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Implementing Security Improvement Options at Los Angeles International Airport

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Prepared for the Los Angeles World Airports
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The research described in this report was conducted under the auspices of the Homeland Security program within RAND Infrastructure, Safety, and Environment (ISE) for Los Angeles World Airports.
PREFACE

Los Angeles International Airport (LAX) is vital to Southern California. It is used by over 60 million passengers each year. More than 2 million tons of air cargo pass through LAX. According to Los Angeles World Airports (LAWA), it provides the Southern California economy with over $70 billion in revenue each year. Despite recent improvements in security, aviation and airports continue to be targets for terrorism.

The RAND Corporation has a long history of research on terrorism, stretching back to the late 1960s. This research provides a comprehensive and continuous critical knowledge base on threat, security, and infrastructure protection issues.

In July 2004, LAWA commissioned RAND to conduct a study on near-term options for countering the threat of terrorism and improving security at LAX. RAND made six recommendations, which are documented in Stevens et al., 2004.

In November 2005, LAWA asked RAND to develop an LAX security implementation plan based on the 2004 recommendations. As part of the implementation plan development, RAND is evaluating installation of security film on windows facing the public roadway.

This documented briefing will be of interest to personnel within LAWA; the U.S. Transportation Security Administration; the Los Angeles International Airport Police Department; the Los Angeles Police Department; the Office of the Mayor of the City of Los Angeles; the Los Angeles City Council; similar staff at other airports; and those in the general public interested in LAX, terrorism, and airport security.

THE RAND HOMELAND SECURITY PROGRAM

This research was conducted under the auspices of the Homeland Security Program within RAND Infrastructure, Safety, and Environment, a unit of the RAND Corporation. The mission of RAND Infrastructure, Safety, and Environment is to improve the development, operation, use, and protection of society’s essential man-made and natural assets and to enhance the related social assets of safety and security of individuals in transit and in their workplaces and community. Homeland Security Program research supports the Department of Homeland Security and other agencies charged with preventing and mitigating the effects of
terrorist activity within U.S. borders. Projects address critical infrastructure protection, emergency management, terrorism risk management, border control, first responders and preparedness, domestic threat assessments, domestic intelligence, and manpower and training.

Questions or comments about this documented briefing should be sent to the project leader, Donald Stevens, at stevens@rand.org. Information about the Homeland Security Program is available online (www.rand.org/ise/security/). Inquiries about research projects should be sent to Michael Wermuth (Michael_Wermuth@rand.org), Director of the Homeland Security Program.
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SUMMARY

The RAND Corporation was commissioned by LAWA to conduct a series of studies on options for protecting LAX from terrorism. In October 2004, Stevens et al. described RAND’s studies and recommended protective actions that could be taken at LAX. In November 2005, RAND was asked to identify how key recommendations from the 2004 documented briefing could be implemented. In addition, RAND was asked to examine if adding security film to the windows facing the Central Terminal Area (CTA) was a cost-effective solution to the car bomb threat at LAX. The CTA encompasses the eight terminals, the horseshoe shaped public roadway, and the central parking area.

This documented briefing summarizes the findings from our 2004 documented briefing (Stevens et al.), examines what has changed at LAX since that time, evaluates the effectiveness of adding security film to the windows, and makes recommendations for implementing key findings from Stevens et al. (2004).

REVIEW OF THE 2004 FINDINGS

Terrorism has long been a serious problem for the air transportation system of the United States and other nations. Over 5,000 deaths have resulted from terrorist attacks on civil aviation since 1980; about 200 deaths occurred in attacks on airports themselves, as opposed to aircraft.¹

LAX has historically been a leader in implementing new security measures. It was one of the first major airports to implement a 100 percent baggage-screening program and to have an on-site bomb squad, a high police presence, a distributed terminal layout, and a large number of explosive-detection dogs. Despite this level of security, there are good reasons to believe that LAX is viewed by some terrorist organizations as an attractive target. Since 1974, LAX has been the target of two bombings, two attempted bombings, and one handgun attack. LAX is also the fifth busiest passenger airport and sixth busiest cargo airport in the world. LAX also fits terrorist organizations’ criteria for economically sensitive targets—according to LAWA, LAX provides the Southern California economy with over $70 billion in revenue each year.

¹ See the MIPT Terrorism Knowledge Base, online at http://www.tkb.org.
The fundamental problem with terrorism is how to influence most effectively the behavior of an unpredictable enemy through an appropriate combination of prevention, protection, and response capabilities that will have a deterrent effect on those adversaries. The logical structure of the problem is similar to the problem of preventing nuclear war, which RAND has studied extensively over many years. The solution is to shape the situation so that in any scenario the outcomes from the adversary’s point of view will be unsatisfactory. This will help to achieve the primary goal of deterrence. Terrorists will look at the airport and decide that attacking it isn’t worth the operational costs and risks or will not achieve a desired outcome.

Operationally, the key to implementing a successful strategy of deterrence is to understand and reduce LAX’s vulnerabilities and to minimize the potential consequences of an attack. In Stevens et al. (2004), we analyzed a wide range of possible terrorist actions and assessed LAX’s level of vulnerability. We then examined possible alternative courses of action LAX could take to reduce these vulnerabilities and mitigate potential consequences.

**Terrorist Attack Scenarios**

We identified 11 major classes of attack. These are not the only possible attacks, but they are the ones that we assess to be most likely and most difficult to prevent. Some of the specifics of these scenarios have been removed at the request of the Transportation Security Administration (TSA). Starting with the likely scenarios most threatening to LAX with its current security procedures, the threats are as follows:

**Insider-Planted Bomb.** A bomb could be placed, with the assistance of an employee with access to the airport, inside a large passenger aircraft, causing it to be destroyed in flight, potentially killing hundreds of passengers. Such a bomb would require between 3 and 20 pounds of explosive, depending on where it is placed.

**Cargo Bomb.** A bomb is placed inside cargo that is loaded onto a passenger aircraft, causing it to be destroyed in flight, potentially killing hundreds of passengers. Like the bomb planted by an insider, it would require between 3 and 20 pounds of explosives, depending on where the cargo is placed.

**Large Truck Bomb.** A bomb in the 1,000–4,000 pound range could be concealed in a truck. If detonated at the lower level, we expect a large number of deaths and severe damage to both the arrival and departure levels of the terminal, along with two sections of elevated roadway.
**Luggage Bomb.** A 50-pound bomb detonated in a crowded screening line could produce a large number of deaths. The number of deaths in this scenario is very sensitive to the density and number of people standing in line. The luggage bomb is also a good surrogate for a suicide bomber.

**Curbside Car Bomb.** A 500-pound bomb detonated in the right lane of the roadway in front of the line of people on the sidewalk waiting for a skycap will cause a large number of deaths on the sidewalk and in the terminal. Again, the number of deaths is very sensitive to the density and number of people standing in line.

**MANPADS.** We assume that a MANPADS (man-portable air defense system, usually shoulder-fired) attack will result in the destruction of an airliner less than 10 percent of the time.

**Public Area Attack.** A well-armed group of three to ten terrorists with body armor and automatic weapons could kill a large number of people before being stopped. Current airport police capabilities would be of limited effectiveness against well-equipped attackers.

**Air Operations Attack.** A well-armed group of three to ten terrorists could enter the air operations area by jumping the fence or entering via an unprotected cargo operator. These terrorists could attack parked or taxiing airliners.

**Tower/Utility Plant Bombing.** We assume that a car or truck bomb with 1,000+ pounds of explosives will result in either the destruction of the tower or the destruction of a significant portion of the utility plant.

**Sniper.** In one possible scenario, a sniper who sets up on airport-adjacent property with a .50-caliber sniper rifle would shoot at loaded planes, firing approximately 50 shots over five minutes.

**Mortar Attack.** In an Irish Republican Army mortar attack on London’s Heathrow airport (March 1995), attackers disrupted airport operations for several days. This type of attack at LAX would kill few people on average, but it is possible, albeit unlikely, that a mortar round could hit a loaded plane.

**Security Improvement Options**

In 2004, we evaluated a series of possible security improvement options that could reduce the potential consequences described in the foregoing threat scenarios. Different security improvement options will have different consequences depending on the threat scenario. We focused on security options that offered the greatest effectiveness against the most-
threatening attacks. We then estimated the costs, both initial and recurring, for each security improvement option.

We found that the security improvement options fell into four broad categories.

1. Low-cost options that greatly reduce the risk of terrorism at LAX. These options should be acted upon immediately.
2. High-cost options that greatly reduce the risk of terrorism at LAX.
3. Low-cost options that modestly reduce the risk of terrorism at LAX.
4. Expensive solutions to modest problems. We did not recommend implementing these solutions.

We suggested that two options in category 1 should be implemented immediately: reducing the density of people in unsecured areas, and adding permanent vehicle security checkpoints with bomb-detection capabilities.

Reducing the Density of People in Unsecured Areas (Areas in Which Baggage Has Not Been Inspected or Areas Near Uninspected Vehicles). Eliminating lines at baggage check-in is very effective because the existing lines create an attractive target where a terrorist could bring a substantial bomb concealed in luggage with little risk of arousing suspicion. Similarly, lines outside terminals are attractive targets for vehicle bombs. Reducing the density of people in terminals is also effective against suicide bombers and other attacks in the terminals (the most significant recent event at an LAX terminal was perpetrated with a handgun).

It is perhaps surprising that the costs of eliminating check-in lines is quite modest, according to our assessments. Overall airport efficiency, including the operations of LAWA, airlines, and the TSA is not significantly enhanced by having people stand in line. The amount of actual work required to check bags and related activities remains the same whether people have waited or not. Substantial reduction of lines can be implemented immediately with small changes to airline and TSA staffing policies. Having two additional people checking in bags during rush periods would dramatically reduce the lines. This was our strongest recommendation.

Adding Permanent Vehicle Security Checkpoints with Bomb-Detection Capabilities. Large vehicle bombs can be effectively detected by quick examination of vehicles entering the airport by well-trained personnel. Improved technology is becoming available, but even simple vehicle scales can identify suspicious vehicles, which can then be diverted before
entering the airport proper. This will greatly reduce the threat from large vehicle bombs and provide some effectiveness against smaller bombs. It will not likely be effective against small bombs concealed in luggage. Detecting smaller luggage bombs would require a detailed search, which currently would be very expensive. We do not see improved efficiencies in technologies for screening automobiles to the point that every car could be screened for small packages.

WHAT HAS CHANGED SINCE 2004?

Several things have changed at LAX since we made those recommendations for security enhancement.

The airport’s long-range plan is being completely reevaluated and studied. In 2004, the long-range plan (Alternative D) called for the airport terminals to be torn down in ten years and replaced by new terminals where the central parking structures currently exist. Because terminals will now not be replaced under Alternative D, enhancements to the terminals will have more than the ten-year life span that was expected in 2004.

There has been an increase in the physical space allocated to TSA operations in the terminals, which has allowed TSA to operate more efficiently. TSA has added screening lines in most of the crowded terminals. TSA is also now hiring part-time staff that can be brought in during peak periods.

Perhaps the biggest change is the large increase in the number of automated check-in facilities that allow passengers to check in luggage and receive boarding passes more efficiently. (An in-depth analysis of this change will be available in a forthcoming document.) This increase in efficiency has resulted in a slight reduction in the lines inside the terminals and a reduction in airline staffing in the terminals.

Two years ago, LAWA commissioned several in-depth studies of options for reducing the crowds in terminals and installing permanent vehicle checkpoints. These studies validated much of the analysis from Stevens et al. (2004).

Lastly, in November 2005, LAWA asked RAND to analyze the blast effects on the windows at LAX and evaluate installation of security film on windows facing the public roadway.
WHAT HAS NOT CHANGED SINCE 2004?

Overcrowded Terminals at LAX

The crowded public areas at LAX continue to be an attractive target for terrorist bombs. Large bombs, in excess of 500 pounds, can be detected by vehicle checkpoints at the entrances to LAX. It is currently nearly impossible for vehicle checkpoints to find luggage bombs or suicide bombers. The only cost-effective solution to these bomb threats is to reduce the level of risk by reducing the density of people at various high-traffic points in the terminals.

The overcrowding of the terminals could be easily mitigated. Most of the people in the terminals are waiting in line; others appear to be lost or confused about what to do next. Modest increases in capacity to check people in through more-efficient systems or increases in staffing at security checkpoints could dramatically reduce the number of people waiting in line.

In our 2004 study, we estimated that the total cost of eliminating the crowding in terminals would be approximately $4 million per year. In 2005, at LAWA’s request, Leigh Fisher Associates reviewed this issue. Our findings were that a 5 percent increase in staffing would decrease the waiting time in lines by 75 percent—with a commensurate decrease in the number of people in line. Leigh Fisher Associates assessed that it would require a 15 percent increase in staffing to reduce the lines by 75 percent. Leigh Fisher Associates did not conduct a comprehensive risk assessment but concluded that a 75 percent decrease in lines was not worth implementing. Our assessment concluded that a 75 percent decrease in lines would substantially decrease vulnerability to luggage bombs and suicide bombers.

We continue to work with LAWA, the Los Angeles Airlines Airport Affairs Committee, and the airlines to understand the crowding issues particular to each terminal. We are also working with LAWA to develop a plan to motivate the airlines to help reduce the crowding in terminals.

Vehicle Checkpoints at LAX

Vehicles can enter LAX through six unsecured locations. Currently there are no checkpoints at LAX to examine incoming vehicles for bombs. Any vehicle could enter the CTA with a large bomb.

In Stevens et al. (2004), we found that for a cost of about $5 million to $7 million of capital expense, LAX could add permanent vehicle checkpoints
without reducing the total number of traffic lanes entering the airport. We found this to be the most cost-effective solution to car and truck bombs.

In December 2004, LAWA completed an in-depth study of adding and staffing permanent vehicle checkpoints. Although their infrastructure costs were about the same as ours, they assumed much higher staffing costs. The LAWA analysis assumed that checkpoints would be staffed 24 hours a day, seven days a week and that every car would be stopped for 5, 15, or 30 seconds. LAWA concluded that the congestion caused by the checkpoints was too disruptive and the staffing costs too high to provide round-the-clock inspections of every vehicle.

We have three recommendations for going forward with permanent vehicle checkpoints. First, we need to revalidate the threat. RAND and LAWA will work with the newly created Airport Security Advisory Committee to determine if car and truck bombs are still a threat to LAX. Second, we will work with LAWA to determine if an effective solution exists for the staffing costs. Finally, we recommend that LAWA work with TSA to develop a testing program for fielding bomb-detection equipment at vehicle checkpoints.

VALUE OF ADDING SECURITY FILM TO WINDOWS

One security option that has been suggested is the addition of security film to the windows facing the public roadways. Security film is a polyester film usually between four millimeters and 15 millimeters thick. It is applied to the interior surface of the glass using a pressure-sensitive acrylic adhesive. It is intended to lessen the harmful consequences of the glass breaking. It is widely used on annealed glass that has not been treated for bomb blasts. It is not widely used on tempered or laminated glass.

LAX is vulnerable to car bomb explosions in the CTA. If a 1,000-pound car bomb were detonated in front of a terminal, there would be a large number of deaths inside the terminal from structural failure and falling debris. Glass would break throughout the CTA.

Three types of glass are used in windows. Annealed glass is the most common glass. Present in high-rise construction, it is not treated to make it safer against bomb blasts. LAX does not have any annealed glass in its terminals. Tempered glass has been heat-treated to shatter into small nuggets. The side windows in automobiles are tempered glass. LAX has about 120,000 square feet of tempered glass for the windows on the terminals facing the CTA. Laminated glass has layers of strengthening
film in between sheets of glass. Tom Bradley International Terminal has about 20,000 square feet of laminated glass facing the CTA.

Although a car bomb would cause glass to break throughout the CTA, the broken glass would not cause many deaths or serious injuries. Only tempered glass within 80 feet of the bomb would be accelerated to a speed that would be lethal. Most people within 80 feet of the bomb would be killed by structural collapse and flying debris. Fatalities would occur from flying debris out to 500 feet from the bomb. Most people who could be killed by flying glass would likely already be dead from the structural collapse and flying debris.

This finding is substantiated by examining the trauma reports from the bombings at Khobar Towers in Saudi Arabia in 1998, the Murrah Federal Building in Oklahoma City in 1995, and in London in 1993. Only one death from all of these attacks could be attributed to accelerated tempered glass, and that one was from Khobar Towers.

One problem with security film is that it has to be properly anchored to the window frame. If the film is not properly anchored, a car bomb could cause the window to adhere to the film but come loose from the frame, flying as one large piece into the terminal and causing serious injuries—for tempered glass, this is worse than having no film because tempered glass breaks into small nuggets. LAX currently has very large windows facing the CTA. To properly anchor the film on these windows would require an anchoring system well in excess of what is available today. The examples we found of windows that had been covered with security film were all much smaller than the windows at LAX.

There are very few examples of commercial buildings where security film has been added to their tempered glass. (There are plenty of examples of adding security film to annealed glass.) Most of the buildings that have added security film to larger panes of glass have also added a system (like a chain mesh) to catch the glass should the anchoring be insufficient.

The laminated glass at Tom Bradley International Terminal is not a safety problem because the terminal is set back more than 80 feet from the curb, making it less vulnerable to car bombs. Also, the terminal’s windows are smaller than other LAX windows and the strengthening film has already been sufficiently anchored.

**CONCLUSIONS AND RECOMMENDATIONS**

In Stevens et al. (2004), we found that the key to a successful strategy of deterrence against an unpredictable enemy is to understand and reduce
LAX’s vulnerabilities and the potential consequences of an attack, making it a less attractive target. The airport is vulnerable in a number of ways but particularly to large truck bombs, luggage bombs, and curbside car bombs. Two steps, relatively easy and cost-effective to implement, could mitigate the risks from all three of these threats.

1. Reduce the probability of the success of the bombers by adding permanent vehicle checkpoints at the entrances to LAX.

2. Reduce potential consequences at LAX by reducing crowds on the sidewalks and inside terminals.

One reason that reducing the crowds at the terminals is more cost-effective than adding security film to the glass is that reducing the crowds mitigates the potential consequences from car bombs, luggage bombs, and suicide bombers, while applying film to the glass is only effective (if properly applied) against car bombs. We stand by our 2004 conclusions.
INTRODUCTION

Los Angeles International Airport (LAX) is vital to Southern California. It is the world’s fifth busiest passenger airport and sixth busiest cargo airport. It is the airport of choice for over 60 million passengers each year. According to Los Angeles World Airports (LAWA), it provides the Southern California economy with over $70 billion in revenue each year. It is, therefore, critical to Southern California that LAX is as safe and secure as it can be within resource limitations.

Since 1980, there have been over 8,000 terrorist attacks against aviation targets worldwide, killing over 5,000 people. Since 1974, LAX has been the target of two bombings, two attempted bombings, and one gun attack. In August 1974, the “Alphabet Bomber” (Muharem Kurbegovic) detonated a bomb in a terminal locker that killed three and injured 36. Another bomb was detonated in the China Airlines baggage processing facility in January 1980, causing extensive damage but no injuries. In May 1982, three members of the Armenian Secret Army for the Liberation of Armenia were arrested while attempting to place a bomb in the Air Canada cargo office. In December 1999, the Millennium bomber, Ahmed Ressam, was caught crossing into the United States with bomb-making equipment. Ressam’s plan was to detonate four timed luggage bombs at curbsides and inside terminals at LAX. His al Qaeda trainers in Afghanistan suggested that he attack an airport. He chose LAX because he had flown through Los Angeles and was familiar with the airport. In July 2002, Hesham Hadayet brought two handguns into the Tom Bradley International Terminal and opened fire while waiting in line at the El Al ticket counter. Two people were killed and four were injured before Hadayet was killed by El Al security personnel.

In 2004, RAND completed a study that examined options for improving security at LAX. That study made six recommendations:

1. **Reduce the density of people in terminals.** There is no easy solution to the risks posed by luggage bombs and suicide bombers. The most cost-effective solution is to reduce the potential consequences from these threats by decreasing the crowds in the terminals and on the sidewalks. This can be done by increasing the
speed of check-in and by adding skycaps, check-in, and Transportation Security Administration (TSA) personnel.

2. **Add permanent automobile security checkpoints with bomb-detection capabilities.** This is the most cost-effective solution to large car and truck bombs. There are currently no vehicle checkpoints at LAX, and a terrorist could drive a large bomb into the Central Terminal Area (CTA). Bomb-detection capabilities should be added as the technology becomes more mature and cost-effective.

3. **Enhance procedures for screening cargo on passenger flights.** This would greatly reduce the vulnerability to and potential consequences from one of the biggest threats. Unfortunately, the solutions are probably very expensive (our initial estimate: approximately $90 million to $100 million for LAX alone). In addition, this estimate does not include the pass-through cargo from other airports. This is likely a very expensive solution to a big problem.

4. **Enhance the screening of airport personnel.** This would reduce the threat of an insider placing a bomb on an aircraft or supporting other terrorist activities at the airport. In August 2004, an insider at the Domodedovo airport in Russia allowed two Chechen terrorists to board two passenger jets. Each aircraft later exploded in flight, killing everyone on board.

5. **Enhance the training of the airport rapid reaction team.** This would reduce LAX’s vulnerability to and the potential damage inflicted by heavily armed terrorists.

6. **Improve the perimeter fence.** This would reduce LAX’s vulnerability to an air operations attack.

The first two recommendations were inexpensive solutions to major threats at LAX. We recommended they be implemented immediately. Recommendations 3 and 4 are probably expensive solutions to major threats. RAND will analyze those measures later in 2006 as part of its current research. The final two recommendations are inexpensive solutions to minor problems, and LAWA is already taking steps to address them. We continue to recommend that all six be implemented.

After we published the results of our 2004 study, LAWA commissioned studies to examine our first two recommendations in greater detail. These studies essentially confirmed our analysis but came to different conclusions.
In November 2005, LAWA asked RAND for help in implementing our first two recommendations from the 2004 study and, in response to suggestions by various stakeholders, to conduct a cost-benefit analysis of adding security film to the windows facing the CTA.
Briefing Outline

• RAND’s 2004 findings
  – Define the threat
  – Identify security options
  – 2004 recommendations

• Where are we in 2006?

• Effectiveness of window film

• Key 2004 recommendations
  – Relieve overcrowding at terminals
  – Install vehicle checkpoints

• Conclusions and recommendations
LAWA’s Concern About Terrorist Attacks on LAX Is Well Founded

- 5,000+ deaths in attacks on aviation since 1980
- Five planned attacks on LAX
- Terrorist target criteria met by LAX
  - Al Qaeda will target vital economic centers
  - Airports are “strategic buildings and important establishments”
  - LAX is sensitive politically and economically
  - Terrorist training includes attacks against airports
  - Al Qaeda revisits prime targets (e.g., World Trade Center)

RAND’S 2004 FINDINGS

Although LAX has been a leader in implementing new security programs, the airport’s security needs continue to be a great concern.

Aviation and airports are a target of terrorists. Since 1980 over 5,000 people worldwide have died from terrorist attacks on aviation targets. (MIPT Terrorism Knowledge Base, n.d.). Roughly 5 percent of these attacks have been on airports.

Since 1974, LAX has been the target of two bombings, two attempted bombings, and one gun attack (MIPT Terrorism Knowledge Base, n.d.). In 1974, “Alphabet Bomber” Muharem Kurbegovic detonated a bomb in the LAX international terminal, killing three and injuring eight. In 1980, a bomb exploded in the China Airlines luggage processing facility, causing extensive damage but no injuries. In May 1982, three members of the Armenian Secret Army for the Liberation of Armenia were arrested while attempting to place a bomb in the Air Canada cargo office. In 1999, Ahmed Ressam was caught crossing into the United States with bomb-making equipment. His plan was to detonate four timed luggage bombs at curbsides and inside terminals at LAX. In July 2002, Hesham Hadayet approached the El Al counter with two handguns, killing two and injuring six.
Al Qaeda training manuals recommend attacks against vital economic centers such as airports. LAX is the sixth busiest cargo airport and accounts for $70 billion a year in revenue to Southern California. In his court testimony, Ahmed Ressam said that one reason for attacking LAX is its political and economic sensitivity. Finally, al Qaeda revisits its prime targets, such as the World Trade Center (MIPT Terrorism Knowledge Base, n.d.).
**Best Response to Unpredictable Threat Is to Reduce LAX Vulnerability and Potential Consequences**

**Problem:** Terrorist plans are unknown. How do we prepare?

**Solution:** Make LAX an unattractive target to terrorists by...
controlling and reducing LAX vulnerability thus...
increasing terrorists’ operational costs and risks

**Results:** Deterrence: Terrorists will avoid targets that have high operational costs or risks
Limit consequences: If deterrence fails, damage will be less

There are two significant features of the threat that shape our strategy for defending LAX against terrorists.

First, there is no method to reliably control or predict what terrorists might do. Therefore, the problem is how to influence most effectively the behavior of an unpredictable enemy through an appropriate combination of prevention, protection, and response capabilities that will have a deterrent effect on those adversaries.

This is a situation that is familiar to law enforcement and to scholars of Cold War nuclear proliferation. The solution is to shape the situation so that the outcomes are unsatisfactory from the terrorists’ point of view. This will help to achieve the primary goal of deterrence. Terrorists will look at the airport and decide that attacking it isn’t worth the operational costs and risks or will not achieve a desired outcome.

The key to both deterrence and damage limitation is to reduce the vulnerability at LAX and to minimize the potential consequences of an attack. Terrorists demand a high probability of success in their attacks. In addition, they want a lot of publicity when they succeed. By reducing LAX’s vulnerability and consequences, we reduce the probability of success and the potential spectacle should terrorists attack.
RAND’s 2004 documented briefing (Stevens et al., 2004) used a scenario-based analysis that examined a suite of possible terrorist attack options and what could be done to reduce LAX’s vulnerability to these attacks.

Shown above are the 11 attack options RAND examined. For a description of the methodology used to develop this list see Stevens et al. (2004). Starting with the likely scenarios most threatening to LAX with its current security procedures, the threats are as follows:

*Insider-planted bomb.* A bomb could be placed, with the assistance of an employee with access to the airport, inside a large passenger aircraft, causing it to be destroyed in flight, potentially killing hundreds of passengers. Such a bomb would require between 3 and 20 pounds of explosive, depending on where it is placed.

*Cargo bomb.* A bomb is placed inside cargo that is loaded onto a passenger aircraft, causing it to be destroyed in flight, potentially killing hundreds of passengers. Like the bomb planted by an insider, it would require between 3 and 20 pounds of explosives, depending on where the cargo is placed.

*Large truck bomb.* A bomb in the 1,000–4,000 pound range could be concealed in a truck. If detonated at the lower level, we expect a large number of deaths and severe damage to both the arrival and departure levels of the terminal, along with two sections of elevated roadway.
**Luggage bomb.** A 50-pound bomb detonated in a crowded screening line could produce a large number of deaths. The number of deaths in this scenario is very sensitive to the density and number of people standing in line. The luggage bomb is also a good surrogate for a suicide bomber.

**Curbside car bomb.** A 500-pound bomb detonated in the right lane of the roadway in front of the line of people on the sidewalk waiting for a skycap will cause a large number of deaths on the sidewalk and in the terminal. Again, the number of deaths is very sensitive to the density and number of people standing in line.

**MANPADS.** We assume that a MANPADS (man-portable air defense system, usually shoulder-fired) attack will result in the destruction of an airliner less than 10 percent of the time.

**Public areas attack.** A well-armed group of three to ten terrorists with body armor and automatic weapons could kill a large number of people before being stopped. Current airport police capabilities would be of limited effectiveness against well-equipped attackers.

**Air operations attack.** A well-armed group of three to ten terrorists could enter the air operations area by jumping the fence or entering via an unprotected cargo operator. These terrorists could attack parked or taxiing airliners.

**Tower/utility plant bombing.** We assume that a car or truck bomb with 1,000+ pounds of explosives will result in either the destruction of the tower or the destruction of a significant portion of the utility plant.

**Sniper.** In one possible scenario, a sniper who sets up on airport-adjacent property with a .50-caliber sniper rifle would shoot at loaded planes, firing approximately 50 shots over five minutes.

**Mortar attack.** In an Irish Republican Army mortar attack on London’s Heathrow airport (March 1995), attackers disrupted airport operations for several days. This type of attack at LAX would kill few people on average, but it is possible, albeit unlikely, that a mortar round could hit a loaded plane.
Shown above are the relative fatalities for each of the attack options against LAX before any security enhancements are implemented. TSA asked that we not state the actual death estimates, so the numbers have been excluded from the axis. We note that the attacks fall into two categories: those that kill a large number of people, which we call “major” threats, and those that kill fewer people, which we call “lesser” threats. We will return to the issue of major and lesser threats later.

We also examined other measures besides fatalities, such as “damage to the airport” and “interruptions to airport operations.” For simplicity, we use potential fatalities as our primary measure.
We organized the list of possible security improvement options for LAX into three categories.

The first category, as shown on this slide, consists of options that improve airport processes. Airport processes can, in turn, be divided loosely into two subcategories: changes to operations—the experience of those using the airport—and changes to the security procedures used by the airport police.

These options tend to have small capital improvement costs and relatively low risk of failure. Some require an increase in personnel, which has a recurring cost.

Potential defenses are identified by examining each attack scenario and seeking ways to (1) reduce vulnerability by reducing exposure to attack, (2) harden the target to withstand an attack, or (3) intercept the attacker.

These options are discussed in detail in Stevens et al. (2004).
New Technology and Construction Could Enhance Airport Security

• Technology
  – Add bomb-detection capabilities to passenger or vehicle inspection
  – Introduce countermeasures to MANPADS
  – Install artillery-locating sensors to locate snipers or mortar
• New construction
  – Harden curbside areas with blast-deflection devices and shatterproof glass
  – Add motion-detection capabilities to perimeter fences
  – Isolate or modify pilings supporting upper roadway
  – Eliminate lane of traffic on upper roadway
  – Restrict access to central roads
  – Harden tower and utility plant

The second category of possible security improvement options for LAX were options requiring new technology. These options tended to have moderate capital and recurring costs but forced us to assume some technical risk of the system(s) operating as planned.

The third category is new construction. These options have high capital expenses (relative to the technology or processes options), but most have low recurring expenses because they don’t increase the number of employees required. They also tend to involve lower technological risks than the technology solutions.

1. Population density of some terminals creates attractive targets
   - Reduce check-in time. Add skycaps and check-in and TSA personnel
   - Reduces vulnerability to baggage and curbside car bombs

2. Unscreened vehicles can access entire airport
   - Add bomb detection at permanent checkpoints as technology matures
   - Reduces vulnerability to large car and truck bombs

3. Current methods for detecting cargo bombs are limited
   - Enhance cargo inspections on passenger jets
   - Reduces vulnerability to the very lethal threat of cargo bombs

4. Airport personnel can access everything on the air operations side
   - Screen air operations personnel more comprehensively
   - Reduces vulnerability to insider threat

In Stevens et al. (2004), we made six security enhancement recommendations for LAX. Shown above are the four recommendations for the major problems. LAX has already begun improvements to deal with the two minor problems (enhance training of the airport rapid reaction team and improve the perimeter fence), so we won’t address them here. This documented briefing focuses on Recommendations 1 and 2 above. Recommendation 3 and 4 will be addressed later this year.

Stevens et al. (2004) first recommended reducing the density of people at various high-traffic points in terminals. This could be accomplished, in part, by adding a small number of additional personnel to check in passengers, thus moving people through the check-in lines faster and reducing the density of people at various high-traffic points in the terminal. This would greatly reduce LAX’s vulnerability to and potential consequences from curbside and luggage bombs.

Stevens et al.’s second recommendation was to add permanent automobile checkpoints with bomb-detection equipment. This would reduce LAX’s vulnerability to large truck and automobile bombs.

Stevens et al.’s third recommendation to enhance inspection of cargo on passenger flights is probably much more expensive than the previous two options, but it would significantly reduce LAX’s vulnerability to cargo bombs.
Finally, enhancing the screening of airport personnel may also be more expensive than the first two options, but it would reduce LAX’s vulnerability to cargo bombs and any threat that is enhanced by an insider threat.

This concludes the summary of RAND’s 2004 study. We will now discuss what has changed at LAX since those recommendations were made. Then we will discuss how (and if) some of these recommendations could be implemented.
**Briefing Outline**

- RAND’s 2004 findings
  - Define the threat
  - Identify security options
  - 2004 recommendations
- Where are we in 2006?
  - Effectiveness of window film
  - Key 2004 recommendations
    - Relieve overcrowding at terminals
    - Install vehicle checkpoints
- Conclusions and recommendations
What HAS Changed at LAX Since the 2004 Study?

- Replacing air terminals in ten years is no longer planned
- Allocation of more physical space to TSA allows more efficiency; TSA has added additional screening lines at crowded terminals
- Increased use of automated check-in facilities has allowed airlines to check bags and issue boarding passes more efficiently
- LAWA commissioned studies of options to reduce crowds in terminals and at vehicle checkpoints
- The effect of blasts on windows has been identified as a security issue

Improvements are in place that make LAX more efficient and secure

WHERE ARE WE IN 2006?

These increases in efficiency should be used to reduce the lines in the terminals and hence our vulnerability to and consequences from terrorist attacks. We have observed that these increases in efficiency have been used for both a reduction in the lines and a reduction in airline staff.

Several things have changed at LAX since we made those recommendations for security enhancement.

The first is that the airport is rewriting the long range plan. The previous plan (Alternative D) called for the current terminals to be torn down in ten years and replaced by new terminals where the central parking structures currently exist. Because terminals will not be replaced under Alternative D, enhancements to the existing terminals will now have more than the ten-year life span that was anticipated in 2004.

We observed an increase in the physical space allocated to TSA operations, which has allowed them to operate more efficiently. During the past year, TSA has added more screening lines at the crowded terminals, which has reduced the number of passengers waiting to get through luggage screening.
Perhaps the biggest change is the large increase in the number of automated check-in facilities, which allow passengers to check-in luggage and receive boarding passes more efficiently. Not only has this increase in efficiency reduced the number of passengers waiting in lines inside the terminals, but it has also reduced airline staffing.

Two years ago, LAWA commissioned several in-depth studies of options for reducing the crowds in terminals and for installing permanent vehicle checkpoints.

Finally, in November 2005, the blast effects on the windows at LAX were identified as a security issue that needed to be addressed.
Unfortunately, two categories of vulnerability at LAX have not changed.

First, the terminals are still overcrowded at times that are easily predictable by a terrorist.

Second, there is nothing to stop or deter a terrorist from driving a large truck or car bomb into the CTA.
**Briefing Outline**

- RAND’s 2004 findings
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- Where are we in 2006?
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- Conclusions and recommendations
Why Is There Concern About the Windows at LAX?

- LAX terminals have large windows that face the public roadway
- LAX terminals are vulnerable to car bomb explosions
- Shattered windows could kill or injure people on the sidewalks and in terminals

EFFECTIVENESS OF WINDOW FILM

In November 2005, RAND was asked to examine the value of adding a security film on the terminal windows at LAX.

LAX is vulnerable to a car bomb explosion in the CTA. Car bombs can be as small as 500 pounds and as large as 1,000 to 1,500 pounds. Bombs larger than 1,500 pounds would probably require a truck. The typical car bomb in Israel or Iraq is about 500 pounds. The truck bomb that was used on the Murrah Federal Building in Oklahoma City in 1995 was about 5,000 pounds.

Bomb blasts have two effects. The first is “overpressure,” which will break things, especially large rigid objects such as buildings. The second effect is “impulse,” which blows objects (like debris) around. The most effective way for a large bomb (500 pounds or more) to kill people is to cause structural failure in a building. Gravity will cause the building to collapse, killing large numbers of people. For smaller bombs (less than 500 pounds), the most effective way to kill people is to accelerate lethal objects to high velocity. This works best when the objects are in direct contact with the explosive, like a nail bomb or the metal casing on a hand grenade.
Shown above are the radii for the lethal range of blast and the range at which glass will break if a 1,000-pound car bomb were to detonate in front of Terminal 6. A 1,000-pound bomb would be a large car bomb that could fit in a sport utility vehicle.

There would be a high number of deaths inside the terminal from structural failure and falling debris. Those who survive would be sprayed with small bits of broken tempered glass from the windows. These bits of broken glass could cause some additional fatalities to those already injured from the structural failure or falling debris and could create injuries to those not injured from the structural failure or debris.

A 1,000-pound car bomb would cause structural damage to the closest terminal, the roadway, and perhaps the support pillars. Glass would break throughout the CTA. As we will see, broken glass is not necessarily lethal.
There are three types of glass used in windows. *Annealed glass* is the most common glass, and it is present in high-rise construction. It has not been treated to make it safer against bomb blasts. Annealed glass will break into dangerous sharp jagged shards when subjected to just 0.5 psi (pounds per square inch) of overpressure. LAX does *not* have any annealed glass in the windows facing the CTA. When contractors who sell film for windows make their comparisons, they almost always compare their product to simple annealed glass. These comparisons are not appropriate for LAX.

The second type of glass is *tempered glass*. Tempered glass is sometimes called safety glass. Tempered glass has been heat treated to shatter into small nuggets. The side windows in automobiles are made of tempered glass. Tempered glass is the industry standard for all commercial buildings. Almost all the glass (greater than 85 percent) at LAX facing the CTA is tempered glass. It is much safer than annealed glass.

The third type of glass is *laminated glass*. Laminated glass has laminates of strengthening film in between sheets of glass and is considered safer than tempered glass.

LAX has about 120,000 square feet of tempered glass in the terminals facing the CTA. The Tom Bradley International Terminal has about 20,000 square feet of laminated glass facing the terminal area. Also, this terminal is set back more than 80 feet from the curb, making it less vulnerable to car
bombs. In addition, the terminal’s windows are smaller than other LAX windows, and the strengthening film in the laminated glass is sufficiently anchored.
The Effects of Bombs and Danger from Flying Glass Decrease with Distance

- For a 1,000-pound bomb, the maximum overpressure reduces rapidly at first, then more gradually
- Broken glass will be lethal only within areas where major structural failures occur
- Broken glass will be distributed but less dangerous over a wide area

A previous slide showed the large area over which glass would be broken. It is important to note that broken glass is not necessarily lethal. Shown above is the peak overpressure as a function of distance from a 1,000-pound bomb. Within 80 feet of the bomb, the peak overpressure is above 10 psi. This will cause structural failure within buildings and glass in windows will be accelerated to a possible lethal velocity. Within 300 feet of the bomb, the peak overpressure will be between 1 and 10 psi. With these overpressures, there could still be fatalities from flying debris, but the glass from the windows will no longer be accelerated to a possible lethal velocity. Outside of 800 feet from the bomb, the peak overpressure will be less than 1 psi. This will still cause windows to break, since the rule of thumb is that glass breaks at 0.5 psi. In truth, large panes of glass will break at much lower overpressures. It is about 1,000 feet across the CTA, therefore it is prudent to assume that windows will break throughout the CTA from a car bomb of this size.

It is also important to note that there is no distance from the bomb where glass from the windows will be accelerated to lethal velocities where there wouldn’t already be large structural damage to the building and fatalities from flying debris. Most people who could be killed by flying glass would likely already have been killed by structural collapse and flying debris.

This finding is substantiated by examining the trauma reports from the bombings at Khobar Towers in Saudi Arabia in 1998, the Murrah Federal
Building in Oklahoma City in 1995, and in London in 1993. Only one death from all of those attacks could be attributed to accelerated tempered glass, and that was from the Khobar Towers bombing. (There were several deaths attributed to broken annealed glass falling from the tall buildings in Oklahoma City, but this isn’t a potential problem for LAX because the buildings are not as tall).
Should Security Film be Added to LAX’s Tempered Glass?

• Tempered glass
  – Shatters easily from bomb overpressure and impulse
  – Is designed to produce small nuggets that are not likely to produce serious injury
  – Has been the industry standard for decades and is widely used at LAX

• Applying security film to tempered glass would keep the small shards together after the window breaks

• However, if the film is not appropriately anchored, a large and potentially dangerous object—the whole window—is released

As discussed previously, glass breaks easily from bomb overpressure and impulse. We should expect a lot of broken glass if a car bomb is detonated in the CTA.

The good news is that LAX currently has tempered glass on the windows facing the CTA. The tempered glass will break into small nuggets, which are not likely to produce many serious injuries. For this reason, tempered glass has been the industry standard for several decades.

The question is: Should LAWA put security film on the tempered glass? As discussed previously, security film will hold the small shards of glass together after the window breaks.
One problem with security film is that it has to be properly anchored to the window frame. With improperly anchored film, a car bomb could cause the window to fly into the terminal as a single sheet of broken glass held together by security film. This could cause serious injuries, and for tempered glass, it is worse than having no film at all. There are three ways to anchor film to the window frame. The first is an “open anchor,” in which the film is applied to the window but is not fastened to the frame. The second is “wet anchoring,” where the film is glued to the frame. Neither method is appropriate for LAX. The third anchoring method is “mechanical anchoring.” This is where the film is mechanically clamped to the window frame. The required strength of the mechanical clamp increases as the size of the window increases. LAX currently has very large windows (e.g., 20 feet by 8 feet) facing the CTA. To properly anchor these windows would require anchoring strength well in excess of the currently available anchoring systems.

After the Khobar Towers attack in Saudi Arabia, the Department of Defense funded a series of tests for securing buildings against car and truck bombs. When tempered glass has security film applied but has been inadequately anchored and there is an explosion, the glass may leave the frame as a single projectile and cause blunt force trauma. Tempered glass without the film was much less lethal than inadequately anchored filmed glass.
The panes of windows on which contractors typically propose to add security film are much smaller than the windows at LAX and thus do not require anchoring as strong as that required on a bigger pane of glass, like those at LAX.
Adding Security Film to LAX Windows Is Potentially Dangerous and Is Not Cost-Effective

- Detonation of a car bomb in front of a terminal will result in
  - Many fatalities from structural failure and falling debris
  - Additional injuries from broken glass

- If LAX does not apply film to tempered glass, there will be many minor injuries from broken glass but few if any fatalities

- Applying security film to tempered glass could make matters worse if film is not properly anchored
  - Current film anchors are not sufficient for LAX windows
  - Adding film requires structural improvements

In conclusion, we found, as we did in Stevens et al. (2004), that adding security film to the tempered windows at LAX is not cost-effective or likely to reduce fatalities. In Stevens et al. (2004), we also found that the two most cost-effective solutions to bombs are vehicle checkpoints to detect large car and truck bombs and reducing the overcrowding of terminals and sidewalks to reduce the risk of smaller bombs, such as small car bombs that can’t be found at vehicle checkpoints, luggage bombs, and suicide bombers.

The cost of putting security film on the windows would be around $2.5 million. It is impossible to get an exact amount because we don’t know how much the anchoring would cost. The cost of installing film with current anchors is about $15 to $20 per square foot. LAX has about 120,000 square feet of tempered glass. Assuming the new stronger anchors might be slightly more expensive than current anchors, we believe that a total cost of $2.5 million seems reasonable.

If a car bomb is detonated in the CTA, there will be many fatalities from structural failure and falling debris. There will also be additional injuries from broken glass.

If LAWA does not put film on the glass, there will be many minor injuries from broken glass but few, if any, additional fatalities.
However, putting film on the tempered glass could make things worse if the film is not properly anchored. LAX has very large windows, and current film anchors are not sufficient for windows of this size. Adding film to the windows will require additional structural costs to build a system to catch the glass should the anchoring system be insufficient.
RAND Has Examined the Value of Security Film on LAX Windows in Previous Studies

- In 2003, we found security film to be one cost-effective alternative to LAX Master Plan Alternative D
- In a 2004 examination of a broader range of alternatives, security film was not found to be cost-effective
- In this 2005–2006 study, we examined security film in greater detail and confirmed earlier findings—it would be more cost-effective to
  - Reduce the crowding in terminals
  - Add permanent vehicle checkpoints

RAND (Shell, Chow, and Grammich, 2003) examined several alternatives to the LAX Master Plan Alternative D. In that document, we reported that several procedural and structural changes could provide increased security, regardless of the modernization option pursued. The primary recommendations included expediting the movement of passengers, hardening high-value targets (where glass was mentioned), and using physical barriers. The 2003 document did not conduct any cost-benefit analyses of different configuration options or specific security improvements. Instead, it noted categories of security improvements that could be made, regardless of the modernization plan chosen. These security changes would have necessarily been less costly than modernization.

Our 2004 analysis picked up where the 2003 analysis left off. Namely, the 2004 analysis examined the costs and benefits associated with a set of specific security improvements in the broad categories of changing processes, new technologies, and new construction. The latter category included an examination of hardening the curbside area with blast deflection and shatterproof glass. Stevens et al. (2004, p. 41) shows that blast deflection and shatterproof glass are effective in the context of the curbside bomb scenario. However, blast deflection and shatterproof glass do not provide substantial benefits against the other threats identified for the airport, as shown in the chart on p. 42 of Stevens et al. Thus, the 2004 analysis did not identify deflection and glass as high-priority security...
initiatives. Within the context of specific security steps, there were other priorities that provided solutions across a broader range of threats and that were therefore more cost-effective. Thus, the deflection and glass security measure ended up relatively low (in terms of cost-effectiveness) on a list of specific improvement measures.

The current study confirms in more detail what the 2004 analysis revealed. Namely, there are more cost-effective alternatives than putting security film on the windows at LAX.
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  - Install vehicle checkpoints
- Conclusions and recommendations
Overcrowded Terminals at LAX Are Prime Terrorist Targets

- Crowded public areas are attractive targets for terrorist bombs
  - Al Qaeda has attacked crowded commuter trains in Madrid, subways in London, and nightclubs in Bali
  - In 1999, Ahmed Ressam was arrested with bomb-making material he intended to use against LAX passengers

- Unsecured areas at LAX terminals are crowded and readily accessible to terrorists

- Conveniences intended to help passengers may also help terrorists move bombs; e.g., luggage carts

KEY 2004 RECOMMENDATIONS

The crowded public areas at LAX continue to be an attractive target for terrorist bombs. Large bombs (weighing more than 500 pounds) can be detected by vehicle checkpoints at the entrances to LAX. It is nearly impossible for vehicle checkpoints to find luggage bombs or suicide bombers. The only cost-effective solution to the threat of these bombs is to reduce the vulnerability by reducing the density of people in the terminals. Al Qaeda and other terrorist organizations understand the vulnerabilities of overcrowded public areas and take advantage of them. Al Qaeda attacked crowded commuter trains in Madrid, subways in London, and nightclubs in Bali. In 1999, Ahmed Ressam (the Millennium Bomber) was arrested while attempting to transport bomb-making materials he intended to use in the crowded terminals at LAX.

These crowded areas at LAX are readily accessible to terrorists. Ahmed Ressam had planned on placing bombs in four luggage carts and exploding them simultaneously in four different terminals.
The overcrowding of the terminals can be easily mitigated. Most of the people in the terminals are not performing an essential function. A majority of the people are waiting in line. Another significant fraction (~30 percent) appear lost or confused about what to do next or where they should go.

Queuing theory (i.e., an understanding of how lines work) is well established. Every major airline applies what is known about queuing in the design and layout of its terminals. Queuing theory suggests that small changes in the airlines’ capacity (to check in passengers, handle luggage, answer questions, etc.) can produce large changes in queue length. Predictable queues, such as those occurring regularly at certain times of the week or at certain times of day, are especially easy to mitigate. These predictable queues are the most susceptible to terrorist attack because terrorists can easily exploit them.

At airports, every passenger must eventually be served; i.e., a passenger is probably not going to decide not to fly or go to another airline at the last minute. (There is very little “balking,” in queuing theory terms.) Because the airport or airline must serve every passenger anyway, it does not save money by allowing a line to form. Modest increases in capacity to check people in through more efficient systems or increases in staffing can dramatically reduce the number of people waiting in line, thus reducing the crowds and hence the consequences from terrorism.
In 2004, RAND Recommended Reducing the Crowding in Terminals

- The 2004 RAND estimate to eliminate crowding in unsecured areas was approximately $4 million per year
- RAND assessed this investment as very cost-effective in reducing LAX vulnerability
- At LAWA’s request, Leigh Fisher Associates reviewed the issue, but RAND does not concur with the conclusions
  - RAND had cited a 75% reduction in waiting time with a 5% increase in staff (from 19 people to 20)
  - Leigh Fisher estimated, for a similar but different scenario, that a 75% reduction in waiting time would require a 15% increase in staff (from 13 people to 15)
  - Leigh Fisher assessed that a 75% reduction in waiting time had no value

In RAND’s 2004 study, we estimated the total cost of eliminating the crowding in terminals at approximately $4 million per year. Most of these costs would be for an increase in staffing. It may be possible to eliminate the crowding less expensively with new concepts for check in. However, in 2004, we believed that reducing the crowds in terminals would be a very cost-effective approach to reducing LAX’s vulnerability to terrorist attack. We still believe that today.

In 2005, at LAWA’s request, Leigh Fisher Associates reviewed this issue. RAND stated in 2004 that a 75 percent reduction in waiting time could be accomplished with only a 5 percent increase in staff (from 19 people to 20). Leigh Fisher Associates’ independent assessment concluded that a 15 percent increase in staff (from 13 people to 15) would be required to reduce the waiting time by 75 percent.

Leigh Fisher Associates did not provide a vulnerability assessment to justify its assumption that there is no value in reducing waiting length by 75 percent. RAND’s assessment concluded that a 75 percent reduction in waiting time would greatly reduce the number of people standing in the terminal and on the sidewalk outside. We assessed that such a reduction in crowding would greatly reduce the loss of life in the event of an attack by a luggage bomb or a vehicle bomb.
In summary, the queuing analysis performed by Leigh Fisher Associates did not greatly disagree with the results of the RAND analysis. The difference was in the assessment of how much additional staffing it would require to reduce queuing.
During this 30-day study, we have not repeated the detailed study we made in 2004 of the queues at LAX. In 2004, we made nearly 40 trips to LAX to examine the crowds and the queues.

RAND has begun to work with LAWA, the Los Angeles Airlines Airport Affairs Committee, and the airlines to understand the different overcrowding issues in each of the terminals. We have recently had several very productive meetings with two airlines. We will continue to work with the appropriate stakeholders to reduce overcrowding in the terminals.

RAND is also working with the Airport Security Advisory Committee (ASAC) to examine changes in the threat since 2004. One significant change in terrorist tactics is the use of new formulations of explosives. These new explosives could present more of a technical challenge than previous explosives have.
2004 Recommendations Included Infrastructure Investments for Permanent Vehicle Checkpoints

Vehicles can enter LAX through six unsecured locations shown in the above map. Shown in the table are the peak flow of cars through each of the entrances, the current number of traffic lanes, and the proposed number of traffic lanes with permanent checkpoints (possible with modest capital improvements).

Currently, there are no checkpoints at LAX to examine incoming vehicles for bombs. Any vehicle can enter the CTA with a large bomb.

Prior to May 2003, any time the Homeland Security Advisory System went to a high threat level (Orange), the Los Angeles Police Department would create temporary checkpoints at LAX using traffic cones and temporary facilities. There were several incidents where officers manning these checkpoints narrowly missed being hit by vehicles. In addition, the temporary checkpoints reduced the number of traffic lanes entering LAX, which caused considerable congestion on Sepulveda and Century Boulevards.

For a cost of about $5 million to $7 million, LAX could make modest capital improvements that would allow permanent vehicle checkpoints without reducing the total number of traffic lanes coming into the airport. Of course, what is important isn’t just the number of lanes but the efficient flow of traffic through the lanes.
In December 2004, LAWA Studied the Feasibility of Adding and Staffing Checkpoints

• Each security checkpoint would include a 5-, 15-, or 30-second search of every car
• All checkpoint lanes would be staffed 24/7
• Infrastructure improvement costs were very close to RAND’s estimate
• Staffing costs were four times as high as RAND’s estimate
• The LAWA study concluded that lines would be too long and staffing costs too high to implement

In Stevens et al. (2004), RAND recommended adding permanent vehicle checkpoints at the entrances to LAX. Vehicle checkpoints are the most cost-effective way to find and deter truck and large car bombs from entering the CTA. In addition, RAND recommended that LAWA deploy bomb-detection capabilities at these checkpoints.

In December 2004, LAWA completed an in-depth study of adding and staffing permanent vehicle checkpoints. LAWA’s costs for the infrastructure improvements were very close to RAND’s estimates. The big difference was in the cost of staffing the checkpoints. The LAWA analysis assumed that the checkpoints would be staffed 24 hours a day and seven days a week. The LAWA analysis also assumed that every car would be stopped for 5, 15, or 30 seconds. LAWA concluded that the congestion caused by the checkpoints was too disruptive and that the personnel costs were too high to provide round-the-clock inspections of every vehicle.

RAND does not agree with these findings. We believe that there may be ways to reduce personnel costs by reducing the staffing during non-peak hours. Random checks may be one possibility. We also believe that there may be quicker options for screening vehicles. On the next slide, we discuss our recommendation for implementing vehicle checkpoints.
We make the following recommendations for proceeding with permanent vehicle checkpoints.

First, RAND will work with ASAC to validate that the threat assumptions used in Stevens et al. (2004) are still valid today. (In January 2006, ASAC was formed to bring together all the entities interested in airport security. Part of the charter of this organization is understanding the threats to LAX.)

Second, RAND will work with LAWA to determine if a solution exists for the personnel costs. A trade-off can be made between staffing and effectiveness. The LAWA study did not consider reduced staffing late at night. Random checkpoints could further reduce costs.

Our final recommendation is that LAWA work with TSA to develop a testing program for fielding bomb-detection equipment at vehicle checkpoints.
Checkpoint Inspections Should Include More-Sophisticated Explosives Detection

- Visual inspection augmented by explosive-detecting dogs is practical now
- Planning for the long term should begin to
  - Add inspection lanes
  - Test advanced inspection technologies
- Tests of advanced technologies should include
  - Weighing vehicles and comparing against a nominal profile in a data base
  - Neutron/gamma ray inspection from under the vehicle
  - X-raying backscatter

Currently, the only practical way to inspect incoming vehicles is visual, perhaps augmented by explosive-detecting dogs to detect traces of explosives. As indicated in the previous slide, this approach requires no new traffic lanes but suffers from three deficiencies: (1) It is disruptive to traffic and can cause significant backups. (2) It engenders substantial manpower costs. (3) The reliability of visual inspection augmented by “sniffer” trace detection is low.

In the long term, adding additional inspection lanes and using automated advanced technologies have potential for solving all three deficiencies. The number of additional inspection lanes is not trivial, and thus the costs will be significant. The technologies need to be tested in a realistic environment. The three leading technologies are (1) weighing vehicles and comparing with profiles; (2) neutron/gamma ray detection, with the potential for identifying the type and quantity of explosives; and (3) X-ray backscatter imaging.

It is conceivable that all three technologies could be used in a layered fashion.

Note that we have ruled out trace detection of explosives for the long term because it can be easily countered.
<table>
<thead>
<tr>
<th>Technology</th>
<th>Time to Detect</th>
<th>Cost</th>
<th>Manpower</th>
<th>Technological Maturity</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Explosives trace detection</td>
<td>Less than 1 minute</td>
<td>$$</td>
<td>At least one person per machine per shift</td>
<td>Fully developed technology</td>
<td>Extremely sensitive</td>
<td>Can be defeated by cleaning vehicle, wrapping weapon</td>
</tr>
<tr>
<td>Vehicle weight assessment</td>
<td>A few seconds</td>
<td>$$</td>
<td>Low; could be automated with smart cameras</td>
<td>Must integrate several technologies (scales, cameras, software)</td>
<td>Speed and simplicity</td>
<td>May miss bombs less than 500 lbs; could have lots of false positives</td>
</tr>
<tr>
<td>Neutron/ gamma</td>
<td>Less than 30 seconds</td>
<td>$$$</td>
<td>At least one person per machine per shift</td>
<td>Very new; reliability not known</td>
<td>Fairly speedy. Can determine composition and amount of explosive</td>
<td>High tech, complex, unproven, involves radiation</td>
</tr>
<tr>
<td>Backscatter X-ray</td>
<td>Multiple minutes</td>
<td>$$$</td>
<td>At least one person per machine per shift</td>
<td>Fully developed technology</td>
<td>Will detect even small threat objects</td>
<td>Quite slow. Cannot determine composition</td>
</tr>
</tbody>
</table>

Shown above are the four technologies we think should be investigated for vehicle security checkpoints. The table includes their pertinent characteristics.

Any technology that takes more than a few seconds should only be considered for secondary testing. That is, every vehicle should only be delayed for a few seconds at the most. Weighing vehicles and comparing their weight to those in a database is the only technology that could be used in a few seconds. We are only searching for large bombs. If the vehicle weighs 1,000 pounds more than it should, it could be pulled over for secondary screening.

Explosives trace detection is a fully developed technology and several contractors have concepts for screening automobiles. It requires more than 30 seconds to complete, so it isn’t useful as a primary screener. In the long term, it probably isn’t viable because it is easily defeated by cleaning the vehicle or wrapping the weapon. All the trace detection concepts need to be compared with what can be done with dogs. Some sort of trace detection is the only currently available technology. It would find a truck bomb the size of the bomb used against the Murrah Federal Building in Oklahoma City.

Backscatter X-ray is another fully developed technology. It would take longer than trace detection—it could take several minutes. It is much harder to defeat than trace detection, but it doesn’t determine the composition of the bomb.
Neutron/gamma ray detection is very new and may be years away from maturity. It is faster than backscatter X-ray and can determine the composition of the bomb. It is probably more expensive than trace or X-ray detectors and requires the use of radiation.
**Briefing Outline**

- RAND’s 2004 findings
  - Define the threat
  - Identify security options
  - 2004 recommendations

- Where are we in 2006?

- Effectiveness of window film

- Key 2004 recommendations
  - Relieve overcrowding at terminals
  - Install vehicle checkpoints

- Conclusions and recommendations
Conclusions and Recommendations

• Adding security film to the tempered glass in the CTA is not as cost-effective as other solutions

• Implementing the most cost-effective solutions to control vulnerability to, and consequences from, car and luggage bombs will reduce terrorists’ probability of success by
  – Improving vehicle screening at airport entrances
  – Reducing crowds on sidewalks and in terminals

CONCLUSIONS AND RECOMMENDATIONS

The most cost-effective approaches to the threat of truck bombs, car bombs, luggage bombs, and suicide bombs are to (1) reduce terrorists’ probability of success by adding permanent vehicle checkpoints at the entrances to LAX and (2) reduce the airport’s vulnerability to smaller bombs by reducing crowds on sidewalks and in terminals.

Adding security film to the tempered glass in the CTA is not as cost-effective as the above solutions. If the film is not properly anchored, it would make the terminals more vulnerable. The current types of film anchors available are not sufficient for the large windows at LAX, so adding security film to the windows would require structural upgrades to catch the glass in the event of a blast.
Implementing the Recommendations

Over the next six months RAND will:

• Work with ASAC to validate the threats to LAX
• Help LAWA and the airlines identify ways to reduce crowding in the terminals
• Work with LAWA to develop an effective and affordable staffing plan for permanent vehicle checkpoints
• Work with TSA and LAWA to develop a testing program for bomb-detection equipment at vehicle checkpoints

To help LAWA implement RAND’s recommendations we will:

• Work with the Airport Security Advisory Committee to validate the threats to LAX. Are the threats we identified in 2004 valid today?
• Identify ways to reduce the overcrowding in the terminals. Each terminal has problems particular to that terminal.
• Identify how permanent vehicle checkpoints can be effectively and affordably staffed.
• Develop a testing program for new technologies that detect bombs at vehicle checkpoints.

This work is scheduled for completion in October 2006.


Karagozian & Case, *To Film or Not to Film: Effects of Anti-Shatter Film on Blunt Trauma Lethality from Tempered Glass*, Burbank, Calif.: Karagozian & Case, 2002.

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MIPT Terrorism Knowledge Base, online at http://www.tkb.org, n.d.


