# Transcendental Terrorism And Dirty Bombs: Radiological Weapons Threat Revisited

by

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## Disclaimer

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# Contents

## ABSTRACT

This paper analyzes the potential for terrorists to employ radiological weapons against the United States and makes recommendations for countering the gaps in security that terrorists will exploit while embarking on such an endeavor. The paper's primary hypothesis is that radiological dispersion devices, contrary to popular contemporary analysis, possess extreme lethal potential. When combined with the prevalent trend for terrorists to maximize the death and destruction associated with their attacks, radiological dispersion devices, unlike other weapons of mass destruction, offer a unique opportunity as radioactive material is readily available and requires unsophisticated technology and knowledge to weaponize.

A fictional scenario backed by calculations is used to demonstrate the lethal potential of a series of covert attacks employing radiological weapons. The paper analyzes the motivations for why terrorists are willing to use weapons of mass destruction and why radiological weapons are a more likely candidate for employment over nuclear, biological, and chemical weapons. Additionally, the relative ease with which radiological weapons of this nature can be fabricated and the ready availability of appropriate radioactive sources is explained.

Finally, the paper concludes that securing the life cycle of radioactive sources through legislation, regulation, and international agreements is the best method for preventing terrorists access to those radioactive sources which are most dangerous and capable of weaponization. However, the paper also concludes that any legislative, regulatory, or agreement based solution will not protect the public in the near term and a nationwide system of radiation detectors is proposed as a possible solution for interdicting radiological weapons before they reach their targeted destination.

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# Chapter 1
# Introduction

Radiological weapons provide a low cost and low technology alternative for terrorist organizations seeking to inflict damage beyond the current capabilities and limitations of conventional explosives but who lack the resources to fabricate or obtain a true weapon of mass destruction. Radioactive sources are readily available and do not require sophisticated or expensive delivery vehicles to achieve effectiveness. Even a poorly planned and executed radiological attack could achieve devastating economic[1] and psychological impact,[2] and a great deal of literature addresses these issues. However, radiological weapons are typically misrepresented as lacking a lethal component[3] due to the unimaginative assumption that radiological weapons must take the form of a dirty bomb, or radioactive material spread through the use of conventional explosives.

While there is relevance in speculating terrorists may employ a dirty bomb primarily to inspire terror and inflict economic damage to disrupt the United State's economy,[4] there is a competing and growing trend among terrorist organizations to maximize the carnage and bloodshed associated with their attacks.[5] These terrorists have transcended the need to connect their acts of terror directly with a political demand. Resultantly, their acts of terror are more commonly brought to a violent conclusion without an offer for negotiation.

This paper will demonstrate that properly employed, radiological weapons can posses an awful potential for lethality which can certainly achieve death tolls on a par with those observed during the 9/11 attacks. Employing such weapons will enable terrorists to achieve both devastating economic as well as human destruction. Following this demonstration, recommendations for countering such radiological weapons are offered.

In order to provide an understanding for the lethal potential of radiological weapons, the following fictional scenario is presented.

## Attack of al-Ameen[6]

We present this narrative to the President of the United States, the United States Congress, and the American people for their consideration. The attacks that occurred between 8 September and 18 September 2006, now commonly known as the Attack of al-Ameen (the faithful), produced shock and suffering on a scale never before witnessed on United States soil. The primary question posed to this commission was, 'How, in a post 9/11 world, with all the advancements in intelligence collection and dissemination, was our nation so unprepared to meet and defeat this challenge?' In order to answer this question, we begin with providing the fullest possible account of the events surrounding the attacks.

### Khalid al-Khalil

Egyptian born Khalid al-Khalil, the ring leader for al-Ameen, emigrated from Egypt to Algeria with his family in 1989. Shortly after his arrival in Algeria, political and social turmoil sponsored by the Armed Islamic Group engulfed Algeria and polarized the nation along secular Islamic versus radical Islamic lines.[7] Unemployment and other socioeconomic factors caused many young disenfranchised men to join the Armed Islamic Group, which sought the violent overthrow of the Algerian Government. Khalid al-Khalil was recruited into the Armed Islamic Group in his early adolescence by his two older brothers and quickly gained an education in extremism and in perpetuating violence to achieve political ends. However, the son of an intellectual and perhaps the smartest of his fellow siblings, he quickly became disenchanted with the limited goals and the uncoordinated efforts of the Armed Islamic Group.

In 1996 he traveled to Afghanistan to meet his ideological hero, al-Zawahiri. Al-Zawahiri, recognizing Khalid al-Khalil's intellectual and charismatic potential, encouraged him to both remain connected to the Armed Islamic Group while simultaneously seeking a western education. Al-Zawahiri emphasized that Khalid al-Khalil's present and future affiliation with the Armed Islamic Group did not necessarily need to be a limiting or constricting factor for his future connections and endeavors.

**Al-Ameen**

Khalid al-Khalil returned to Algeria in 1997, reconnected with the Armed Islamic Group, and quickly applied to several western universities. He was accepted to the University of Texas and received a full academic scholarship under a foreign student program. A gifted and dedicated student, he completed his undergraduate studies in physics in just three years and was admitted into a graduate level program in 2001 and received funding through the university's student loan, financial aid, and teacher's assistant programs.

In his first year at university, Khalid al-Khalil founded a study group for foreign Muslim students. Initially drawn to the study group by the need for tutored assistance and language translation, most members eventually found Khalid al-Khalil's charisma undeniable and continued attending the study group well beyond their academic needs. Khalid al-Khalil, appealing to a common Muslim identity, subtlety transformed the group meetings from strictly academic in nature to a mixture of academics combined with fundamentalist Islamic teachings. Through open discourse, he was able to identify those Muslims who were more predisposed to radical Islam either by their religious or cultural background. These Muslims he recruited into an inner circle he called his al-Ameen where the teachings of radical Islam were openly discussed.

Throughout this time period, Khalid al-Khalil maintained sporadic contact via courier, letter, and email with both al-Zawahiri and his Armed Islamic Group leadership. Inspired by messages from al-Zawahiri and the actions of al-Qaeda, Khalid al-Khalil began to formulate his own plans for terrorist attacks originating on United States soil using radiological weapons. Al-Zawahiri provided support, guidance, and inspirational leadership to both Khalid al-Khalil as well as the Armed Islamic Group and approved of Khalid al-Khalil's plan in principle.

In June of 2001, al-Zawahiri, anticipating the logical second order effects of al-Qaeda's future planned operations against the World Trade Center, diversified al-Qaeda's financial holdings in order to prevent them from being completely frozen or seized. Part of this diversification plan involved distributing significant portions of al-Qaeda funds to other radical Islamic organizations.[8] Among these, the Armed Islamic Group received significant funding with the stipulation that Khalid al-Khalil's plans in the United States reach fruition.

**Getting Connected**

With financial backing secured, Khalid al-Khalil began his planning in earnest. Over the summer of 2001 he utilized his links with al-Qaeda to make contact with radical Chechen Islamic leaders[9] and described his desires to obtain radioactive sources[10] from former Soviet Union defense installations or from corrupt Russian or Commonwealth Independent State officials. Concurrently in July of 2001, Khalid al-Khalil started monthly trips to Los Angeles, where he repeatedly attempted to make contact with influential gang or organized crime leadership in an effort to obtain radioactive sources from within United States borders. On his second trip to Los Angeles in August of 2001, he successfully made contact with street level representatives of the Mara Salvatrucha gang and began negotiations for meetings with the gang's local leadership.

Not part of al-Qaeda's inner circle, the attacks of 9/11 caught Khalid al-Khalil by surprise. Fearing that raised security awareness and new security measures would soon make it impossible to obtain the materials he needed for his radiological weapons, Khalid al-Khalil redoubled his efforts for procurement. In October of 2001, Khalid al-Khalil traveled to Grozny, where he met with leaders of the radical Chechen Islamic rebels. Following two weeks of negotiation and a $100,000 initial outlay to defray Chechen expenses, he was able to convey his exact needs and obtain a commitment. Khalid al-Khalil returned to the United States on 8 November and immediately began semi-monthly trips to Los Angeles. In February of 2002, on his ninth trip to Los Angeles, he finally worked through lower level functionaries of the Mara Salvatrucha gang and, for a confidence payment of $50,000, achieved an audience with Mara Salvatrucha gang leaders. During this meeting, Khalid al-Khalil agreed to pay all expenses necessary to locate and obtain a radioactive source meeting his specifications and detailed several locations where such a source might be found.

With regular progress reports now flowing in from Chechen and Mara Salvatrucha contacts, Khalid al-Khalil turned his attention to recruitment. Calling on his closest friends from his al-Ameen, he appealed to their religious zeal and recruited Mu'ammar al-Nadir, Yazid al-Tayyib, and Aban al-Abbas. Directing them to specific cities around the United States, he instructed his recruits to seek employment at public facilities and stressed the importance of infiltrating large entertainment industrial complexes such as stadiums and concert halls. To offset expenses, Khalid al-Khalil paid each recruit $20,000 annually and required they keep him informed of all job offers. However, Khalid al-Khalil kept his specific plans a secret and only told his recruits their day of jihad would soon come.

By May of 2002, Khalid al-Khalil was increasingly concerned with the slow progress of the Chechen and Mara Salvatrucha networks in locating appropriate radioactive sources. Utilizing information gleaned from university physics department documents, he initiated efforts to obtain radioactive source material legally. In June of 2002, he applied for and obtained a small business license under the company name of Steris Isomedix Inc. In August of 2002, using this business license, he applied for and received a General License to hold and use radioactive material directly from the state of Texas, an Agreement State with the Nuclear Regulatory Commission (NRC).

Although a General License legally allowed Khalid al-Khalil access to only minor amounts of radioactive material, current international agreements allow foreign distributors to ship radioactive sources, regardless of their size and strength, direct to General License holders and do not require notification of host nation officials or host nation regulatory agencies.[11] In September of 2003, Khalid al-Khalil purchased 50 grams, or 55,000 curies, of cobalt-60 from the Canadian firm MDS Nordion. Although it is their normal practice to verify the legitimacy of new customers, and despite the fact that they had never shipped to a Texas address before, MDS Nordion was unconcerned with this particular transaction, as they assumed they were doing business with Steris Isomedix Services Inc., a medical firm with which they regularly conducted business.[12] On 22 September 2003, MDS Nordion shipped the cobalt-60 material to Khalid al-Khalil by rail. Khalid al-Khalil took custody of the shipment on 28 September.

After several failed attempts to obtain powerful gamma emitting radioactive sources, the Chechen rebels contacted Khalid al-Khalil and informed him they had instead located a 300,000 curie source of strontium-90 at an abandoned nuclear powered lighthouse along the Russian northern coastline. Khalid al-Khalil considered the strontium-90 source acceptable and subsidized the Chechen rebels an additional $100,000 to obtain and ship the radioactive source. Concurrently, the Mara Salvatrucha reported they had located an abandoned food irradiator at a recently bankrupt and deserted private contracting firm located in Mexico City.

On 15 October 2003, the Chechen Islamic rebels shipped the radioactive source through an international commercial shipping currier. On 15 November 2003, the shipping container passed through customs at Charleston Port Authority, Charleston South Carolina and was shipped by rail to Austin, Texas, where Khalid al-Khalil took possession on 11 December 2003.

In October of 2003, the Mara Salvatrucha located an unemployed technician who had formerly worked at the now bankrupt food irradiation complex and offered $1,000 for his assistance in removing the radioactive source material from the abandoned building. On 23 October, the Mara Salvatrucha broke into the complex and, with the aid of the technician, removed the source material along with its intrinsic shielding. The source material was placed in the trunk of a car and driven across the Mexico-Texas border. The 200,000 curies of cesium-137 were delivered to Khalid al-Khalil on 26 October 2003.

Throughout 2004, the recruits of al-Ameen applied for numerous jobs in their respective cities. However, only one of the recruits was successful in obtaining work at an entertainment complex. Eager to proceed, Khalid al-Khalil directed his remaining recruits to take positions that had been offered within the transportation and food preparation industries.

With the employment situation stabilized, Khalid al-Khalil finalized his attack plans, based on the opportunities generated by the special access afforded to each recruit. By June of 2005 the planning was complete, and Khalid al-Khalil spent the remainder of the year moving the required radioactive material by car to or near each of the target cities and storing it in rented self storage units. Only Khalid al-Khalil knew the location of each radioactive source. In fact, at this time, none of his recruits knew the planned attacks would involve radioactive material or even that the radioactive material had been pre-positioned to support the attack. With all the elements in place, Khalid al-Khalil sat back and waited for events to align.

**Cementing Plans**

The 2006 football season provided the perfect nexus of opportunity for Khalid al-Khalil and his al-Ameen. Following a dismal 4-12 season in 2005, the Green Bay Packers sought to lower their salary cap burden by releasing veteran quarterback Brett Favre to free agency. In contrast, the Cleveland Browns spent considerable money in the 2005 to 2006 off season recruiting an all star offensive line and, in a shrewd round of negotiations, traded first, second, and third round draft picks to the Houston Texans in order to obtain the number one first round draft position. For their first pick, they planned to select Heismann Trophy winner and former USC running back Reggie Bush, who announced he was leaving college football one year early and was eligible for the draft.[13] Cleveland determined they needed a veteran quarterback to cement a solid running game and jumped at the opportunity to sign Brett Favre. With Favre closing out the 2005 football season at 53,615 yards in passing, he had quietly surpassed John Elway to become the all time second ranked quarterback for total yards passing behind Dan Marino.[14] Proud of their off season acquisitions, confident they would make a bid for the AFC North Division Championship, eager to fuel the recent resurgence of fan support sparked by local radio and television programming, and with Favre’s historic achievement left uncelebrated by the Green Bay Packer organization during the 2005 regular season, the Cleveland Browns organization planned a gala celebration during game two of the 2006 regular season in honor of Favre’s career achievements.

It was this event around which Khalid al-Khalil planned his attacks. In June of 2006, he left the University of Texas and spent the next several months traveling to each of the target cities. He used this time to spiritually prepare his recruits, reconnoiter the target sites, and prepare the radioactive sources as weapons.

**Attack on the Washington State Ferry System**

In early September of 2006, Khalid al-Khalil traveled to Boston, where his close friend and recruit, Mu'ammar al-Nadir, was living and now worked for Amtrack's Acela Express. On 8 September 2006, Khalid al-Khalil and Mu'ammar al-Nadir traveled together from Boston to Seattle, where Khalid al-Khalil revealed to Mu'ammar al-Nadir for the first time the full scope of his plans. Mu'ammar al-Nadir would travel with Khalid al-Khalil and provide assistance and security throughout the campaign of planned attacks. Together they collected the cobalt-60 sources Khalid al-Khalil had prepared and stored in the self storage unit and transported them by rented van to the downtown Seattle ferry terminal. Riding the ferry system several times over the next few days, the two men carried the sources from the van to the passenger sections of the ferry in a shielded apparatus. Finding an empty section of the ferry, the two men secretly attached the radioactive sources to the underside of chairs.

Khalid al-Khalil and Mu'ammar al-Nadir placed 250 sources on each of Seattle's largest ferries, the Tacoma, Puyallup, and Wenatchee. In order to delay discovery of the harmful radioactive sources, the cobalt-60 source strength was chosen such that an individual would receive a lethal dose only after riding the ferry twice and in one of the affected chairs.

**Attack on the Acela Express**

On 10 September, Khalid al-Khalil and Mu'ammar al-Nadir returned to Boston. On 11 September the two men retrieved the cobalt-60 sources Khalid al-Khalil had pre-positioned in Boston. Using Mu'ammar al-Nadir's access to secured areas of Amtrack, the two men boarded an Acela Express train in the early morning hours prior to the train's first commute from Boston to New York City. Making a small incision in the fabric, the two men placed radioactive sources inside 75 of the business class chairs. Each source was designed to deliver a lethal dose of radiation to the occupant during the 3½ hour commute to New York City.

**Attack on Hartsfield-Jackson Atlanta International Airport**

On 12 September, Khalid al-Khalil and Mu'ammar al-Nadir flew from Boston to Atlanta. Here the two men picked up a suitcase containing two fifty foot long strips of ¼ inch wide vinyl veneer molding with an adhesive backing. Along the adhesive strip, Khalid al-Khalil had placed particulate cesium-137. The two vinyl strips were rolled up and stored inside of a single 8 mm film canister. This film canister was placed underneath eight other film canisters filled with lead for shielding. Six more film canisters containing actual film were placed on top of these canisters as a diversion for security personnel. The two men smuggled the radioactive material through Hartsfield-Jackson Atlanta International Airport security without incident. Posing as maintenance technicians, the two men attached the adhesive strips into the overhead, on opposing sides, and along the length of a single train car servicing the four terminals. The two strips contained sufficient cesium-137 to deliver a lethal dose to passengers who rode the train for approximately seven minutes or the equivalent of traveling at least three of the four terminals.

**Attack on Browns Stadium**

From Atlanta Khalid al-Khalil and Mu'ammar al-Nadir traveled to Cleveland, where they met with Yazid al-Tayyib, who had been working on the maintenance staff for Cleveland Browns Stadium. The three men rested until Saturday, 16 September. By this time several thousand victims had been unknowingly exposed to lethal amounts of radiation either in Seattle, Boston, or Atlanta. Most had suffered violent nausea for two to three days but had assumed they were symptomatic of the flu or food poisoning. Few sought medical attention, and those who did were prescribed medications for their flu-like symptoms and were released.

With Brett Favre appearing in his first home game at Cleveland Browns Stadium, the Browns organization had organized a five-minute ceremony to take place during the game two halftime show. Brett Favre would be personally congratulated by John Elway, a short film documenting Favre's achievements would be played on the stadiums two video screens, and a short pyrotechnics display designed to shower the entire stadium with shooting flares, streamers, and confetti would conclude the ceremony.

On the evening of 16 September, Khalid al-Khalil, Mu'ammar al-Nadir, and Yazid al-Tayyib gained access to Browns Stadium and packed particulate cesium-137 into 16 of the 40 pyrotechnics packages designed to distribute confetti and streamers throughout the stadium. On the morning of 17 September, the three men traveled to Orlando. Here they met with Aban al-Abbas, who had been working for the Orange County Public School District at a centralized kitchen responsible for preparing approximately 3,400 meals daily and distributing them to 20 of Orlando's 196 elementary, middle, and high schools.

On 17 September, the halftime show was executed as planned. Cesium-137 showered down over a packed stadium. Thousands of victims began showing symptoms of radiation sickness shortly after the completion of the football game, and local health officials were overwhelmed. On 18 September, representatives from the Center for Disease Control in Atlanta traveled to Cleveland and diagnosed the symptoms as radiation sickness. The Federal Bureau of Investigation was notified. Believing only a single attack had occurred, a 48-hour moratorium was placed on notifying the press to facilitate the initial portions of the investigation.

**Attack on Orlando School Systems**

In Orlando, Khalid al-Khalil obtained the strontium-90 he had stored in the city. The strontium-90 had been ground into a fine powder. Khalid al-Khalil gave the strontium-90 to Aban al-Abbas, instructing him to mix 0.15 grams per serving into the dessert item for the next day. On 18 September, Aban al-Abbas placed 486 grams of strontium-90 into the 3,400 servings of chocolate pudding destined for distribution throughout the Orlando School District. Students consumed an estimated 3,300 of the 3,400 servings.

**Capture of Yazid al-Tayyib**

With the dose rate of the strontium-90 laced pudding selected to deliver a lethal dose over a ten-day period, Khalid al-Khalil and his co-conspirators were primed to leave the country. The four men checked in individually to four separate flights destined for different locations in Europe. Only Yazid al-Tayyib was flagged in the Computer Assisted Passenger Prescreening System (CAPPS), as he was wanted for questioning by the FBI when he did not appear for work at Browns Stadium on 17 September. Khalid al-Khalil, Mu'ammar al-Nadir, and Aban al-Abbas all made it safely to their European destinations before the FBI had a chance to secure detailed information from Yazid al-Tayyib.

By 19 September, federal authorities had learned enough information from Yazid al-Tayyib and from Khalid al-Khalil's confiscated computer to commence investigations for unsecured radioactive sources in Orlando, Atlanta, Boston, and Seattle. A press release revealed what federal authorities knew about the attacks, and the transportation, entertainment, and food industries came to a screeching halt as routes and events were cancelled and consumers refused to purchase or consume food from sources they did not trust.

**Casualty Estimate**

Estimates for the total economic impact of these terrorist attacks is still underway but is already approximated to be in the hundreds of billions of dollars. Estimates for the total number of people potentially exposed to harmful doses of radiation based on statistical analysis, observed mortality rates, and total validated cases presented to health care providers suggest some 24,000 people were exposed to harmful doses of radiation. Quick mobilization of medical resources prevented local health care providers in Cleveland, Atlanta, Boston, New York City, Washington D.C., and Seattle from being completely overwhelmed by the massive amount of "worried well" citizens who presented themselves to health officials. However, the hysteria these attacks spawned greatly increased the difficulty of public health officials who were trying to properly triage victims. Some victims who required medical attention were dismissed, as they were asymptomatic at the time of observation and lacked a credible coherent connection to one of the distributed radioactive sources. Of the estimated 24,000 victims irradiated with lethal doses of radiation, initial figures suggest 50% achieved mortality.

# Chapter 2
# Scenario Analysis

The scenario presented in the previous section paints a grim picture for what a committed group of terrorists might accomplish. However, the scenario does not answer the key and critical question: is such an attack plausible? To answer this question we must examine four fundamental aspects: 1) Do terrorists posses the will to attack the United States with the intent of producing mass casualties? 2) Do terrorists posses the organizational capacity and technical knowledge required to plan and execute such an attack? 3) Do radioactive materials exist in sufficient quantities to produce the desired results, and what is the likelihood of terrorists obtaining these materials? 4) And lastly, are the casualty figures presented in the scenario realistic and achievable? This section will answer these questions.

**The Will to Kill**

Do terrorists posses the will to attack the United States with the intent of producing mass casualties? The simple answer to this question is yes, and to look no further than al-Qaeda for supporting evidence. However, this is an unsatisfying answer, as not all terrorist organizations are al-Qaeda and therefore may have different motives and objectives. To answer this question more fully, we must understand the origins and trends of modern terrorism, the motives for terrorist acts, and their desired objectives.

Acts of terror are rife throughout history, and this paper does not suggest that terrorism is a new invention. However, the roots of modern terrorism can be traced back to the 6 September 1970 hijacking of four jet airliners by the Popular Front for the Liberation of Palestine (PFLP).[15] Prior to this event, acts of terrorism were sporadic, sparse, unorganized, and were relatively non-lethal.[16] After 1970, terrorist attacks took on a new flavor. Increasingly dominated by Palestinians or Islamic groups inspired by or identifying with the Palestinian cause, terrorist attacks steadily became more regular, organized, and lethal.[17]

Examining how this change in terrorism occurred reveals insight into the motivation and political objectives of terrorists.

The 6 September hijacking was designed from the beginning to be a media spectacle.[18] The PFLP hoped to interrupt peace negotiations between Egypt, Jordan, and Israel and draw international attention to the plight of Palestinians.[19] Journalists from across the globe were invited to a deserted airstrip in Zerqa, Jordan, where the hijacked jets were forced to land. Recognizing that bloodshed would not garner international support for their cause, the PFLP ensured none of their hostages were harmed while they awaited Western nations to meet their meager demands. The images spread on the nightly news and on the front covers of news magazines captivated the world[20] and, for a short period of time, earned the PFLP recognition for their struggle.

However, the hijacking escalated tensions between Jordan and the Palestinians encamped on Jordanian soil.[21] Open fighting between the Jordanian military and the Palestinians eventually erupted and resulted in the death of thousands of Palestinians and the expulsion of their political and militant leadership from Jordan.[22] Known as Black September, this bloody expulsion from Jordan hardened the resolve of militant Palestinians, who were now forced to fight further for their security and national identity in Lebanon.[23] Hardened, bloodied, and jaded by conflict, Palestinians were no longer willing to take hostages and leave them unharmed. Subsequently, Palestinian terrorist attacks inspired by Black September steadily became more lethal.[24] Over the intervening decades between Black September and the present, terrorist demands steadily became less specific, more far reaching, and in some cases non-existent, indicating their true goal was no longer to garner international support but instead to inspire a level of fear and public outcry that would enable them to engage successfully in power politics.[25]

Additionally, as their political demands became more far reaching, terrorists grew to expect less immediate results from their actions. With the lack of a direct cause and effect connection between terrorist acts and any tangible results, the act of terrorism itself began to take on its own meaning and purpose.[26] Termed "Transcendental Terrorism," this newly evolved brand of terrorism values the act of terrorism itself for its religious and political significance.[27] With this transformation, the only motive terrorists require is the desire to create an event of religious or political significance. The only direct, immediate or tangible objective, political or otherwise, that terrorists expect to achieve is recognition.

This change in terrorist philosophy created a number of second and third order effects. First, no longer restrained in preventing bloodshed in order to garner international support for their cause or immediate demands, terrorists are now free to commit horrific acts.[28] Second, shifting the objective of terrorist acts from direct political outcomes to one of recognition requires terrorists to tailor their attacks to ensure the greatest amount of media coverage for the longest period of time.[29] Third, the struggle for mass media recognition places terrorist organizations in direct competition with one another. The convergence of these three effects creates an environment where terrorists must produce bigger and bloodier spectacles in order to assure they achieve the media recognition they desire[30]. While opponents may rightfully point to recent evidence that massive terrorist attacks are in fact designed to disrupt or damage the economy or to achieve a specific and immediate political objective, the historical evidence is clear and more telling. The means to achieve these ends have steadily become more lethal, bloody, and gruesome. This trend is expected to continue into the future.[31]

**Capability of the Terrorist**

Do terrorists posses the organizational capacity and technical knowledge required to plan and execute such an attack? Information necessary to understand the propagation of radiation and the physiological effects on the human body can all be easily found on the internet, and, while a background in math or physics is helpful, it is not necessary. A first year science or engineering major of any discipline could easily put together the required calculations contained in Appendix A in order to plan a deadly attack. This, then, leaves the question of organization.

The scenario only required four terrorists to execute their attacks. In the wake of 9/11, where 19 terrorists were required,[32] a cell of four is obviously a small requirement which many terrorist organizations could easily meet. However, these four terrorists did require funding as well as contacts with organized crime and other terrorist organizations in order to obtain the required radioactive material. Is this likely? While there is only anecdotal evidence to suggest Mara Salvatrucha has active contacts with terrorist organizations,[33] there is a good deal of evidence to suggest organized crime is willing to assist terrorist organizations in trafficking people and goods, even radioactive material, as long as the price is right.[34]

Are other terrorist organizations likely to support decentralized planning and control structures such as al-Qaeda's? Do terrorist organizations really share resources, information, and money? Is al-Qaeda a one of a kind terrorist organization whose influence will die with the organization? The answers to these remaining questions are best answered by an analysis of al-Qaeda's effect on world terrorism.

Al-Qaeda gained center stage in the world of terrorism with their attacks on the World Trade Center. In so doing they became a significant source of inspiration and a model for other terrorist organizations to emulate. Their decentralized structure provides al-Qaeda great resiliency and may even prevent al-Qaeda from fracturing if Osama Bin Laden is eventually captured or killed.[35] This decentralized structure is likely to become the model for many terrorist organizations in the future and is the fundamental characteristic supporting independently planned and organized terrorist attacks such as the one presented in the scenario.[36]

Al-Qaeda's method of using the internet to communicate and to raise and transfer funds has already been adopted by other terrorist organizations.[37] The coalition of supporting terrorist organizations al-Qaeda has formed under its influence provides a network for the passage of information, money, and goods between individual terrorist organizations that otherwise would not be connected.[38] This ability to move ideas, money, and goods throughout an illicit but only loosely allied organization is a strength to all participating terrorist organizations and is a key enabler for the type of scenario described above.

Al-Qaeda does not need to survive into the future for their brand of terrorism to flourish. They have already provided the inspiration and leadership necessary to transform the future of terrorism.[39] The genie is out of the bottle. Destroying al-Qaeda, while a noble goal, may fracture the current coalition of terrorists but will ultimately only make room for decentralized but allied terrorist organizations on the ascendancy.

**Availability of Radioactive Sources**

Do radioactive materials exist in sufficient quantities to produce the desired results and what is the likelihood of terrorists obtaining these materials? The International Atomic Energy Agency (IAEA) estimates there are over a million radioactive sources worldwide.[40] Of these, experts estimate only 10,000 are present in sufficient quantities or provide a source strength powerful enough for weaponization as a radiological weapon.[41] However, the real problem isn't the number of candidate radioactive sources available for weaponization but rather the inadequate level of control exercised over radioactive materials over the past fifty years.[42] This inadequacy, combined with other political factors, generated an environment where radioactive sources are not only readily targeted for theft but are also frequently lost or stolen by accident.[43]

Naturally occurring radioactive sources are rare and generally characterized by low energy and radioactivity levels. By contrast, manmade radioactive sources are generally more powerful and more radioactive. These manmade radioactive sources, produced in the second half of the twentieth century, became more abundant as their usefulness to the medical, commercial, industrial, and research industries became apparent.[44] Recognizing radiation is harmful if used improperly, most nations, the United States included, established regulations for the possession and handling of radioactive materials to ensure public safety. However, these regulations were typically aimed at providing guidance for how to inventory and store the materials to protect the public from accidental exposure.[45]

Under this system, all licensees were viewed as rational actors with the public interest in mind. As a result, the focus for licensing merely became the exercise of tabulating a list of businesses and organizations who would require regulation and inspection after the license was granted instead of an exercise in determining who should be allowed, from a national security perspective, to hold radioactive sources in the first place. Even today, in a post 9/11 world, there is very little in the NRC's code discussing the credentials potential subscribers must meet before granting a General or Special License.[46] Similar holes exist in the NRC's memorandum of agreement with Agreement States who issue General Licenses.[47] And while the NRC currently recognizes the need to modify their code and policy, they have yet to take action to change the code or to conduct a review of all current General and Special License holders within the United States.[48] To make matters worse, this same thought process, which assumes all licensees will be rational actors, creates a number of gaps in the regulation process that present serious security concerns.

One such gap is that international trade agreements allow sellers to distribute any amount and type of radioactive source to holders of a General License and do not require the seller to notify or register the radioactive source with the nation state where the buyer resides.[49] This effectively undercuts the purpose of the General and Special License system, which was intended to limit the type and quantity of radioactive material General License holders could legally possess. It also allows buyers to keep their purchases undisclosed and, therefore, not subject to regulation. When considering rational actors, this system is acceptable, as General License holders would not be expected to overstep their bounds and attempt to purchase radioactive sources for which they are not licensed and presumably would inform the licensor of any purchases made from overseas suppliers. However, this gap does allow irrational actors to purchase and conceal radioactive materials for malevolent purposes.

Another gap exists in the regulations and infrastructure designed to accept disposal of radioactive sources. Specifically, the failure of the Yucca Flats initiative to reach fruition and provide a place for the disposal of radioactive material has created a system encouraging licensees to store obsolete but still very dangerous radioactive sources on site.[50] Typically, the security arrangements for these obsolete radioactive sources are minimal,[51] as they are designed to be cost effective and also assume the general public as a whole are rational actors who do not desire to steal highly radioactive sources. This gap sets the stage for a Goiania-type disaster, where thieves in Brazil searching for scrap metal broke into an abandoned cancer clinic and stole an abandoned teletherapy machine containing 1,375 curies of cesium-137.[52] Scrap yard workers who received the stolen equipment unknowingly and unwittingly spread the contamination throughout Goiania.[53] The results were five deaths, 151 people who suffered internal contamination and who required monitoring and medical assistance,[54] decontamination efforts requiring the demolition of 85 buildings and homes, and 140,000 people who were "worried well" and, although probably never exposed to the radioactive source, sought medical attention due to panic and perception.[55] The total economic impact from this disaster is difficult to measure but is estimated to have been in the hundreds of millions of dollars.[56] While these are disturbing facts for Brazilians, similar events where lost or stolen radioactive sources have reappeared in the public domain inside the United States should give us pause to consider the potential consequences of failing to take proper action to provide a national repository for obsolete radioactive materials. While the distribution of cesium-137 in Goiania was not the result of deliberate terrorist action, it certainly provides insight into where terrorists might expect to obtain their radioactive materials, the level of security they might encounter, as well as the potential for death, destruction and disruption.

Lastly, the NRC has been ineffective in creating a meaningful regulatory climate. No national[57] or international[58] register exists to provide inspectors and regulators with a list of all the radioactive materials held by General and Special License holders. Under funded and understaffed, the NRC all but ignores General License holders.[59] Special License holders are only infrequently inspected or monitored.[60] Companies and institutions who are occasionally found negligent in their inventory and security practices are even less occasionally fined or punished in some meaningful manner.[61] These problems with regulating radioactive sources are not unique to the United States. The IAEA estimates that globally there are thousands of orphaned radioactive sources - meaning lost, stolen or discarded - which are no longer under any inventory or security control, with several hundred more added to this total annually.[62]

This problem is amplified by the some 46 failing or failed states,[63] most of whom possess some radioactive source material. States which belonged to the Former Soviet Union are key concerns, as they were technologically advanced and had industrial and military facilities that contained hundreds of highly radioactive sources.[64] With the collapse of the state institutions responsible for managing these radioactive sources came a great deal of source orphaning.[65] With this wide availability in unmonitored and uncontrolled access to radioactive sources, the key question is not ‘Can terrorists obtain radioactive materials?’ but rather, ‘Which terrorists already have radioactive materials?’

**Bring Out Your Dead**

Are the casualty figures presented in the scenario realistic and achievable? Appendix A details the calculations used to generate the casualty figures presented in the scenario. While many assumptions were made regarding each attack, each assumption was chosen for its conservative nature in limiting the total number of casualties achieved. Equally as important, Appendix A shows that delivery of the radioactive material to the target is possible without causing injury to those involved.

Although the success of the terrorist attack scenario requires three terrorists to achieve access to relatively secured areas of Amtrack, Browns Stadium, and a centralized kitchen facility, these are not strictly required elements. Any of several thousand entertainment facilities, concert halls, theaters, etc. nationwide would provide similar opportunities for terrorists as Browns Stadium provided in the scenario. Many of these venues would also supply their own pyrotechnic show that would handily provide terrorists a covert method for distributing their radioactive material over an unsuspecting crowd. Similarly, there are thousands of centralized food production facilities nationwide which process pre-packaged ready to eat meals such as TV dinners and frozen pizzas. Access to a centralized kitchen is not strictly necessary. Additionally, if gaining undisturbed access to such facilities proves to be too difficult, terrorists could always produce radioactively contaminated chili or clam chowder in their own kitchens for entry into any one of a number of annual contests or festivals with the hopes of achieving similar casualty results. Nationwide, the transportation industry provides an equivalent number of opportunities for radiological attacks and, as the scenario attacks on Seattle and Atlanta demonstrate, secured access to these facilities is not always required to achieve effectiveness.

The bottom line is this: wherever people congregate in sufficient numbers, terrorists are afforded the opportunity they need to conduct an effective radiological attack and only a minimum of imagination is required to design an attack to ensure it is covert as well as lethal.

**Where's the Beef?**

Critics of this analysis will undoubtedly point out there has yet to occur a radiological attack, and there has never been an arrest or uncovering of a credible plot to use a radiological weapon. The arrest of Jose Padilla[66] and the 2005 dirty bomb scare in Boston[67] seem testament to this fact and support the argument that radiological weapons do not constitute a significant threat. If radioactive sources are so readily available and if they can cause such destruction, then why have they not been used already and why do we need to fear their use in the future? To answer this question and refute the argument, there is existing evidence that shows terrorists do seek weapons of mass destruction in order to further their aims as transcendental terrorists.

Terrorists are seeking methods to obtain and disperse weapons of mass destruction. Osama Bin Laden, one of the most influential terrorist leaders, has made it a religious imperative to obtain and use a weapon of mass destruction on Western civilizations.[68] And in fact, even if he were not advocating such methods, the trend of terrorist organizations toward transcendental terrorism requires terrorists to plan and execute attacks with ever escalating body counts.[69] With death tolls already in the thousands from a single attack based on conventional materials and explosives, it will not be long before terrorists are forced to seek a weapon of mass destruction capability.

While a nuclear attack with a fission or fusion bomb probably remains at the top of most terrorist organizations wish list, these devices are beyond the capability of terrorist organizations to manufacture organically.[70] This requires terrorists to obtain a ready made nuclear weapon. State actors within even the most irresponsible states are unlikely to provide terrorists with a nuclear weapon. This leaves theft, most likely from Russia, as the only credible source for a nuclear weapon. For the moment, however, it would appear that intense international efforts to secure and decrease Russia's nuclear stockpile, combined with intense intelligence efforts in this area, have significantly reduced the hopes and prospects for potential terrorists.[71]

Biological and chemical weapons are the next logical choice for terrorists. However, manufacturing, purifying, and weaponizing biological and chemical agents is incredibly difficult and is again beyond the reasonable scope for most terrorist organizations. The Japanese cult Aum Shinrikyo is in part proof of this. From 1990 through 1995 the cult conducted approximately a dozen attacks using biological and chemical agents.[72] Only two of these attacks achieved casualties which were limited by the ineffectiveness of the agents and weapon design.[73] More importantly, these poor results were achieved by an organization with 300 scientists on the payroll who had access to superior laboratories and resources.[74]

This leaves radiological weapons as the logical choice for terrorists. They are abundant and can be obtained from many unsuspecting sources. They do not require sophisticated delivery platforms. In this way, radiological weapons are unlike nuclear, biological, and chemical weapons and are, therefore, uniquely attractive to terrorists.

Terrorist organizations recognize this and have attempted thefts of powerful radioactive sources.[75] While all known endeavors to obtain such a powerful radioactive source have apparently resulted in failure, terrorists have placed crude bombs with small amounts of radioactive materials in public parks to inspire fear.[76] These acts show terrorists do recognize the potential radiological weapons posses for destruction and disruption and also show the intent to use radiological weapons. Statements by Osama Bin Laden designed to motivate al-Qaeda and al-Qaeda inspired terrorists direct radical Islamic organizations to seek and employ radiological weapons. And even though Jose Padilla at the time of his arrest was no longer conspiring to build a dirty bomb, he was initially seeking this information when he first left for Pakistan.[77] Perhaps if al-Qaeda's organizational structure hadn't suffered so many setbacks following the invasion of Afghanistan, he would have been supplied with the requisite materials and knowledge.

If anything, the most convincing argument for why radiological weapons have not and will not be employed is that such attacks, like the one in the scenario, lack sufficient media coverage of bloody bodies and smoking ruins which is the current trademark of terrorist organizations. However, conventional explosives are reaching the limits for the amount of death and carnage they can create in a single attack. To achieve the higher casualty rates transcendental terrorists now desire, they will need to employ weapons of mass destruction. As previously argued, terrorists will have to overcome a great deal of logistical and technological problems to successfully employ nuclear, biological, and chemical weapons. These combined forces may cause terrorists to shift their reasoning to accept weapons that deliver less visible carnage and destruction in favor of less immediately gratifying, but ultimately more long term destructive, radiological weapons. In fact, biological and chemical weapons will require a similar shift in thinking before they can be truly accepted by terrorists, yet we have no difficulty in imagining terrorists currently desire to use these types of weapons. Powerful radioactive sources are out there, they are available through theft or the abuse of current trade agreements and regulations, and terrorists want them. It is only a matter of time before terrorists successfully employ a radiological weapon.

# Chapter 3
# The Technological Solution

It is not the proposal of this paper that a wholly technological solution to the problem of defeating radiological weapons exists. It, in fact, does not. There is far more ground to be gained by improving domestic legislation and regulation, strengthening international institutions, and through State Department initiatives. The Nunn-Lugar act provided the necessary funding to locate and secure hundreds if not thousands of potentially harmful orphaned radioactive sources within the Former Soviet Union states.[78] Similarly, the IAEA has taken an aggressive role in securing orphaned sources worldwide.[79] The IAEA is also seeking to strengthen international controls over radioactive sources by obtaining more member states under the IAEA umbrella and through strengthening import and export controls of those member states.[80] The Dirty Bomb bill,[81] the Yucca Flats proposal,[82] and NRC initiatives[83] promise to shore up a number of the gaps in our current policies and procedures regarding the handling and disposing of radioactive sources within the United States. This regulatory, legislative, and international agreement focus is most important, as it will provide the greatest security for and protection from radioactive materials and their potential misuse.

However, there is plenty of guiding literature discussing these initiatives and their potential for success in the future.[84] What is conspicuously absent from these discussions is the proposal of a technological approach to detecting and preventing the use of radiological weapons.[85] While this approach may not be as effective as those described above, it nevertheless can play an important role in successfully detecting and preventing the use of radiological weapons and is relatively inexpensive when compared to other programs designed to defeat radiological weapons. Most importantly, while improving regulations, legislation, and agreements is a worthwhile pursuit, it ultimately will not protect the citizenry from any radiological weapons that slip through the cracks. This section of the paper provides a framework for the role of technology in defeating radiological dispersion devices.[86]

### Detecting Radioactive Sources

Weapons relying on radioactive sources have a unique Achilles heel: they all, by definition, emit energy. Additionally, the spectrum and intensity of the energy released is unique to each radioactive element, occurs on a predictable schedule, and cannot be altered under the currently understood laws of physics.

Shielding will exponentially reduce the amount of observed radiation from gamma emitters; however, no amount of shielding will bring this observable to zero. Radiation detectors relying on analysis of the spectrum of observed energy are effective in rejecting the vast amounts of background radiation, thus raising the recognition differential and allowing the observation of very low levels of radiation to be accurately categorized.[87]

While shielding can effectively reduce the observable radiation from alpha and beta emitters to zero, sources that exclusively emit alpha and beta radiation are rare, and the decay chain of these elements most often includes gamma emitters. The net result of current state of the art technology is that radioactive sources are very difficult to conceal, regardless of the amount of shielding employed, if the correct technology is applied. It is upon this technology, the detection of radiated energy, that any technological solution to the problem of identifying and preventing radiological weapons must reside.

**A Systems Based Approach[88]**

Although radiation detection technology is relatively mature, advanced, and inexpensive, it would be foolish to think that simply providing this technology to local law enforcement agencies would provide an effective system to detect and prevent the use of radiological weapons. A system is required to alert and queue law enforcement officers, and a concept of operations must be developed detailing how this system should be employed. Additionally, any technological system of this nature will be subject to false detections, which must be minimized to prevent overtaxing law enforcement agencies. Several technologies are available today that could be implemented in relatively short order to create the necessary system. Of these technologies, mesh networks, Radio Frequency Identification (RFID), and iridium phone technologies, combined with current state of the art radiation detection technology, provide a promising solution to the problem.

**Overt Versus Covert Threats**

This paper is in agreement with articles and analyses showing dirty bombs are little more lethal than the initial explosive event. Even the massive amounts of cesium-137 used in the scenario against Browns Stadium would cause few deaths if it were distributed by an overt explosion that serves to alert officials to the presence of the radiation hazard. Proper employment of time, distance, and shielding concepts, along with prompt decontamination efforts, would greatly reduce the absorbed radiation and the number of personnel who are internally contaminated, thus preventing high mortality rates.

It is the explosive event itself that acts as a warning sign and indicator that a radiological attack may be occurring. With this in mind, agencies tasked as initial responders who include in their concept of operations a survey for radiation when responding to explosions will provide adequate safety for the general public from most scenarios involving radiological weapons. This reduces the act of properly detecting and classifying an overt attack to the simple employment of detection equipment by initial responders. However, such overt attacks using explosive devices are not the focus of this paper and a more complicated system is required to detect and defeat a covert threat.

Preventing the employment of a covert radiological weapon through such a system of detection and interdiction can be broken down into three fundamental areas. First, detection systems and accompanying procedures must be deployed to monitor and prevent illegal shipments of radioactive materials from entering the United States. Second, detection systems and accompanying procedures must be developed to monitor and prevent illegal movements of radioactive materials within the United States. Failing to detect illegal shipments or movements, population centers must employ systems and procedures to detect and interdict harmful radiation as it is entering the targeted public facility.

**Intercepting Illegal International Shipments**

Detecting illegal radiological shipments as they enter the United States requires deploying detection equipment at the major points of entry into the United States: seaports, international airports, international mail distribution centers, and border crossings. Detection systems and their accompanying concept of operations at these locations can remain relatively simple as these facilities are continuously manned with personnel who are trained to look for and interdict contraband. Systems such as Radiation Assessment and Identification (RAID)[89] and Sensor for Measurement and Analysis of Radiation Transients (SMART),[90] developed by Sandia National Laboratories, are examples of ready to deploy systems that can accurately detect radiation as personnel and goods are moved in bulk, such as in a vehicle, past the detector at moderate speeds.

The most significant implication of this strategy is that the term “Illegal Shipment” will need to be defined in legal terms. This will require legislation, regulations, and international agreements to reach consensus on the required elements and characteristics of legal shipments. Finally, to prevent legal radiological shipments from being unnecessarily delayed as they enter the United States, some system of documentation or advance notification will have to be developed which will allow customs and clearing officials to expeditiously pass the legal radiological shipment.

**Intercepting Illegal Internal Movements**

Detecting and interdicting illegal movements of material throughout the United States is a much more complex matter due to the vast number of available highways, interstates, railways, domestic seaports, and regional airports that exist for terrorists to exploit. Regional airports and domestic seaports could be eliminated from those areas requiring monitoring, based on the argument that roads or railways will ultimately be used to bring the radiological weapon to a population center. However, this reduction of the problem amounts to little gain, as road and railway systems throughout the United States are so vast and complex. Additionally, such globally applied strategies risk opening avenues for exploitation in cities such as Seattle, Charleston, and Pittsburgh, which are built on or near extensive waterways or in regions such as Alaska, where regional air travel is more prevalent.

Instead, each state must produce a plan, based on their specific geography and the defining characteristics of their transportation systems, which details the best locations for radiation detectors. These specific plans should seek to locate key nodes where traffic patterns converge. Sophisticated detectors that break down the radiation energy spectrum, such as the RAID and SMART detectors, will certainly be a necessary component of this system. However, these detectors are expensive and it is not economically feasible to deploy a system of detectors of this quality to monitor our nation's entire transportation systems. Smaller, cheaper detectors that are equally as sensitive to radiation[91] but are less capable in breaking down the energy spectrum to determine the exact radioisotope involved should be employed side by side with the more capable radiation detectors in order to keep the total systems cost reasonable while maximizing the coverage of the transportation system.

Similar to the problem of interdicting illegal shipments, interdicting illegal movements will require a legal definition and a method for identifying legal movements from illegal movements. Systems based on proper documentation would likely be bogged down by excessive paperwork and bureaucracy and would ultimately be flawed. This would result in wasted resources, as local law enforcement agencies track down unregistered detections of radioactive material in order to determine their legality. Instead, a system that utilizes RFID technology provides a simple technological solution to the problem. Under this system, all legal radioactive sources would be tagged with a unique RFID. Radiation detectors, upon sensing a radioactive source, would scan for a federally registered RFID. Law enforcement agencies would only need to respond to those movements of radioactive materials that could not be associated with a properly registered RFID. Heavy fines for moving registered radioactive sources without its associated RFID tag would ensure responsible source holders comply with requirements.

### Intercepting Radiological Weapons at the Target

Even the best conceived and implemented system of detectors along our nation's highways, railways, waterways, etc. will do little to detect and allow authorities to interdict radiological weapons that terrorists acquire in the same city they intend to target or who devise a method of delivery which does not rely on current transportation systems. To defeat this threat there is no substitute for a vast system of radiation detectors located anywhere terrorists would otherwise have access to vast segments of the population from a single key nodal point. Such locations for monitoring would include any public venue where significant numbers might congregate such as a concert hall or sports arena, corral points that direct and regulate a heavy flow of regular foot traffic such as the entryways to large buildings, all public transportation systems, private food processing facilities, and central kitchens.

It is worth emphasizing that such a proposed system would not require small businesses like the local Starbucks to install a radiation detection system.  The relatively low throughput of customers makes this type of venue an unattractive and unlikely target for terrorists.  Instead, radiation detectors would be deployed in those locations where, if left unprotected, would allow terrorists access to vast segments of the populace.  Similarly, the type, capability, and cost of detection systems deployed would also depend in part on the volume of people who patronize the venue. These cost benefit decisions would be made by local representatives to balance the threat versus the potential costs of the system and would presumably be codified as part of local building codes.

Like the networks deployed to monitor the nation's roadways, the radiation networks deployed to protect facilities would also need to rely on RFID technology in order to reduce false detection rates from legal movements.  Upon the detection of a radioactive source unaccompanied by a valid RFID, local authorities would be alerted to intercept to determine the legality of the movement.

**Collecting the Data**

Detecting radioactive sources with a system of detectors as described above certainly gives law enforcement officials a more than reasonable chance to interdict radiological weapons and prevent their use against the general public.  However, it would be cost prohibitive for each detector to have an associated law enforcement officer poised to capture suspected terrorists should the detector, in fact, detect a radioactive source.  To be cost effective, individual detectors need to be networked in order to allow the monitoring of many detectors by a small number of specially trained people.  While networked infrastructures could be developed that place the monitoring burden upon each state, this would be an inefficient use of resources as it would require each state to establish a monitoring station, train their own personnel, and all to prevent an illegal activity which will most likely occur on only rare occasions at best.  This would not only be an enormous duplication in effort, it would also establish natural barriers that could prevent the flow of lessons learned, best practices for organization and implementation, and possibly even prevent the timely flow of real time detection information from one state to another.

Instead, a nationwide network administered by a federal agency should be established. Many agencies such as the Department of Transportation, the Department of Energy, or the Federal Bureau of Investigation are good potential candidates to operate this system; however, the Department of Homeland Security, who by the National Response Plan[92] would be in charge of consequence management for any radiological incident of national significance, is perhaps the best choice. Each state, under the supervision of the governing federal authority, would be responsible for determining the necessary infrastructure of fielded radiation detectors required to adequately monitor the states transportation systems. States would also be responsible for developing the communications plan for how federal authorities would disseminate information quickly to local law enforcement authorities. The federal authorities would in turn provide a central monitoring station alleviating the states of a significant hardware, personnel, and training burden. The centralized facility would also allow for quicker implementation of lessons learned, new database or analysis algorithms, and any other advancement.

**Role of Internet**

In order to provide a central monitoring facility with the data collected from literally thousands of detectors distributed throughout the nation requires each detector have a link with the central monitoring system. The natural solution to this problem is to exploit the internet. Exploiting the internet prevents having to build a complete data network infrastructure from the ground up and has the added advantage that the internet is largely maintained and updated by the public sector. For the highway and interstate system detectors, the overwhelming majority of detectors, even if not located directly adjacent to the large population centers they are intended to protect, would likely be located near a population center with sufficient phone line or cable connections to allow direct connection to the internet. For those detectors located away from cable or phone connections, data could be transmitted to the internet using embedded iridium phone technology. For detectors within large population centers, mesh networks should be utilized to transmit required data to nearby internet servers to reduce costs associated with iridium phone technology.

## Interdiction

Still, detection of the event and transmission of that data to a central monitoring facility does not equate to interdiction. Local law enforcement officials must receive relevant and reliable information vectoring them to the terrorists and their radioactive source. This requires some method of identifying the terrorists from the rest of the crowd and their relative direction of motion. Cameras collocated with each detector and designed to capture critical information such as vehicular description, license plate information, or physical characteristics of individuals will pass the most pertinent data to law enforcement officials and relies on cheap and dependable technology. The central monitoring agency, through established communication plans and using preexisting communication networks, would alert state and local law enforcement officials of the potential threat and vector them in for interdiction. Local authorities would use hand held detectors to search out and confirm the presence of a radioactive source, apprehend the perpetrators, and preserve any required forensic evidence.

## Technological Solutions Bring Technological Problems

Any technologically based system designed to detect and record an event will be subject to false detections. The false detection rate observed by the system will depend upon many factors. However, the false detection rate for a system designed to detect radiation will be dominated primarily by two factors: 1) the total number of detectors included in the system and 2) the sensitivity of those detectors. As the size of a detection system increases, the total number of false detections the system experiences will increase proportionally with the number of detectors connected to the system. Similarly, the more sensitive a detector is designed to be, the more false detections that detector will observe. Additionally, detectors designed to detect events near naturally occurring background levels of radiation experience false detections at a rate increasing in a non-linear fashion with sensitivity.

The shear number of detectors required and the necessary sensitivity these detectors must posses to provide adequate security against radiological weapons could potentially create a system overburdened with false detection rates. Large false detection rates would overwhelm law enforcement officials, who would eventually become jaded to the process. Even modest or small false detection rates would risk public panic when law enforcement officials fail to apprehend terrorists that do not exist. For these reasons, the false detection rate for any employed system must be maintained as close to zero as technically possible.

Researchers and designers of the overall system will need to rely on several methods to reduce the number of false detections the system observes. Collimating the detector window using shielding, increasing detector dwell time by positioning detectors in areas where traffic patterns are slower, reducing the sample size by isolating or limiting the number of objects observed, and spectrum analysis are all methods that effectively reduce the ratio of background radiation to target radiation observed and are industry standards for reducing false detection rates. Computer algorithms designed to analyze the observed energy spectrum could potentially eliminate some false detections by identifying those events where parent nuclides are detected in the absence of their decay daughters, by requiring coincident detections of two or more collocated detectors, or by employing filtering algorithms similar to those used by commercial and military RADAR and SONAR systems. Radiation detectors working in conjunction with optical, motion, or weight detectors could eliminate some false detections based on a lack of corroborating evidence. Similarly, radiation detectors separated in space but located on a common route could be required to display detections within a specified time interval in order for the detection to be considered valid. Finally, watchdog diagnostic systems designed to monitor detector health could identify failing or failed detectors, allowing technicians to remove these detectors from the system before they contribute to false detections.

The significance of reducing the false detection rate to an acceptable value cannot be overstated and is perhaps the most significant technological problem any proposed system will have to overcome. With this as a given, there are many methods readily available for reducing the number of false detections and field operations, tests, and evaluations of SMART and RAID systems have yielded remarkable fidelity in their ability to detect and locate radioactive sources and have yet to encounter a false detection.[93] These results are promising evidence that a massive system comprised of many such detectors could be successfully designed and employed.

**Order of Magnitude Cost Analysis**

It is difficult to determine the exact cost of a networked system without first performing the required nodal analysis to determine where and how many detectors will be required, how many people will be required to man the system, etc. A detailed analysis of the needs to support just one state is beyond the scope of this paper. However, an analysis that only concerns itself with determining the order of magnitude instead of the exact numbers can provide insight into the relative cost of the proposed program. Under this methodology, the goal is not to determine whether we need 120 or 180 people to run the program, the goal is to determine whether we need 100 or 1,000 people. This is the level of analysis that will be applied to determine a rough estimate of the expected cost of a technologically based program to support interdiction of illegal radiological shipments and movements.

Within this cost analysis, it is assumed mesh networks supporting wireless connectivity will be developed and fielded by private industry, by local government civic improvement projects, or by some combination of the two. Federal and state governments may choose to accelerate the creation of wireless networks through economic and tax incentives; however, it is maintained the rewards of creating such systems will far outweigh the costs. As the next natural extension of the internet, many cities have already undertaken projects to provide their citizens complete wireless coverage.[94] It is likely that market economy and political pressure will force most major metropolitan areas to follow suit. Consequently, this paper assumes zero cost for establishing mesh or wireless networks. Where this assumption proves to be false, the cost of connecting individual detectors directly into existing cable or telephone lines or through iridium phones is already factored into the cost calculations for detectors discussed below.

Similarly, it is assumed the cost of radiation detection systems designed to protect critical access points to the public will be absorbed by the private and public facilities. Most facilities will only require a few detectors located at key choke points such as entrances and exits and will not need detectors throughout the entire structure. The cost of implementing such a system would be small and on the order of paying for a fire safety system or a physical security system.[95] While the total cost to business will be large, the cost to any single firm will be small and quickly recapitalized by passing the cost on to customers, who will only recognize a fraction of a penny difference.

Finally, it is assumed that local and state law enforcement officers, customs officials, United States Postal Service personnel and all other professional organizations who will operate the fielded detector systems are already part of a regular training program, and that this training program is capable of absorbing the costs of the required training for their personnel to ensure they understand and can adequately operate the systems fielded.

This leaves the cost analysis of fielding a comprehensive system of radiation detectors as the sum of essentially four separate but integral parts. One, the cost of radiation detectors designed to detect illegal shipment of radiation sources into the United States through mail, rail, shipping, airport, or border control stations. Two, the cost of radiation detectors designed to detect radioactive sources as they are illegally transported throughout the United States. Three, the cost of placing hand held radiation detectors into the hands of local law enforcement officials. Four, the cost of establishing a centralized monitoring facility.

Before we can begin the cost analysis, we must have an understanding of the cost of individual detectors. The cost of a single RAID or SMART type detector is well documented and can be expected to run $25,000 to $30,000.[96] Smaller detectors that have less capability to perform spectral analysis can be as cheap as a few hundred dollars.[97] Embedded hardware and software required to recognize an event, take required pictures, and transmit data also rely on technology available in the hundred dollar range. The exact cost of each type of detector would of course depend on the quantity ordered and other details of the procurement process and contractual agreement. However, a reasonable cost estimate can be calculated assuming the larger detectors capable of more granular spectral analysis will cost $30,000 while the smaller less capable detectors can be purchased for $1,000. Reasonable handheld detectors that will allow local law enforcement to localize and confirm the presence of radiation sources can be purchased for approximately $500.[98]

There are 317 ports of entry for personnel and goods to enter the United States.[99] These ports of entry supervise the nation's shipping ports, international airports, and border crossing stations. Some ports of entry service multiple facilities, making the exact number of locations where radiation detectors are required difficult to determine. However, the assumption of 500 such facilities is a reasonable figure for an order of magnitude cost analysis. Also assumed in this figure are the 21 major mail distribution centers, which are not monitored by the ports of entry but are a potential avenue of transportation for terrorists to exploit.[100] All of these facilities would require the larger, more expensive, and more accurate radiation detectors in order to allow bulk movements of material past the detector for screening. Additionally, some facilities will require more than one detector to efficiently process the goods and personnel moving through the facility. In keeping with the order of magnitude analysis, the figure of 1,000 detectors fielded to these locations is assumed. At $30,000 per detector, the total cost of this portion of the system is $30,000,000.

There are approximately 43,000 miles of Interstate System roadways.[101] Clearly, placing a radiation detector each mile would be overkill, while placing a detector every 100 miles would probably not create a sufficiently robust system. In keeping with the order of magnitude analysis, we will assume a detector is required for every 10 miles of interstate in order to provide adequate monitoring. Assuming the number of other transportation nodes within a given state which also require monitoring do not increase the total system requirements by more than a factor of 10, then some 43,000 detectors are required. In keeping with our order of magnitude analysis, we will assume a total number of 100,000 detectors distributed nationwide in order to provide adequate monitoring of the nation’s transportation systems. With the additional assumption that strategic detector placement will allow for a roughly equivalent amount of money to be spent on expensive and inexpensive detectors, then these 100,000 detectors can be purchased for a total of $200,000,000. Assuming the cost of installation for a detector will be roughly equivalent to the cost of that detector, the total cost of purchasing and positioning the 100,000 detectors becomes $400,000,000.

While there is a real threat that radiological weapons may be used against us in the near future, it is unlikely the United States will be struck with such a number of concurrent attacks as to require a handheld detector in every patrol car. A few such hand held detectors positioned strategically throughout any given state, combined with a process designed to keep these detectors in the hands of trained officers throughout daily shift turnovers, will provide sufficient response time statewide to radiological threats. The exact number of detectors each individual state needs will depend on the size of the state, the quality and quantity of their highway system, and any other factors affecting the speed and mobility of detectors from one location to another. However, in keeping with the order of magnitude analysis, it is assumed that 100 such detectors will give states sufficient coverage of their territory to ensure timely response of qualified and equipped officers to the scene of radiological threats. With 50 states and at $500 a copy, this brings the total cost of hand held radiation detectors to $2,500,000.

Establishing a central monitoring facility will require sufficient personnel to man and monitor the network 24 hours a day, to maintain the detectors and the network hardware, to program upgrades and improve algorithms to reduce false detection rates, and to act as liaisons between the central monitoring facility and local/state officials. An order of magnitude analysis would suggest such an undertaking would require in the neighborhood of 1000 personnel. The cost of salary to support these personnel is an annual cost and is considered later. However, it is reasonable to assume the cost of initial training for these people as well as the cost of equipment and infrastructure that these people will operate will be on an order of magnitude equivalent with their annual salary. Sources documenting the per capita income in the United States vary from $33,000 to $40,000 per individual. In keeping with our order of magnitude analysis, an annual salary of $50,000 is assumed. Multiplying this value by 1,000 personnel and then by a factor of two to account for initial training and infrastructure required gives a figure of $100,000,000 for initial setup costs.

This brings the total cost for the initial outlay of the program to approximately $533,000,000. Assuming annual maintenance, repair, and training costs run at approximately 10% of this figure, and adding in the annual wages for employees, the program will require an additional $100,000,000 annually to maintain efficiency.

**Cost Deference Strategies**

Measuring in at only .02% of our annual federal budget[102] and only .1% of our current defense budget,[103] $500 million hardly seems like a figure requiring strategies to help defer the costs. However, in an era where radiological weapons have yet to be used against us, it is reasonable to expect citizens and their elected representatives to baulk at such a figure. The following cost deferral strategies are recommended to reduce the perceived cost.

The obvious source of funding for any new program is taxation. While unpopular, and perhaps a political landmine, there are lucrative areas of private enterprise which have successfully resisted new taxes. One such area is internet sales. Frequently crossing state boundaries, these transactions are left untaxed by either state. With annual internet sales approaching $20 billion,[104] each 1% federal tax aimed at interstate internet transactions would realize $200 million. Similarly, our nation's ports receive over six million containers annually.[105] A simple flat tax per container could raise tens to hundreds of millions of dollars to help offset costs.

Another option is to kill competing programs. Programs such as the Office for Domestic Preparedness' Homeland Security Grant Program funneled over four billion dollars in 2004 to local law enforcement and first response agencies in an effort to better prepare them for the threat posed by terrorists.[106] Removing or reducing the size of these programs in favor of more detailed and purposed programs is a potential source of funding.

Another option is to combine the initiative for detecting radiological weapons with other WMD programs. Adding the potential to these detectors to monitor for high explosives, chemical, and biological agents is within our capability. While this strategy will certainly raise the total cost of the fielded detectors, it may achieve economies if it reduces the total cost of similar weapon of mass destruction initiatives through the utilization of a common monitoring and maintenance infrastructure.

Similarly, the radiological detection initiative could be combined with other programs such as Weigh in Motion (WIM). WIM is a system that most State Departments of Transportation are funding in order to automate the weigh station process by measuring the weight of trucks as they pass over weight detection systems at normal highway speeds.[107] Combining state and federal funds and the project objectives of WIM and the radiological detection initiative may allow state and federal governments to realize true cost savings in investment for initial installation and infrastructure.

The cost of providing security along our nation's highways and interstates could be funded by current highway and interstate maintenance and improvement programs. The federal government alone expends approximately $100 billion annually[108] to maintain and expand the nation's interstate. A simple redirection of only .1% of these funds would be enough to fund the proposed system and would arguably contribute to the safety of the interstate system.

Finally, the most satisfying answer may be to make those industries and institutions responsible for creating and fueling the problem to pay for the solution. The IAEA estimates that radiation technologies contribute nearly $300 billion to the United States economy annually.[109] Tapping this portion of the market with even modest levees of less than 1% would pay for the proposed program outlined above. Furthermore, this extra regulation and the fees and additional bureaucracy it would entail might encourage businesses to seek alternative technologies that do not rely on radioactive sources thus reducing the threat overall by reducing the existence of radioactive sources in the United States

# Chapter 4
# Conclusion

For terrorists seeking an asymmetric advantage against the United States, radiological weapons offer unique opportunities; discrete, lethal, requiring only limited technology to employ, and with radioactive material readily available they contain an awesome potential for psychological disruption. Radiation is energy in one of its purest and most elemental forms. As such, radioactive sources can possess incredible energy density that is in every respect as lethal as traditional kinetic weapons. Invisible to all five senses, radiation is also an insidious weapon that can wreak tremendous damage on the citizenry long after the initial employment of the parent weapon and long before health and law enforcement authorities identify that an attack has occurred. Furthermore, radiation's discrete and lethal nature, combined with the low level of technology required for its employment, will create a sense of psychological dread in the average American that his health and well being is held at risk at almost any time and any location without warning or indication. It is logical to assume such a profound psychological impact will exist following the first successful use of a radiological weapon so as to cause tremendous economic and social disruption.

To illustrate the potential for powerful psychological disruption, consider the events which occurred in Goiania, Brazil in 1987. Victims of the accidental spread of radioactive cesium suffered from Acute Radiation Syndrome for 15 days before medical authorities properly diagnosed the symptoms and then only after the diagnosing doctor was provided a sample of the cesium-137.[110] Out of a total population of 800,000,[111] only 249 people were ever discovered to have been exposed internally or externally to the radioactive cesium.[112] Of these, only five people were exposed sufficiently to cause death, and only 49 were considered sufficiently exposed to warrant admission to a hospital.[113] From a psychological perspective, this should be no scarier than the crash of a jet airliner.

However, the psychological impact of these events was far more significant. Fearful of unidentified exposure during the 15 day delay it took authorities to establish the accidental release of radioactive contamination, an estimated 140,000 residents of

Goiania sought medical attention to determine their relative health risk.[114] The psychological impact on Brazil as a whole was profound enough to inspire general fear of Goiania, resulting in a reversal of the previously observed growth in the region and a waning demand for Goiania products, which translated into a 40% reduction in the prices they could demand at market, costing the local economy hundreds of millions of dollars.[115] The strong psychological fears associated with radioactive contamination necessitated elaborate investigation and contamination surveys of Goiania, time consuming cleanup efforts by highly trained individuals, the destruction of 85 contaminated buildings and facilities, and the generation of 3,500 cubic meters of radioactive waste.[116] The sum total of cleanup efforts is estimated to have cost the Brazilian Government over $20 million. To make matters worse, experts who have studied the Goiania tragedy have concluded that during a terrorist attack some health professionals may abandon their patients due to their own fears and concerns.[117] All of these effects resulted from the accidental release of approximately 1200 curies of radioactive material.[118] Imagine the psychological and economic impact following the release of ten to a hundred times this level of contamination in a fashion more purposeful in its intent to inflict death and cause disruption.

The threat of terrorists employing a radiological weapon is further exacerbated by the widespread use of radioactive sources in industry today under poorly constructed national and international regulations that fail to adequately control their creation, transportation, distribution, handling, and disposal. The resultant system is devoid of any meaningful custodial controls and is easily bypassed or corrupted. Terrorists who desire radioactive sources will have no difficulty finding or obtaining them. Consider, again, the example of Goiania. While the criminals in question were not specifically targeting the radioactive cesium for theft, the events clearly demonstrate that controls over radioactive sources are insufficient in their ability to prevent such targeted theft, should determined terrorists make obtaining radioactive sources a priority. What's more, the removal of radioactive sources from custodial controls is not unique to Goiania and is, instead, a pattern repeated hundreds of times per year in almost every nation employing radioactive sources in industry.[119]

Beyond the example and lessons of Goiania, it is important to view radiological weapons as more than merely possessing powerful psychological effects and representing an economic threat. These weapons can produce massive casualties. It is true that to achieve truly massive casualty figures similar to those described in Appendix A, multiple parallel and/or serial attacks must be executed. However, the invisible and enduring nature of radiation presents the potential for persistent covert attacks which are capable of generating hundreds of casualties per day over several days of operations and also provides the necessary stealth to allow the execution of such attacks without detection.

Given the trend toward transcendental terrorism, it is only a matter of time before terrorists move from creating carnage exclusively through the use of high explosives to creating destruction through the use of biological, chemical, or radiological agents. There is a real need to protect the public from this type of terrorist and the weapon of mass destruction threat. With significant scientific and technological hurdles separating terrorists from the successful use of biological and chemical weapons, it is likely that enterprising terrorists will default to employing radiological weapons.

With all of the above as a given, there are some serious disadvantages terrorists will have to overcome before they can successfully employ a radiological weapon. As Appendix A identifies, employing radiological weapons will be greatly complicated by the amount of shielding required. Terrorists will need to design and develop their own tools to allow the effective handling of radioactive materials at a distance. These tools are likely to be bulky and heavy due to the intrinsic shielding required. Bulky, heavy tools designed to maintain radioactive materials at a distance will be cumbersome to employ and will present further challenges to terrorists who are trying to maintain their operations covert. Even suicidal terrorists who forgo shielded tools during placement operations will need extensive shielding while transporting the radioactive material to ensure they live long enough to get the radioactive material to the target. The opposing constraints for sufficient shielding and adequate mobility is a sobering drawback that will push many terrorists to their creative edge all while providing well trained authorities the necessary clues to initiate further investigation. After all, a carry-on bag containing eight film canisters full of lead shielding may be a clever way of transporting radioactive material but will most certainly weigh far more than its contents would imply.

This is not meant to suggest that radiological weapons can be effectively countered by well trained and inquisitive authorities. Clever terrorists will devise methods to overcome and defeat any system so overly dependent upon a human in the loop. Instead, maintaining a focus on improving regulations, legislation, and international agreements designed to improve the controls over radioactive materials will yield the most significant gains in any effort to prevent terrorists from employing radiological weapons. Regulatory controls must be meaningful, must contain teeth, and must adequately regulate the entire life cycle of radioactive sources from their creation through their sale, distribution, transportation, employment and to their ultimate disposal.[120] Real security and safeguards must be present at each phase in a sources lifecycle, with special measures in place during the transition periods between phases, where the risk of loss from custodial controls is arguably the greatest. Denying terrorists access to radioactive material is the greatest means to the end of countering radiological weapons.

While improving regulatory controls is an absolute necessity, this is a long term solution to a real threat that exists today. No future regulation, law, or agreement can provide the general public the security they deserve today from the literally thousands of radioactive sources that have already slipped through bureaucratic and administrative cracks. A stopgap measure independent from these future regulations must be put in place to provide public security for the short term interim period. This stop gap measure must, therefore, rely more on physical controls than administrative and regulatory controls. Whereas many other physical security plans less dependant upon a system of interconnected radiation detectors could be postulated, they would likely be more man labor intensive, sluggish in their ability to process checks, and ultimately more expensive.

Even as the cost of fielding a network of detectors is in the neighborhood of $500 million, experts estimate the cost of decontaminating an area following the dispersal of even a small non-lethal amount of radioactive material could easily approach hundreds of billions if not trillions of dollars.[121] Combine this economic cost with the potential for further economic and social disruption based on psychological fears, and the potential for real human destruction from a more successful radiological attack, and the question is not ‘How much will such a program cost?’ but rather, ‘What is the cost of not funding such a program?’

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[9] Al-Qaeda's connection with Chechen Islamic rebels is notional; however, Al-Qaeda maintains inspirational leadership over and acts as the connecting thread for a coalition of militant Islamic organizations. Al-Qaeda is seeking to expand this coalition and it is conceivable that militant Chechen Muslims could become part of this coalition. Al-Qaeda's coalition is documented at:
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body. However, strontium-90 that is ingested can cause significant damage as the more sensitive internal tissues and organs are now exposed directly to the harmful radiation without the protection of the intervening shielding effects of air, clothing, and skin. These three radioactive sources are among those that experts believe terrorists will find most appealing when designing a radiological dispersion device. Other potential radioactive sources that terrorists might employ can be located in:
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