide in which behavior to engage (e.g., flee, help, hide).

Fleeing behavior spreads as crowds move farther away from the bomb and as time passes. Importantly, fleeing from the IED can act as a contagion and result in more people fleeing outward from the explosion. Fleeing can also cause additional injuries if it results in a stampede or crush behaviors. If there does not appear to be an ongoing risk, initial fleeing will shift to normal evacuation behaviors. Finally, fleeing may also be more prevalent at soft targets where a

crowd is already primed to react to a threat. These primes could be rumors of threatened attacks, recent attacks at the same or nearby locations, or if the soft target is in a town or country with high rates of targeted attacks.

**Only a relative few will engage in helping behaviors after an IED functions, but they may reduce the number of fatalities, create calm, and facilitate evacuations.**

Although descriptions of helping behaviors are most likely overrepresented in media accounts, after-action reports, and inquiries about IED events at soft targets, the importance of individuals choosing to help cannot be overemphasized. Those with some level of training, such as nurses, doctors, first responders, or event staff will often help with first aid, evacuation, and providing leadership. However, even if these individuals are not present, some people without official training will choose to help. Even a few helpers can reduce casualty counts by providing immediate first aid to the injured or facilitating a calm evacuation until first responders arrive. These behaviors were seen within the blast radius across multiple cases.

In some cases, if emergency medical supplies were more prevalently stocked and accessible (e.g., on subway trains or sports arenas), it is likely these helpers could have produced even better outcomes. Even where emergency medical personnel are readily available, such as at staffed events, additional medical supplies can be allocated to civilian helpers to assist those who were injured by the blast.

Individuals can help in other ways as well. Attempting to calm people down or facilitate evacuations away from the blast site can reduce additional injuries from stampede and crush behaviors. People who engage in helping behaviors can appear at any time or place after the IED functions and may also approach the blast from further away, ignoring the potential risk to themselves.

Helping behaviors may be focused on specific individuals. For example, individuals may approach the blast site immediately after the explosion to search for and help a family member or friend. This subgroup of helpers will be hyper-focused on the person or persons they know and will not assist others. Similarly, the more time that passes, the more likely people will arrive looking for missing family members and friends. In these scenarios, these behaviors may be more disruptive than helpful to first responders.



**Making additional medical supplies available can magnify the impact of civilian helpers.**

**Individuals who engage in behaviors such as gawking, hiding, and wandering may present unique challenges to first responders and other helpers.**

By the time first responders arrive at a blast site, especially if they were offsite, most people have fled the area, while some have stayed to help. A few may still be in shock and frozen in place. However, a small minority of people will be gawking, hiding, or wandering. These behaviors can occur at any distance but are more disruptive the closer they are to the explosion. Those who gawk may be taking videos or photographs or simply standing around watching. In some cases, these individuals might be in the way of people still trying to evacuate or first responders and others entering the blast site to help. As such, they inhibit quick, safe movement, which can create a hazard.

If a person believes there is a risk of another explosion, or injury from the crowd, they may hide. How long and where they hide will depend heavily on the characteristics of the explosion and the environment. Hiding behaviors are more likely with multiple IEDs and in environments where there are objects to hide below or behind. In some cases, those who hide will not leave the spaces they perceive as safe until first responders or others find them and facilitate their evacuation. During evacuation, law enforcement, security personnel, and others will need to divert resources to search for people who are hiding, some of whom might also be injured. Managers and employees of businesses or other facilities near an explosion will also need to search for people hiding on their premises.

Finally, some people will still be in shock but instead of freezing in place, they will wander around the environment. These individuals will need assistance from first responders or others to help them evacuate and possibly seek medical care. Like individuals who hide, those who wander will spread across the environment and resources will need to be diverted to find and help them. Civilian helpers may assist these individuals before offsite first responders arrive and will likely continue to help as needed and directed.

**A person's occupation and training can impact how quickly they respond to an IED functioning and which behaviors they will engage in.**

Those with prior experience, training, and occupations that prepare them for mass casualty events will likely engage in behaviors decidedly different from those who lack these backgrounds. The time they spend responding impulsively before transitioning to new behaviors will be shorter than those without similar backgrounds. This group may include law enforcement, doctors, paramedics, military personnel, photographers, firefighters, and security officers. For instance, event security officers at Manchester Arena stepped into

direct casualty response and evacuation efforts in the immediate aftermath of the bombing. They also directed the flow of fleeing civilians and tried to block them from seeing what happened at the blast site. In London, doctors near the bus explosion quickly set up a triage area inside their office building to provide care. At Zaventem Airport, one photographer felt compelled after the first explosion to document what was happening around her. In Boston, video evidence at the finish line shows law enforcement officers transitioning to helping behaviors within several seconds and running toward the blast site.

**People seek leadership following an explosion; when first responders aren't available, civilians will fill that void.**

When first responders are present, civilians at the soft target seek them out for instructions and guidance. When first responders are absent, civilians will look for anyone who projects an official air of authority (e.g., transportation staff, event employees, security personnel). Across cases where first responders were not immediately onsite, survivors spoke of how disconcerting it was that no officials were there to provide direction. They also spoke about how others stepped in to fill the leadership void. On one of the London Underground trains, a survivor recounted how they selected a leader from the group to decide what actions to take. Another London survivor spoke of how the Underground station staff arrived at the site prior to law enforcement and assisted in evacuating those who were not severely wounded. At Manchester Arena, event staff provided leadership and guidance throughout the evacuation process. Leadership can manifest itself through providing medical care and comfort to victims, assisting with evacuations, and attempting to keep those around them calm.



**Training soft target location staff on evacuation procedures can facilitate safe evacuation following an attack.**

**A person's motive or goal at the time of the explosion may be strong enough that they continue their baseline behaviors.**

Depending on an individual's baseline behaviors or predetermined goal, they may have a delayed reaction to the IED functioning or even ignore it entirely. For example, runners in the Boston Marathon continued towards the finish line when the first IED functioned. Although there were small, kneejerk reactions to the explosion, most of the runners did not stop or deviate from their path. This was a unique situation: the runners had spent hours working toward a specific goal and were physically and mentally exhausted, which most likely reduced their body's ability to process and react to the explosion.

A more common goal, however, that may affect behavioral outcomes would be people with, or waiting for, family members and friends. One example of this includes the behaviors of parents at Manchester Arena. These individuals remained near the blast site, continuing their pre-explosion goal of waiting for their children after the concert. Another example from Boston includes the photographers near the first explosion recording the runners finishing the marathon. In addition to their training and experience resulting in a reduced reaction time, they continued their prior goal of recording events at the marathon and transitioned quickly from photographing the runners to photographing the aftermath of the explosion.



## Insights into Group Characteristics & Human Behaviors

**Crowd dynamics shape the behaviors that are available to individuals and which behaviors they are most likely to engage in.**

Behaviors can act as a contagion. When a person is alone, their reactions are not influenced by the behaviors of others. However, if they see people around them behaving a certain way, such as fleeing, they may be more likely to adopt that behavior, even if they would not have chosen this behavior when alone.

Crowd behavior and contagion behaviors are also directly related to crowd density. High crowd density and crowd behaviors can force others into behaviors in which they otherwise would not engage. One example is after the first IED functioned at the Boston Marathon, people close to the blast impulsively fled, pushing into others, who also fled. Individuals outside of the blast radius who fled likely would not have done so as quickly, if not for the crowd pushing into them. Another example is inside Manchester Arena, where the panicked fleeing of concertgoers created a stampede in the center aisles towards the exits. Individuals in that crowd were pulled along; standing still would have risked being trampled. In these cases, individuals have no choice but to join the crowd or otherwise risk serious injury. Crowd movements can quickly result in panic, stampedes, and crushing events depending on the circumstances of the IED event and the surrounding environment. Crush events occur when crowd densities reach unsafe levels and create pressure on the bodies of those in the center of the throng. In these scenarios, individuals may not even be able to move on their own and are pushed along with the crowd.

Fortunately, crowd dynamics are not always destructive – some can even be beneficial. They can calm individuals who otherwise may panic and encourage those who might flee to evacuate safely. For example, in some cases, survivors acknowledged that the fact that there were others around them who were calm kept them calm as well.

**People who came to the soft target in groups will try to reunite with their friends and family before fleeing or evacuating.**

Members of groups who would otherwise flee or evacuate to safety may wander through the environment looking for other group members and even approach the area where the explosion occurred to see if they were injured or killed. They will engage in these behaviors even if that means increasing the risk to themselves and others. The stronger the connection with the individuals in their group (e.g., parents looking for children), the more likely it is they will risk placing themselves in danger. In Manchester, some family members ran from the blast site into the arena to find their loved ones rather than evacuate. In Atlanta, people waited until they were reunited with their friends and family before exiting the park. In Boston, a father shuttled one child to safety and then immediately returned to the blast site to help his wife and daughter who had been severely injured.



**Attacks that occur at locations that draw large numbers of families will result in more people choosing to remain on site to search for their group.**

**The distribution of behaviors within a crowd becomes more predictable and streamlined as people get farther away from, and more time passes after the explosion.**

Although infrequently occurring behaviors (e.g., gawking, hiding) are possible at any time, the farther away from the explosion, both geographically and temporally, the more predictable and similar people's behaviors become. For example, people in or near the blast radius are more likely to adopt fleeing and evacuating behaviors after a couple of minutes have passed following the explosion. Similarly, freezing and wandering behaviors are drastically reduced during this period as people in these states are helped by other survivors and first responders. Also, individuals in these zones further away from the explosion are less likely to engage in rare behaviors and are more likely to flee or evacuate normally even when accounting for delayed responses or freezing.



## Insights into Event Characteristics & Human Behaviors

### The magnitude of an explosion determines how fast, how far, and which behaviors spread.

The size of the explosion plays a role in behavioral responses. Other things being equal, the larger an explosion, the farther away it can be seen, heard, and felt, and the larger the blast radius, whereas a smaller blast may not be heard or seen uniformly around the soft target. This variation in blast size results in differences in how many people receive information about the explosion, impacting group responses and crowd dynamics. Larger blasts may trigger immediate fleeing behaviors as the perceived risk is greater, whereas smaller explosions may result in more freezing behaviors or delayed reactions caused by an individual's inability to determine what is happening and what to do next.

### Responses to attacks involving multiple IEDs are often different than those employing a single bomb.

People may at first interpret stimuli from a single IED functioning as an accidental explosion or may even ignore the sights and sounds, depending on the IED's size and a

person's location. However, two or more explosions appear to universally register as targeted attacks and increase responses such as fleeing. In Boston, Brussels, and Madrid, many individuals transitioned immediately to fleeing following the explosion of a second bomb. In cases without multiple explosions, individuals may freeze longer or choose to evacuate normally or not at all.

However, the functioning of a second (or even third) IED also increases uncertainty and risk among the crowd about how to safely evacuate. Uncertainty about the risk of fleeing or evacuating may make hiding behaviors more common in cases of multiple attacks. In Brussels, several people hid until someone told them it was safe to evacuate. In Boston, one couple remained in place, deciding it was safer to stay there than risk entering the blast radius of another IED. This pattern likely has implications for attacks involving more than one type of weapon (e.g., IEDs and firearms). For example, individuals who hide or freeze to protect themselves from another IED may unwittingly make themselves more vulnerable to being shot.



**Hiding behaviors may be more common after attacks with multiple devices.**



## Insights into Environmental Characteristics & Human Behaviors

### The environment impacts the physical effects of an IED functioning, in turn impacting human behaviors.

There are many ways that the environment impacts the thermal, blast pressure, and fragmentation effects of the IED. The thermal effect, or the heat and fire of the explosion, can be shielded or contained by objects in the environment. This effect is the most visible and in open, or partially open, environments it is the first signal to people outside of the blast radius that an explosion occurred. The larger, more predominant, and better visibility of the thermal effect, the more likely individuals outside the blast radius will see and react to the explosion. For example, individuals may freeze or flee if they see a fireball in the sky and hear the explosion but will have a delayed response to the IED functioning if the visible indicator is hidden within an enclosed environment.

The blast effect, which includes blast overpressure and the shock wave, is reflected and amplified by surrounding structures in the environment. This effect causes catastrophic injury to humans through soft tissue damage and other serious bodily harm. In

Madrid, London, and Brussels, explosions inside subway and train cars contained the most devastating effects of the shockwave, but also caused large numbers of injuries and deaths within the enclosed environments. These resulted in the need for more emergency medical care and help within the blast radius.

The blast wave destroys the bomb components and the surrounding environment, causing additional injuries and deaths through primary and secondary fragmentation. Shrapnel from the fragmentation effect can be deadlier at farther distances and is less predictable in its lethality. Fragmentation does have the potential to injure people outside of the blast radius. This means that wounded individuals may be found far away from the blast site and may evacuate to find medical care on their own depending on the severity of their injuries.

### The physical environment shapes and limits how and where people can move after an explosion.

Besides how the environment can alter the physical impact of an IED, it can shape and limit human behavioral responses in

other ways. Indoor or closed environments within or near the blast radius can trap people inside or reduce their ability to flee (e.g., on subway and train cars). In the Brussels Maelbeek metro bombing, people in the cars surrounding the blast site could not open the doors of the train car and were therefore forced to wait until someone could help them evacuate.

Complex indoor environments, such as in buildings or large transportation centers, can also be difficult for people to navigate to safety, particularly if they are unfamiliar with the layout. Environments with narrow passages and hallways can slow egress, creating crowd crush scenarios or leaving people vulnerable to additional IEDs. During evacuation efforts, indoor environments will need to be searched for people, possibly injured, who are frozen, hiding, or wandering. On the other hand, closed environments can also provide a sense of security and reduce the perception of risk for those outside the blast radius. These types of environments can make it easier for individuals to hide and gawk.

Even in relatively simple outdoor environments, like in Atlanta and Boston, security fencing, barricades, and other objects can impact how and where people behave. These physical features are hazards when crowds flee but potentially create spaces for hiding and protecting oneself from another explosion. Open environments can also provide more accessible escape routes that allow for the movement of large numbers of people to exit the blast radius quickly and with a relatively low risk of further injury.



**The complexity of the physical environment—indoor or outdoor—influences how many people flee or evacuate on their own and how many need assistance.**

**The environment shapes how much information about the explosion reaches a person and, subsequently, their behavior.**

Human behaviors are impacted by the amount and type of information they receive when the IED functions. Given complete information and enough time to process it, most individuals will choose behaviors they perceive will lower their risk of injury or death. The environment plays an important role in how much direct and indirect information reaches a person.

## Conclusion

These insights provide empirically supported evidence that begins to answer the question – *How do people respond immediately after an explosion at a soft target and crowded place?* The array of human behaviors, such as freezing, fleeing, and helping, are shaped by the complex interactions of the explosion, the crowd, and the environment. These behavioral responses, and the mechanisms that drive them, provide actionable information for trainers, policymakers, and security experts to better prepare for future responses to targeted IED attacks at soft targets and crowded places.

Direct information about the explosion includes sensory inputs like seeing, hearing, or feeling the blast. Examples of indirect information include sensory input of non-explosion related stimuli, such as crowd panic or someone passing along information. This could be in the form of a train engineer using the telecom system to make an announcement or a person fleeing and telling others what they witnessed.

In relatively open environments, like the Boston Marathon course, thousands of people received direct stimuli from both IEDs functioning as they could see, hear, and feel the explosions. The closer they were, the more information they received. In closed environments, such as Manchester Arena, the amount of information was dependent on where the person was when the IED functioned. In the foyer area where the explosion occurred, all senses were impacted. People in the hallway between the arena and the foyer heard the explosion and saw the cloud of smoke and then began to react. Those in the arena could hear the blast but could not see what had happened. Without the visual of the explosion, it took time before a mass of people began to flee. This reaction was based, in large part, on the sight of people fleeing from areas closer to the blast, as well as the spread of information that the sound was caused by a bomb.

**Soft targets hosting events may be better prepared for IED events than those that are not.**

Environments that are hosting events, such as concerts or sports competitions, are likely better prepared to respond to an IED functioning. They will already have on-site a contingent of law enforcement, security, and medical personnel. Three of the case studies were at soft targets hosting events and three were attacks on transportation systems. The soft targets hosting events—Atlanta, Boston, and Manchester—included staff who had received at least some training on incident response procedures. In Atlanta and Boston, medical staff were on site, allowing for a rapid response and quick treatment of the injured. Additionally, staff at these events had been primed by event organizers who indicated that a terrorist attack was possible and designed security based on the possibility of such an event. In Atlanta, this priming contributed to the discovery of the IED before it functioned and provided time, albeit little, for spectators to evacuate. It is unclear if the staff on site in Madrid, London, and Brussels had received any training on incident response. Even if they had, it is unlikely they were prepared for the mass casualty events that occurred.

# 4 Background on Human Behaviors After an Explosion

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## Introduction

This section provides background information about the multi-case analysis developed to provide the narrative of human behaviors after an IED functions as well as the insights into those behaviors. First, it provides information about the multi-case study research methodology and the six high-profile targeted IED attacks selected for analysis. Next, this section explains about the types of behaviors humans engage in immediately after an IED functions as well as the geographic and temporal categories used to understand these behaviors across time and place. This information is necessary for understanding the extended narrative presented in the next section.

## A multi-case analysis of high-profile bombing events

Little systematic research has been done on human behaviors after targeted attacks at soft targets. To explore this phenomenon, this analysis employed a multi-case study methodology to examine responses to bombing events. Six case studies on high-profile bombing events in the United States and Western Europe were purposefully selected and more information about these cases can be found in Table 2.

The multi-case study methodology allows for research on a topic with relatively few events for which there is little or inconsistent information. This methodology is uniquely suited for researching individual cases of bombing events because data about them often lack detailed, coherent information about human behavioral responses at the micro level. This makes it difficult to analyze human behaviors, let alone identify shifts in those behaviors. Using the multi-case study approach overcomes this issue by combining all information collected on multiple cases and treating that information as data on one overarching phenomenon: the study of human behaviors immediately after an IED functions.

For this research, open-source data were collected for each case and included, but were not limited to, news reports, videos, investigative reports, and court documents. These documents were reviewed for any information about human behaviors in the immediate aftermath of an IED functioning. This information was then coded for discrete variables (e.g., behavior type, temporal and spatial location, and emergent patterns and themes). A more detailed explanation about the research methodology can be found in Appendix A.

The findings from the analysis provide information about each case as well as cross-case IED attacks and behavioral trends that are likely to be seen in future events. Moreover, the comparison allows for an understanding of why some people react counter to expectations and what contextual factors influence these different responses. Additional explanations about how these patterns and trends are categorized and defined are provided throughout this section.

Table 2. Overview of Case Studies Examined in this Report

CASE	CONTEXT	SOFT TARGET TYPE(S)	HOSTING EVENT (Y/N)	NUMBER OF IEDS	SIZE OF IEDS	CASUALTIES	LOCATION(S)
<b>Atlanta Centennial Olympic Park Bombing</b>	The Centennial Olympic Park Bombing occurred at 1:20 a.m. on July 27, 1996, during the middle of a concert at the Atlanta Summer Olympic Games.	Park	Yes	1	40 lbs.	2 dead, 111 physically injured	Outdoor concert venue with open access
<b>Madrid 11M Bombings</b>	On March 11, 2004, 10 IEDs functioned near unison on four commuter trains heading into the center of Madrid, Spain. The attacks occurred during the morning rush hour.	Commuter trains	No	10	20-25 lbs.	190 dead, 1,800 physically injured	Inside moving subway cars
<b>London 7/7 Bombings</b>	On July 7, 2005, four suicide bombers targeted three Underground subway cars and one city bus in London, UK.	Subway cars, City bus	No	4	10 lbs.	52 dead, more than 700 physically injured	Inside moving subway cars and a bus
<b>Boston Marathon Bombings</b>	The Boston Marathon bombings occurred on April 15, 2013, when two IEDs functioned within sight of the race's finish line.	City street	Yes	2	8-16 lbs.	3 dead, 281 injured	Venue was outdoors, but barricades erected for the race limited movement
<b>Brussels Bombings</b>	On March 22, 2016, Brussels suffered two terrorist attacks: at 7:58 a.m., two IEDs functioned at Zaventem International Airport; just over one hour later, a third IED functioned at Maelbeek Metro Station, close to European Union (EU) headquarters.	Airport, Subway car	No	3	33-66 lbs.	32 dead, 340 physically injured	Inside crowded airport and moving subway car
<b>Manchester Arena Bombing</b>	Minutes after fans started leaving an Ariana Grande concert on May 22, 2017, a powerful IED functioned in the City Room outside the Manchester Arena.	Indoor concert arena	Yes	1	79 lbs.	22 dead, 239 physically injured	Indoor venue with many exits

## Identifying & Categorizing Human Behavioral Responses After an Explosion

### Human behaviors after an explosion can be grouped into a limited number of distinct categories

In the wake of an explosion, people act and react in a variety of ways. When reviewing eyewitness accounts, victim testimonies, and video evidence of events after an IED functions, patterns in these behaviors emerge. These behaviors were identified and verified during the multi-case analysis and can be grouped into a limited number of categories. People *evacuate, flee, freeze, gawk, help, hide, or wander*. In some cases, depending on the amount of sensory input, individuals will continue their baseline behaviors—what they were doing prior to the IED functioning—and have a delayed reaction to the explosion.

The multi-case analysis identifies whether a majority or minority of people engage in these behaviors. The prevalence of these

behaviors was estimated by reviewing eyewitness testimony, photographic evidence, journalistic accounts, government records, and other open-source documents. Placing the behaviors into these general categories was based on an overall assessment of the available data – they do not reflect detailed counts or statistics of bystander behavior. At different times after an explosion, one majority (i.e., most common) behavior—or two relatively equal behaviors—and a few minority behaviors are typically observed. While the majority and minority behaviors are the rule across the examined cases, there are exceptions – behaviors that are rare. These exceptions showcase individuals' sometimes random and chaotic behavior when faced with extraordinary and unfamiliar circumstances. In other words, although it is expected that most people will engage in a limited set of behaviors after an IED functions, a few may engage in unusual or unpredicted ways.

### The primary human behaviors identified across the case studies include:

<b>EVACUATING</b>	Individuals may leave the soft target of their own accord in a slower, deliberate manner (this is distinct from fleeing).
<b>FLEEING</b>	Individuals may run away from the blast site or other perceived risks. Fleeing can be impulsive or deliberative.
<b>FREEZING</b>	Individuals may stay in place due to an inability to decide between competing behaviors, such as fleeing or helping. Freezing may also result from being temporarily stunned by the physical impact of the explosion (e.g., being concussed or knocked unconscious by the blast wave and unable to react). For most people, freezing is an inability to choose a path forward; however, some may choose to remain in place if they believe this is safest.
<b>GAWKING</b>	Individuals may watch or document with a camera phone or other audiovisual recording device the blast site and the immediate aftermath of the explosion. Although this may look like freezing, the individual is making a deliberative decision to stay and watch.
<b>HELPING</b>	Individuals may help those around them, even when it could increase risk of personal harm. This includes providing medical assistance to the wounded, helping with the emergency evacuation, or acting as a leader. Helping is almost always a deliberative choice. However, there are uncommon examples of individuals engaging in spontaneous helping, such as grabbing another individual and helping them flee immediately after an IED functions.

## Section 4. Background on Human Behaviors After an Explosion

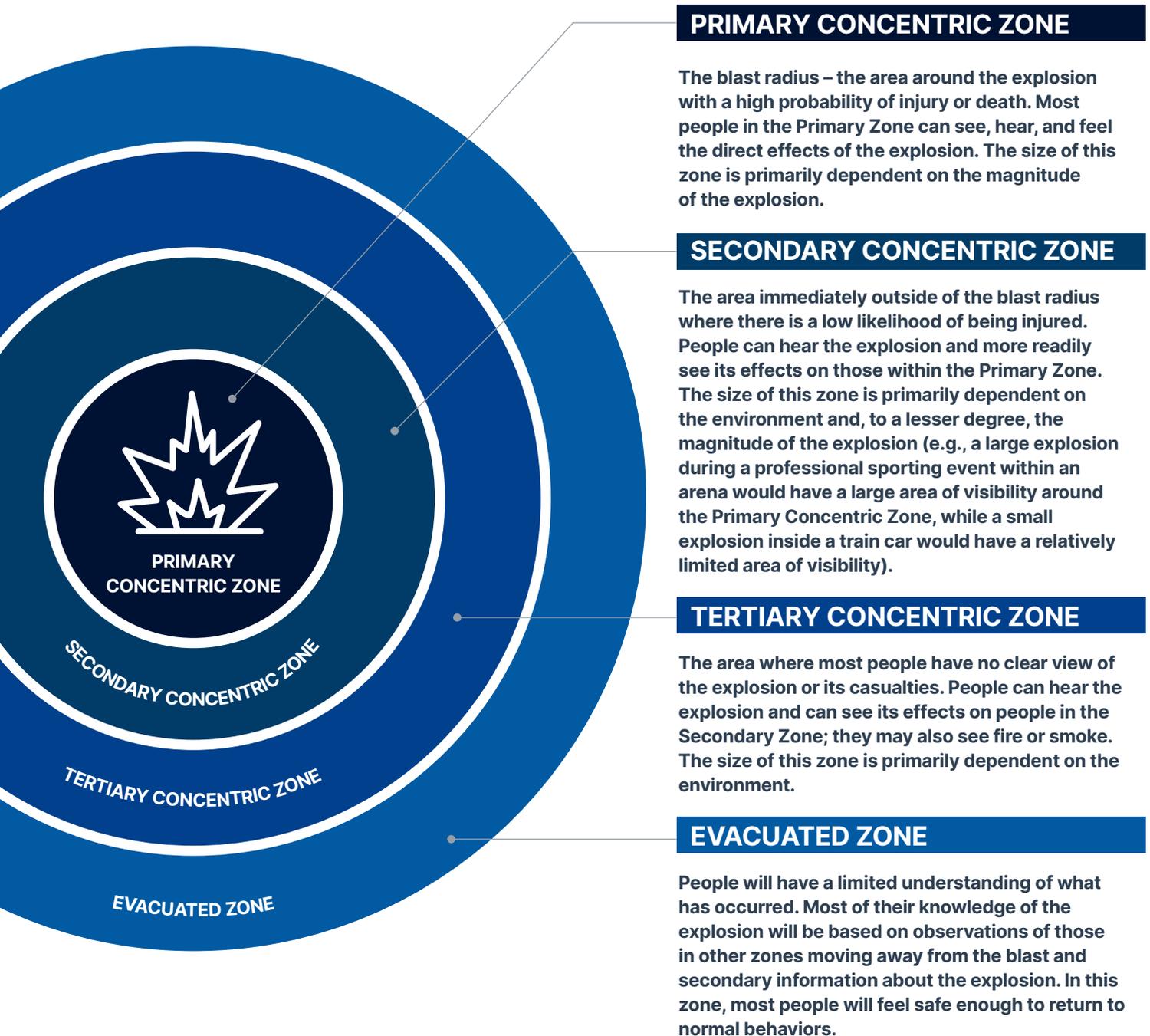
<b>HIDING</b>	Individuals may hide after an explosion if the environment allows it. This often involves maneuvering around the space so that an object, such as a wall, is between themselves and the blast site.
<b>WANDERING</b>	Individuals who can move, but are still confused or shocked by the explosion, may aimlessly wander around the soft target.
<b>DELAYED REACTION</b>	When individuals receive limited stimuli related to the explosion, they may have a delayed response and continue engaging in their baseline behavior. This is more likely the farther away from the explosion an individual is located. This behavior is different from freezing, as the person is not stuck between two competing behaviors; they are unaware that there is even a need to shift behaviors.

Perceptions of risk, personal characteristics, the design of the environment, available information about the explosion, and prior experiences or training all play a role in how people respond. Response behaviors are strongly influenced by a person's physical distance from the explosion and the amount of time that has passed since the explosion occurred. These characteristics also play a role in whether people react impulsively or deliberately, that is if they react at all and are not frozen in shock. In the first couple of seconds after an IED functions, people are more likely to react impulsively, especially if they are close to the explosion. Impulsive behaviors are subconscious, automatic, and reactionary. They are guided by a primal flight or fight response that is meant to limit risk and escape danger. An example of an impulsive

behavior is people in the blast radius, who are not severely injured, that immediately sprint away from the explosion to avoid the danger. However, with time and distance from the explosion, people begin to process what is happening and select behaviors using rational or deliberative decision making. An important caveat is that these decisions appear rational to those making them based on the information they have available at the time. An example of a deliberative decision is when an individual on a city street chooses to hide inside a nearby store after hearing multiple explosions and seeing people running several blocks away. Neither type of reaction is inherently correct or wrong, and both are designed to reduce risk, remove danger, and activate behaviors that result in increased safety.

## Behaviors vary based on how close a person is to the explosion

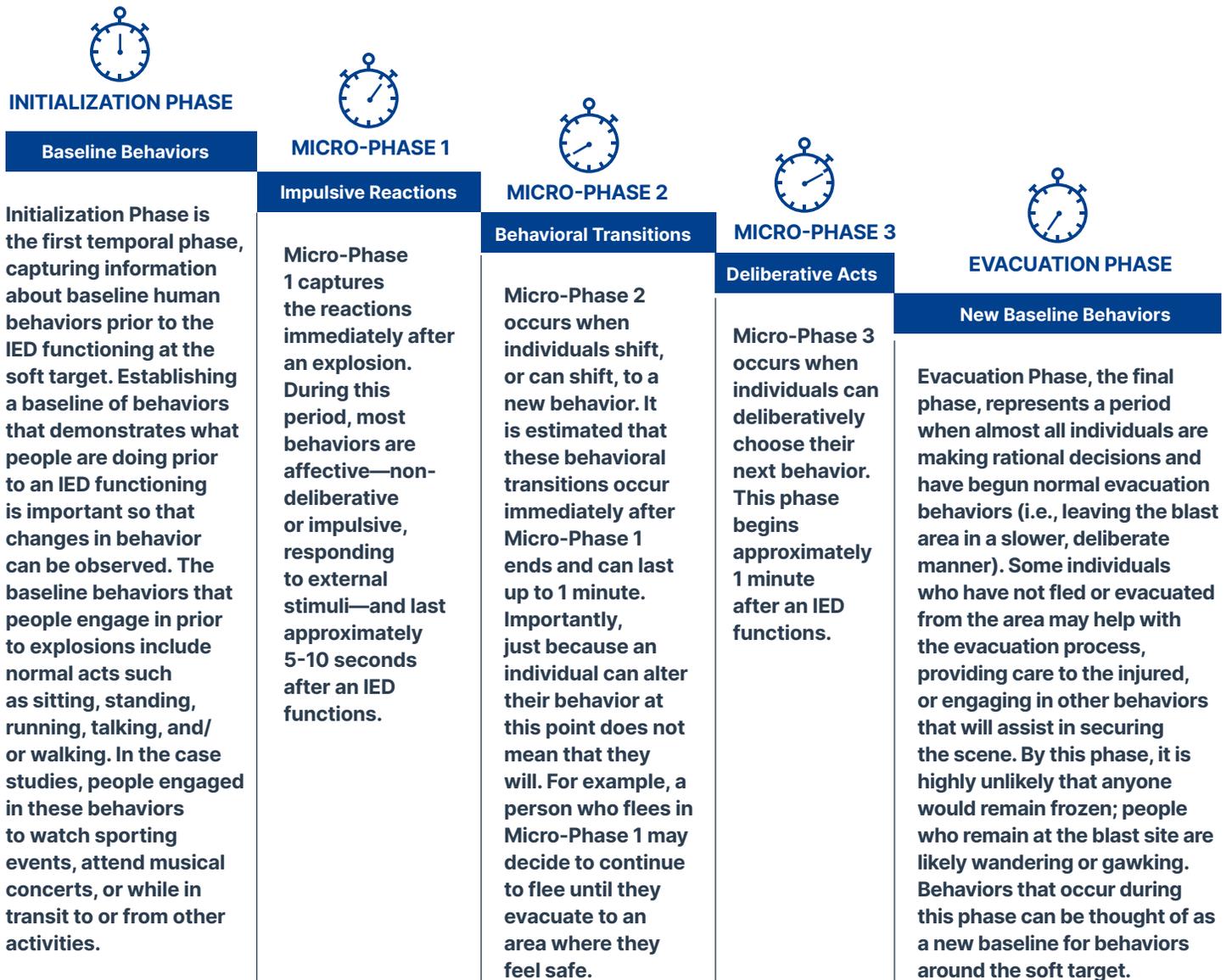
A person's distance from the explosion affects their behavior. Depending on their proximity to the blast, a person may sustain shrapnel wounds, contact burns, hearing loss, confusion, and other physical effects that can impact behavior. The distance from the explosion also determines how much information a person has about the threat to their safety. To account for this variation, how far people were from the explosion is categorized into concentric zones radiating away from the epicenter of the blast site. Conceptually, these zones geographically segment the experiences and behaviors of those reacting to an explosion. This allows for a nuanced understanding of the relationship between blast proximity and behavioral responses and to observe possible similarities and differences across distance.



## Behaviors vary based on how much time has passed since the explosion

How much time since the bomb functioned also affects a person's behavioral response, and this research disaggregates the period of interest, the first few minutes after an explosion occurs, into five phases. Three of these phases are labeled as micro-phases as they last a relatively short period of time. The Initialization Phase and the Evacuation phase are periods used to examine baseline human behaviors prior to the explosion and then new baseline behaviors once most people have recovered from the initial shock and are making deliberate decisions to engage in behaviors such as helping, fleeing, or evacuating.

In the first few seconds after witnessing an explosion, people are more likely to respond automatically, without making deliberative decisions. After the initial shock wears off, there is a period where people begin to shift from acting on impulse to thinking deliberately about their actions and can transition to a new behavior. This transitional phase does not necessarily mean that their behaviors will change, only that they can. After this phase occurs, people can make conscious decisions to act and engage in behaviors of their choosing. For example, a person whose initial impulse is to freeze may transition to fleeing, and then decide to stop and help. The final phase, where most people have evacuated or had the chance to evacuate, captures a new baseline for human behaviors post-explosion. These temporal phases, like the geographic concentric zones, are meant to create categories that allow an understanding for how behaviors may change across time.



## Conclusion

To understand how human behaviors change over time, this section identified and defined important ideas for organizing and describing such behaviors. First, the types of behaviors identified during the multi-case analysis were listed and described in detail. In *Section 5. An Extended Narrative of Human Behaviors After an Explosion* and *Appendix B: Case Studies*, many real-world examples of how people engage in these behaviors after an explosion are provided. Second, this section also divided the area around the blast site into concentric zones. By segmenting the physical space based on the location where the IED functioned, this provides a framework for examining how behaviors change across place. Finally, the time after the explosion was also broken down into phases to understand how behaviors may shift. In the next section, the geographic and temporal categorizations are used to examine in detail human behaviors after an IED functions.



# 5 An Extended Narrative of Human Behaviors After an Explosion

## Introduction

The following section describes in detail how humans behave after an IED functions at a soft target and crowded place. The analysis of these six case studies revealed patterns in human behaviors. While these behaviors are not universal, they demonstrate consistency in human behavior. Which behavior a person adopts is impacted by characteristics of the individual, the IED event, the soft target environment, and crowd characteristics. Identifying and describing these behaviors provides information for soft target security experts to develop new policies and trainings to reduce unintentional and avoidable harms that occur after an IED functions. The results of the analysis are separated across time and place, utilizing the geographic concentric zone and temporal phases framework described in Section 4 to categorize and present the observed human behaviors.

## PRIMARY ZONE



### INITIALIZATION PHASE: Baseline Behaviors

Of the 21 IEDs that functioned across the six case studies, one was inside an arena's foyer connecting the building to public transportation, three were outdoors inside or near crowds, two were inside an airport lobby outside of security, one was on a double decker bus, four were on subway cars, and 10 were on commuter trains. The baseline behaviors included commuters taking crowded public transportation to work, travelers checking in to flights, parents and their teenage children leaving a concert, others attending an outdoor concert and celebrating a global sporting event, as well as family members and friends watching the end of an internationally renowned marathon. These baseline behaviors in the Primary Zones of each bombing were normal, everyday acts that millions of people engage in every day.

### MICRO-PHASE 1: Impulsive Reactions

Everyone is immediately and physically impacted by the IED functioning – eardrums rupture, vision diminishes, bodies and clothing shred. Many are killed or grievously injured. The majority of people freeze. They are confused, concussed, and cannot choose a path forward. Some will impulsively flee if there is space to move and the crowds around them allow it.

Victims and witnesses in the Primary Zone described similar experiences across the cases during the first several seconds after the IEDs functioned. The IED produced a flash of light and a loud blast and instantly inflicted serious damage to the people and infrastructure near it. The blast wave tore clothes and bodies apart and damaged hearing. Shrapnel pierced flesh and broke bones. The air smelt of burnt metal. Dark smoke obscured visibility. Many were immediately killed and many more severely injured. Across several cases, a moment of eerie calm after the explosion was quickly replaced with screams of pain and crying.



## PRIMARY ZONE

Most people froze in place. Some froze because the physical effects of the explosions knocked them unconscious, concussed them, or caused a general sense of confusion. On the London Underground, one witness described feeling stuck in place and then briefly losing consciousness.<sup>8</sup> Some victims described the inability to know how much time had passed. Others froze in shock, unable to choose between competing behaviors, such as fleeing or hiding. Inside the Primary Zone of Manchester Arena, one victim described feeling hit by the force of heat and instinctively curling into a ball on the ground because she did not know what was happening.<sup>9</sup>

A small proportion of people fled, although the frequency of this behavior across cases appears to be correlated with the environment. For example, in enclosed environments, such as the subway and commuter trains, mobility inside the cars was limited. Many people were stunned for a longer period by the blast wave than those in open environments. In a few cases, several people were able to exit quickly out open exits or even the holes blown into the bus and trains. Where doors were locked or damaged, people had nowhere to immediately go. In open environments, fleeing behaviors were more common. At Atlanta Centennial Olympic Park, one concertgoer described instinctively starting to run when the blast occurred just yards away from her. It was only later that she realized she'd been injured.<sup>10</sup>

In Boston, crowd density played a key role in the behavioral responses.<sup>11</sup> The Primary Zone consisted of the sidewalk, packed with thousands of spectators, their movements limited by fencing and barricades along the marathon route on one side and buildings on the other. When the IED functioned, many near the device immediately fled as an impulsive reaction, pushing into those around them, who also began to flee.<sup>12</sup> This chain reaction resulted in hundreds of people running, a much higher proportion of fleeing than seen in other cases. Most who did not flee were either severely injured or were motivated to stay with injured family and friends.

Small numbers of individuals engaged in hiding and helping during the first several seconds after a blast. The first IED that functioned at Zaventem Airport in Brussels brought down ceiling tiles and air vents. Some people in the Primary Zone instinctively hid behind or below barriers to protect themselves. One airline employee jumped into a luggage chute.<sup>13</sup> These behaviors could last for seconds, minutes or until first responders arrived to help safely clear the scene. In this phase, helping behaviors appeared to be more impulsive than deliberate decisions to assist the injured. Some survivors spoke of grabbing, or being grabbed by, individuals as they fled from the blast.

## MICRO-PHASE 2: Behavioral Transitions

Smoke and the smell of burnt metal and flesh hangs in the air. As the initial shock wears off, many flee. An equal number still freeze in shock – unable to decide their next move. A decision complicated by the presence of the injured – some family and friends – crying out for help. Some people are trapped in enclosed environments where escape is as risky as staying. After several seconds or more, depending on the individual and characteristics of the IED attack, individuals can start transitioning away from their impulsive reactions. During this phase, more people begin to flee, and fleeing and freezing occur at similar rates. In the Primary Zone of Centennial Olympic Park, it only took a couple of seconds before the recognition of what had happened began to spread and many people began to flee. In Boston, video evidence shows many people still fleeing during Micro-Phase 2, a behavior that only increased when the second IED functioned a hundred yards away from the first.

A considerable proportion continued to freeze. For example, in the Primary Zone of Zaventem Airport, some people remained frozen in place, even as those around them engaged in what was described as a stampede. One witness described a woman near her: “She was in shock, speechless... There was no crying, no shouting. She was only looking around with fear.”<sup>14</sup> On the subway and commuter trains in Madrid, London, and Brussels, many people still were frozen, their ability to decide what to do next was difficult and drastically limited by the enclosed environment in which they were trapped. To flee would require the ability to find a way to exit.

Small numbers of individuals began to shift to other behaviors, such as helping. In the foyer inside the Manchester Arena, the force of the blast initially knocked most in the Primary Zone to the ground. However, after the initial concussion, some people got up and started to help the wounded around them.<sup>15</sup> In the London Underground, some who were not severely injured began to help those who were while others pleaded for calm.<sup>16</sup> In Madrid, some who initially fled returned to help.<sup>17</sup> There were also accounts, albeit few, of gawking. At the Brussels Zaventem airport, a photojournalist took pictures of the carnage.<sup>18</sup> Finally, some people who were frozen from shock during Micro-Phase 1 began to wander around the Primary Zone in Micro-Phase 2.



## PRIMARY ZONE

### MICRO-PHASE 3: Deliberative Acts

The majority of people can now choose their behavior. Many flee in panic, some evacuate with self-control. Those who remain assist the injured as best they can – offering comfort, staunching open wounds, providing leadership where first responders have not yet arrived. Uninjured helpers with specialty skills outside the blast site begin to arrive.

Approximately one minute after an IED functions, many people who were not severely injured transitioned away from freezing. Fleeing and normal evacuation behaviors then became the majority behaviors. People in the Primary Zone of Centennial Olympic Park were screaming and running towards the edges of the park.<sup>19</sup> In London and Madrid, where there were ways to exit the train cars, most survivors exited into the tunnels or onto the tracks. Importantly, when there was a second explosion, like in Boston, those fleeing from the second IED kept from running back into the first IED's Primary Zone.

Helping was also a common behavior and, after most people fled, became the dominant behavior for those who remained in or had just entered the Primary Zone. For example, first responders and civilians from the other concentric zones began to enter the area to help those who were injured. In Boston, because they were already on-site, first responders began to enter the Primary Zone, although many were delayed by the fencing and barricades. Medical doctors who ran the Boston marathon, or were in the crowds, also approached to help. Atlanta was similar, law enforcement who were not at the blast site reached it during Micro-Phase 3. If people with specialty training were nearby, they also approached to help. At the London Bus bombing, medical doctors from the British Medical Association headquarters, which was next to the explosion, rushed out to help.<sup>20</sup>

Importantly, where no law enforcement or first responders were immediately available, people stepped in to fill in the leadership void. The conductor of the train where the Brussels Maelbeek Metro bombing occurred reached the blast site and began to evacuate those who were still alive, similar to what happened on a train in London.<sup>21</sup> In Madrid, people from the neighborhood began to arrive at the station to help.<sup>22</sup> Individuals on trains helped where they could by applying tourniquets, talking with victims, and attempting to keep people calm.

Finally, the behaviors of hiding, gawking, wandering, and freezing still occurred, but at a much lower rate.

### EVACUATION PHASE: New Baseline Behaviors

First responders with medical training replace those who chose to stay and help. The severely injured are stabilized and taken away. Friends and families follow. The helpers, as well as those still frozen or wandering, are examined and provided first aid. Law enforcement secure the blast site to start collecting forensic evidence.

The Evacuation Phase represents a time when new baseline behaviors begin. It also represents a period when, in most cases, off-site first responders start to arrive if they were not already assigned at the location of the bombing as part of their routine duties or working an event. Most people who wanted to flee, and could, already had. Helping was the majority behavior during the evacuation phase for those individuals who were left and those who were entering the Primary Zone. By this point in most cases, first responders had arrived in the Primary Zone to provide medical assistance to the wounded, although there were some exceptions where the injured waited for up to 30 minutes before help arrived.

Civilians continued to play a helping role and make their way to the injured, although some did leave once first responders arrived. For example, as concertgoers exiting the Tertiary Zone of Manchester Arena passed through the Primary Zone, many stopped to help the wounded evacuate. First responders relied on these members of the public to assist with casualty care and gave them first aid kits; had there been more supplies, civilian helpers would have been able to do even more to provide emergency care.<sup>23</sup> In contrast to the other cases, a number of parents who had come to the Manchester Arena to pick up their kids defied requests to evacuate and continued waiting in the Primary Zone to find their children.<sup>24</sup> As the evacuation phase continued, friends and family evacuated with the wounded they had stayed behind to help. Ambulances and medics transported the injured to the hospital. Law enforcement officers secured the blast sites to collect forensic evidence and investigate the crime scene.



## SECONDARY ZONE

### INITIALIZATION PHASE: Baseline Behaviors

The Secondary Zone, or the area immediately outside of the blast radius, consisted of subway or commuter train cars, at least in part, for Madrid, London, and Brussels. These included the cars on either side of where the IED functioned and, in some cases, station platforms and nearby trains. These areas were crowded with commuters. For Atlanta and Boston, two outside events, the Secondary Zones were determined based on the size of the explosion and the physical environment and filled with spectators and event participants. Atlanta's was crowded with those whom law enforcement had evacuated from the Primary Zone or who were watching the concert. Boston's included the marathon route where runners were finishing the race, event volunteers, and law enforcement. There were also sections of spectators watching the race. No matter the event, however, the Secondary Zone represented an area where the probability of being physically injured was relatively low, but people could at least partially see the injured and killed within the Primary Zone.

### MICRO-PHASE 1: Impulsive Reactions

The sound of the IED functioning damages hearing, and a flash of light is visible to most. The dead and injured are seen by fewer. Many witness the panicked masses rushing away from the blast. Many flee from the explosion and the incoming crush of people. A roughly equal number freeze. Few will help.

In the first several seconds following an explosion, the dominant or majority behaviors were freezing and fleeing. Minority behaviors included helping, hiding, wandering, and delayed reactions. At Manchester Arena, people in the hallway outside the Primary Zone heard the explosion and saw the hallway fill with smoke, causing many there to freeze while they processed what was happening.<sup>25</sup> Witnesses at Centennial Olympic Park described a hush coming over the crowd before people began to panic.<sup>26</sup> The people in Madrid and London on the train and subway cars next to the cars where the IEDs were placed, also froze. It took time to process the incomplete information, most not knowing that an explosion had occurred; other than smoke, there were limited signs of an immediate or ongoing risk to personal safety.<sup>27</sup> In Tavistock Square in London, medical professionals described being momentarily frozen before shifting to helping behaviors in subsequent phases and approaching the injured in the Primary Zone.

In Boston, which provides the best video evidence of human responses in the Secondary Zone, law enforcement immediately reacted, stepping backward, and turning to observe the explosion before grouping together and moving towards the blast site. They begin to shift behaviors much faster than other people, an example of how those with training and strong goals can act differently from others in the same zone. Boston also presents an excellent example of a delayed reaction to an IED functioning. Runners who were finishing up the last block of the marathon had little to no reaction to the explosion. Some instinctually flinched. As a group, they slowly shifted their trajectories away from the side of the street where the IED functioned. However, no one froze or appeared to react in any meaningful way except one runner who collapsed, although he had not been hit by any shrapnel. This continuation of their original goal, which was to finish the marathon, demonstrates how an individual or group's motivations can delay or counteract the predicted effects of witnessing an explosion.

Fleeing, another majority behavior, occurred in most instances where the physical environment allowed it. In the Secondary Zone of Manchester Arena, many immediately began to run, pushing and shoving those near them to get out faster.<sup>28</sup> In Madrid, video evidence shows people momentarily stopping and turning after the first IED functioned, but then fleeing when additional events occurred.<sup>29</sup> Part of this fleeing behavior, like in the Primary Zone, was based on how close people were to the blast and how great the perceived risk was. Multiple IEDs that were very close together, as was the case with Madrid behaviors, demonstrate how behaviors such as freezing will immediately shift to fleeing as more stimuli occurs. On one of the commuter trains, survivors described calmly exiting the train from the Secondary Zone when the first IED functioned, but this evacuation immediately turned into a stampede once the second IED functioned.<sup>30</sup>



## SECONDARY ZONE

### MICRO-PHASE 2: Behavioral Transitions

Fleeing from the danger prevails. Both those within the blast radius and immediately outside take flight. A minority continue to freeze, still in shock from the IED functioning and unable to overcome their paralysis to choose. More begin to help those around them or head towards the injured. A few hide if they can find shelter. Others gawk, watching and recording the carnage nearby. Onsite first responders pass through to provide aid within the blast zone.

During Micro-Phase 2, fleeing is the majority behavior, although freezing, helping, and hiding are important minority behaviors. In the Secondary Zone, there are people fleeing through the zone during Micro-Phase 2, including those who started their escape in the Primary Zone during Micro-Phase 1. Those individuals act as additional stimuli and can create a chain reaction in which individuals who were previously frozen shift to fleeing now that they can shift behaviors. For example, people in the Secondary Zone at Centennial Olympic Park saw and heard the blast occur and watched as people in the Primary Zone began to flee, triggering many in the Secondary Zone to flee as well.<sup>31</sup> In Boston, where crowds of spectators were behind the barricades, individuals went from frozen to fleeing as people from the Primary Zone pushed into them, causing a panic and stampede. At the Zaventem Airport in Brussels, similar behaviors occurred. Unfortunately, some people fled directly into the blast radius of a second IED.<sup>32</sup> In circumstances where there is not imported stimuli and groups from the Primary Zone, individuals can still choose to flee during this transitional period, and many do once the initial shock wears off.

An important minority behavior during this phase is freezing. People may continue to freeze because the environment provides them limited and difficult choices, but they may also still be in shock. Passengers inside the train cars surrounding the Primary Zone of the Maelbeek Metro bombing were stuck inside the car. The explosion caused the power to go out and left them unable to open the doors. Many of the passengers waited inside, crying, until the Evacuation Phase.<sup>33</sup> Behavior like this also occurred on the train and subway cars in Madrid and London.

As time passes, more individuals choose to help, either in their original zone, or moving forward closer to the blast site. In Madrid, an off-duty law enforcement officer began to initiate a normal evacuation of a train car where there were few or no injured. In Boston, law enforcement officers who had been approaching the first explosion found themselves moving away after the second IED functioned. This additional input seemed to delay their helping response as they reassessed the situation and had to decide whether to continue to the first blast site or change course and run to the second blast site.

Other minority behaviors include hiding and gawking. Nine seconds after the first IED functioned at Zaventem Airport, a second IED functioned in the Secondary Zone. Some people dove immediately behind newspaper kiosks to hide. One mother grabbed her child and hid below a check-in counter. People remained in hiding until security officials told them it was safe to leave.<sup>34</sup> The prevalence of hiding behaviors following the Brussels airport bombings was likely due to the infrastructural damage caused by the explosions and fear that a third explosion may be coming. In Boston, photographers and videographers who were already on-site capturing images of the marathon began or continued to take pictures and record the aftermath of the explosion.

### MICRO-PHASE 3: Deliberative Acts

Most have already fled, but those who transition from a frozen state may now choose to flee away from the chaos. Of the few who are left, many help. They help by providing calm, evacuation assistance, first aid, and leadership. Very few remain frozen, but those who do receive help from the remaining survivors before the first responders arrive.

Although it appears that fleeing is still the majority behavior, it may not be the most important behavior on which to focus. During Micro-Phase 3, the Secondary Zone has fewer people compared to when the IED functioned. Those who will flee have already done so or will do so in this phase as they shift from an initial state of shock to one where they can deliberately choose what to do. In Manchester, as people unfroze, they fled to the exits.<sup>35</sup> One couple at Zaventem Airport was looking at magazines when the explosions occurred. They remained where they were until they saw people running towards them, then joined the crowd and ran towards the exit.<sup>36</sup> In Madrid, most had already fled from the platforms and others engaged in a similar behavior, evacuation, as they exited the trains and moved away. On the Circle Line near Edgware Station, the driver assisted in evacuating the first car.<sup>37</sup>

By the end of this phase there are fewer people in this zone, and many who remain are engaged in an important behavioral response – helping, which manifests in multiple ways. Some help the injured. In the chaos, a couple at Centennial Olympic Park noticed a man with a stomach wound near them. Together, they carried him to a park bench and used this as a stretcher to bring him towards medical assistance.<sup>38</sup> Some fill the leadership void. In one car in London where the commuters could not evacuate immediately, they nominated a spokesperson to provide guidance and leadership.<sup>39</sup> Some help to evacuate or help others reach the wounded. In Boston, on-site first responders and the public removed the barricades and fencing, opening up access to the Primary Zone. Many on-site first responders and others with medical training immediately entered the Primary Zone to assist the injured.



## SECONDARY ZONE

Finally, freezing, a majority behavior immediately after the first IED functioned, still occurred, although less frequently. On subway cars with no way to exit, there were reports that people sat motionless in their seats, despite being physically uninjured.<sup>40 41</sup>

### EVACUATION PHASE: New Baseline Behaviors

Off-site first responders arrive including law enforcement, firefighters, and paramedics. Evacuation occurs from areas deemed unsafe or unstable. Where possible, the location is used for triaging the injured. Ambulances transport the severely wounded to hospitals. First aid, water, and oxygen are distributed as needed. As the crime scene is processed, law enforcement evacuate the zone and extend the secure perimeter as needed.

During the Evacuation Phase in the Secondary Zone, most people who were there when the IED functioned and were not injured are now gone or are evacuating with the assistance of first responders. Some people who had been frozen during the first three phases had delayed fleeing reactions. The timing of this phase depends on how quickly law enforcement, firefighters, security personnel, and medics could reach the sites. For example, those in the train cars surrounding the Primary Zone of the Maelbeek Metro bombing could only start evacuating when someone brought a ladder to the side of the car. Most exited calmly and helped those near them get out of the train car onto the tracks.<sup>42</sup> Similar evacuation behaviors were observed in the London Underground. Many of the people at Zaventem Airport who had gone to the ground or hid after the explosions started to get up and evacuate. Several people waited until they heard a security official tell them it was okay to leave.<sup>43</sup>

Although in some Secondary Zones there remained people who were injured there, the locations often became triage and staging areas where the severely wounded were evaluated before being evacuated to a hospital. People with specialized skills, such as medical doctors, might still be assisting the wounded although in some cases the non-severely wounded were still being helped by family, friends, and strangers. Law enforcement officers also began to fill these zones as the response shifted from an emergency rescue to a crime scene where forensic evidence needed to be secured and collected. Law enforcement and others also removed any remaining gawkers, hiders, wanderers, or people frozen in place.

Interestingly, in the case of the Manchester Arena, individuals who previously remained calm while evacuating from the Tertiary and Evacuation Zones started to engage in fleeing behaviors that resulted in crowd panic and stampede-like group behaviors.<sup>44</sup> This delayed reaction to the IED functioning appears to have been caused by rumors circulating through the crowd and allowing people from outer concentric zones to evacuate past the Secondary and Primary Concentric Zones to reach a mass transit station. This is the only example in the case studies where human behaviors escalated once the Evacuation Phase began.



## TERTIARY ZONE

### INITIALIZATION PHASE: Baseline Behaviors

People in the Tertiary Zone have limited information about the IED event. They may have heard a loud noise or saw smoke rising from the blast site but might not know these were caused by an IED, or even that an explosion occurred. Typically, they cannot see the dead or injured. They are reacting to the behaviors of those in the Secondary Zone or other indirect information. As more stimuli and information reaches those in the Tertiary Zone – crowd panics, multiple explosions, screams of fear and pain – the more their behaviors will shift from delayed reactions to more typical reactions such as fleeing and freezing.

Depending on where the IED functioned, the Tertiary Zone can encompass multiple types of environments. For example, the Tertiary Zone for the Madrid and Brussels trains and the London Underground bombings was limited to other cars on the same or nearby trains or, if close enough, transit stations. The baseline human behaviors in these areas were like those seen in the Secondary Zones – commuters and others traveling calmly throughout the cities. In Boston, however, the Tertiary Zone consisted of distinct areas and people engaged in distinct tasks; spectators in the grandstands watching the marathon; runners a block or more away from the first IED; volunteers, law enforcement, and medical staff supporting runners as they completed the marathon; spectators on sidewalks, in the streets, and in nearby restaurants and businesses. Other examples of baseline behaviors in Tertiary Zones include civilians in the outskirts of Centennial Olympic Park; people traversing nearby sidewalks, streets and parks around Tavistock Square; concertgoers in the main arena at Manchester Arena and the transit center connected by the foyer area where the IED functioned; and airline passengers beyond security.

### MICRO-PHASE 1: Impulsive Reactions

Information that an IED functioned is extremely limited. Some hear a noise, others see a flash, an involuntary reflex or shudder, screams drift in from the distance. Most people do not know what has happened, only that something has happened. The vast majority freeze or have a delayed reaction, both behaviors driven by the lack of knowledge. Those who have more insight, or need less information to decide, flee. During attacks where multiple IEDs function, these additional stimuli result in less indecision and more action.

A combination of freezing and delayed reactions were predominant responses, combined because of the difficulty to ascertain whether an individual is frozen and unable to choose a behavior, or they have not yet received enough information to know that there is a threat to which they need to respond. In Boston, even with better than normal views of the Primary Zone, those in the grandstands across the street from the explosion stood and watched.<sup>45</sup> They flinched and ducked when the IED functioned, but this appeared more as an instinctive reflex. Very few people showed any signs of movement, and those who did moved slowly or turned to gather up their belongings. On the London Underground many had delayed reactions. The trains were stopped by the explosions, an act that knocked some people over, but people did not know why. In some cases, they may have heard a loud bang, or even saw some smoke, but for the most part no one knew an explosion had occurred.<sup>46</sup> In Atlanta, some individuals in the Tertiary Zone heard the blast but assumed the sound was from fireworks or was just part of the show.<sup>47</sup>

Fleeing was also a prominent behavior. Inside Maelbeek Station, away from the platform, commuters heard the IED explode and the majority of them instantly began to run.<sup>48</sup> Some at Maelbeek Station may have been more likely to interpret the sound as a bomb following news of the terrorist attack at the airport just one hour prior. Similarly, outside of the trains in Madrid, where people could see multiple explosions from the platform and people fleeing from the Secondary Zone, those in the Tertiary Zone also fled.<sup>49</sup> Visibility of the bus explosion in London elicited similar responses.<sup>50</sup>



## TERTIARY ZONE

### MICRO-PHASE 2: Behavioral Transitions

As people flee from the blast site and immediately outside of it, they reach those with limited information about the explosion. Their movement in the Primary and Secondary Zones results in most people no longer freezing, nor delaying their reaction, but fleeing for safety. Sometimes this panic results in a stampede and crush injuries. Onsite first responders and individuals with specialized training travel to the blast site. In secluded locations, where people still have limited information about the explosion and little to no contact with those closer to the blast, freezing behavior is still common.

As more information became available to those in the Tertiary Zone, fleeing became the majority behavior. Fans at the Ariana Grande concert stood inside the arena for about ten seconds before they began to panic and run for the exits. The rush for the exits caused a mini stampede, with some fans jumping over the staircase railings, on top of people to get out faster.<sup>51</sup> In Boston, the second IED functioning created an impetus to flee for the majority of people standing in the grandstands.<sup>52</sup> This new stimulus created clarity around the extreme, ongoing risk. Runners on the course near the second explosion shifted to the far side of the street at a trajectory and pace much more dramatic than the runners near the first explosion. On the subway and commuter trains, as it became obvious something horrible had happened, those who felt they could safely leave exited the trains and began to flee.<sup>53</sup>

Freezing was an important minority behavior. Although many fled when others pushed into their zone, some were unable to decide what to do as they received more information about the explosion. In Boston, before the second IED functioned, most people were still frozen or began to transition to gawking behavior. At least one person made a conscious decision not to evacuate, stating that after the second explosion her boyfriend, who had military training, advised that there could be additional explosions and it was best to stay where they were.<sup>54</sup>

### MICRO-PHASE 3: Deliberative Acts

The dominant behavior is still fleeing, both for those in this zone and those moving away from the blast site. In many environments, the Tertiary Zone is a transitory zone during this phase in other respects as people also head toward the explosion to help. Very few people are still frozen or wandering; those who are will most likely need assistance from others.

Fleeing continued to be the majority behavior as time passed in the Tertiary Zone. In Boston, people fled through the side streets and into buildings, away from the explosions.<sup>55</sup> These behaviors were similar in other areas in Atlanta, Brussels, London, Madrid, and Manchester. Other non-majority behaviors included freezing, like in Manchester Arena where some remained frozen in place, unsure of how to respond, and, helping.<sup>56</sup> For example, in London, passengers on a train that was trapped next to the bombed one passed water to the injured through the windows.<sup>57</sup> Triage areas were set up around Tavistock Square to bring the injured away from the explosion and to a safer location.<sup>58</sup> In Boston, law enforcement in the Tertiary Zone had already left and were approaching both blast sites.<sup>59</sup> Delayed reactions and wandering were also minority behaviors. One concertgoer in Atlanta only recognized that an attack had occurred when he noticed the National Guard running towards the Primary Zone and saw people lying on the ground.<sup>60</sup> In Madrid, some aimlessly traversed the train platforms seeking help.<sup>61</sup>



## TERTIARY ZONE

### EVACUATION PHASE: New Baseline Behaviors

Almost all people have fled or are evacuating with first responders. Some stay to gawk, curious or uncertain where to go. Others take pictures and record the aftermath of the explosion and the chaos that ensued. Depending on the physical environment, triage areas may be set up, further pushing out any necessary perimeters to ensure the ability to provide care for the wounded, safety for first responders, and security of the crime scene evidence.

In the Evacuation Phase, most people have left the Tertiary Zone or began to evacuate when ordered. The people inside Manchester Arena who had remained near their seats or standing near the stage were approached at this point by event staff or law enforcement and asked to evacuate. On the London Underground trains, many waited for first responders to appear before leaving the trains and evacuating calmly, partially because they feared that they would be electrocuted.<sup>62</sup> Those who were left were typically helping or gawking. At the edges of Centennial Olympic Park, bystanders clustered in small groups watching as paramedics rushed towards the Primary Zone to care for the wounded.<sup>63</sup> And, like areas in the Secondary Zone, locations in the Tertiary Zone were utilized by first responder as staging areas and triage zones where oxygen, water, and first aid could be provided to the injured.<sup>64</sup>



## EVACUATED ZONE

### INITIALIZATION PHASE: Baseline Behaviors

The Evacuated Zone is any area outside the Tertiary Zone where people flee and feel safe from the risk presented by the initial explosion. Depending on the magnitude of the explosion and the physical environment, those in the Evacuated Zone may not even be aware that an attack has occurred. For these case studies, the Evacuated Zones consisted of urban areas around transportation centers, concert venues, and the streets. Specifically, for Brussels, it was the area outside of the airport and the street above Maelbeek station. In London and Madrid, the Evacuated Zone was a mixture of train and subway stations, city streets, and nearby neighborhoods. People evacuated out of the arena into the parking lots and surrounding streets in Manchester. Finally, in Atlanta and Boston, surrounding streets, restaurants, bars, and other businesses made up the Evacuated Zone.

### MICRO-PHASES 1-3: Impulsive Reactions, Behavioral Transitions, Deliberative Acts

The majority of people continue their baseline behaviors for the first several minutes after the IED functions. They are too far away and have too little information to immediately understand what is happening. Smoke, multiple explosions, or people fleeing from the blast site shift behaviors in sporadic pockets of people across the Evacuation Zone. Some will stay in place or go toward the explosion, to help or to gawk. Some will join the fleeing crowds.

There is less variation in behaviors across the cases the farther from the explosion people are, both geographically and temporally. This often means there is not enough information, nor is it necessary, to separate behaviors across the distinct micro-phases. However, because of the time it took for information about the explosion, and people fleeing from closer to the blast, to reach the Evacuated Zone, most of the described behaviors most likely occurred during Micro-Phase 3.

Fleeing, helping, and gawking are the initial observed behaviors after the IED functions. Fleeing behaviors may be more common in cases where those in the Evacuated Zone have visual access to the explosion, and likely increase as people in the Evacuated Zone begin to see the reactions of people in other zones. For example, at Zaventem Airport, people waiting outside the Departures Terminal heard the blasts and ran. They were joined by others who fled from the

Primary and Secondary Zones, exiting through the terminal doors, and running towards the street.<sup>65</sup> Similarly, in Atlanta, people fled through the streets to get away from the explosion and into the Evacuated Zone. Even in stations far away from the explosions in the London Underground, people fled to the streets above with those who escaped through the tunnels.<sup>66</sup>

Helping behaviors were also common both from those leaving the zone to go towards the blast site to help and those inside the zone helping people who fled the blast. In Brussels, on the street level outside of the subway station, people could feel tremors and see smoke come out of the station.<sup>67</sup> Some responded by leaving the Evacuated Zone and heading towards the station to help, while others remained on the street and provided assistance as the wounded exited the station.<sup>68</sup> In London, people who were not severely injured made it to some of the Evacuated Zones and were helped by bystanders and Underground staff as first responders had not yet arrived.<sup>69</sup> Those in buildings around Tavistock Square, where the IED functioned on a bus, came out to assist the injured where they could.<sup>70</sup> Some brought the wounded and injured off the street and into their buildings. In Madrid, people from the Evacuated Zone—the neighborhoods adjacent to the stations—went to help.<sup>71</sup> Some threw down blankets from their windows to be used to help the victims.<sup>72</sup> When victims dazed from the attacks wandered into the neighborhood, the community and local law enforcement took them to safety.<sup>73</sup>

Finally, to a limited degree, some in the Evacuated Zone were able to gawk, both at the aftermath of the explosion and the behaviors of those fleeing. For example, in Boston, there is CCTV footage of crowds of people far down Boylston Street watching the smoke rise two blocks away.<sup>74</sup> There are also eyewitness accounts from hotel rooms above the street where people watched the chaos unfold below.<sup>75</sup> Similarly, people at bars and hotels near Centennial Olympic Park described feeling the tremor from the blast and then watching as people fled the park.<sup>76</sup>



## EVACUATED ZONE

### EVACUATION PHASE: New Baseline Behaviors

The inner concentric zones empty as pedestrians evacuate outward from the blast site. Most are calm and head home. Some need help. First responders flow inward to provide medical care and secure the crime scene. Services may be staged for witnesses, survivors, family members and friends of victims, and those displaced by the explosion. Normal life continues, albeit with a heightened sense of awareness.

During the Evacuation Phase in the Evacuated Zone, people engaged in most behaviors – fleeing, wandering, gawking, helping; however, evacuating was the most common. At the airport in Brussels, the Evacuated Zone was used for staging to get people way from the airport and to a crisis center using buses. Those who did not want to wait for a bus walked away

on their own.<sup>77</sup> In Manchester, people leaving the arena rushed into the streets and to their cars while law enforcement closed off the area so no one could return.<sup>78</sup> However, hundreds still stayed in the area waiting to be reunited with family and friends.<sup>79</sup> In Atlanta, some people stayed, wandering through the Evacuated Zone and returning close to the park to gawk. Others evacuated to their homes and hotels. Injured and uninjured survivors continued to trickle out of the tunnels in London and into the stations and the streets above, looking for help. When they finally showed up, first responders provided water, oxygen, and first aid.<sup>80</sup> In Madrid, makeshift field hospitals and triage areas supported the injured.<sup>81</sup> Family members and friends arrived, looking for their loved ones. Finally, in Boston, people evacuated through the streets, into nearby businesses, and finally back to their hotels and homes.<sup>82</sup>

## Conclusion

This section presented a detailed narrative about human behaviors after an explosion. The narrative is based on real-world data collected and analyzed using a multi-case study research methodology. The behavioral patterns identified demonstrate that human behavioral responses to targeted IED attacks can be discovered in large amounts of textual and videographic data. Importantly, the behaviors of the majority of people, as well as the behaviors of the relative few, provide a deeper understanding of what occurs in the first few minutes after an explosion at a soft target and crowded place. This knowledge can be leveraged by first responders, trainers, security experts, and policymakers to mitigate the harm of an IED attack if one occurs.

# 6 Conclusion

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## How do humans behave after an explosion at a soft target and crowded place?

This research begins to answer that question through an analysis of open-source documents and videos that record the observations of victims, eyewitnesses, and first responders. The results demonstrate that within the first few minutes after an IED functions, there are universal patterns of behaviors that are consistent across time and place. People will engage in a limited number of behaviors – they freeze, flee, help, hide, gawk, and wander. Sometimes they will calmly evacuate. It is not uncommon for their responses to be delayed if they have limited information about the explosion. Importantly, which behaviors occur and are dominant appear to be affected by other factors such as a person's location, how much time has passed since the explosion, crowd dynamics, and even characteristics of the environment.

The research has produced insights into human behaviors after an IED functions. Some of these insights provide descriptive information about behaviors, creating a narrative of what occurs after an explosion through the triangulation of anecdotal, video, and forensic evidence. These narratives can be used to prepare security managers and first responders for IED-related events and to assist in planning for the probable individual and crowd behaviors that will occur. Other insights can be used to inform soft target security protocols and policies. For example, knowing that some civilians will begin to help victims within minutes, if not seconds, of an explosion, organizations in charge of security at soft targets might consider the on-site storage of first aid supplies that are readily accessible and visible to the public in emergency situations.

Building on this knowledge, future research should explore additional bombing events at soft targets, especially those where offenders employ firearms and other weapons in addition to explosives. Events outside of the United States and Western Europe should also be analyzed. Although the core behaviors most likely will remain the same, how they are distributed across time and space, as well as which rare and minority behaviors become important insights for first responders and emergency planners, remains to be seen. More research that incorporates other types of soft targets and crowded places is necessary, as differences in environments, crowd behaviors, and event characteristics may also play a role in how people react. Educational campuses, houses of worship, transportation hubs, and commercial centers are all examples of soft targets and crowded places that could be targeted for IED-related attacks and, consequently, where human behaviors should be researched and understood.

Immediately after an IED functions at a soft target and crowded place the people near the explosion begin a complicated chain reaction of behaviors. Some behaviors appear to be universal and will be employed by most people. Other behaviors are unique. This research creates a general knowledge base about who engages in these behaviors and when, where, why, and how they occur. The groundwork can be used to guide future inquiries into the subject. Securing soft targets and crowded places is a priority for homeland security. This research, which provides insights and understanding into human behaviors after an explosion can be utilized by security experts, policymakers, and others to focus on that priority and to maintain public spaces for safe use by all.

## Appendix A

# Methodology & Case Study Architecture

## Individual & Multi-Case Study Methodology

### | Methodological Overview

Each of the six case studies provide detailed information about human behaviors immediately following a bombing event at a soft target and crowded place. The architecture of each case study also includes contextual information about each bombing event so that readers can understand how human behaviors fit within the larger context of a high-profile terrorist event. Finally, the multi-case study research design takes the data collected across all cases and analyzes it for common patterns and themes. These results provide knowledge about the full spectrum of human behaviors immediately following a bombing event. First responders and security experts can then utilize this knowledge to develop plans and training to mitigate further loss of life in the unfortunate event of an IED functioning at a soft target and crowded place.

Each case study collected information from a wide-range of open-source materials, such as journalistic accounts, government documents, video recordings, and social media on the selected bombing events. The materials were then used to write a brief on each event that (1) developed a narrative for each case study about how humans behaved immediately after a bombing event and (2) provided context about each bombing event. These individual case studies were then analyzed together to identify patterns and themes about human behavioral responses immediately after an IED functions.

The multi-case study approach allows researchers to treat all cases as representative of a single phenomenon, which is important when examining rare events with inconsistent amounts and types of data. Although news articles, government documents, and scholarly research exist for most of the bombing events selected, the depth and diversity of this coverage varies. Under this methodological approach, researchers had the ability to not only compare across cases, but also pull case information and analyze data as one overarching topic; together, these analyses provide the amount of detail necessary to explain a complex, poorly understood, and relatively rare phenomenon.

### | Case Selection

The cases selected for this research included high-profile ideologically motivated terrorist events with one or more IEDs that functioned. Like other research<sup>83</sup> that examines

human behaviors after targeted attacks, we focused on Western countries, specifically European countries and the United States. The bombings selected occurred at soft targets and crowded places between 1996 and 2017, included deaths and injuries, and were covered in-depth by the mass media. Multimodal attacks that included additional weapon types were excluded.

The six case studies selected include:

- **Centennial Olympic Park Bombing**  
Atlanta, USA | July 27, 1996.
- **11M Commuter Train Bombings**  
Madrid, Spain | March 11, 2004.
- **7/7 London Underground and Bus Bombings**  
London, England | July 7, 2005.
- **Boston Marathon Bombings**  
Boston, USA | April 15, 2013.
- **Brussels Airport and Subway Bombings**  
Brussels, Belgium | March 22, 2016.
- **Manchester Arena Bombing**  
Manchester, England | May 22, 2017.

### | Data Collection

For each case study selected, there was a systematic data collection process to identify information about the bombing events. First, the U.S. Major Dailies database by ProQuest was searched using keywords that included the word “bombing” and the city where the attacks occurred.<sup>84</sup> The newspapers included in this database were *The Chicago Tribune*, *The Los Angeles Times*, *The New York Times*, *The Wall Street Journal*, and *The Washington Post*, as well as some smaller, regional newspapers. Articles were selected and downloaded as a text file if they were published within two days of the bombing.

Researchers conducted additional searches for bombings that occurred in non-US countries, using similar keywords to search coverage from major national newspapers. Searches were adapted for non-English speaking countries to include keywords in other languages. In cases where information was published in a language other than English, researchers translated the websites and documents, using Google Translate when necessary.<sup>85</sup> Google was also used to search for court

documents, after-action reports, government commission reports, police reports, academic journal articles, and other documents focused on detailing the bombings and their aftermath. These documents were also downloaded and stored for further analysis. Videos of each event were searched and downloaded using the same keywords through traditional search engines and search engines that focus specifically on video content. When necessary, targeted searches were also completed to inform factual questions about the IED, perpetrator, casualties, and emergency response.

## Data Analysis & Presentation of Results

The collected documents were reviewed to identify information about the bombing events, generally, and human behaviors, specifically. Textual evidence about the events was thoroughly read and segments of text about human behaviors were entered into a spreadsheet. Text segments varied in detail – some provided detailed information from a known person who directly witnessed the IED functioning and how people behaved afterward, and some were vaguer, offering high-level summaries of human behaviors without context. Figure X provides examples of the text segments used for analysis. Similarly, information from videos, whether witness or victim statements, or video of actual human reactions to the explosions, were recorded. These data points were compiled to create a dataset for each case that included information about human behaviors prior to, during, or after the bombing event on the day of the targeted attack.

Examples of these text segments include:

“People inside the carriage started panicking, including myself. I was thinking that the smoke was fire smoke and so at one point dropped on to all fours to try to breathe better. The carriage remained completely black, and I remember a man, I think the grey-haired man who had been sitting next to me earlier, had a small key-ring-type torch which he used. People were trying to break windows and open doors to get out of the carriage. I could also hear moaning and the sounds of people in pain and distress coming from the rear of the carriage.”<sup>86</sup>

“We all fell to the ground and smoke came out. I managed to get out of the train. I looked to my right, and to my surprise I saw a blown-up train car.”<sup>87</sup>

“Everyone just stopped and turned around. The whole area just froze. We passed two volunteers who were two blocks from it and they told all the volunteers to just start running.”<sup>88</sup>

“One witness...said some passengers emerging from an evacuated subway station had soot and blood on their faces. He told BBC TV that he was evacuated along with others near the major King’s Cross station and only afterward heard a blast.”<sup>89</sup>

“It was chaos. It was confusion, screaming, yelling, smoke. And I remember that my ears -- it was difficult – it was weird hearing and trying to figure out what happened, just remembering that I had been smiling, and laying on the ground wondering if I was dreaming, did I really get to the marathon. And it only took a few minutes because I could hear people screaming for people to get down -- you know, nobody really knew at that point what really had happened -- and then there was another explosion and then there was more chaos, even worse than the first time, and more screaming and yelling. And by that time I had tried to sit up and looked at my foot and my leg and realized something terrible had happened to us.”<sup>90</sup>

“According to his testimony, many residents of this neighborhood went to the train with blankets and water. Access was made difficult by a cement wall of approximately one and a half meters, built to prevent access to the tracks, but this precisely became a serious obstacle, first for the residents and later for the rescue teams.”<sup>91</sup>

Text segments and data points from other sources, such as videos, detailing human behaviors were then coded to capture, where available, the approximate microphase and concentric zone of the observation in relation to the explosion(s). If applicable, the behaviors were also grouped into categories such as freezing, helping, fleeing, or gawking. Other information was also included in the narrative, such as the actors who were engaging in the behaviors (e.g., civilians, staff, first responders), the environment where the behaviors were occurring (e.g., inside a train car, on a city street), and if they were part of a larger group (e.g., parents with children). The segments were then sorted to inform a narrative for each case study on what people were doing before, during and after the explosions – from the Initialization Phase to the Evacuation Phase. The temporal and geographic categorizations allowed researchers to organize the narrative to describe those behaviors as they changed over time and distance from the explosion.

The narratives from the individual case studies were then used to conduct the multi-case analysis, which compared and compiled information across each case. This analysis created a detailed narrative of human behaviors after an IED functions through the identification of patterns and themes that occurred within each phase and zone. These patterns were weighted based on frequency of behaviors and whether they appeared in multiple cases. Minority behaviors were also identified and discussed in each narrative as important components of understanding behavioral reactions to bombing events. In addition, researchers considered the distinct aspects of each case (e.g., the design of the physical environment, IED characteristics) to investigate which factors may have contributed to differences in responses seen across cases. Finally, the multi-case narrative was examined with the individual case studies to identify the insights described in Section 3 of the report.

## Case Study Components

As stated, data on six bombing events were collected to complete six individual case studies, which were then used to conduct a multi-case study analysis. This analysis compared human behavioral responses within a single bombing event and across multiple bombing events. For each case study, in addition to human behavioral responses, selected information was presented on the bombing event's background, perpetrator(s), improvised explosive device(s), and casualties. The most important information on each case is also presented as a summary section on the case study's first page.

### Context

Each case study provides context about the bombing events. The first of these sections includes context surrounding the bombing events. The contextual information falls into four categories: (1) Background; (2) Perpetrator(s); (3) Improvised Explosive Device(s); and (4) Casualties.

- **Background.** The background section of each case study provides an overview of the bombing event. This information can include, but is not limited to the location, date, and relevant political and/or social atmosphere surrounding the attacks. In addition, societal responses at both the local and national level may be detailed.
- **Perpetrator(s).** Information about the perpetrators, such as the number, relevant biographical data, and their motivations are discussed in this section.
- **Improvised Explosive Device(s).** With the details made publicly available, this section describes how the bombs were built and detonated. Also, a description of any logic as to the placement of the devices may be provided.
- **Casualties.** For this section, an overview of the number and types of casualties is presented for each event. Information may include the number and type of casualties, as well as how long it took to access, treat, and transport casualties after the functioning of an IED.

### Human Behavioral Responses

Understanding how humans behave after a bombing event is complex. To that end, human behaviors were organized across space, time, and types of individuals. There are up to four sections in each case study outlining behaviors based on their geographic and temporal locations in relation to where the explosion occurred. Specific to geographic distribution, information about behavioral responses is separated into four Geographic Concentric Zones. Each case study contains a section on each zone. **The four Geographic Concentric Zones include the Primary, Secondary, Tertiary and Evacuated Concentric Zones.** Geographic concentric zones are defined by the likelihood of injury from the

explosion and the amount of information reaching each space. These factors are strongly impacted by the physical design of the environment and the size of the IED; thus, the physical size of each zone varies across cases.

Data about each geographic concentric zone is further divided into temporal phases. Presenting information about human behaviors across time allows for a more nuanced understanding about the initial impact of an explosion on an individual and how people may shift behaviors over time. Phases also are impacted by other variables, such as the size of the explosion. The larger the explosion, the longer it may take for individuals to recover from the initial shock. Finally, the temporal distribution of phases should be treated as an estimate of the average time that individuals take within each phase. The real length of time for each phase will vary across persons based on individual and situational characteristics. **The five Temporal Phases include the Initialization Phase, Micro-Phase 1: Impulsive Reactions, Micro-Phase 2: Behavioral Transitions, Micro-Phase 3: Deliberative Acts, and the Evacuation Phase.**

In many cases there is no precise delineation between zones and phases, nor does the open-source documentation always provide enough evidence to accurately assign an individual to the zone or phase where they were located when engaging in the behavior recorded. Therefore, the zones and phases should be viewed as an organizing principle that provides a method for uncovering behavioral patterns of individuals and groups across time and place.

Each of the Zones and Phases are described in more detail in *Section 4. Background on Human Behaviors After an Explosion.*

Finally, where able, behaviors are also connected to groups of individuals (e.g., civilians, law enforcement, emergency medical technicians, security staff). Distinguishing group type is important as it may impact individuals' goals and behavioral responses: while a civilian's goal may be to reach safety for themselves or their families, the goals of a law enforcement officer may be to reach the site of the explosion, assist in administering aid, and/or assisting with the emergency evacuation.

This narrative,, built upon descriptive, testimonial, and video evidence, creates a body of knowledge that social science lacks – a fundamental understanding of how humans behave in the moments immediately after a high-profile terrorist bombing event. As discussed, this research adopted a methodology that segments these behaviors so that they can be observed and recorded across time and space, relative to the location and moment of the explosion.

Appendix B.

# Case Studies

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## Appendix B-1.

### Atlanta Centennial Olympic Park Bombing

DATE



July 27, 1996

CASUALTIES



2 dead



111 physically injured

NUMBER OF IEDS



1

SOFT TARGET TYPE(S)



Park



## Context

### Background

At approximately 1:20 a.m. on July 27, 1996, an IED functioned at Centennial Olympic Park in Atlanta at a concert during the Olympic Games. On the evening of July 26th, an estimated 50,000 people had gathered in the 21-acre park to watch a concert performed by Jack Mack and the Heart Attack.<sup>92</sup> Rudolph planted a knapsack containing a pipe bomb, leaning it against a bench next to the sound tower facing the stage at 12:18 a.m. Just before 1:00 a.m., authorities in the park identified a suspicious bag leaning against a sound tower near the concert stage and began evacuating civilians from the area. It functioned a few minutes later.<sup>93</sup> Local officials responded quickly and effectively to the blast. Federal, state, and local law enforcement provided medical aid, directed the evacuation, and secured the crime scene within minutes.<sup>94</sup> After the explosion, city officials immediately closed off around 20-square blocks surrounding the blast site to allow law enforcement to search for additional explosive devices.<sup>95</sup> The Atlanta Commission of Olympic Games (ACOG) shut down its headquarters and press center until the park had been secured.<sup>96</sup> City officials also temporarily shut down Atlanta's public transportation system, Metropolitan Atlanta Rapid Transit Authority (MARTA), and blocked off highway exits into the downtown area.<sup>97</sup> The Olympic Games continued as planned, with extra security at official venues.<sup>98</sup>

### Perpetrator

Rudolph selected the Olympics as a target to inflict economic and reputational harm against the U.S. for its abortion policies. Rudolph had originally planned to plant a succession of bombs across a five-day span, hoping this would force U.S. officials to cancel the games or cause enough fear to lead visitors to stop attending events. He abandoned his plan after seeing the degree of injuries caused to civilians.<sup>99</sup> Rudolph did not begin serious planning until six weeks before the Games began. Rudolph used the initial week of the Games to visit the event spaces and investigate security measures. Upon discovering the level of security at official venues, Rudolph zeroed in on Centennial Olympic Park as an initial target.<sup>100</sup> Rudolph evaded police for six years before police apprehended him on May 31, 2003. In that time, Rudolph placed three more bombs – two more in Georgia, and one in Birmingham, Alabama. In 1998, the Federal Bureau of Investigation (FBI) named Rudolph one of the Ten Most Wanted Fugitives.<sup>101</sup> The FBI's investigations indicate that Rudolph was affiliated with the Army of God and Christian Identity movements, both of which are extremist, white supremacy groups.<sup>102</sup> Rudolph entered into a plea agreement with the federal government rather than stand trial. In his statement, Rudolph professed his attacks were motivated by his anti-abortion beliefs. While Rudolph claimed that he was not "an anarchist" or against the government, the full text of his statement also reveals significant anti-government, anti-authority, and homophobic beliefs.<sup>103</sup>

### Improvised Explosive Device

At 12:18 a.m., Rudolph planted a military-style knapsack containing a pipe bomb against a bench next to the sound tower of the stage.<sup>104</sup> The device was a home-made, low-tech, improvised explosive device composed of three galvanized pipes filled with low-explosive powder, nuts, bolts, nails, and screws.<sup>105</sup> Rudolph used an Army backpack known as an ALICE pack (i.e., All-Purpose Lightweight Individual Carrying Equipment) to conceal the device.<sup>106</sup> Analysts suspect that Rudolph designed the pipe bomb to send shrapnel horizontally, toward the stage.<sup>107</sup> It was set to have a 55-minute delay. Rudolph planted the bomb and walked ten minutes away before making his first call to 911. Fearing that the operator did not understand his voice through his voice distortion device, Rudolph walked further and placed a second call to 911 from a phone booth at a Days Inn.<sup>108</sup>

### Casualties

Two people died and 111 were injured because of the explosion.<sup>109</sup> Alice Stubbs Hawthorne died of "multiple penetrating injuries", a direct fatality of the bombing. The second death was Melih Uzunyel, a Turkish journalist, who died of a heart attack brought on by the explosion.<sup>110</sup> Within 30 minutes of the explosion, paramedics brought 96 of the 111 victims to four hospitals within three miles of the bombing. All of the wounds suffered by victims were shrapnel-related, either from the pipe bomb itself or from the nails and screws in the adjacent containers in the bag. Most injuries were relatively minor and treated on the spot; 24 victims were admitted for additional care, including 14 who required surgery.<sup>111</sup>

## Behavioral Responses



### PRIMARY ZONE

#### INITIALIZATION PHASE

Evacuation efforts by on-site security began around 1:17 a.m., three minutes before the IED functioned.<sup>112</sup> Some witnesses estimate that they had cleared about 75 to 100 people from the immediate vicinity before the explosion occurred.<sup>113</sup> However, many in the Primary Zone remained unaware of these efforts and continued listening to the concert. Some people close to the bomb were told to evacuate but refused to leave, a decision potentially influenced by the fact that many had been drinking. The IED was placed near a sound tower that stood about 150 feet from the stage and was surrounded by grass. The stage itself was very large; behind it stood tall tents that essentially formed a barrier between the stage and the area behind it. The IED sent shrapnel flying for a 100-yard radius, which constituted the Primary Zone.

#### MICRO-PHASE 1: Impulsive Reactions

In the immediate aftermath, witnesses describe a brief window of time in which everybody froze, regardless of whether they were with a group or alone, injured, or not injured. Witnesses describe this as “one long second”, during which everyone stood still.<sup>114</sup> Due to the size of the bomb, many individuals within the Primary Zone were injured by the blast: 111 people received injuries from the shrapnel; ten of whom were police officers or other security officials who were there to evacuate the area.<sup>115</sup> Non-wounded agents stood in place, trying to register what had just happened; many of the wounded attendees reported the same experience, not even registering that they had sustained an injury until several moments later. Those with serious injuries fell to the ground. While some individuals began running, the dominant behavior during this phase was freezing.

#### MICRO-PHASE 2: Behavioral Transitions

As individuals began to process what had happened, many shifted to new behaviors. Most civilians in the Primary Zone began to run, including those with injuries. While some people began to run instinctively, many reported running away from the site of the blast because they had seen others around them running. Many of those who had been separated from their family and friends tried to reunite with their group. During this phase, shock began to wear off and those who had been wounded became aware of their injuries. Many of those who obtained surface-level injuries proceeded to evacuate. Those with more serious injuries remained on the ground. As people became more aware of what was happening around them, non-wounded civilians noticed the injuries others had sustained. The two most common behaviors were freezing and running.

#### MICRO-PHASE 3: Deliberative Acts

When Microphase 3 began, most non-wounded civilians in the Primary Zone continued to run; however, some of those who were near injured civilians began to help those around them. This included people helping their family and friends and some helping strangers near them as they waited for more law enforcement and first responders to arrive.<sup>116</sup> Witnesses described the area as chaotic, as some people ran, others remained on the ground, and many cried and screamed.<sup>117</sup> Law enforcement officers who had been at the site to evacuate civilians before the bomb went off resumed evacuation efforts. These officers remained relatively calm as they tried to clear the area.<sup>118</sup>

A few minutes after the explosion had occurred, law enforcement officers who were on site but not near the blast site reached the Primary Zone to help evacuate remaining civilians and assist the injured. In this phase, most people exhibited one of three behaviors: running, freezing, and helping.

#### EVACUATION PHASE

During the evacuation phase, a handful of medical professionals and first responders who were at the park to attend the concert moved from the Secondary and Tertiary Zones into the Primary Zone to help the wounded in the Primary Zone. Witness accounts describe doctors, Emergency Medical Technicians (EMTs), and veterans among those who went towards the blast site to assist. Overall, however, the majority of “helpers” were not trained professionals, but ordinary civilians who stepped in to assist those around them.<sup>119</sup> Those who could evacuate did so. However, many injured individuals stayed on the ground awaiting medical assistance. Others stayed with family members, friends, and strangers near them who had been wounded by the blast. Because the park was an open, outdoor space, there was no single avenue for evacuation, or a clear evacuation zone to go to; rather, individuals and groups fled and evacuated in all different directions. While some remained frozen, most people in the Primary Zone ran or helped during the evacuation phase.



## SECONDARY ZONE

### INITIALIZATION PHASE

The Secondary Zone began approximately 100 yards away from the blast, inside the park. Individuals in the Secondary Zone reported seeing a cloud of smoke and hearing a loud, concussive bang when the explosion occurred. Most individuals in this zone were not wounded; however, some were hit by errant pieces of shrapnel.

### MICRO-PHASE 1: Impulsive Reactions

There was nothing separating those in the Secondary Zone from the Primary Zone. People in the Secondary Zone could therefore see the blast and hear the bang that occurred when the IED functioned. Analysis of video footage available from the bombing suggests that it took several seconds before there was widespread recognition among those in the Secondary Zone of what had happened.<sup>120</sup>

Most civilians looked around to see how others were reacting. Some people continued to dance during this time, unaware that the sound they had heard was a cause for concern.<sup>121</sup> In addition to the sound of the bang and smoke in the air, some witnesses shared that it was the smell of sulfur that made them realize the bang was likely from a bomb, and not fireworks.<sup>122</sup>

### MICRO-PHASES 2 AND 3: Behavioral Transitions and Deliberative Acts

After about ten seconds, individuals in the Secondary Zone began to scream and run as they saw those in the Primary Zone begin to evacuate.<sup>123</sup> Due to the openness of the park, there was no clear route that civilians took to evacuate; groups and individuals appeared to look for any openings in the crowd and leave through that direction. Many people in this zone took defensive positions as they moved through the park: some crouched down as they walked; others tried to shield their heads.<sup>124</sup>

One minute after the blast occurred, most had left the Secondary Zone. Still, many pockets of people remained there, wandering until law enforcement asked them to leave. Several non-injured civilians began to help the injured around them. At this stage, the most common behaviors were freezing, fleeing, evacuating, and helping.

### EVACUATION PHASE

Like those in the Primary Zone, some of the wounded civilians in the Secondary Zone described being in shock for the first several minutes of the evacuation, realizing only later that they had been injured.<sup>125</sup> Those who were able proceeded to evacuate with non-injured civilians; however, there were many in the Secondary Zone who received shrapnel wounds that left them unable to run with the others. Most of these individuals lay on the ground, waiting for medical assistance.<sup>126</sup>

Reports suggest that there were no law enforcement officials within the Secondary Zone when the blast occurred. Those who were in the Primary Zone at the time the IED functioned remained there to help facilitate evacuation efforts; other on-site security officers went straight to the blast site initially. Law enforcement then worked their way from the Primary Zone into the Secondary Zone, asking civilians to evacuate. As they awaited professional medical assistance, many civilians started to help the injured around them who needed assistance.

Most people in the Secondary Zone evacuated or helped during the Evacuation Phase.



## TERTIARY ZONE

### INITIALIZATION PHASE

The Tertiary Zone included the edges of the park and streets surrounding it.

### MICRO-PHASES 1, 2, AND 3:

Impulsive Reactions, Behavioral Transitions, and Deliberative Acts

Most people in the Tertiary Zone did not see the explosion but heard the same concussive bang.<sup>127</sup> Many witnesses in the Tertiary Zone reported thinking that the bang was just fireworks, or part of the show, until seeing those in the Primary and Secondary Zones running away from the blast site. Individuals in the Tertiary Zone also witnessed some of the injuries in the Secondary Zone.<sup>128</sup>

People in the Tertiary Zone responded more to the actions of others than to the bomb itself. The reaction of people in the Secondary Zone signaled to them that something bad had happened. This perception was reinforced by the influx of police, followed by the sound of sirens as firetrucks and ambulances arrived on the scene.<sup>129</sup> Many fled the park, understanding that something bad had happened; others, however, remained to gawk. Some even moved from the Tertiary Zone into the Primary Zone to see what had happened.<sup>130</sup> As individuals in the Tertiary Zone moved from an affective response to deliberative decision-making, the primary behaviors were fleeing, freezing, and gawking.

Some towards the edges of the park had a delayed reaction to the explosion: they heard the blast but had attributed it to something else. This only changed when they saw people fleeing from the Secondary Zone into the Tertiary Zone around them or the beginning of response operations. One concertgoer in Atlanta only recognized that an attack had occurred when he noticed the National Guard running towards the Primary Zone and saw people laying on the ground.

People in the Tertiary Zone were closest to the surrounding streets. As they began to flee the park, law enforcement removed the barricades separating the lawn from the street to facilitate evacuation.<sup>131</sup>

### EVACUATION PHASE

Individuals in the Tertiary Zone describe seeing people in the Primary and Secondary Zones running out of the park and through the Tertiary Zone.<sup>132</sup> At the same time, an influx of law enforcement and first responders came running through the Tertiary Zone to help clear the area and attend to the injured.<sup>133</sup>

Some remained in the Tertiary Zone as the Evacuation Phase was underway, wandering around the edges of the park. Others remained to gawk, looking to see what was happening around them.

## EVACUATED ZONE



### INITIALIZATION PHASE

The Evacuated Zone consisted of the neighborhood around Centennial Olympic Park, which included bars and restaurants, hotels, and adjoining streets. In the minutes before the explosion, people in the Evacuated Zone drank and ate with friends, loitered around the streets, and made their way home from the Olympic festivities.

### MICRO-PHASES 1, 2, AND 3:

Impulsive Reactions, Behavioral Transitions, and Deliberative Acts

People in neighboring buildings and the streets around the park felt the reverberations of the blast. Even up to a block away, bar and restaurant patrons reported feeling the building shake when the IED functioned. Those who were closer to the blast could hear the bang.<sup>134</sup> Seconds later, they saw people begin to flow out of the park into the streets. Without knowing what had happened, many of those in the Evacuated Zone stayed and watched as people ran away from the park.<sup>135</sup>

### EVACUATION PHASE

After civilians evacuated the park, non-injured spectators roamed the surrounding streets without any clear direction from security personnel other than to keep away from the park. Many people continued to their homes or hotels; others, however, remained in the vicinity – either going to nearby bars and restaurants or clustering in the streets surrounding the Park. Several buildings surrounding the park were evacuated.<sup>136</sup> While many fled the area, most of those who remained near the park engaged in gawking behaviors.<sup>137</sup>

## Appendix B-2.

# 11M Madrid Commuter Train Bombings

### DATE



March 11, 2004

### CASUALTIES



**190** dead



**1,800** physically injured

### NUMBER OF IEDS



**10**

### SOFT TARGET TYPE(S)



Commuter trains



## Context

### Background

On March 11, 2004, 10 IEDs functioned almost simultaneously on four commuter trains during the morning rush hour in Madrid, Spain. The explosions occurred on the same line at the Santa Eugenia, El Pozo, and Atocha Stations, with the fourth occurring close to Atocha Station near Téllez Street. One IED functioned on the train at Santa Eugenia Station, two at El Pozo Station, four near Téllez Street, and three at Atocha Station. Three IEDs that failed to function were also discovered, one of which technicians disarmed and used as evidence. One hundred ninety-one people were killed by the explosions and close to 1,800 were wounded.<sup>138</sup> The bombings were one of the deadliest terrorist attacks in Europe.<sup>139</sup> Although ETA, a terrorist organization based in Spain was initially blamed, it was soon concluded that the bombers were part of a larger terrorist cell inspired by al-Qaeda. The explosions occurred days before a national election, and it is argued that the attacks and the government's response to them altered the election's outcome.<sup>140</sup>

### Perpetrator

A terrorist cell was responsible for the bombings. The group, which was based in Madrid, was formed by Islamic extremists, and likely inspired by al-Qaeda. Although no direct operational link was ever proven, members of the cell had connections to members of al-Qaeda.<sup>141</sup> One of the suggested motives for the attack was Spain's military involvement in the invasion of Iraq led by American forces in 2003.<sup>142</sup> It is also believed that the perpetrators wanted to influence the outcome of the upcoming election.<sup>143</sup> Seven suspects connected to the bombings killed themselves and a police officer in an explosion when trapped in an apartment by Spanish law enforcement officers more than three weeks after the attacks.<sup>144</sup> Eventually, 29 suspects were arrested and indicted for their role in the bombings.<sup>145</sup> Five of those were directly connected to the attacks, while the others were charged with varying degrees of support (e.g., selling the explosives to the perpetrators). The outcome of the trial found eight suspects acquitted (one partway through the trial because of lack of evidence), and 18 were found guilty of less severe charges.<sup>146</sup> Four of the convicted later had their convictions overturned during the appeals process.<sup>147</sup>

### Improvised Explosive Device

To carry out their attack, the Madrid perpetrators acquired a sizable quantity of the commercially manufactured high explosive, Goma-2 ECO dynamite, through an undisclosed criminal network with access to a mine in northern Spain. This plastic-based explosive was used to manufacture the 13 IEDs later distributed across the Madrid rail network. Encased by nail and screw enhancements and contained within duffel bags and backpacks, each IED weighed between 22 and 26 pounds. Their size enabled the perpetrators to hand-carry the devices onto the four trains departing from Alcalá de Henares Station without raising any suspicion. Within 20 minutes of their boarding, the attackers had dispersed the IEDs across the train cars before disembarking. Remotely, they triggered the devices using the alarm function of one or more cell phones. Ten of the devices were set off in as many minutes to ensure they functioned as each train was scheduled to arrive at their respective station. The attackers had placed the IEDs close to the car doors. Investigators surmise they had done so to maximize casualty counts on both the trains and the adjacent platforms. Two devices did not function for unknown reasons, and one did not function because it had been wired incorrectly. Following the incident, explosive ordnance experts located these remaining devices and safely removed them from the site for controlled destruction.

### Casualties

At the Atocha station, 29 people were killed by the bombings.<sup>148</sup> On the train near Atocha station, 65 people were killed. In the El Pozo and Santa Eugenia stations, 67 and 17 people were killed, respectively. The other fatalities succumbed to their injuries later, most frequently at the hospital. Of those commuters on the trains and the station platforms that were not killed, hundreds were injured. Body parts and bodies littered the blast sites.<sup>149</sup> Victims and witnesses described facial lacerations, blood gushing from wounds, internal trauma from the blast pressure wave, burns from the IED's thermal effects, shrapnel buried into flesh, and the amputation of limbs.<sup>150 151 152 153 154 155</sup> Specific to the emergency response, it was estimated that across the four attack sites emergency medical services took an average of seven minutes to reach the scene.<sup>156</sup> A systematic review of hospital care provided to bombing victims found that facial, head, and neck injuries were the most common type for which victims were treated.<sup>157</sup> Nearly half of the victims suffered hearing damage. The study also found that the fatality rate was higher on train carriages that had their doors closed when the IEDs functioned.

## Behavioral Responses



### PRIMARY ZONE

#### INITIALIZATION PHASE

Prior to the explosions, the trains were filled with commuters heading to work and school. The four trains targeted were all traveling toward the city center on the same line. Inside the carriages there was a mixture of people seated and standing as the trains traveled from station to station. Although the trains typically were crowded during this time, at least one eyewitness observed that one of the trains was not as busy as usual.<sup>158</sup>

#### MICRO-PHASE 1: Impulsive Reactions

The explosions blew holes into the sides of the train cars and the force tossed people out onto the ground.<sup>159</sup> The trains stopped.<sup>160</sup> On one train, it was estimated that everyone within 30 feet of the IED had been killed. Survivors said that their bodies were frozen, and they were unable to move. They lost their hearing, but could smell the burnt metal.<sup>161</sup> One victim described being in pain and feeling like their body had been torn apart.<sup>162</sup> Another said they did not hear the explosion and only saw the flash of light and the black smoke that followed.<sup>163</sup> At least one victim was hurled onto the roof of the station next to the train and another outside of the station completely and onto the street.<sup>164 165</sup> The carriages filled with black smoke.<sup>166</sup> The people who could run rushed out of the trains, trampling the wounded in the chaos.<sup>167</sup>

#### MICRO-PHASE 2: Behavioral Transitions

Within a short period of time, others exited the train in shock, wandering around, deafened by the explosion.<sup>168</sup> These individuals were disoriented and unable to process what had occurred.<sup>169</sup> Others were trapped within the carriages as their exits were blocked by the dead and the debris.<sup>170</sup> One victim recounted their ordeal crawling out of the wreckage while another was dragged to safety.<sup>171 172</sup> Others remembered being controlled by the fear caused by the explosion and explaining that they were only thinking about survival.<sup>173</sup> Some who initially fled began to return and help.<sup>174</sup> Unfortunately, in some cases, they were returning to additional explosions.<sup>175</sup>

#### MICRO-PHASE 3: Deliberative Acts

The injured were removed from the trains and placed on the ground or platforms.<sup>176</sup> Security personnel at the stations who were already onsite assisted in evacuating the damaged trains.<sup>177</sup> Victims that could move, evacuated themselves.<sup>178</sup> The victims who were living in Spain and undocumented, attempted to leave the area even though they were severely injured.<sup>179</sup> At some of the blast sites, people from the neighborhood began to arrive to offer aid before first responders. For example, a doctor arrived and prioritized the victims based on the severity of their injuries.<sup>180</sup> A survivor recounted a man returning to the train car and applying pressure inside his chest to a wound, slowing the bleeding and saving his life.<sup>181</sup> At many of the sites, uninjured commuters, employees at the train station, and people from the street were already caring for the wounded by the time first responders arrived.<sup>182</sup>

#### EVACUATION PHASE

There were additional moments of chaos as new devices were potentially discovered and packages were detonated. First responders and others fled those areas searching for safety.<sup>183</sup> Law enforcement ordered civilians who had come to help the wounded to evacuate.<sup>184</sup> First responders and volunteers helped to evacuate those who were able to a nearby recreational center.<sup>185</sup> As the day and evening wore on, bodies were removed from the blast sites and lined up on the ground or station platforms.<sup>186</sup>



## SECONDARY ZONE

### INITIALIZATION PHASE

The Secondary Zones at the blast sites mostly consisted of the train carriages adjoining the ones where the bombs were located. At least one of the targeted trains was next to a crowded platform filled with commuters.<sup>187</sup>

### MICRO-PHASE 1:

#### Impulsive Reactions

In some areas, no one moved after the first explosion—the eyewitnesses frozen in shock. Survivors in cars around the blast sites described being relatively calm as they exited the train. However, after more explosions occurred, everyone who could run did so, stampeding toward the station exits and away from the trains.<sup>188</sup> People realized with subsequent explosions that the first was not an accident.<sup>189</sup> In some areas there was chaos as crowds rushed the stairs and escalators to exit the station and get away from the explosions, crushing each other in the process.<sup>190</sup> Others attempted to approach and help after the initial blast, but also turned and fled as more explosions occurred.<sup>191</sup> At the Santa Eugenia Station, where only one explosion occurred, a witness described coming out of a tunnel between the tracks and being showered with debris. They then approached the affected car to see victims with shredded clothing and blood over their bodies.<sup>192</sup> On the trains, those in the cars without IEDs described feeling the impact of the explosion, the lights in their car going out, and a general sense of confusion.<sup>193</sup> At Atocha Station half of the train was still inside a tunnel and survivors described fearing the roof would collapse while they were stuck in the dark.<sup>194</sup>

### MICRO-PHASES 2 AND 3:

#### Behavioral Transitions and Deliberative Acts

An off-duty law enforcement officer on a non-damaged portion of the train initiated an evacuation by asking others to open an emergency exit.<sup>195</sup> The conductor activated an emergency alarm to alert others about the explosion.<sup>196</sup> After the train stopped, those in on the unaffected cars exited and moved away from the train. Others approached the wounded and helped as best they could.<sup>197</sup> One conductor, after exiting the train, paced uncontrollably in a panic. Teenagers sat on the ground crying.<sup>198</sup> Eventually, emergency triage centers were setup along the tracks and the stations.<sup>199</sup>



## TERTIARY ZONE

### INITIALIZATION PHASE

The Tertiary Zones for most of the blast sites included the areas of the stations not directly beside the explosions. In one case, it also included a train heading in the opposite direction, which lost power and stopped on the tracks. The pre-event behaviors were like those in the other zones, commuters traveling to work on school and either waiting at the stations or already traveling on the trains.

### MICRO-PHASES 1 & 2: Impulsive Reactions & Behavioral Transitions

On the platform at Atocha Station, the crowds fled in every direction, trampling each other, some even into nearby train tunnels.<sup>200</sup> The massive number of commuters on the station platforms made it extremely difficult for people to flee, many were trapped with no way to get out.<sup>201</sup> On the trains, some individuals remained calm and asked others to do the same, afraid that they might flee and be killed or injured by another bomb.<sup>202</sup>

### MICRO-PHASES 3: Deliberative Acts & The Evacuation Phase

Unexploded IEDs were found by civilians and first responders.<sup>203</sup> Disembarking from another train that had been stopped short of the station, some ran to help those who had been injured on a train that had been bombed.<sup>204</sup>

In the Tertiary Zones inside the station many of the injured wandered around seeking help.<sup>205</sup> On the tracks outside the Atocha Station, commuters who were on other trains had to evacuate past the devastation as the bombed train blocked their path. The wounded gathered nearby, lying on the ground, being provided oxygen, water, and basic first aid.<sup>206</sup>

## EVACUATED ZONE



### INITIALIZATION PHASE

The neighborhoods outside of the train stations constituted the evacuation zones. Prior to the explosions, behaviors in these areas included individuals in their homes and on the streets engaging in their normal routines.

### MICRO-PHASES 1, 2, AND 3: Impulsive Reactions, Behavioral Transitions, and Deliberative Acts

Looking out the windows of their homes, which shook or were broken from the explosions, witnesses reported smelling burning plastic, gun powder, and seeing smoke.<sup>207</sup> They could hear the sounds of the victims screaming and moaning in the distance.<sup>208</sup> Near the Atocha Station, it was reported that approximately 30 people in the adjacent neighborhood headed toward the disaster to help and arrived before any first responders.<sup>209</sup> Similarly, near the Santa Eugenia and El Pozo Stations, residents of the surrounding communities did the same.<sup>210</sup> Others threw down blankets from their windows and balconies to be taken to the blast sites and used to comfort and support the injured.<sup>211</sup> In some of the adjacent neighborhoods, witnesses reported commuters wandering dazed away from the tracks and stations and into the community.<sup>212</sup> Local law enforcement working in the neighborhood led these individuals to nearby buildings.<sup>213</sup>

### EVACUATION PHASE

Passengers were evacuated to makeshift field hospitals and triage sites outside of the stations to receive medical aid and be treated for their wounds.<sup>214</sup> As the injured were transported for medical care, many were still disoriented when they arrived, some suffering from memory loss.<sup>215</sup>

Also, outside the stations, family members and friends showed up desperately seeking information about their loved ones.<sup>216</sup> Law enforcement officers were used to secure the area and keep people from interfering with the medical treatment and crime scene investigation.

## Appendix B-3.

# London 7/7 Bombings

### DATE



July 7, 2005

### CASUALTIES



52 dead



784 physically injured

### NUMBER OF IEDS



4

### SOFT TARGET TYPE(S)



Subway cars, City bus



## Context

### Background

The London bombings occurred on July 7, 2005, between 8:50 and 9:47 a.m.. Three underground trains and a bus were individually targeted by four individuals.<sup>217</sup> The bombers traveled together to King's Cross Station and dispersed from there onto separate trains headed in various directions throughout the city.<sup>218</sup> With them, the bombers carried IEDs contained within rucksacks.<sup>219</sup> The first three attackers detonated their IEDs within minutes of each other while the trains were traveling between stations.<sup>220</sup> Shortly thereafter, train service was cancelled for the city, and the London Underground stations were evacuated.<sup>221 222</sup> As a result, one of the attackers—whom investigators presume<sup>223</sup> had intended to detonate his IED on one of the trains—was forced to relocate above ground, where he boarded a double-decker bus<sup>224</sup> in Tavistock Square and detonated the final IED, nearly an hour after the first three. Across the four bombing sites, 56 people were killed, including all four bombers, and at least 784 were injured.<sup>225 226</sup> Because the site occurred across multiple sites, three of which had no access to mobile network coverage or radio signal, the emergency response was city-wide.<sup>227</sup> The ensuing investigation revealed that the bombers had manufactured the IEDs themselves in a London apartment using peroxide-based explosives.<sup>228</sup>

### Perpetrator

Four men were responsible for the 7/7 attacks: Mohammed Siddeque Khan, Shazad Tanweer, Hasib Hussein, and Jermaine Lindsay, all of whom were British nationals raised in the United Kingdom.<sup>229</sup> Each man died carrying out their respective attack. None had any known, direct ties to al-Qaeda, although they are believed to have been inspired by the group's ideology.<sup>230 231</sup>

Hussein and Lindsay's involvement in attack planning and preparations remains unclear. Prior to the bombings, they were unknown to British security services.<sup>232</sup> However, Khan and Tanweer had been under British security review for their associations with known Islamic extremists.<sup>233</sup> Khan was also known to be "committed to the extremist cause".<sup>234</sup> MI5 had received intelligence about Khan's paramilitary training<sup>235</sup> in Afghanistan and Pakistan and his ownership of a vehicle used by known extremists.<sup>236</sup> However, they were unable to attach these facts to Khan; the reports contained insufficient information to indicate, decisively, that they were connected to the same person. Following the bombings, security services learned that Khan had spent time with Tanweer in Pakistan between 2004 and 2005, where British security services believe they completed operational training.<sup>237</sup> The security services also learned that Tanweer and Khan were among several previously unidentified men at a meeting among known Islamic extremists.<sup>238</sup> At the time of the attacks, MI5 had an ongoing investigation<sup>239</sup> related to a disrupted bomb plot. During this investigation, Khan and Tanweer were identified

as peripheral subjects of interest.<sup>240</sup> However, neither were placed under surveillance.<sup>241</sup> British security services have concluded that there was insufficient information available—or feasible to uncover—to identify their attack planning in advance.<sup>242</sup>

### Improvised Explosive Device

The perpetrators employed homemade, peroxide-based explosives (triacetone triperoxide, or TATP), each weighing between 4.5 and 11 pounds.<sup>243</sup> Selecting this explosive material enabled the bombmaker to manufacture the devices with other commercially available ingredients using open-source instruction manuals. During the post-incident investigation, bombmaking equipment and remaining materials were found in an apartment in Leeds, Great Britain.<sup>244</sup> Intelligence reports indicate that production began there on or about March 31st, 2005, when the first necessary material purchase was made.<sup>245</sup> Although the apartment was rented on behalf of Lindsay, it is unclear which persons were involved in making the bombs.<sup>246</sup> \*

Once completed, the devices were placed inside four rucksacks, which the four men individually carried onto the train cars at Luton Station on 7/7.<sup>247</sup> Forensic evidence indicates that they placed the bags beside or beneath their seats or standing area and manually triggered the devices, causing instant explosions.<sup>248</sup> Police located smaller IEDs in one of the attacker's vehicles, parked outside Luton Station, which British security services believe were only to be used if the attackers were intercepted on their way to the train station.<sup>249</sup>

### Casualties

The explosions killed 52 victims, plus the four bombers, and injured an additional 784.<sup>250 251</sup> All but three of the fatalities died at the scenes.<sup>252</sup> Among the injured, 55 received priority dispatch<sup>253</sup> for their injuries, and 20 were identified as critically wounded.<sup>254</sup> Where crowd density was higher, so too were fatality rates.<sup>255</sup> The first explosion, on the train between Aldgate and Liverpool Street Stations, resulted in eight fatalities and 171 injured.<sup>256</sup> The second explosion, on the train at Edgware Road Station, resulted in seven deaths and 163 injuries. The third explosion, on the train between King's Cross and Russell Square Stations, killed 27 and injured over 340.<sup>257</sup> On or near the bus at Tavistock Square, 13 victims were killed and over 110 were injured.<sup>258</sup> Injury patterns across the incident sites were similar,<sup>259</sup> with two notable exceptions: many victims of the train bombings suffered moderate to severe burns,<sup>260</sup> while most on the bus experienced minor burns;<sup>261</sup> also, on the bus, several experienced crush-related injuries<sup>262</sup> due to the collapse of the bus's top deck. Otherwise, injuries were consistent with other closed-space blast incidents, including significant primary blast injuries (e.g., eardrum perforations), secondary blast injuries (e.g., soft-tissue wounds), and tertiary blast injuries (e.g., fractures and amputations).<sup>263</sup>

\* Lindsey, Hussain, and Tanweer are suspected to have been involved in the IEDs' production. Besides asking a former roommate to rent the Leeds apartment for him, Lindsay, as well as Hussain, bought face masks preceding the attack. Additionally, Tanweer and Hussain's families noticed, independent of the other, that the men had lighter hair, which forensic experts suspect would have been caused by the bleaching effect of chlorine—a chemical used in the production of peroxide-based explosives.

## Behavioral Responses: London Underground



### PRIMARY ZONE: LONDON UNDERGROUND

#### INITIALIZATION PHASE

For the three subway train bombings in London's Underground, the Primary Zone consists of the car where the IED detonated. As this was during morning rush hour on a weekday, the trains were filled with commuters.<sup>264</sup> Regular commuters described at least one of the trains as busier than usual.<sup>265</sup> Some sat, while others stood, holding onto the bars for support. All trains were underground, out of a station, and inside tunnels of varying sizes.

#### MICRO-PHASE 1: Impulsive Reactions

The IED functioned in different cars for each train line, but the human behaviors were similar. Those in the Primary Zone described seeing flashes of orange and yellow light and said that they did not even hear the explosion as the blast wave damaged their hearing before their bodies could register the sound.<sup>266</sup> The trains came to an immediate stop and were derailed.<sup>267</sup> The effects of the explosion were described as the feeling of being electrocuted.<sup>268</sup> Clothes were shredded from bodies and some people were blown out of the train cars onto the tracks.<sup>269</sup> The lights went out, plunging the carriage into darkness.<sup>270</sup> Thick, black smoke filled the subway car, causing people to struggle to see and to breathe. The IED caused damage in the flooring of the trains, the sides, the ceiling, and shattered many of the windows.<sup>271</sup> People were thrown through the air, knocked to the ground, and piled atop of each other. Depending on how close individuals were to the explosion impacted whether they were knocked unconscious and for how long. The train on the Piccadilly Line was in a deeper, narrower tunnel and the force of the blast reverberated off the tunnel walls causing more damage.<sup>272</sup> Another train was immediately next to a train that was passing it in the opposite direction and the blast damaged both. As the subway trains were crowded and there was no immediate way to exit, there is no evidence that individuals immediately fled. Most were stunned, frozen, unconscious, or dead.

#### MICRO-PHASE 2: Behavioral Transitions

After the initial silence, there were screams of agony from the injured that many could not hear clearly because of the damage to their eardrums. Emergency lighting in the tunnels began to turn on. As the subway passengers transitioned to new behaviors, those behaviors depended on their level of injury. Those who were in the train car, but farther away from the explosion, had the ability to begin assessing the situation, providing help to those around them, and even ask for everyone to remain calm.<sup>273</sup> Those in the Primary Zone listened for instructions from the driver or someone else in a position of authority to provide instructions. For those who were injured, they remained in place, many not even conscious yet as those around them began to move.<sup>274</sup> There was no cell phone coverage in the tunnels for people to call for help. Those from nearby cars began to enter the Primary Zones to see if they could offer help and to look for an escape.<sup>275</sup>

#### MICRO-PHASE 3: Deliberative Acts

On subway cars where there was a way to exit, those who could, evacuated and fled down the tunnels. Some waited for others to leave the cars before deciding to also flee.<sup>276</sup> The act of evacuating was based on, in most accounts, whether there was an immediate exit open to those who were not seriously injured. Damage to the train's structure also prevented people from escaping as metal had warped, bent, or broken the carriages, restricting the opening of doors and windows.<sup>277</sup> Those who decided to stay helped the injured and even provided guidance to others on how to do the same.<sup>278</sup> There are even examples of those who were severely injured, in one case losing a leg to the blast, who were able to apply a makeshift tourniquet to their own wounds.<sup>279</sup> In at least one case, the driver of the train helped evacuate those from the Primary Zone who could walk out of the car and sent them down the track towards the station.<sup>280</sup> The injured, and those caring for the injured who stayed behind, described the train as calm once those who could, fled.<sup>281</sup> One man who helped the wounded when he could have evacuated on his own was described as inspiring others to help as well.<sup>282</sup>

#### EVACUATION PHASE

In many cases, it took an extended period for outside help to reach the injured and dead. On the Circle Line leaving Edgware Station, the first responders were London Underground workers from the closest station.<sup>283</sup> On the Piccadilly Line, medical assistance and law enforcement did not reach the train until thirty minutes about the explosion occurred.<sup>284</sup>



## SECONDARY ZONE: LONDON UNDERGROUND

### INITIALIZATION PHASE

The Secondary Zone included subway train cars on either side of those bombed. In one instance, a train passing on a nearby track was damaged and stopped when the explosion occurred. These carriages were also filled with morning commuters.

### MICRO-PHASE 1: Impulsive Reactions

The explosion shattered many of the car windows next to the car that had been bombed. In some instances, dependent on their location in the Secondary Zone, people were knocked to the ground by a combination of the force of the blast and, more likely, the train coming to an abrupt stop.<sup>285</sup> There was a worry, in some cases, that the smoke was from an ongoing fire that was at risk of spreading further.<sup>286</sup>

### MICRO-PHASE 2: Behavioral Transitions

Those in the Secondary Zone attempted to assess the situation in the Primary Zone. One witness described crawling through the wreckage to reach the Primary Zone to see what had happened and to help where they could.<sup>287</sup> In one case the driver was able to speak to some of the passengers through the train's announcement system. In another, where there was no immediate information from the driver, people began to panic from the smoke and the darkness.<sup>288</sup> Some screamed for windows to be broken and for help to come. Others calmly knelt close to the ground and covered their mouths and noses with fabric.<sup>289</sup>

### MICRO-PHASE 3: Deliberative Acts

People attempted to open doors to access the wounded, but in at least one train could not because of the damage from the blast.<sup>290</sup> On the Circle Line near Edgware Road Station, the first car of the train quickly evacuated with the assistance of the driver. In one car, where the commuters could not evacuate immediately, they nominated a spokesperson to provide guidance and leadership.<sup>291</sup> Some were still frozen and unable to move, even though they suffered no severe physical injuries.<sup>292</sup> One witness described returning to the train to inform others that they were being evacuated only to then realize that there had been a bombing and many were injured or dead.<sup>293</sup> On the other side of the blast, people used a metal bar to break a window and climb out.<sup>294</sup> On the Piccadilly Line, some of the public stayed in their train car for an estimated 15 minutes before they could exit.<sup>295</sup> On a train next to one that had been bombed, passengers pried open the doors and smashed windows to let fresh air in and have better visibility.<sup>296</sup>

### EVACUATION PHASE

Where they could find an exit and safely evacuate onto the train tracks, many people did. On the Piccadilly Line one of the drivers assisted in evacuating from the train. A passenger on the train reflected on the importance of an authority figure providing informational updates and instructions and how it helped keep him calm.<sup>297</sup> On the Circle Line heading to Aldgate, another passenger described how those on their car sat down on the floor and waited calmly until a law enforcement officer arrived to assist in their evacuation, which was estimated up to 40 minutes after the IED detonated in the car next to them.<sup>298</sup>



## TERTIARY ZONE: LONDON UNDERGROUND

### INITIALIZATION PHASE

The Tertiary Zone included subway cars that were carriages away from where the explosions occurred and in the train across the tracks. Once again, these cars were filled with commuters.

### MICRO-PHASE 1:

Impulsive Reactions

Even in the Tertiary Zone on some trains, there were reports of black smoke. Although people reported being knocked out of their seats, most likely from the train screeching to a halt, many remained calm even though they did not know what was happening. For those who did not know what happened, several cars in front or behind them, there was little evidence that a bombing had occurred. Depending on the train and the car, some travelers were not even knocked down nor saw any black smoke.<sup>299</sup> Some witnesses described the smell of an electrical fire and heard people screaming in other cars.<sup>300</sup>

### MICRO-PHASE 2:

Behavioral Transitions

In some cases, those in the Tertiary Zone were more frantic than those who were around the device, or those who could see the damage from the explosion.<sup>301</sup> Where there was an exit to do so (e.g., the door at the end of the train or a side door), most people in the Tertiary Zone fled as quickly as possible after the initial shock of the blast wore off.<sup>302</sup>

### MICRO-PHASE 3:

Deliberative Acts & The Evacuation Phase

In one case, a train was passing the bombed train and was also stopped by the explosion. Those who could help did so by passing water and other items across the tracks through the windows.<sup>303</sup> In one instance, those in the Tertiary Zone on an affected train had to evacuate through the car where the explosion occurred nearly 30 minutes after.<sup>304</sup> In this instance, those evacuating were described as calm and patient. Others described being trapped on their trains as they were worried about being electrocuted by an electrified third rail and there were no individuals in positions of authority around to tell them whether it was safe.<sup>305</sup> In another, a witness commented on what felt like a very delayed response by paramedics after the bombing.<sup>306</sup>

## EVACUATED ZONE: LONDON UNDERGROUND



### INITIALIZATION PHASE

The Evacuation Zones consisted of subway tunnels, underground stations, the city streets, and nearby businesses.

### MICRO-PHASES 1, 2, AND 3:

Impulsive Reactions, Behavioral Transitions, and Deliberative Acts

As the IED detonated on a train in a tunnel, those in a nearby station could hear the explosion. At the station, even though it was further away, there are descriptions of people panicking and fleeing.<sup>307</sup> Even outside the stations there were reports of feeling buildings shake from the explosions.<sup>308</sup>

Those who were not severely injured got off the trains and went to the stations before emergency medical personnel. Witnesses from unaffected trains described seeing hundreds of people covered in soot and bleeding evacuating from the tunnels into the station.<sup>309</sup> Others in the stations reported that the areas were chaotic with no first responders onsite to coordinate helping the shocked and injured except the London Underground staff.<sup>310</sup>

### EVACUATION PHASE

Once the injured reached the Evacuated Zones, almost always in the Evacuation Phase for those from the Primary, Secondary, and Tertiary Zones, they were provided water, oxygen, and other medical care.<sup>311</sup> In some cases, those with little to no medical knowledge stayed at the stations to help once they saw people evacuating from the tunnels.<sup>312</sup> First responders staged at the underground stations closest to the explosions.<sup>313</sup> Upon exiting the tunnels into the stations, some of the victims reported seeing firefighters and law enforcement officers standing around and pleading with them to go help.<sup>314</sup> However, safety concerns for the first responders, in some cases, kept them from immediately going to the trains. Retail stores were used as triage areas to assess injuries and to get information from the passengers.<sup>315</sup> In one case there were reports that medical staff from a conference being held nearby went to the Evacuated Zone to help.<sup>316</sup>

## Behavioral Responses: Tavistock Square



### PRIMARY ZONE: TAVISTOCK SQUARE

#### INITIALIZATION PHASE

As the underground trains were no longer running, the public turned to an alternate means of transportation for the morning commute to work. Some of the passengers that got on the number 30 bus, or tried to, as it traversed Tavistock Square had narrowly escaped the underground bombing close to the nearby subway station or had been redirected because the subway lines had stopped running.<sup>317</sup> The IED was brought onto the bus by a suicide bomber inside a black backpack. The Primary Zone of the blast was the bus itself and the immediate area surrounding the vehicle. There were approximately one to two dozen people on the bus prior to the explosion.<sup>318</sup>

#### MICRO-PHASE 1: Impulsive Reactions

Around 9:47 in the morning, the IED functioned on the top level of a red double-decker bus in Tavistock Square. The explosion ripped the roof off the bus and blew a hole in the floor of the second level.<sup>319</sup> Victims were injured and killed both on and off the bus.<sup>320</sup> The explosion was followed by some of the injured screaming and others saying nothing while in shock.<sup>321</sup> Many next to the bus fled and still were hit by shrapnel even though they hid behind nearby vehicles.<sup>322</sup> Many on the bus froze, while a few jumped down from the second level to flee.<sup>323</sup> Blood was splattered on the bus, the sidewalk, and even the nearby buildings.<sup>324</sup> Body parts were strewn around the area. A witness described fleeing the bus with damaged hearing, his clothes shredded, and his body injured.<sup>325</sup> Those passing nearby in the crowds of people were hit by debris and knocked to the ground.<sup>326</sup>

#### MICRO-PHASE 2: Behavioral Transitions

There is little evidence about what occurred inside the bus during Micro-Phase 2. Most survivors either described the actions they engaged in as immediate or focused on what occurred several minutes after. Those who were not frozen either wandered away from the bus or were helped off after the initial shock from the explosion wore off and people entered the bus to help the wounded.

#### MICRO-PHASE 3: Deliberative Acts

Even after several minutes, individuals who were near the blast and injured still wandered around the immediate area.<sup>327</sup> People who could provide help, such as medical doctors from the British Medical Association headquarters entered into the Primary Zone to give aid.<sup>328</sup> Some individuals wandering around the area appeared fine, but were still in a state of shock and were unable to describe any injuries that were not immediately visible.<sup>329</sup>

#### EVACUATION PHASE

Paramedics arrived to aid the doctors in the area and transport the wounded.<sup>330</sup>



## SECONDARY ZONE: TAVISTOCK SQUARE

### INITIALIZATION PHASE

The Secondary Zone included areas near the bus, such as the park on the other side of the street and some of the buildings directly beside it. In front of the bus where the IED functioned, was another bus collecting passengers.

### MICRO-PHASE 1: Impulsive Reactions

Members of the public who were nearby shouted at those in the Primary Zone to flee, many crossed the street and into the park.<sup>331</sup> In some nearby buildings, individuals began almost immediately pulling the wounded inside to offer assistance.<sup>332</sup> The public, both those injured and those who were not, also fled into these areas for shelter and to seek medical care on their own.<sup>333</sup> Trained medical professionals described being in shock at the sight of the devastation before they were able to shift into helping the wounded.<sup>334</sup> On the bus directly in front of the one where the explosion occurred, as well as other nearby buses, people panicked and fled onto the street away from the explosion.<sup>335</sup> Many people within the square and the surrounding area also fled, some into nearby shops.

### MICRO-PHASES 2, 3, & EVACUATION PHASE: Behavioral Transitions, Deliberative Acts, & Evacuation Phase

Some individuals from this area gawked at the aftermath of the bombing. Others, after hiding within nearby buildings, came out also to see what had happened.

## TERTIARY ZONE: TAVISTOCK SQUARE

### INITIALIZATION PHASE

The Tertiary Zone consisted of the city streets and buildings near the bus, but with limited visibility of the explosion.

### MICRO-PHASES 1-3 & EVACUATION PHASE

Even in this zone, the first instinct for some was to flee.<sup>336</sup> Medical doctors who worked at the British Medical Association building next to where the blast occurred brought the wounded into the building's courtyard to provide treatment and triage victims to a nearby hotel.<sup>337</sup> These individuals helped soon after the blast occurred and for hours afterward.

## EVACUATED ZONE: TAVISTOCK SQUARE

### INITIALIZATION PHASE

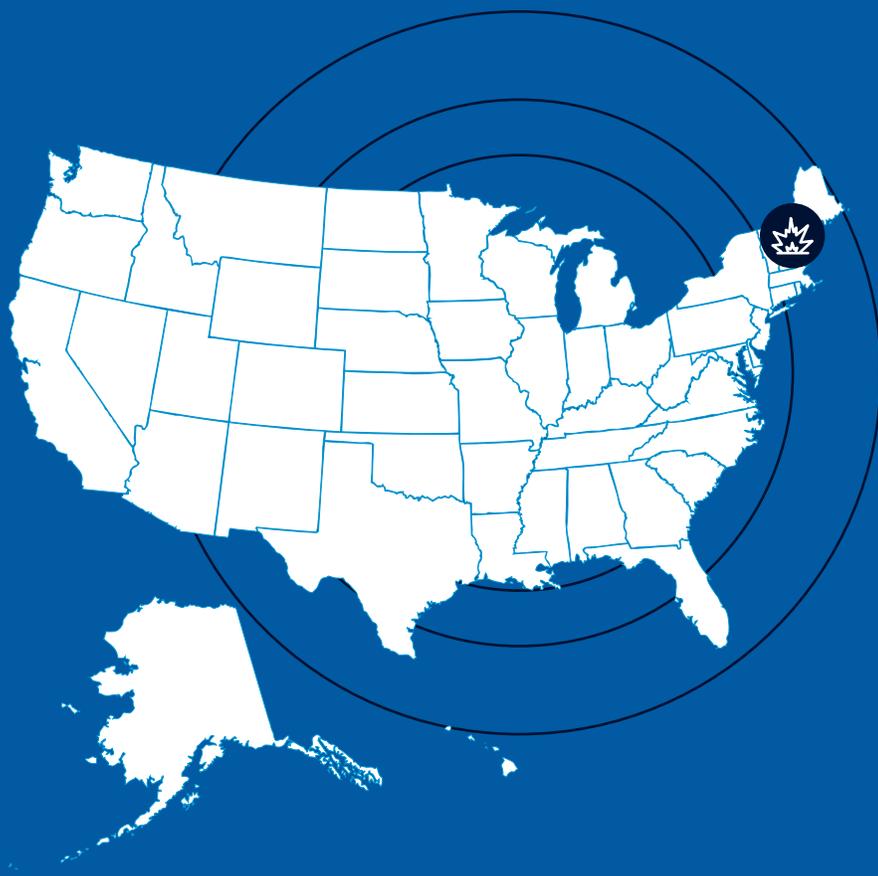
The Evacuation Zone of the Tavistock Square bus bombing consisted of streets outside of the immediate area with no direct line of sight of the bombing. It also included the interiors of buildings with no visibility of the explosion.

### MICRO-PHASES 1-3 & EVACUATION PHASE

Workers inside nearby offices who heard the explosion, but could not feel or see it, left their offices and businesses to come out to the street level to see what had happened and to provide help where they could.<sup>338</sup> These businesses provided areas for triage and their employees even helped remove the injured from the buses and clear the area.<sup>339</sup> Pedestrians on the street also attempted to approach the blast site, knowing that at an explosion had occurred, but not knowing it was from an IED.<sup>340</sup>

## Appendix B-4.

# Boston Marathon Bombing



### DATE



April 15, 2013

### CASUALTIES



**3** dead



**281** physically injured

### NUMBER OF IEDS



**2**

### SOFT TARGET TYPE(S)



City street

## Context

### Background

On April 15, 2013, at 2:49 p.m. in Boston, Massachusetts, two IEDs functioned<sup>341</sup> within the final two blocks of the Boston Marathon, an annual event<sup>342</sup> that is one of the most prestigious marathons in the world. The explosions injured hundreds<sup>343</sup> and killed three people<sup>344</sup> – 8-year-old Martin Richard, 23-year-old Lu Lingzi, and 29-year-old Krystle Campbell. On the day of the bombings, there were approximately 27,000 runners<sup>345</sup> and an estimated 500,000 spectators.<sup>346</sup> The marathon falls on Patriots Day, a state holiday in Massachusetts. The racecourse, which is 26.2 miles long,<sup>347</sup> started in Hopkinton, Massachusetts and ended on Boylston Street close to Copley Square in the Back Bay neighborhood of Boston.

### Perpetrator

The two perpetrators were brothers, 26-year-old Tamerlan and 19-year-old Dzhokhar Tsarnaev.<sup>348</sup> Dzhokhar and Tamerlan were both born in Kyrgyzstan and immigrated to the United States with their families in 2002 and 2003, respectively.<sup>349</sup> Two years before the bombing, Tamerlan was investigated by the FBI's Joint Terrorism Task Force in Boston after Russia informed the United States that he may have been radicalized.<sup>350</sup> An ethnic Chechen and Muslim,<sup>351</sup> it was implied that Russia was concerned that Tamerlan was interested in fighting against the Russian government with Chechen liberation and jihadi organizations.<sup>352</sup> The United States investigation did not uncover any information<sup>353</sup> that linked Tamerlan to terrorist activity and the Russian government did not respond to requests from the FBI<sup>354</sup> for more information about Tamerlan's suspected radicalization. Subsequent investigations after the bombing have found, to varying degrees, evidence that Tamerlan may have been radicalized while traveling to Russia in 2012.<sup>355</sup> Also, investigations into Tamerlan and Dzhokhar's digital footprints identified an interest in jihadism through online websites, videos, and communications.<sup>356</sup> At the time of bombing, Dzhokhar was a student at the University of Massachusetts, Dartmouth and had become a naturalized citizen in September 2012.<sup>357</sup> <sup>358</sup> Tamerlan had been a competitive boxer and was married with a daughter.<sup>359</sup>

### Improvised Explosive Device

The two IEDs used to target the Boston Marathon were carried to the event<sup>360</sup> in black backpacks and placed approximately 200 yards apart.<sup>361</sup> The devices were comprised of two 6-quart pressure cookers packed with low explosives, ball bearings, nails and other metal used as shrapnel, with an ignition device inside.<sup>362</sup> Forensic examiners determined that the residue left over from the explosions most likely came from 8 to 16 pounds<sup>363</sup> of powder from fireworks and/or similar pyrotechnic materials, which was supported by additional evidence that found the suspects had purchased and stored fireworks.<sup>364</sup> The IEDs functioned using what experts stated included, in part, electronic remote-control components from model cars and a Christmas tree lightbulb that together acted as an electrical fusing system.<sup>365</sup> A toggle switch was also installed that interrupted the flow of electricity to make sure that the device did not function while being built or during transport.<sup>366</sup> In addition, a hobby fuse was also included as a secondary means to ignite the low explosives in the case that the first method did not work.<sup>367</sup> Two separate remote-control hobby car receivers<sup>368</sup> were used to detonate each bomb by sending a signal to a receiver, which utilized the battery packs to send power through the device and light the Christmas tree bulbs that had the glass cover broken<sup>369</sup> and removed, which subsequently sparked, igniting the low explosives, and functioning the IEDs.<sup>370</sup>

### Casualties

Across both bombs, there were 3 deaths<sup>371</sup> – one at the first bomb site and two where the secondary device functioned.<sup>372</sup> All three were killed at or near the explosions. There were also 281 injuries,<sup>373</sup> many of which suffered injuries to their legs.<sup>374</sup> Most of the injuries were caused by blast overpressure for those closest to the IEDs, as well as shrapnel and flash burns. It is estimated that first responders and bystanders initially applied makeshift tourniquets<sup>375</sup> onsite to slightly more than 11% of those injured<sup>376</sup> to stop bleeding caused by severe wounds to soft tissue and bone in the extremities. Almost two-thirds of the injured were treated in an emergency department within 24 hours of the explosions.<sup>377</sup> Of that group, approximately 43 percent<sup>378</sup> had at least one injured extremity, while 15 of these victims<sup>379</sup> had at least part of one leg amputated. These were similar to IED injuries seen in modern war zones.<sup>380</sup> There were six Level-1 trauma centers<sup>381</sup> and 21 additional hospitals<sup>382</sup> in the area to which the injured were transported from the blast sites after triaging at medical tents<sup>383</sup> that had already been set up for the marathon runners. Years of experience and planning for the annual marathon resulted in the ability for first responders to quickly communicate with hospitals and efficiently manage transport coordination.<sup>384</sup>

## Behavioral Responses



### PRIMARY ZONE

The first bomb at the Boston Marathon was placed near the finish line by the temporary fencing that separated the runners from the spectators. This fencing was wider than normal and created a buffer between the spectators and the runners but contained the blast to the sidewalk area. The blast radius was the sidewalk on the northside of Boylston Street between the buildings and the temporary barrier and extended on the sidewalk. The area was crowded with spectators watching the runners finish the last hundred yards of the marathon. Behind the spectators on the sidewalk, there was a pathway wide enough for others to walk two to three abreast. Almost all civilians around the bomb were spectators or runners that finished the race and were standing in the crowd, walking through the narrow pathway behind the crowd, or standing in a less densely packed area closer to the buildings.

#### INITIALIZATION PHASE<sup>385</sup>

#### MICRO-PHASE 1: Impulsive Reactions

When the first IED functioned, the shrapnel sprayed through the crowds nearest to the device, shattering bone, ripping apart flesh, and splattering blood over the sidewalk.<sup>386</sup> Some immediately lost their legs from the explosion; others would have them amputated later due to the seriousness of their injuries.<sup>387</sup> One woman, who did not die instantaneously, bled out soon after the explosion.<sup>388</sup> The clothes of some of the wounded were on fire.<sup>389</sup> White smoke rose into the sky.<sup>390</sup> Witnesses reported that people were crying, screaming, confused, and in shock.<sup>391</sup> Video evidence showed that spectators on the periphery of the primary zone ran away en masse from the blast and down the sidewalk.<sup>392</sup> Many covered their ears and their heads. Some fled into nearby businesses and others were pinned against the barrier by the fleeing crowd.<sup>393</sup> Those injured and/or stunned by the explosion lay on the ground.<sup>394</sup> Witnesses consistently spoke of the confusion and disorientation that occurred immediately after the explosion, damaged hearing caused by the overpressure of the detonation, and the smells associated with the burnt fireworks powder and the damage to the victims' bodies.<sup>395</sup>

#### MICRO-PHASE 2: Behavioral Transitions

The transition to Micro-Phase 2 began as individuals shifted from their immediate reactions to the explosion. This transition began approximately 5 to 10 seconds after the first detonation for those who did not immediately flee but was interrupted when the second IED functioned approximately 200 yards away. Even within the blast radius of the first bomb, people were seen in the video ducking and looking, reacting to the second explosion.<sup>396</sup> Spectators who were not seriously injured began providing medical assistance to those who were on the ground even as the white smoke of the first bomb still hung in the air.<sup>397</sup> Access to the area was still restricted by the barrier, which law enforcement, the national guard, and other spectators began to remove.<sup>398</sup> Although there was initial confusion to what caused the first explosion, the second explosion could only be interpreted as a purposeful act of violence.<sup>399</sup>

#### MICRO-PHASE 3: Deliberative Acts

The Primary Zone of the first IED filled with on-site first responders who provided first aid.<sup>400</sup> More individuals returned to help. A mix of first responders, spectators, volunteers, and photographers entered the area to aid about 12 to 24 severely injured persons and document the explosion's aftermath. Some of the injured moved or were moved to create space to provide care. Many of these helpers arrived from outside of the Primary Zone. The people who fled from the Primary, Secondary, and Tertiary Zones of the second IED appeared to only enter similar zones for the first IED if they were runners still attempting to finish the race, individuals hoping to help, or spectators using a side street to flee. The most common behaviors were fleeing and helping.

#### EVACUATION PHASE

Several minutes after the IEDs functioned, additional law enforcement arrived as the barrier between the sidewalk and Boylston Street was completely removed.<sup>401</sup> These first responders, almost all of which were already onsite for the marathon, naturally split between the two groups of victims at each blast site.<sup>402</sup> In the Primary Zone of the first IED, a mix of injured and non-injured spectators were grouped on the sidewalk. Emergency medical technicians, doctors, and law enforcement officers provided care to those on the ground. At this point, mostly first responders, the injured, photographers, and friends and family members of the injured remained within the blast radius.<sup>403</sup> As the injured were stabilized and moved to the marathon medical tents for triage, more law enforcement arrived to secure the crime scene.<sup>404</sup>



## SECONDARY ZONE

### INITIALIZATION PHASE

The concentric zone distribution highlights the importance of the environment when studying human behaviors after an IED event. The barricades separating the runners from the spectators, and the grandstands limiting their movement, played a key role in determining the distribution of the concentric zones and how to study human behavioral responses. For example, without the temporary barricade separating the marathon course from the spectators on the sidewalk, some law enforcement, runners, and marathon volunteers would have been in the blast radius and possibly injured or killed. The barricade blocked the most severe effects of the IED blast, keeping it contained between the barricade and the buildings lining the street, artificially constraining the size of the Primary Zone. The approximate area of the Secondary Zone consisted of the marathon course's final stretch on Boylston Street between the intersection at Exeter Street to the west and past the marathon's finish line to the east.<sup>405</sup> Before the IED, there were over 50 marathon runners finishing the race in this zone and about a dozen volunteers wearing yellow jackets on both sides of the street. More than a dozen law enforcement officers stood around the perimeter, some alone and others forming small groups. Miscellaneous civilians with an assortment of goals, such as photographers, were scattered throughout the zone.

### MICRO-PHASE 1: Impulsive Reactions

When the IED functioned, almost all individuals reacted instinctually by flinching or ducking.<sup>406</sup> The runners slightly shifted their trajectories and moved closer to the south side of the street, away from the bombing, while still heading forward, focused on their goal of crossing the finish line. Some runners, whose backs were to the IED, looked over their shoulders to see the smoke rising from where the explosion occurred. The civilian marathon volunteers did not react in a uniform way – some ran, others stayed in place and huddled together, several began to move toward the explosion to provide help. Law enforcement officers initially stepped away from the bombing and, if with others, formed tight groups. Many unholstered their weapons. In less than ten seconds, all were heading towards the explosion. Finally, in the sidewalk area of the Secondary Zone, based on the limited video evidence available, it appears that most individuals who could flee did so immediately after the IED functioned, leaving that area nearly empty. Law enforcement officers transitioned to new behaviors quicker than other groups. Runners continued toward the finish, their goal seeking behavior mitigating their reactions to the bombing.

### MICRO-PHASE 2: Behavioral Transitions

Although some individuals had already begun to transition into new behaviors, especially the law enforcement officers, the second explosion reset these behaviors.<sup>407</sup> As discussed, multiple IEDs functioning can reset and/or alter the behavioral transitions in which individuals are engaging. In the case of the Boston Marathon bombings, almost all individuals in the Secondary Zone, both civilians and law enforcement, reset that transition and moved away from the location of the first bombing in response to the second IED functioning. Although the Secondary Zone of the first IED was also the Evacuated Zone of the second IED, the input from the second explosion caused an immediate behavioral transition from those already primed by the first explosion. Some began to flee, others froze. Some law enforcement officers, after their new behavioral transition to the second bombing, headed toward the second blast's location. After a few moments others headed back toward the first blast site to help.

### MICRO-PHASE 3: Deliberative Acts

As the Impulsive Reactions transitioned to deliberative acts in the Secondary Zone, civilians and on-site first responders, including law enforcement and the National Guard, dismantled the fencing and barricades that separated them from the injured inside the Primary Zone.<sup>408</sup> These helping behaviors occurred until all the barricades were completely removed and drug to the other side of the street. During this period, some crossed into the Primary Zone to help the wounded while others exited to the Tertiary or Evacuated Zones to help near the second explosion.

### EVACUATION PHASE

During the Evacuation Phase in the Secondary Zone there were no barriers restricting access to the Primary Zone.<sup>409</sup> This allowed civilians and on-site first responders to flow freely between zones and use this area to evacuate the injured. Once the injured were stabilized and transported, law enforcement secured the crime scene for forensics.



## TERTIARY ZONE

When the first IED functioned at the Boston Marathon, the Tertiary Zone encompassed multiple types of areas populated with civilians, volunteers, law enforcement, and other first responders. Recall that the Tertiary Zone is one outside of the Secondary Zone – individuals will have limited direct sensory input from the explosion, limited views of the Primary Zone, and relatively good positioning to see and hear what is occurring within the Secondary Zone. Based on this definition, the grandstands on the southside of Boylston Street, the area east of the finish line, and west of the intersection at Boylston and Exeter Street, were labeled as the Secondary Zone for the first IED.

Across three grandstands, there were hundreds of spectators watching the race.<sup>410</sup> Although there were civilians sitting and standing throughout the grandstands, there were localized concentrations of individuals in areas closer to the street where there were better views of the runners. These crowds included VIP seating for family members and friends of the runners.<sup>411</sup> There were pathways in front of the grandstands and those for ingress to and egress from the grandstands where civilians could watch from street level. In addition to the spectators, there were yellow jacket volunteers in this area of the Tertiary Zone. Due to the elevation of the grandstands, some civilians potentially had a better view of the Primary Zone than those in the Secondary Zone. However, due to their distance from the IED, any injury from the explosion was extremely unlikely.

Outside of the grandstands, other areas of the Tertiary Zone included the marathon course and viewing areas at the intersection of Boylston and Exeter Streets and a segment of road west of the intersection.<sup>412</sup> This area included runners, law enforcement, yellow jacket volunteers, and spectators. Also, the area East of the finish line, where the runners were ushered away to additional resources such as the medical tent, liquids, and their belongings, was a portion of the Tertiary Zone.<sup>413</sup> There were runners who had just finished the race, medical staff, law enforcement, and additional volunteers in this area.

### INITIALIZATION PHASE

#### MICRO-PHASE 1: Impulsive Reactions

When the IED functioned, most spectators in the grandstands stood in place, flinching, or crouching from the explosion.<sup>414</sup> Some stepped backwards or sideways and very few began exiting the grandstands. Further west, including the intersection at Boylston Street and Exeter Street and beyond, runners moved to the far side of the road, but at a slower pace than those in the secondary zone. Law enforcement can be seen in videos heading toward the explosion to help, some entering the Secondary Zone before the second blast occurred.

#### MICRO-PHASE 2: Behavioral Transitions

At the start of this phase, before it is interrupted by the second IED functioning, spectators in the grandstands were watching, crouching, or looking for their belongings.<sup>415</sup> Some appear to be recording video or taking photographs with their phones. Very few have started to transition to leave the grandstands. When the second IED functioned, there was a noticeable increase in movement as more spectators reacted – flinching, crouching, and then moving through the grandstands. The number and speed of egress from the grandstands noticeably increases. One spectator from the grandstands described what she observed after the first and second IED functioned. However, she decided not to flee after her boyfriend told her that, based on his military training, there could be additional explosions.<sup>416</sup>

When the second IED functions, areas of the Tertiary Zone for the first bomb become the Secondary and Tertiary Zones for the second explosion. Runners on the course, the most visible in the available videos, who were already moving to the far side of the course during Micro-Phase 1, move much quicker when the second blast occurs.<sup>417</sup> Law enforcement officers stop and freeze, now having two bombing scenes to choose from for which to administer aid.

#### MICRO-PHASE 3: Deliberative Acts & The Evacuation Phase

Most video evidence and statements of those within the Tertiary Zone ends prior to the start of Micro-Phase 3. However, many people fled the area, apparently cognizant of the fact that additional IEDs could function.<sup>418</sup> Law enforcement officers head toward one of the two blast sites to provide aid. Based on the evidence available, it is difficult to tell the percentage of spectators who may have also frozen, gawked, or hid in the Tertiary Zone during Micro-Phase 3 and the Evacuation Phase.



## EVACUATED ZONE

### INITIALIZATION PHASE

The Evacuated Zone of the first bombing consists of the side streets and areas outside of the view of the bomb and further west on Boylston near the location of the second bomb and beyond. In these areas, spectators, runners, law enforcement, and volunteers are watching the race on Boylston, frequenting businesses in the area, and moving around in the Boston neighborhood of Back Bay. Because it is the day of the race, these areas, to varying degrees, were heavily trafficked and crowded.

### MICRO-PHASES 1-3 & THE EVACUATION PHASE

After the first IED functioned, CCTV video outside a restaurant where the second IED functioned showed spectators of the race and patrons of the restaurant turning in the direction of the explosion and watching, although some looked over their shoulders.<sup>419</sup> In the background, runners can be seen still moving toward the direction of the finish line. Eyewitness statements from the Evacuated Zone varied based on the individual's specific location in relation to the IEDs.

When the second IED functioned, those nearby in the Evacuated Zone of the first IED were still looking in the direction of the first explosion. Video evidence of this area demonstrated how a second event can reset and even escalate behaviors outside of the first device's Primary Zone. In available video evidence, as limited as it is, individuals near the second IED evacuate faster and more chaotically than those in similar locations after the first explosion.

In the Evacuated Zone of the first IED, at first there was little evidence that any individuals fled or felt unsafe. However, immediately after the second IED functioned, those close to that explosion reacted quickly and even those further away understood that their safety was at risk from additional explosions.<sup>420</sup> Although there appears to be no uniform response across different sections of the Evacuated Zone because of the wide variation in the environment and the amount of information about the explosion reaching people. These variations may partially be attributed to a person's distance from the IED and the level of information they have about what occurred.

## Appendix B-5.

# Brussels Bombings



### DATE



March 22, 2016

### CASUALTIES



32 dead



340 physically injured

### NUMBER OF IEDS



3

### SOFT TARGET TYPE(S)



Airport, Subway car

## Context

### Background

Just before 8:00 a.m. on Tuesday, March 22, 2016, Khalid el-Bakraoui, Najim Laachraoui, and Mohamed Abrini entered the departures terminal of the Zaventem International Airport, pushing luggage trolleys as they approached the check-in counters.<sup>421</sup> They remained in the check-in area, one of the few locations in the airport that is accessible without going through airport security. The first IED functioned at 7:58 a.m.; the next one functioned nine seconds later.<sup>422</sup> By 8:45 a.m., the Belgian government had raised the regional threat level and initiated a crisis response plan, including canceling all outgoing flights and re-routing incoming flights to other airports.<sup>423</sup> Shortly after, Ibrahim el-Bakraoui boarded the middle of a three-car subway train at the Maelbeek metro station. The IED he carried functioned at 9:10 a.m., as the train pulled away from the station. Following the news of the Maelbeek bombing Belgian authorities halted all public transportation. Schools were evacuated and office workers were told to shelter in place. Belgium quickly deployed soldiers to assist police and tightened border controls, and the EU raised its threat level to “orange.”<sup>424</sup> That afternoon, police began searches of the Molenbeek area to find the third airport bomber. The taxi driver who had driven the three airport bombers to Zaventem contacted the police and led them to the apartment where he had picked them up.<sup>425</sup> Police continued these searches for days following the attacks.<sup>426</sup>

### Perpetrator

The Brussels bombings involved four attackers: Ibrahim el-Bakraoui, Najim Laachraoui, and Mohammed Abrini targeted Zaventem Airport, and Khalid el-Bakraoui targeted the metro. Khalid and Ibrahim el-Bakraoui were brothers who were born and raised in Brussels. By the time of the 2016 attacks, both brothers had amassed significant criminal histories. In 2011, Khalid was convicted of criminal conspiracy, armed robbery, possession of stolen cars and possession of weapons; he served two to three years in prison before being paroled in 2013 or 2014. Ibrahim worked with his brother on at least one of these robberies. In 2010, while serving as the watch, he accidentally shot a police officer, a crime for which he was served four years in prison.<sup>427</sup> In 2015, Ibrahim el-Bakraoui was detained in Turkey near the Syrian border before being deported to the Netherlands with a warning from the Turkish government that he might have terrorist connections.<sup>428</sup>

Najim Laachraoui was an experienced bombmaker with known connections to the Paris attacks. Less than 24 hours before he attacked the airport, Belgian authorities issued a public notice calling for anyone with knowledge of him or his whereabouts to contact the authorities.<sup>429</sup> Laachraoui was a Belgian citizen who was born in Morocco but raised in Brussels. Investigators suspect that he learned how to make the IEDs used in the Paris and Brussels attacks during a 2013 trip to Syria.<sup>430</sup>

The third bomb was brought to the airport by Mohammed Abrini, an ISIS operative who had been involved in the 2015 Paris attacks. When his IED failed to function, Abrini fled the airport and quickly became Belgium’s most wanted fugitive. For two weeks following the attacks Abrini stayed in various hideouts before eventually being arrested on April 8, 2016.<sup>431</sup> Abrini and nine others are currently on trial in Brussels for their role in planning the attacks, including Salah Abdeslam.<sup>432</sup>

### Improvised Explosive Device

The bombs used in the Brussels attacks relied on TATP, also known as triacetone triperoxide. TATP is a highly explosive substance that was also used in the Paris attacks. Due to its instability and sensitivity to shock, friction, and heat, bombs that rely on TATP require much attention and care to manufacture. The strength of the explosions at the Zaventem airport indicates that the bombs included a large amount of TATP. However, these bombs could have been even more lethal: in the raids following the bombings, investigators found 30 pounds of TATP inside an apartment police believe was used to prepare the IEDs.<sup>433</sup> The IED used in the metro bombing was four times less powerful than the airport IEDs; still, given the confined space of the metro car, it was just as deadly.<sup>434</sup>

### Casualties

The explosions caused 32 deaths, plus the three suicide bombers (35 total). 340 people were physically injured in the bombings.<sup>435</sup> Even more were psychologically scarred by the events.<sup>436</sup> Due to the severity of injuries suffered by the wounded and the number of foreign citizens involved, it was difficult for the authorities to identify the dead and wounded.<sup>437</sup> People at Zaventem suffered injuries from the bombs, falling ceiling tiles, and other debris from the building that the explosions created.<sup>438</sup> Those injured at Maelbeek suffered severe burns and loss of limbs. Those who went to the hospital were treated for burns, deep lacerations, fractures, and other serious injuries.<sup>439</sup> Fifty-seven were still hospitalized two weeks after the attacks.<sup>440</sup>

## Behavioral Responses: Zaventem International Airport



### PRIMARY ZONE: ZAVENTEM INTERNATIONAL AIRPORT

#### INITIALIZATION PHASE

The bombings at the Zaventem International Airport occurred in the Departures terminal on the third floor of the airport, before the hallway to the security checkpoint. In the minutes leading up to the Zaventem bombings, the departures terminal was filled with people checking in to flights and getting ready to go through security. Just before 8:00 a.m., the three bombers entered the departure terminal spread out upon entering the terminal – one went to the right of the check-in area, one went to the left, and the third left his luggage trolley in the middle.<sup>441</sup> Some travelers report that they heard shouting in Arabic and the sound of gunfire, although others dispute this claim.<sup>442</sup> The first IED functioned at check-in row 11 at 7:58 a.m. near an American Airlines check-in counter. This explosion occurred in a semi-enclosed area of the departures hall that included two check-in rows and a desk. It was separated from the rest of the Departures Hall by a partial wall, which contained much of the blast radius to the area around the American Airlines counter. This semi-enclosed area constituted the Primary Concentric Zone. Most people in this zone were travelers, with some airline staff, airport security, and law enforcement in the area as well. Nine seconds later, the second bomb occurred down the hall by check-in row 2 in the Secondary Concentric Zone.

#### MICRO-PHASE 1: Impulsive Reactions

The first explosion blew out windows, brought down ceiling tiles, and left a fire burning in the middle of the floor.<sup>443</sup> The IED was powerful, causing severe injuries to those near it. Several people lost limbs, including a police officer. Others sustained serious burns. The size of the blast caused people in the Primary Zone to fall to the floor; others dropped to the floor instinctively to protect themselves. For a moment after the blast, it was silent in the Primary Zone. This silence was followed by screaming, groaning, and crying. Eyewitness accounts suggest that a larger than typical group of people hid following the explosion: some airline staff jumped into the luggage chutes, while others ducked below the check-in counters. This is likely due to the infrastructural damage caused by the bomb: even after the IED functioned, pieces of the ceiling and other building components continued to fall to the floor. Some people began to run, others instinctively hid. However, most people in the Primary Zone froze.

#### MICRO-PHASE 2: Behavioral Transitions

A few seconds after the explosion, many people began to register what was happening, and the degree of the damage wrought came into focus. Those who were not injured saw the victims near them who had lost limbs and the amount of blood on the ground. Some people remained in shock, frozen in place. At least one person in the Primary Zone was a photojournalist; as she transitioned to deliberative action, she began to take pictures of what was happening around her.<sup>444</sup> Others in the area started to help the wounded around them. The majority of people who were able to move ran away from the blast site towards the other end of the hall, unknowingly bringing them closer to where the second IED was about to function.<sup>445</sup> Those who sustained minor injuries began to move away from the blast site too. One person described it as a stampede.<sup>446</sup> Due to the severity of injuries caused by the blast, many of the wounded were unable to flee and remained on the floor, including a number of elderly people. Only seconds after the first IED functioned, however, the second blast occurred, resetting behaviors. By the time the second IED functioned, most of the people who remained in the Primary Zone were wounded, those who were helping the wounded, and those who were hiding. People once again froze.

#### MICRO-PHASE 3: Deliberative Acts

Those who had been hiding in the Primary Zone stayed where they were in case, yet another explosion occurred. At this point, very few people were entering the Primary Zone. It is likely that some people continued to flee the area, however, many of the people who remained were those who were too injured to evacuate. One person, who had grabbed a child near them and shielded them below a counter, passed the child to a police officer before evacuating.<sup>447</sup>

#### EVACUATION PHASE

After a few minutes had passed, all those who had been hiding began to evacuate or help those around them. Some airline staff helped to carry out some of the severely wounded individuals away from the blast site before first responders arrived to take over.<sup>448</sup> Civilian “helpers” and law enforcement helped to guide the walking wounded out of the airport and onto the tarmac where law enforcement was assembling people to await evacuation into the city.



## SECONDARY ZONE: ZAVENTEM INTERNATIONAL AIRPORT

### INITIALIZATION PHASE

The Secondary Concentric Zone encompassed the rest of the Departures Terminal on the third floor of the airport. This part of the terminal was a long hallway with a row of ten check-in counters for various airlines as well as a Starbucks and some other small shops. At 8:00 a.m., the Secondary Zone was crowded with the morning rush of travelers. The area was primarily filled with civilians, but there were also dozens of airline staff. There was also an airport security and law enforcement presence. The second IED functioned at check-in row 2, near a Brussels Airline counter and the Starbucks.

### MICRO-PHASE 1: Impulsive Reactions

The force of the explosion was blocked by a partial wall, creating confusion among people in the Secondary Zone about what had happened. Some knew instantly that it had been a bomb. Others saw or heard the explosion but thought it was something else – fireworks, construction, or a lithium battery exploding. Those who were close to the Primary Zone could see the devastation the blast had caused. Some who saw this hid behind the tables and counters near them in an effort to protect themselves from the falling debris in the Primary Zone. Some who were further down the hall hid as well, potentially fearing a second explosion. People fleeing the Primary Zone ran into the Secondary Zone and continued towards the opposite end of the terminal. Many people in the Secondary Zone reacted solely to the sound of the blast and instinctively began to run. Others froze from uncertainty or simply did not react because they believed the sound to be from something innocuous.

### MICRO-PHASE 2: Behavioral Transitions

As people from the Primary Zone ran through the Secondary Zone, awareness that something bad had happened spread among those who had not seen the explosion. People began to shout to “get down”, leading several to get low to the ground in case a second blast occurred. Others fled towards the exits. Tragically, many of the people running away from the Primary Zone only brought themselves closer to the blast radius of the second IED. Nine seconds after the first IED functioned, the second explosion occurred, resetting people’s behavior. The second explosion was even more powerful than the first, bringing down pieces of the ceilings and walls, shattering the windows nearby, and injuring a new wave of people. Like the first IED, this explosion caused several people to lose limbs and gave others serious burns. The force from the blast threw those near it through the air.<sup>449</sup> A white smoke hung in the air for several minutes following the blast making it difficult to see. Some who had been running were sprayed with shrapnel. People once again froze. Some who had been knocked to the ground during the blast remained there, afraid that to move in case there was another explosion.<sup>450</sup> Not knowing where was safe, many people tried to shield themselves from the falling debris by hiding. People used the check-in counters, tables, and suitcases as protection.

### MICRO-PHASE 3: Deliberative Acts

Seconds after the second IED functioned, people shifted once again from affective to rational decision-making. Many people continued to run, heading towards the emergency exits. However, the fear of another potential blast or of falling debris caused many to remain frozen in place, either on the ground or in their hiding place. Some called out asking if there were soldiers or police present, likely hoping that they could help them evacuate.<sup>451</sup> Video footage shows that some of the people who did leave their hiding places continued to crouch down as they moved toward an exit. At this point, the law enforcement and security personnel in the Secondary Zone began to direct people towards the exits. Some people described them as adding to the panic.<sup>452</sup>

### EVACUATION PHASE

People fleeing the Secondary Zone ran out of the airport in many different directions. Law enforcement and airport security began to direct people who remained in the Secondary Zone to exit the airport onto the tarmac, where busses would come pick them up and bring them into the city. At this point, paramedics and firemen rushed into the Departures Hall to provide immediate assistance to the wounded and help them evacuate.<sup>453</sup>



## TERTIARY ZONE: ZAVENTEM INTERNATIONAL AIRPORT

### INITIALIZATION PHASE

The Tertiary Zone encompassed hallway leading to the security checkpoint, the checkpoint itself, and gates beyond it, where travelers were able to hear the blast, but could not see it and faced no risk of injury. In the minutes leading up to the blast, this area was bustling with morning travelers making their way through security and to their gates. Airport security officers guided them through security, employees worked kiosks, and a few law enforcement officers patrolled the airport.

### MICRO-PHASE 1: Impulsive Reactions

One floor above the Departures Hall, passengers waiting at their gates heard a loud blast. People started looking around them and asking others if they knew what had happened. Those who knew what had happened told people near them that they should run.<sup>454</sup> Soon after the blast occurred, an announcement played over the airport speaker system directing passengers to evacuate.<sup>455</sup> Even with this announcement and the sound of sirens, many passengers who were far away from the Departures Hall did not seem alarmed.<sup>456</sup>

### MICRO-PHASE 2: Behavioral Transitions

Seconds after airport staff began instructing passengers to evacuate the airport, the second blast occurred. This blast occurred closer to the Tertiary Zone; thus, some passengers who were in or just past security could not only hear the explosion, but they could also feel it. Smoke from the explosion filtered through the hallway connecting the Secondary and Tertiary Zones.<sup>457</sup> Those near the Secondary Zone soon saw people crying and fleeing the blast and trying to get out of the airport, prompting some in the Tertiary Zone to run as well.<sup>458</sup>

Further away, panic began to spread as law enforcement officers ran through the terminal telling people there were bombs.<sup>459</sup> News of what had happened began to spread, and travelers told those near them that many had been hurt and they needed to leave.<sup>460</sup> People began to scream and run through the hallways.

### MICRO-PHASE 3: Deliberative Acts

People near the exit began to rush the doors, pushing to get out. Some eyewitnesses reported that some of the exits were only open for people with badges. Travelers tried to push through them to get out before being directed to a door that opened onto the tarmac, where officials had established an evacuation site.<sup>461</sup> Some people paused to help children and the elderly out of the building before exiting themselves.<sup>462</sup>

A long hallway led from the flight gates to the exit. As people filled the hallway, people were forced to slow down and walk towards the exit.

### EVACUATION PHASE

Airport officials directed passengers to leave their hand luggage and evacuate the building.<sup>463</sup> Video footage shows large groups of people walking together through the hallways of the airport towards the exit. While inside the hallway towards the exit, the group remained relatively calm and quiet. However, once this hallway opened up into a more open space, people began to run.<sup>464</sup>



## EVACUATED ZONE: ZAVENTEM INTERNATIONAL AIRPORT

### INITIALIZATION PHASE

The evacuated zone included the area outside the airport. While some people continued to flee the area once outside, many waited on the tarmacs or surrounding roads for vehicles to transport them away from the airport.

### MICRO-PHASES 1, 2, AND 3:

#### Impulsive Reactions, Behavioral Transitions, and Deliberative Acts

The second explosion blew out several of the windows of the Departures Terminal. People standing outside of the airport at the time heard the blast and saw the windows break before witnessing people from the Secondary Zone pushing to get out of the airport.<sup>465</sup>

Once people got outside, they continued to run. Video footage shows large groups of people running down both sides of the road at the Departures drop-off point.<sup>466</sup>

Police arrived on the scene around minutes after the attacks occurred, and quickly restricted access to the airport to allow emergency vehicles in.

### EVACUATION PHASE

Around two minutes after the IED functioned, the official evacuation of the Primary, Secondary, and Tertiary Zones began. Security officials directed individuals to areas surrounding the airport, where chartered buses would eventually come to pick them up and bring them to a Crisis Center. Evacuation efforts continued for hours after the attacks. Some decided to head out on their own, walking away from their airport until they reached a point where other transportation was available.<sup>467</sup> However, many people remained stranded at the airport until 5:00 p.m. that day.

While people waited for transportation, first responders and airline staff provided blankets to adults, and food and water to children.<sup>468</sup>

The psychological impact of the double attack continued to influence civilians' behavior during the evacuation phase. One airline passenger reported that once outside the airport, she stayed away from cars, fearing a car bomb.<sup>469</sup>

## Behavioral Responses: Maelbeek Metro Station



### PRIMARY ZONE: MAELBEEK METRO STATION

#### INITIALIZATION PHASE

In the hour following the attacks on the Zaventem airport, news of the bombings started to spread. At 8:45 a.m., the government had raised the regional threat level; by 9:03 a.m., it initiated a crisis response plan.<sup>470</sup> This response plan included closing down the metro for several hours; however, the news of this decision never reached the Brussels International Transport Company (STIB), the train management agency, and the trains continued to run.<sup>471</sup> Around this time, the Maelbeek metro station was filled with commuters. Some eyewitnesses reported being aware of these bombings. However, there is no evidence that knowledge of these prior attacks influenced the behavior of commuters. As commuters at Maelbeek boarded the arriving train headed towards Arts-Loi, Ibrahim el-Bakraoui moved from the third subway car to the second one. The train consisted of three cars; el-Bakraoui targeted the middle one. The walls of the train car confined the blast to the middle car, making it the Primary Zone. According to one estimate, there were approximately 70 people on the middle car of the train.<sup>472</sup>

#### MICRO-PHASES 1, 2, AND 3:

Impulsive Reactions, Behavioral Transitions, and Deliberative Acts

At 9:10, as a crowded subway train pulled away from Maelbeek Station, the IED strapped to Ibrahim el-Bakraoui functioned inside the middle car. The blast from the IED caused severe damage to the car and instantly killed 16 people. The metal frame of the train car ripped apart, and flames engulfed the inside of the car.<sup>473</sup> Photographs of the damage show wires coming down from the ceiling, seats and railings destroyed. Bodies were tangled together. Multiple people were on fire. Those who weren't killed started groaning and crying, including one mother who cried for her baby.<sup>474</sup>

Immediately following the blast, the conductor stopped the train. Due to the extent of damage done to the car itself and severity of injury to those inside, survivors of the blast had to wait for assistance before they could evacuate.

Quickly after the blast, the train conductor made his way to the Primary Zone to assist passengers. The conductor helped four people evacuate from the train car before first responders arrived to assist with evacuation.

#### EVACUATION PHASE

When first responders arrived on the scene, their first priority was to evacuate the Primary Zone and sweep the area to ensure there were no more bombs.<sup>475</sup>



## SECONDARY ZONE: MAELBEEK METRO STATION

### INITIALIZATION PHASE

The Secondary Zone included the two cars on in front of and behind the middle car where the blast occurred, as well as the platform at Maelbeek Station. At the time of the attack, these cars were filled with commuters on their way to work and some children. When the IED functioned, these commuters could hear the explosion and feel the train shake from the force of the blast. Because the cars were full of people, the view of the blast was blocked for most, although some reported seeing a bright flash of light outside their window when it occurred. The thick walls of the train cars protected people in the Secondary Zone from serious injury, although some may have sustained minor injuries from the train stopping. The train was close enough to the station that when the explosion occurred, those waiting on the platform at Maelbeek Station could hear and see the blast, feel the concussion, and were also exposed to flying debris.

### MICRO-PHASES 1, 2, AND 3: Impulsive Reactions, Behavioral Transitions, and Deliberative Acts

When the IED functioned at 9:10, the whole train shook and came to a sudden stop. Inside, the power went out and everything went dark. Then, smoke started coming through the windows of the front and back cars of the train. Passengers could feel the heat emanating from the blast. People in the train began to cry but were unable to evacuate. Some people had heard the news about the airport bombings that had occurred just one hour before and quickly understood that this was related.<sup>476</sup> In at least one of the two cars, the force of the explosion had caused all of the windows to go down, leaving them open. People inside the train cars could not open the doors, leaving them stuck inside, unable to evacuate. Still, for many, their instinct was to flee: one passenger described how his first thought was to get away as quickly as he could.<sup>477</sup>

The platform at Maelbeek Station was heavily damaged in the blast. It is unclear how people at the platform responded to the blast, however, available data suggest that several who were waiting were injured by flying debris.<sup>478</sup>

### EVACUATION PHASE

After a couple of minutes, someone approached one train car with a ladder and a light to help people evacuate out of the back of the train car. Some of the children cried as the passengers exited the train onto the dark train tracks. At least one person jumped over the people in front of them to try and get out faster. For the most part, however, people remained calm as they evacuated, and helped those around them exit the train. Passengers in the other train car could not get the doors open; instead, they had to crawl out of the train through the open windows. They described seeing burning debris as they evacuated. Once outside the train, passengers walked down the dark tunnel to the nearest metro station. From there, they evacuated to the Rue de la Loi where first responders were arriving to provide medical assistance.<sup>479</sup>



## TERTIARY ZONE: MAELBEEK METRO STATION

### INITIALIZATION PHASE

At the time the train carrying el-Bakraoui left Maelbeek Station, there were other trains on the tracks. These trains were far enough away from the Primary Zone to be in the Tertiary Zone. A second train was one stop behind the primary train, leaving Schuman Station in the direction of Arts-Loi. Meanwhile, a different train left Arts-Loi towards Maelbeek. The passengers on these trains could hear the explosion and feel the reverberation it caused but did not have a visual of what happened in the Primary Zone and were at no risk of injury from the explosion itself. Like those in the Secondary Zone (i.e., on the primary train), these passengers were forced to evacuate through the tunnel to the station closest to them. The Tertiary Zone included the other trains and the areas of Maelbeek Station beyond the platform, such as the stairwells and hallways leading outside.

### MICRO-PHASES 1, 2, AND 3:

Impulsive Reactions, Behavioral Transitions, and Deliberative Acts

When the IED functioned at 9:10, the other trains shook. The trains stopped, and the power went off, leaving the train cars in darkness. Most people went to the ground, unsure of what was happening, and many started to scream and cry. Shortly after the trains stopped, an announcement alerted passengers that something had happened and that the train would remain stopped. Many passengers remained on the ground for a minute or two, until it seemed like the danger had passed. One passenger described prying the car doors open with his hands to get out.<sup>480</sup>

People inside Maelbeek Station beyond the platform could hear the blast and feel the building shake. While a small amount remained frozen in place, most people immediately began to run towards the exits. After a couple of seconds, nearly everyone in the Station was fleeing.<sup>481</sup>

### EVACUATION PHASE

Like those in the Secondary Zone, passengers on the other trains had to walk along the train tracks through the darkness to get to a subway platform so they could evacuate. Those evacuating through Maelbeek Station had to walk through the damage the station had occurred: a thick smoke still hung in the air, and broken glass littered the floor.<sup>482</sup>

Once first responders had evacuated all of the wounded from the Primary Zone, they turned to evacuate Maelbeek Station.<sup>483</sup>

## EVACUATED ZONE: MAELBEEK METRO STATION



### INITIALIZATION PHASE

On the morning of the attack, crowds of people were waiting at the Maelbeek and Arts-Loi Stations for coming trains.<sup>484</sup> When the IED functioned, these people could hear the blast and feel the reverberations it caused. People evacuating the Primary, Secondary, and Tertiary Zones walked through the train tunnel to the Maelbeek or Arts-Loi Stations and out to the Rue de la Loi, the street above the station. The Rue de la Loi constituted the Evacuated Zone.

### MICRO-PHASES 1, 2, AND 3:

Impulsive Reactions, Behavioral Transitions, and Deliberative Acts

When the IED functioned, the reverberations from the blast could be felt on the street and in the buildings above the train tunnel. The tremors were strong enough that bricks began to fall from a wall at the Arts-Loi station. Photographs show smoke coming up through the subway station to the street above. Some people who had been on the street at the time of the explosion ran down into Maelbeek Station to try and help.<sup>485</sup>

### EVACUATION PHASE

Many of those who were not wounded in the blast evacuated through the Maelbeek or Arts-Loi Stations and continued running away from the blast site. Those who were wounded, however, began to congregate on the Rue de la Loi awaiting medical assistance. As the wounded staggered onto the street, civilians in the area stepped in to help as they could, offering some first aid and comfort.<sup>486</sup>

## Appendix B-6.

# Manchester Arena Bombing

### DATE



May 22, 2017

### CASUALTIES



22 dead



239 physically injured

### NUMBER OF IEDS



1

### SOFT TARGET TYPE(S)



Indoor concert arena



## Context

### Background

On May 22, 2017, Ariana Grande performed at Manchester Arena, which was filled with an estimated 19,500 people.<sup>487</sup> Minutes after she finished her final song, Salman Abedi initiated an IED hidden in his backpack in the public foyer outside the main hall (i.e., the City Room), which was full of 350 people, including event staff, exiting concertgoers, and family members waiting to pick up their loved ones from the show. Another 92 people were in the vicinity of the explosion. ISIS later claimed responsibility for the attack. Fearing that Abedi was part of larger network that had planned additional attacks, the British government raised the threat level to “critical” and deployed 900 soldiers to assist police through Operation Temperer.<sup>488</sup> The government maintained this threat level for the week following the attack. It was reduced to “severe” on Saturday, May 27th after no further plots were discovered, and troops were redeployed on Monday, May 30th.<sup>489</sup> The Manchester Arena bombing was the second major terrorist attack carried out in the UK in 2017. Earlier that year, Khalil Masood crashed his car into a crowd of citizens on the Westminster Bridge in London, and emerged brandishing knives, which he used to stab a police constable.<sup>490</sup>

### Perpetrator

Salman Abedi was a British citizen of Libyan descent who started showing signs of radicalization several years before he carried out the attack. He returned to Libya in 2011 to fight alongside his father in the Libyan Islamic Fighting Group (LIFG), which was working to oust the Qaddafi regime.<sup>491</sup> Following that visit, Abedi began to show increasing signs of radicalization. During a subsequent visit to Libya in 2015, Abedi connected with the ISIS unit that has been linked to the 2015 terror attacks in Paris—Katibat al-Battar al-Libi. Intelligence suggests that Abedi may have traveled to Syria during his final trip to Libya, from which he returned just one week before the Manchester attack. His sister later speculated that seeing the deaths of Syrian children from Western airstrikes motivated his decision to bomb the Ariana Grande concert, an event he likely knew would have an audience of mostly teenage girls.<sup>492</sup> Abedi began preparations for the attack as soon as he got home from Syria.

Abedi was known to law enforcement. In 2012, Abedi was arrested on minor theft and assault charges.<sup>493</sup> Later, community members reported him to police for suspected involvement in terrorist activities.<sup>494</sup> Reports indicate he never received services from PREVENT, the UK’s CVE program,<sup>495</sup> and was deemed by law enforcement to not pose a serious threat.<sup>496</sup>

Abedi died during the attack, but British law enforcement pursued close family members and others they suspected may have been involved in the planning. At least 17 people were eventually arrested in connection with the attack. Hashem Abedi was found “jointly responsible” for the attack, receiving a 55-year prison sentence for 22 counts of murder, attempted murder, and conspiracy to cause an explosion likely to endanger life.<sup>497</sup>

### Improvised Explosive Device

The IED Abedi carried closely resembled the bombs used in the November 2015 attacks in Paris and the March 2016 Brussels attacks, all of which used TATP (i.e., triacetone triperoxide).<sup>498</sup> Abedi used over 65 pounds<sup>499</sup> worth of nuts and screws as shrapnel, and packed the bomb inside a metal container, which he carried in a backpack. The IED was designed to inflict maximum damage,<sup>500</sup> constructed with a Yuasa 12-volt, 2.1-amp lead-acid battery that is more powerful than what is usually used in bombs of similar styles. The detonator was strapped to Abedi’s waist and appeared to have a small circuit board soldered inside one end.<sup>501</sup> Experts asked about the matter shared that the bomb Abedi built was relatively complex and would have been difficult for someone to correctly construct the first time around. It is likely that Abedi received some degree of assistance from ISIS, potentially that someone else even made the bomb and delivered it to him.<sup>502</sup>

### Casualties

Twenty-two people died as a result of the explosion, plus the bomber.<sup>503</sup> All of those who died were in the City Room when the IED functioned. An inquiry into these fatalities found that one of these deaths could potentially have been prevented with more timely medical assistance; the rest, however, suffered nonsurvivable injuries.<sup>504</sup> The blast physically injured an additional 239 people, 160 of whom went to the hospital. Of these, 87 were admitted, including 28 who required critical care. A large number of those injured were children.<sup>505</sup> Hundreds more suffered serious psychological injuries.

## Behavioral Responses



### PRIMARY ZONE

#### INITIALIZATION PHASE

The City Room of Manchester Arena constituted the Primary Zone of this attack. The City Room is part of the Victoria Exchange Complex, linking Victoria Station to Manchester Arena. While it is connected to the Arena, the City Room is an open space with public access. In the minutes before Salman Abedi detonated the bomb, attendees began to filter out of the Arena into the City Room. Parents, friends, and family members of concertgoers had gathered to wait for their loved ones to leave. Also in the City Room at the time were event staff and security. By the time Abedi initiated the IED at 10:28p.m., the foyer had filled with 350 people.<sup>506</sup> The people closest to Abedi were within six feet of him; dozens of others were within a few meters.<sup>507</sup>

#### MICRO-PHASE 1: Impulsive Reactions

In the immediate aftermath of the explosion, witnesses described a moment of calm, followed by loud screams.<sup>508</sup> The blast was very powerful – when the IED functioned, the force of it threw several people near Abedi in the air.<sup>509</sup> The explosion killed 22 people, plus the bomber, and caused serious injuries to many others in the foyer, including loss of limb and shrapnel wounds. Others were left with blurry vision. The heat and pressure from the explosion triggered an instinct among many in the blast radius to try and protect themselves from the explosion. Since there was nothing in the vicinity to hide behind or under, people curled up to hide their heads.<sup>510</sup> Witness accounts suggest that very few people fled in the first moments following the explosion, likely due to the severity of the explosion and the widespread injuries it caused. Instead, the dominant reaction was freezing.

#### MICRO-PHASE 2: Behavioral Transitions

A few seconds after the blast, individuals began to realize what had happened. For some, the recognition came from seeing the injured around them.<sup>511</sup> Panic spread among the crowd and the screaming continued. Hundreds had been hurt; many of the wounded were still in shock at this point, and only realized they were wounded when they looked down and saw their injuries.<sup>512</sup> At this stage, those who were able began to look for the friends and family members they had been with at the time of the explosion, including searching those who had been wounded and killed. Most of those who were able began to flee the area, seeking safety or medical assistance for shrapnel wounds. Parents carried injured children outside to get them to help. A few people began to help the wounded, tying tourniquets around wounds or just providing comfort. Many others were injured too severely to leave on their own and waited in the foyer for first responders or other civilians to help them evacuate.<sup>513</sup> Dominant behaviors included fleeing, gawking, and helping.

#### MICRO-PHASE 3: Deliberative Acts

By Microphase 3, many in the Primary Zone transitioned to helping those around them. Many of these helpers were event staff and others who were not connected to the injured around them.<sup>514</sup> Civilians began to use the materials around them to create tourniquets and provide basic first aid while awaiting the arrival of first responders.<sup>515</sup> People who were not wounded or had sustained minor injuries continued evacuating and helping their wounded loved ones evacuate. Severely wounded people remained on the ground waiting for medical assistance, including young children crying out for their parents.<sup>516</sup> People who had not yet connected with their friends and family continued to search for them or began calling them. One witness relayed that she called her mother to alert her in case there were bombs at other exits of the Arena.<sup>517</sup> Some parents ran from the foyer into the Arena to try and find their kids.<sup>518</sup> Within a minute of the attack, British Transport Police (BTP) officers and Northern rail employees at Victoria Station responded to the scene, joined shortly thereafter by additional BTP officers, an Emergency Training UK (ETUK) medic, a self-deployed North West Ambulance Service (NWAS) paramedic, as well as event staff.<sup>519</sup> All provided medical aid to the victims within their capabilities.<sup>520</sup> The most common behaviors at this point were fleeing and helping.



## PRIMARY ZONE

### EVACUATION PHASE

Many of the people in the City Room were there waiting for loved ones at the concert. As the evacuation phase began, many of them remained there to find their friends and family members who were evacuating from the Secondary and Tertiary Zones.<sup>521</sup> They stayed in the Primary Zone despite directives from first responders to evacuate. The severely injured remained on the floor, unable to move without medical assistance.<sup>522</sup> Others remained on the scene to provide first aid and reassurance to the wounded.<sup>523</sup> Concertgoers evacuating the Arena through the City Room passed through the blast area on their way out of the venue. Some of these individuals stopped to help the injured evacuate and provide first aid.<sup>524</sup> Others stopped in the City Room and looked for their friends and family among the wounded and killed.<sup>525</sup> Within seven minutes of the explosion, nine BTP officers had arrived in the City Room to assist casualties alongside event staff.<sup>526</sup> First responders from the NWS began to carry casualties out of the City Room into Victoria Station, where they had established a Casualty Clearing Station (i.e., the Tertiary Zone). During the evacuation phase, most individuals were fleeing, helping, or gawking.

## SECONDARY ZONE



### INITIALIZATION PHASE

The Secondary Zone was very small – it included only the hallways and exit areas leading into the Primary Zone, where individuals could see and hear the blast, but were unlikely to be injured from it.<sup>527</sup> In the minutes before the explosion occurred, people began leaving the concert, many of whom headed towards the City Room. When the IED functioned, an estimated 92 people were in the Secondary Zone.

### MICRO-PHASE 1: Impulsive Reactions

When the IED functioned, the hallways connected to the Primary Zone filled with smoke, and panic set in. Many people in the hallway heard the bang and instinctively began to run.<sup>528</sup> They spread in different directions, pushing and shoving each other to get to an exit faster.<sup>529</sup> Some who were close to an emergency exit were able to exit immediately. Others froze, unsure of what had happened or what to do.<sup>530</sup> The dominant behaviors during these phases were freezing and fleeing.

### MICRO-PHASES 2 AND 3: Behavioral Transitions and Deliberative Acts

As people transitioned to deliberative thinking, many people shifted their behaviors. People who had initially frozen looked around and started running towards available exits.<sup>531</sup> Some people fled to an emergency exit, while others ran towards the exit leading into the City Room. People who had been at the edges of the Tertiary Zone ran into the Secondary Zone. The Secondary Zone filled with people, most of whom tried to exit. The dominant behavior at this point was fleeing.

### EVACUATION PHASE

Concertgoers and staff fled the Arena and entered the corridors during the evacuation phase, rushing to reach the exits. Some people reported that it was only upon reaching the Secondary Zone that panic set in. Inside the Arena, staff had reassured people that everything was okay. In the corridor, people were shouting about a bomb. People began pushing and shoving each other to try and get to the exits faster.<sup>532</sup> Children and teenagers who had attended the concert were screaming as they tried to leave. Some parents were trying to carry their kids above the fray. Groups with people in wheelchairs pushed through the crowd.<sup>533</sup> Unlike the inside of the Arena, there was not a strong security presence in the Secondary Zone to help people find the exits or control the crowds.<sup>534</sup> The flow of people eased significantly as they reached the main staircase leading into the foyer, from which they began running in various directions towards different exits.<sup>535</sup> The size of the crowd in the Secondary Zone made it difficult for people to move within it; still, nearly everyone during this phase was fleeing.



## TERTIARY ZONE

### INITIALIZATION PHASE

The Arena itself and Victoria Station constitute the Tertiary Zone, as individuals in these areas had no clear visual of the explosion and no chance of being injured by the IED itself but could see some of the actions of the people in the Secondary Zone. The Tertiary Zone also included a hallway leading concertgoers directly from the Arena into Victoria Station. In the final minutes before the IED functioned, Ariana Grande finished her concert. As part of the finale, Grande released large pink balloons into the crowd. Fans began to fill the aisles waiting to leave the concert. At this point, however, most were still inside in the Arena. In Victoria Station, transport police and staff manned their stations.

### MICRO-PHASE 1: Impulsive Reactions

Inside the Arena, fans heard a loud blast, and the crowd grew quiet.<sup>536</sup> Without a clear visual, many concertgoers thought this sound was one of the pink balloons bursting.<sup>537</sup> Within a couple of seconds, however, fans near the top of the stairs began to see a cloud of smoke and hearing screams from the Primary and Secondary Zones.<sup>538</sup> The blast was also heard inside Victoria train station, which prompted a group of 15 Northern rail staff and 3 BTP officers to run from their posts to the foyer to help.<sup>539</sup> Inside the Arena, most experienced delayed reactions. In Victoria Station, the dominant behavior was helping.

### MICRO-PHASE 2: Behavioral Transitions

It took about 10 seconds after the bomb went off before people in the Arena started to register that something serious had happened.<sup>540</sup> At that point, concertgoers began to rush towards the exits and panic spread. Concertgoers screamed and pushed into the aisles trying to get to an exit, causing a stampede of people.<sup>541</sup> Others, seeing the aisles fill with people, began to climb over the rows of stairs to get to an exit faster.<sup>542</sup> People did not know where to go. While this led most to run towards the closest exit, many people stood in place, unsure of what to do.<sup>543</sup> This was especially true of the people closest to the stage, although it's unclear if that occurred because they froze or decided to wait until the aisles cleared. At this phase, the most common behaviors were fleeing and freezing.

### MICRO-PHASE 3: Deliberative Acts

As fans continued to push for the exits, the crush of people grew stronger. Some concertgoers high up in the stands climbed over the railing and jumped on top of people in the center aisles in an effort to get out.<sup>544</sup> Many parents were separated from their children as the crowds of people pushed towards the exits. Some of them refused to leave until they were reunited with their children.<sup>545</sup> Fans in wheelchairs were stuck as crowds swarmed around them.<sup>546</sup> With the stairs crowded with people, they had to wait until event staff were able to help them leave the building.<sup>547</sup> People were screaming and shouting as they tried to exit.<sup>548</sup> Event staff began to help facilitate evacuation. Staff members used their bodies to block the exits that led directly into the foyer. Other staff stood inside the Arena directing people to leave.<sup>549</sup> Over the PA, one staff member made repeated calls asking people to leave slowly and calmly.<sup>550</sup> As most people were trying to get out of the Arena, some parents rushed inside to look for their kids.<sup>551</sup> Some people remained frozen in place inside the Arena. People in the Tertiary Zone who had started evacuating fled into the Secondary Zone, or the hallway between the Arena and Victoria Station. By this point, the dominant behaviors by concertgoers and staff were fleeing, freezing, and helping.



## TERTIARY ZONE

### EVACUATION PHASE

Most concertgoers continued to push towards the exits to leave the Arena. However, some who were closest to the stage continued to stand there and wait, even as event staff urged them to leave.<sup>552</sup> Armed police officers entered the Arena during this phase to assist with evacuation and relieve event staff.<sup>553</sup> Although no one in the Arena sustained injuries during the blast, some concertgoers were injured during the evacuation or were unable to leave on their own for other reasons, such as one girl who suffered an asthma attack while trying to evacuate; her mother kicked down a security barrier to get her to an officer who carried her out.<sup>554</sup> Many of the fans in attendance were young girls who were easily swept into the crowds. In the stampede of people, people climbed on top of each other.<sup>555</sup> In addition to directing the flow of traffic, some officers provided assistance and helped carry people out.<sup>556</sup> Some people who had evacuated through the hallway into Victoria Station stood at the bottom of the steps waiting for others in their group. Most, however, continued to run once they reached the Station. First responders from the NWS established a Casualty Clearing Station within Victoria Station, where they brought casualties from the Primary Zone to prepare them for transport to local hospitals. As fans left the Arena, staff members began to leave as well. By 11:00 p.m., all non-injured concertgoers and staff had evacuated.<sup>557</sup>

## EVACUATED ZONE

### INITIALIZATION PHASE

The Evacuated Zone encompassed the car park and streets surrounding the Arena.

### EVACUATION PHASE

People rushed out of the Arena onto the sidewalks surrounding the building. The arriving police officers told people to keep running away from the Arena and Victoria Station.<sup>558</sup> Some people who had driven to the concert rushed to the car park to get to their vehicles and drive away. Officers quickly established a police cordon to block off the site and prevent people in the area from approaching the Arena.<sup>559</sup> This cordon also kept cars from leaving the car park. Although they encouraged people to get away from the Arena, many remained outside waiting to be reunited with friends and family.<sup>560</sup> One eyewitness estimated there may have been “hundreds” of people congregated outside.<sup>561</sup> Some of the wounded who were able to make it outside the Arena laid on the grass waiting for medical assistance.<sup>562</sup>

Thirty-eight minutes after the attack, ambulances pulled up to the Arena to begin evacuating the injured.<sup>563</sup> People in the area reported hearing the sirens and an automated message warning that something had happened.<sup>564</sup>

Individuals and businesses in the neighborhood opened their doors to help those fleeing the concert.<sup>565</sup> Within two hours of the explosion, the hashtag “#RoomforManchester” began trending, offering concertgoers stranded by the halt on public transportation a place to stay.<sup>566</sup>

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