32. Transportation Security

Abstract. The transportation of nuclear materials involves the movement of material from one location to another, often outside the protection boundaries of a fixed-site location. Although the same physical protection elements (detection, delay, response) are present, the transportation system in use is continuously exposed to the public, whereas the fixed site by its very nature restricts public access. The material transport system can be considered a moving facility. It may consist of several material transports and response force carriers such as military escort vehicles and railcars. The area surrounding the facility (transport mode) automatically changes as the transport moves throughout the designated route. The terrain can change from flat level ground to rolling hills or mountains in a matter of moments. In addition to terrain variations, the transportation operation exposes the transport system to several types of public domain, including both urban and rural settings.

32.1 Introduction

Overview

A well-designed physical protection system (PPS) contains elements of detection, delay, and response, all of which are essential for the proper operation of the system. Likewise, a transportation PPS contains the same elements. The synergism that occurs between the guard force and the technology is one of the keys to an effective, balanced security system.

32.2 Transportation Safeguards

Transportation Security System Has Same PPS Elements as a Fixed Site

In a transport system, the three basic security elements are present, but their relative importance changes. For this discussion, the transportation system is assumed to be a security-hardened material transporter accompanied by at least one separate vehicle carrying additional members of the response force. The transportation system can be described as a movable entry control area with built-in delay systems. Instead of being posted at fixed stations, the guards move with the convoy.

The communication systems, both within the response force itself and to a central command post, are more complex in a transportation system. Because of the movements of the various elements of the convoy, long distances may exist between convoy elements and the even longer distances between the convoy and its central command post or off-site response.

Response Force

In a transport operation, the adversary can decide on the location of the attack. They may pre-position themselves and place personnel devices. The adversary can own the position, particularly on remote routes. Thus, in transportation security, the response force must contend with the fact that they come to the adversary unlike a fixed site, where the adversary must come to them.

Detection

Access to the transport vehicle when moving would be very difficult. When the transporter is stopped, the response force accompanying the shipment provides detection by observation of its exterior. Detection and subsequent assessment are accomplished primarily by direct human observation rather
32. Transportation Security

Need for Access Delay Depends on How the Response Force Survives the Initial Attack

than relying upon technology. These elements frequently occur almost simultaneously as members of the convoy become aware that they are under attack.

The synergistic balance of the technology and response force is important. If the size of the accompanying response force surviving the initial attack is substantial, the need for access delay diminishes. If, however, the number of response force personnel who survive the first portion of the attack is small, there needs to be a greatly increased time between the initiation of the attack and removal of the cargo to allow the remaining force time to redeploy to defend the cargo and/or for additional response personnel to arrive.

Differences in Security Imposed by Transportation

In many respects, ground transportation security is more challenging than security at a fixed site. Operation in the public domain is frequently required and so the same degree of access limitation is not possible as in a protected fixed site. In addition, and perhaps even more importantly, an attack can occur anywhere along a route of up to several thousand miles, giving the adversary a wide choice of potential attack locations. In most cases, this choice could be in locations where it will be virtually impossible for any sizeable secondary response force to arrive within a useful period of time. Because of these differences, response force personnel in transit play a more dominant role in the security of a mobile system than they do for a fixed site. In all cases, however, the system time delay required to provide the response force with time to react must be provided primarily by transportation vehicle technology elements.

32.2.1 Facility Characterization

Characterize the Transport Vehicle Structure and Existing PPS

Characterizing a transport system involves the same methodology as a fixed-site, although some components to be characterized are different. The structure of the transport vehicle is characterized in terms of walls, ceiling, and floor, which is most often accomplished with engineering drawings and visual observation. Next, the analyst identifies any physical protection systems, including operating systems such as communication and alarm annunciation.

Transport Modes Category I and II

Four transport modes are acceptable for Categories I and II. In ground transportation (road), a dedicated, exclusive-use conveyance must be used. During any extended stop, the vehicle should be immobilized and guarded. Rail transport must use freight trains with exclusive use that are fully enclosed, and locked. Extended stops are only acceptable if at appropriately equipped and secured stopover facility. For maritime transport, the material must be in secure, locked, and sealed compartments or containers. Guards should accompany the load-carrying ship. Air transport must use an aircraft designated for cargo only, with secure, locked, and sealed compartments or containers.

While nuclear material is on board pending departure, provisions should be made for sufficient access delay or compensating measures to meet the threat assessment or DBT.
Transportation Security

<table>
<thead>
<tr>
<th>Transportation Routes</th>
<th>Transportation routes should be reviewed in detail, with special attention to:</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>• Potential danger zones or choke points</td>
</tr>
<tr>
<td></td>
<td>• Locations for scheduled stops</td>
</tr>
<tr>
<td></td>
<td>• Possible adversary infiltration and egress routes</td>
</tr>
<tr>
<td></td>
<td>• Speed and distance, which affect the timing at which events occur</td>
</tr>
<tr>
<td></td>
<td>Vehicles traveling slowly up a steep grade offer the adversaries a better</td>
</tr>
<tr>
<td></td>
<td>target than one moving faster on a level road</td>
</tr>
</tbody>
</table>

Analysts should perform security surveys prior to the departure of the transport(s).

Understand the Operating States for a Transport System

<table>
<thead>
<tr>
<th>Convoy Configuration</th>
<th>Transport operating states must also be determined, such as:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Stopped at a scheduled (predetermined) location – day or night</td>
</tr>
<tr>
<td></td>
<td>• Stopped at an unscheduled location – day or night</td>
</tr>
<tr>
<td></td>
<td>• Rolling to a stop – day or night</td>
</tr>
<tr>
<td></td>
<td>• Moving at various speeds – day or night</td>
</tr>
</tbody>
</table>

Each state may be affected by terrain and environment.

Understanding the transportation vehicle and the convoy states are an important part of the transport system characterization. The elements in a convoy must be distributed so that they are far enough to survive initial adversary ambush, yet close enough to respond, interrupt, and stop the adversary before they can complete their objective.

Once the transport system has been fully characterized, the second step of the Design and Evaluation Process Outline (DEPO), the characterization of the existing PPS, can begin.

32.2.2 Detection Requirements

| Response Force Provides Detection | All movements of nuclear material outside the protected area of a fixed site must be accompanied by response force personnel who can observe the vehicle at all times. This level of observation requires personnel in the material transport vehicle as well as escorts in front of and behind the vehicle. These response force personnel are continuously observing the surface of the vehicle and serve as the detection and assessment elements of the security system. Response force capabilities depend on tactics and terrain—rural versus urban. In addition, some effective means of entry control and interior intrusion detection can serve to give an alarm if unauthorized personnel attempt to enter the material transport vehicle. For Category I and II shipments, it is recommended that the entry control system incorporate a two-person rule to minimize threats from the insider. |
### 32.2.3 Delay Requirements

<table>
<thead>
<tr>
<th><strong>Delay Time Required</strong></th>
<th>An attack may occur in remote areas of the route where sizeable secondary response assistance is not available immediately. The required delay is that time needed by the response forces who accompany the shipment to deploy in the manner to best protect the shipment.</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>If the analysis shows that response forces external to the convoy are needed, the <em>minimum delay time</em> is the time estimated to allow this response to arrive before the cargo has been removed from the scene or sabotaged.</td>
</tr>
<tr>
<td></td>
<td>Depending on composition and spacing of the convoy vehicles and the response force tactics, sending additional forces could take several minutes.</td>
</tr>
<tr>
<td><strong>Example Delay Techniques</strong></td>
<td>It is difficult to design delay systems that will ensure these types of delays for all possible sets of adversary capabilities and tactics. However, systems that use items such as visual obscurants, vault-like structures, gases, hardened containers, razor tape, chains, etc., can be designed to successfully delay most such attacks.</td>
</tr>
<tr>
<td><strong>Delay and Response Force Are the Main Elements</strong></td>
<td>Delay and an effective response are essential to an effective PPS. It is nearly impossible to develop technology-only security systems that can withstand a well-planned attack for long enough to allow secondary responders to arrive from a distant location.</td>
</tr>
<tr>
<td><strong>Lethal vs. Nonlethal Technology</strong></td>
<td>In this course, we assume that non-lethal deterrents are used in the delay system. Use of lethal deterrents has the potential to significantly increase delay time at a lower hardware cost; however, the social and potential legal costs of accidental or inappropriate activation of these deterrents may outweigh their effectiveness advantage.</td>
</tr>
</tbody>
</table>

### 32.2.4 Response Requirements

<table>
<thead>
<tr>
<th><strong>Number of Response Forces Required</strong></th>
<th>The number of guards assigned to transportation depends on consideration of (a) relatively high cost since the guards must be on duty around the clock, be well trained, and be highly capable, and (b) the estimated size, capability, and objectives of the attacking force.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>The defined ratio of defenders to attackers for fixed sites may be somewhat low for use in ground transportation systems, because any engagement with the adversary during transport does not occur on <em>friendly ground</em> and thus is not as easily defended. In addition, response force personnel may be more vulnerable to a surprise attack given that they travel through public areas.</td>
</tr>
<tr>
<td><strong>Communication Requirements</strong></td>
<td>Communications are necessary:</td>
</tr>
<tr>
<td></td>
<td>• Between the various elements of the convoy to provide an essential detection and assessment function.</td>
</tr>
<tr>
<td></td>
<td>• Among the members of the security force should they have to deploy, for organizing and carrying out a coordinated defense.</td>
</tr>
</tbody>
</table>
• Between the convoy and the central control station for reporting back to the central station to notify authorities that an incident has occurred and for summoning secondary response force reinforcements, if needed.

The relative degree of importance of each of these systems depends on procedures, composition of the convoy, and where it operates. Communication requirements must be determined on a case-by-case basis.

32.3 Transport Vehicle

The design of the material transport vehicle (Figure 1) must provide sufficient access delay so the convoy response force can respond to an attack and defeat the adversary before the adversary task is accomplished. An enhanced transporter can provide increased access delay and ballistic protection together with enhanced safety, while potentially reducing the required number of accompanying security escorts. In addition, vehicle entry control and response force communication capabilities are essential to protect nuclear material in transit.

Figure 1. Example of a Transport Vehicle

32.3.1 Basic Vehicle Requirements

The primary security requirements for the transporter are ballistic protection, entry control, and access delay for the vehicle. Methods include:

• A very strong vault wall panel design
• Robust access doors for the cargo compartment
• Two-person entry controls
• Vehicle immobilization hardware

Safety enhancements are required to help reduce impact effects in an accident, especially to reduce the risks from fire during an accident. For example, specific design goals could be to provide thermal protection for vault cargos for 20 minutes in a 1000°C fire. Design features include:
• A strong vault structure
• Strong cargo tie downs
• New insulating foam materials
• Limited vehicle fuel capacity

These basic design features are passive, which substantially reduce concerns about safety and premature initiation or failure of any active delay systems.

32.3.2 Vault

Construction
The vehicle vault should be an integral structure incorporating panels of multi-layer corrugated steel armor, rigid foam, inner and outer stainless steel skins, and other barrier materials on a tubular steel frame. The vault structure should be designed fracture-tough with special steels for primary load members. The corrugated armor together with the overall thickness of the wall panels provide access delay and ballistic protection for the cargo.

Vault Cargo Volume
The vault cargo volume should be designed to accommodate as broad a range of container sizes and weights as possible. The vehicle capacity is dependent upon the truck chassis selected for the vehicle and whether the cab armor option is selected. Aircraft-type cargo tie-down tracks should be provided in the vault floor and perhaps on the vault sidewalls and roof. This arrangement allows flexible cargo tie-down schemes for containers, palletized loads, or sidewall racks.

32.3.3 Entry Control

Use Two-Person Rule and Hardware for Entry Control
An entry control system is needed to control authorized access to the cargo vault area. The system should provide for two-person entry control. An example would be a 3- to 8-digit individual code entry from a plug-in, limited-view, scramble pad pendant. An electronic lock that can accommodate up to 1000 valid user codes with limited try features, as well as easy code entry and recode is recommended.

Electromechanical Door Lock
Output from the entry control system should control an electromechanical door lock incorporated into the door. This type of mechanism incorporates aircraft-quality actuators for operating a locking block upon receipt of a valid entry code. The locking block drives multiple, distributed locking pins that physically secure the door to the vault frame. A passive locking wedge should provide hinge-side locking. The door lock should also use stressed glass and thermal relockers to provide additional forced entry protection.
32.3.4 Chassis

Design Considerations

The cargo vault could be installed on essentially any vehicle chassis capable of carrying the necessary payload. A heavy-duty front axle allows for the additional weight of cab armor if required. The vehicle should:

- Meet all legal requirements for operation on public streets and all applicable federal regulations
- Have an engine powerful enough to allow cruising at 88 km/hr and operation on 10% grades
- Include air brakes, air suspension, and a cold weather starting package

32.3.5 Immobilization

Immobilization capabilities can prevent an adversary from simply driving the vehicle away if it is captured. The vehicle should incorporate chassis immobilization features that can be activated from the vehicle cab or remotely from one of the escort vehicles.

Imobilization Methods

Chassis immobilization methods could include:

- An engine fuel shutoff device
- A turbo air shutoff valve
- An accelerator linkage disablement device
- Controlled braking of the vehicle to bring it to a stop within several seconds after initiation

The immobilization system may be reversible either by a variable timer or by manual resets.

32.4 Transport Security Plan

Purpose of a Transport Security Plan

The Transport Security Plan identifies security responsibility for all involved stakeholders. It documents security measures and procedures throughout the entire transport operation, as well as provides a basis to test and evaluate the security system, and take corrective actions as needed. The Transport Security Plan supports and should be coordinated with the Contingency and Emergency Plans.

When is Transport Security Plan Required

A Transport Security Plan is required when Category I or II nuclear material is shipped. The Competent Authority should ensure that there is clear responsibility for and ownership of the Transport Security Plan. This plan may also be required in situations when required by another regulatory body or deemed necessary by a shipper or carrier.

In addition, a Transport Security Plan is recommended for the shipment of any package that requires an enhanced security level, i.e., for a package in a
The following sections should be included in the Transport Security Plan:

- Allocation of responsibilities
- Arrangements for transfer of responsibility
- Review of operations and vulnerability assessment
- Testing and evaluation of Transport Security Plan
- Review and update of Transport Security Plan
- Requirements for timely reporting (routine and incidents)
- Records of shipments (packages and nuclear material)
- Description of transport physical protection system
- Measures to ensure protection of sensitive information
- Trustworthiness of personnel
- Pre-shipment security verification checks
- Response planning, contingency plans, and coordination with emergency plans

The following are requirements for all nuclear material when protecting against unauthorized removal:

- Minimizing the total time during which the nuclear material remains in transport
- Minimizing the number and duration of nuclear material transfers, e.g., (a) transfer from one conveyance to another, (b) transfer to and from temporary storage, or (c) temporary storage while awaiting the arrival of a conveyance, etc.
- Protecting nuclear material during transport and in temporary storage in a manner consistent with the category of that nuclear material
- Avoiding the use of predictable movement schedules by varying times and routes
- Requiring predetermination of the trustworthiness of individuals involved during transport of nuclear material
- Limiting advance knowledge of transport information to the minimum number of persons necessary
- Using a material transport system with passive and/or active physical protection measures appropriate for the threat assessment or design basis threat
- Using routes that avoid areas of natural disaster, civil disorder, or with a known threat
- Ensuring that packages and/or conveyances are not left unattended for any longer than absolutely necessary

shipment that exceeds the established radioactivity threshold, or when otherwise required by a Competent Authority, e.g., in a performance-based approach.
Table 1 provides a list of requirements per nuclear material category, based on a graded approach.

Table 1. Applying a Graded Approach

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Cat I</th>
<th>Cat II</th>
<th>Cat III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Requirement for a shipper and/or carrier to develop a transport security plan (Transport Security Plan) for regulatory approval</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Additional authorization by CA just prior to commencing transport</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Advance notification and coordination between shipper, carrier and receiver, estimated time of arrival of shipment;</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Time, place and procedures to transfer responsibility for security;</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Confirmation by receiver to accept delivery of shipment</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Procedures / security related to locks, keys, and tamper seals are commensurate to category of material;</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Use of high strength and high security locks;</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Appropriate coordination and planning between shipper, receiver, and carrier</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Surveillance of cargo, compartment or conveyance</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Armed guards should escort shipment</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continuous two way voice communication (conveyance ↔ guards)</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Sufficient delay in conveyance</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Timely &amp; adequately sized response forces to prevent unauthorized removal</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Use of Transport Control Centre (TCC)</td>
<td>X</td>
<td></td>
<td></td>
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<tr>
<td>Road conveyance specifically designed to resist attack (to include disabling device)</td>
<td>X</td>
<td></td>
<td></td>
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<tr>
<td>Frequent reporting by guards or crew to TCC</td>
<td>X</td>
<td></td>
<td></td>
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</tbody>
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32.5 Analysis of System Effectiveness

<table>
<thead>
<tr>
<th>Vulnerability Assessment and System Effectiveness Evaluation</th>
<th>Vulnerability assessment is the systematic and performance based methodology for analyzing the transport security system.</th>
<th>A system effectiveness evaluation is a step in the VA process used to determine the performance of the physical protection system in meeting the objectives in relation to the threat.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methods of Performance Testing</td>
<td>Stand-alone test is an examination of whether a specific element of the Transport Security Plan or component of the PPS functions as designed. Examples include communication systems, procedures, etc.</td>
<td>An exercise is a scenario-based performance test using a credible scenario to evaluate the performance of any aspect of the Transport Security Plan. Examples include drills, tabletops, battle-boards, and field exercises, e.g., Force-on-Force.</td>
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</table>

Scenario Analysis

For a transport system, the layers of protection that an adversary team must penetrate to gain access to the target are limited. This situation makes path analysis less suitable for analyzing the effectiveness of the PPS of a material transportation system. A more effective tool is scenario analysis. The process of scenario analysis is covered in greater detail in Scenario Analysis, Section 22. The methodology for conducting a scenario analysis is the same for a fixed site as it is for a transport system.

Scenario Development

Sources for the DBT or the threat assessment include performance test data and industry standards.

The chief question facing the DBT is how to stop the vehicle. With the Hollywood element removed, the adversary is going to either try and attack the vehicle in a position where they know the vehicle will stop.

The adversary could try to buy this information from an insider (someone who works directly or indirectly with the convoy but has sufficient access and knowledge to know the way points). The risk for the adversary is exposure by adding another individual to the team. It generally takes time and funds to purchase this type of information. But it is a legitimate threat as identified in the IAEA definition of DBT (Adversary = outsiders and insiders).

The adversary could also detonate explosives to stop the vehicle. This is a common tactic that we are seeing from the adversary in current war zones. While the intention and capabilities are completely different from what we are talking about today than what the US faces in these war zones, the tactics for stopping the vehicle is applicable. They identify a payload vehicle and detonate sufficient explosive to stop that vehicle which causes the escort vehicles to dismount. The end result is the protective forces are required to engage an adversary who have established interlocking fields of fire.
Once the vehicle is stopped, what does the adversary need to do?
In a fixed facility, the barriers to entry for the adversary were two lines of
fencing, two regular building doors, a vault door, and the container.
When we did the convoy characterization, we identified the number of
vehicles that would be present in the base line run for the assessment. These
vehicles serve as our barriers to entry.

By lying out the convoy configuration and understanding the type of
vehicles involved will establish a probable scenario (not really a path) on
how the adversary can try to sabotage or steal the material.
Essentially, we need to come up with an attack plan.

Areas of consideration include the following:

- Threat attributes and characteristics?
- Likelihood of theft and/or sabotage?
- How and where will the threat stop the vehicle?
- How will the threat carry out the attack?
- Do capabilities match the threat matrix?
- Location of the shipment?
- Critical points/places along the route?

**Engagement Analysis**

Once the scenarios are fully understood and defined, an engagement
analysis should be conducted to determine if the response force is able to
deploy effectively and then interrupt and neutralize the adversary team. This
analysis is typically conducted with computer models, subject matter
expertise, and force-on-force exercises.

**How to Increase System Effectiveness**

When the analysis results indicate the need for increased effectiveness,
areas that can be considered for upgrades include providing immediate
detection, increasing delay, enhancing response force capabilities, including
numbers, weapons, equipment, and vehicles. Other areas that should be
considered include providing more effective procedures and plans, initiating
proactive protection, enhancing training, improving planning, conducting
route and intelligence analysis, practicing counter-surveillance techniques,
and employing unpredictable operations (schedule / routes / scheduled stop
locations) or look-alike shipments or decoys.

### 32.6 Summary

**PPS Considerations**

Just as the physical protection system for a fixed site requires a careful
balance of detection, delay, and response elements, a transport vehicle
carrying nuclear material also requires:

- **Detection** – Accomplished by convoy observation or by interior
  intrusion detection devices
- **Delay** – Implemented by building a vault-type enclosure on a truck
  frame
**Response** – From convoy response forces who should be relied upon when analyzing engagement effectiveness. Local law enforcement may not be available at the time and/or location of an attack.

**Resources**

Analysis methods should be used to determine if the overall safeguards elements together provide an adequate level of safeguards. *The Convention on the Physical Protection of Nuclear Material* (IAEA INFCIRC/274) clearly places the responsibility on the State to provide the required level of physical protection of all nuclear material in international transport, but preserves the sovereign right of States to determine the manner of providing that level of protection. The three principal international documents that provide guidelines for the physical protection of nuclear materials in transit are:

- Security of Nuclear Material in Transport (NSS-26G)
- The Physical Protection of Nuclear Material and Nuclear Facilities (NSS-13)