# Assessment of the Best Safety Practices of Six Chemical Plants and their Five Primary Carriers

An Interactive Qualifying Project Report
submitted to the Faculty
of the

WORCESTER POLYTECHNIC INSTITUTE

in partial fulfillment of the requirements for the

Degree of Bachelor of Science

by


**Brooke Buchholz**

**Michael Corbett**

**Sam Gharabally**

**Laura A. Matejik**


Date: December 11, 2002
Approved:

**Professor Gregory Theyel, Major Advisor**

**Professor Paul W. Davis, Co-Advisor**

## Table of Contents

**Abstract**

Preventing accidents is a challenging task, involving various behavioral, vehicular, and environmental factors. To address these factors for a particular manufacturing firm, this study examined its plants and contracted truck carriers to develop a list of validated Best Safety Practices. Using this list, we created an action plan to improve safety procedures, plant-carrier interactions, and safety awareness, while reducing the number of truck accidents.

## Executive Summary

### *Objectives*

This study focused on prevention measures for three major causes of truck accidents: behavioral, vehicular, and environmental. We examined six chemical plants and five truck carriers in Europe and North America using interviews and observations as the methods of data collection. The objective of this study was to raise the level of safety awareness by creating a set of best safety practices that can be implemented across plants located in Europe and North America.

### *Solutions*

Through the course of our visits, we observed many safety practices. To be considered in this study, a practice had to address behavioral, vehicular, or environmental factors. To prove which of these were best practices, we attempted to justify each one with research in the form of studies and incident reports from the Company's Transportation Incident Database. Below we have listed these justified best safety practices.

### Plant Best Practices

Inspections

*Pre- and Post-load Inspections*

At one of the sites we visited, each truck was inspected at the Truck Control Center before entering the site. This truck inspection included a 360-degree walk-around to check the condition of the truck and tires, both an internal and external vacuum test on the back valve, and a check of the condition of the gasket lining the inside of the manhole cover.

After each truck was loaded, it returned to the Truck Control Center where it was subjected to a post-load inspection. This also consisted of a 360-degree visual check of the truck for leaks, along with an inspection of the back valve and top manhole to ensure that both were closed and sealed correctly.

Through the analysis of the Company's Transportation Incident Database, we discovered 64 incidents over a four-year period that could have been prevented if a pre- and post-load inspection had been performed. These incidents consisted of items such as loose wash caps and butterfly nuts, which resulted in product spills while driving.

*Random inspections with check list*

One site performed inspections on a random basis because it was not feasible to check every truck, due to the high volume of trucks entering the site each day. About 40 percent of the incoming trucks were inspected, with different criteria for dangerous and non-dangerous goods.

During our visit to this site, the gate personnel refused a truck admission to the plant for not having all of the required safety equipment for the product being transported. We also observed a database that contained data from all of the random inspections performed. By keeping and analyzing a database of all incidents of noncompliance with safety requirements, a site can identify the major problems with safety equipment and modify its protocol to reflect the data.

We feel that the company and the carriers should work together to implement one of these types of inspection processes. In all cases, the Company and its carriers should establish a checklist for these inspections that should be distributed to all of the carriers' drivers. At all plants, the results of the inspections should be tracked in a database and analyzed by both the Company and its carriers to identify problem areas that they can improve together.

Pictorial safety rules and map of plant

At another plant, each driver was given a document at the reception desk explaining the safety procedures in place at the site, such as speed limits and requirements for Personal Protective Equipment (PPE). The procedures were represented pictorially for ease of understanding. This paper also contained a map of the site. Using this map, the receptionist showed each driver how to get to the loading station. Upon receiving the document, the driver had to sign and return it to the receptionist before s/he entered the plant. The driver was allowed to keep the carbon copy so s/he could refer back to it if s/he had any questions.

Raymond Finney, Occupational Safety & Health Administration (OSHA) Area Director, feels accidents involving workers improperly trained because of a language barrier are increasing ("Language Barrier Leads to Accident," 2001). Pictorial representations of instructions may help those who do not speak a common language to understand and follow safety rules. A study on pictorial manuals performed by Trotter-Cox in 1999 found that long-term retention of symbols was dramatically greater than retention of text.

Near-miss incident reports

One of the plants we visited had a goal of reporting at least 200 near-miss incidents each year. A near-miss report tracks an incident caused by risks that could pose a problem, but where no serious accident occurred. The purposes of this goal were to encourage employees to observe both themselves and each other, to report anything that could potentially cause an accident if ignored in the future, and to identify protocol that could be added or changed to reduce the risk of these incidents.

By studying the information revealed in near-miss reports, the root causes of accidents can be identified and the chain of reactions that cause accidents can be better understood. By analyzing the causes, it is easier to identify the risks, as well as develop better prevention methods ("Safety Data Initiative," 2001). The United States Department of Transportation (U.S. DOT) Safety Council feels it is necessary to take a proactive approach by utilizing near-miss systems to prevent accidents and spills.

The Company and its carriers should share near-miss incident reports to increase their knowledge of potential dangers. Local branches of the Company should then meet with their respective primary carriers to discuss ways to remedy these dangers. This practice will not only resolve these problems, but also open a line of communication between the Company and its carriers.

Driver active in the loading process

At two plants we visited, the driver was very active in the loading process. At the first plant, the drivers and the Company personnel shared the loading tasks fairly equally and there was a large amount of interaction between the Company personnel and the driver. At the second site, the drivers did everything except select the storage tank from which to load. By keeping the drivers active in the loading process, drivers were required to interact with the Company technicians at the loading station.

Involving the drivers in the loading process can serve as a cognitive test of the alertness of each driver before s/he starts his/her trip on the road. A study conducted by the United States Midwest Transportation Center (1997) tested drivers using a cognitive test for both audio and visual spatial processing and selective attention. Immediately following this test, each driver was subjected to an on-road driving performance test. The study found that "losses in certain cognitive skills can be identified as being related to increasing potential for driving errors" (Mercier, Mercier, O'Boyle, and Strahan, 1997).

By having the driver interact in the loading process, one more line of communication between the Company and its carriers is opened. Through this line of communication, the loading personnel can observe the condition of the driver, check to ensure the driver is wearing PPE, and develop a professional friendship with those drivers who frequently load at the plant. This ensures that both the drivers and loading technicians are working together to safely load the truck.

Safety Awareness

Improving safety through increased awareness is a key theme present in the Company's safety program. The Company hopes that by setting a goal of zero accidents, employee and driver safety awareness will be raised, improving behavior on-site and on the road. During our site visits and discussions with managers at the Company, we compiled a list of ways to increase driver awareness of safety on the road.

Driver awareness of safety is identified by the U.S. DOT as a countermeasure to prevent commercial vehicle accidents from occurring ("Commercial Vehicle Preventable Accident Manual"). To raise safety awareness, the Occupational Safety & Health Administration (OSHA) designed seven guidelines for the Voluntary Training of Employees. Guideline number three is "Identifying Goals and Objectives," which is when a clear, attainable goal is set and information is provided as to how to reach that goal (Cohen and Colligan, June 1998). The Company is doing this by stating its goal for obtaining zero accidents by 2005 and providing instruction on how to attain this goal by making safety programs and material available to drivers and employees. Below, we have listed a set of practices we observed and researched that will reinforce these goals.

*Signs for "Zero truck accident goals" on way into plant*

On the road leading to one site, there were multiple signs that stressed safety to both drivers and visitors. One sign stated the Company's goal of zero truck accidents, while another displayed a time graph of the number of on-site injuries, highlighting the downward trend of the number of injuries over time.

The Company and its carriers should work together to develop a set of signs, including site-specific and Company-wide safety goals. This standard set of signs should be posted at each Company site, as it will reinforce the idea of safety and its importance to both the carriers and the Company.

*Trucker safety day*

One plant held a trucker safety day where a pavilion for the drivers was located outside the front gate. Drivers coming to load that day were invited to spend some time at this event. The pavilion contained multiple booths showcasing different aspects of truck safety. At the end of each driver's visit, s/he was encouraged to fill out a survey to give his/her thoughts about the plant. This practice familiarized drivers with new truck and safety equipment. It also emphasized the importance of drivers to the Company and provided a venue to communicate current site access information and road safety issues. Free mugs, hats, and hot dogs were also an incentive for truck drivers to attend.

The Company should implement some type of trucker safety day at each of its sites in conjunction with its respective primary carrier. This way, the carriers can promote these events to encourage their drivers to attend and can also provide safety information to display at the event.

*Near-miss report/Driver comment box*

A box placed in the drivers' lounge where drivers can submit near-miss reports can serve as a line of communication between the driver and the management of the Company. If a driver notices a safety concern while on- or off-site, s/he can fill out a near-miss report to inform the Company of the problem. Having a box in the lounge shows that the

Company is concerned with the driver and his/her input, and in turn, it encourages the safety awareness of its drivers.

The Company should share completed near-miss reports or comment forms that relate to problems on the road with its carriers. The carriers and the Company should then work together to address the problems that can be resolved and make the drivers aware of all the problems that appear in the reports.

*Driver award programs*

Many of the carriers we visited had driver award programs to recognize drivers who were leaders in safety. These drivers were rewarded in a number of different ways, but only by their carriers. The Company's individual sites should work in conjunction with their carriers to be a part of these reward programs by sending a representative to each carrier's award ceremony to show the awardee that the Company appreciates the driver's hard work. This program should also be used to improve safety awareness at the Company by hanging plaques in the drivers' lounge that recognize each driver who has won an award. These plaques will be seen by each driver while s/he waits in the drivers' lounge and will serve as a constant visual reminder of the importance of safety.

The Company should also be involved in the carriers' reward programs. In addition to having a Company employee attend any award ceremony the carrier arranges, the Company should implement its own reward programs for drivers at each site.

*Safety posters*

Posters displaying safety issues that drivers should be aware of, such as the proper use of PPE and graphs of causes of on-the-road accidents, should be placed in the loading area and in the drivers' lounge. The United States Naval Education Center advocates the use of posters as a "passive training method" to promote safety in the workplace (The Navy Advancement Center). These posters should be placed in appropriate, high traffic areas, so the most people will see them. Posters should contain a current, relevant idea and be changed often, so people continue to notice and pay attention to them (The Navy Advancement Center).

The Company and its carriers should work together to develop a set of safety posters to be distributed to both Company sites and carrier locations. At the Company sites, the posters should be placed in the reception area, the loading station, and the drivers' lounge. The same posters should also be placed at the carrier locations, so drivers will see the same message at both the Company and their employers.

## Carrier Best Practices

<u>Computer systems in trucks</u>

Three carriers we visited implemented computer tracking and communication systems in some or all of their vehicles. These systems permitted communication between the driver and the dispatch without the use of mobile phones. The carrier was able to communicate information to the driver such as loading instructions, problems with the truck, or weather problems. One of the systems was mounted on the passenger side dashboard of the truck, forcing the driver to pull the vehicle to the side of the road in order to send or receive a message.

Three separate incidents recorded in the Company's Transportation Incident Database showed that excess speed on curves resulted in accidents occurring. The computer systems currently in place could be improved by adding features that can track appropriate speeds on commonly used routes. It would then be possible to recommend speeds at which to negotiate curves. Another example of a computer system with similar abilities is adaptive cruise control. In studies, truck drivers have reported that adaptive cruise control is helpful, both in saving fuel and in decreasing driver fatigue (Bishop, 2000).

Planners managed small units of trucks and drivers

One of the carriers assigned planners to manage different areas of its operating region. Each planner was responsible for about 30 to 45 drivers and approximately fifteen trucks. It was the planner's job to assign loads to the drivers and to choose trucks to use that were clean and in good condition. The reasoning behind this system was that the planners would know their drivers well and would be able to keep their trucks running 24 hours a day, seven days a week. The carrier assigned the responsibility to the planners to track how long each of their drivers had been driving and to understand the skills and experience each of their drivers had. By using this knowledge, the planner would be able to maximize the use of the drivers and trucks available.

A November 5, 1999 report in the Company's Transportation Incident Database indicated that a fatigued driver was the cause of an accident. This driver was on the road due to poor planning, as no other drivers were available to pick up the load. If better planning measures had been employed, another driver would have been available to make that trip.

Reward programs

Two of the carriers we visited had programs in place to reward safe drivers. At one carrier, drivers could pay to be a part of the reward program. Whenever a driver had an accident-free year, s/he received a silver pin. At the other carrier, all drivers were automatically included in a reward program. If a driver had no speeding tickets, accidents, or other traffic violations, the annual insurance return that the carrier received was given to that driver.

A literature review of over 120 safety-related publications found that incentives were generally more effective in enhancing safety than engineering improvements, selection of personnel, and disciplinary action (Fox, Hopkins, and Anger, 1987, and McAfee and

Winn, 1989). Likewise, the United States National Safety Council feels that "safe driving recognition or incentive programs should be an integral part of a formal fleet safety program" (Underride Network, 1991).

If safety is a shared responsibility, then rewarding safety should also be a shared responsibility. The Company and its carriers should work together to develop a cooperative reward program. Though the carrier should implement this program, the Company should involve itself both by having a Company employee present at the award ceremonies and posting award recognition in the reception area or the drivers' lounge. This involvement will stress to the drivers that the Company appreciates their safe driving.

Inspection checklist

At two of the carriers, an inspection checklist was printed on the daily log that drivers had to complete before each day of travel. Each day, the drivers had to pass in their logs to certify that they had inspected their vehicle before going on the road. If a driver discovered any mechanical problems during the inspection, s/he submitted a repair request and used a different truck for his/her trip.

In a study on inspection processes in the United States, the Federal Motor Carrier Safety Administration (FMCSA) observed 253 truck inspections in six different states (2000). In discussions following these observations, the FMCSA noted that the process of these inspections varied greatly. Given these results, the FMCSA recommended that all inspections should be performed in a uniform manner and should be supervised in order to improve the effectiveness of these inspection procedures.

Driver manual outlines pre-trip inspection

Rather than preparing a checklist to be completed each day, two of the carriers included the daily pre-trip inspection protocol in the driver's manual. The management of the carriers believed that a checklist was easy to falsify, so inspections were included as a part of the driver's everyday responsibility. The management also felt that this system eliminated needless paperwork.

Deborah L. Frailey, a consultant who has developed and managed audit programs and conducted employee training, believes that safety philosophy is "visible only when the policy is demonstrated by managers and supervisors." She suggests one method of communication as an employee/driver handbook, which facilitates communication between the driver and the management. By establishing clear rules and expectations, the driver will better understand and have a helpful reference to define his/her role in preventing hazards on the road (Frailey).

Defensive driving classes

One carrier previously held defensive driving classes for its drivers, but over time, this program disappeared. About 60 percent of its current drivers are trained in defensive driving techniques.

The United States Federal Motor Carrier Safety Administration suggests that a trucking company should train its employees in defensive driving by having a qualified person ride along with each driver and evaluate his/her driving skills. It also suggests that the company promote and encourage defensive driving, as well as have a standard for judging safe driving performance.

The Company should involve itself in defensive driver classes by encouraging its primary carriers to implement such programs by either subsidizing the costs or offering better contracts to those companies that have defensive driving programs. Also, the Company should work together with the carriers to develop these programs, such that both the Company and the carriers are addressing the shared responsibility for safety on the road.

Periodic Inspections

*Additional truck inspection besides government requirement*

Some countries have laws requiring all commercial trucks to be inspected by a government official on a yearly basis. Two of the carriers we visited performed an additional truck inspection every year for each of their trucks.

*Periodic inspections en route*

One carrier requires its truck drivers to stop every 200 miles to perform en route inspections of their trucks. In order to inspect his/her truck en route, the driver must pull over, forcing him/her to take a break from driving and to observe the condition of his/her vehicle. If these inspections are performed properly, the trucks will be kept in good operating condition.

Using a mathematical model in a 1975 study, Symons and Reinfurt proved that more inspections performed on a truck will continually decrease the chance of a mechanical defect occurring, as well as help prevent large mechanical problems that could occur in the future. In agreement with this, the United States Department of Transportation emphasizes that worn or failed parts can result in or contribute to accidents. Periodic inspections can prevent failures and ensure that the vehicle is drivable ( "Accident Countermeasures Manual- Preventative Maintenance and Inspection Procedures").

Discussion-based driver training in small groups

Many of the carriers we observed hold small group driver training sessions. Two of the carriers travel to different geographic locations to conduct sessions with groups of about 15 to 30 drivers at a time. At another carrier, the managers arrange a safety meeting with three driver representatives from each of their two divisions. After these three drivers

attend the meeting, it is their responsibility to meet with the rest of the driving staff to explain what was discussed at the meeting. All of the drivers receive written copies of the minutes from this safety meeting.

In a 1996 study, Howard/Stein-Hudson Associates, Inc. and Parsons Brinckerhoff Quade and Douglas found that in small group discussion-based meetings, participants are more likely to contribute and share their opinions. Because of these open discussions, meetings are more productive.

Discussion-based driving sessions should be a joint venture between the Company and its carriers. The Company and its carriers should work together to develop the agenda for these meetings, where goals to address safety concerns can be brainstormed. Together, the carrier, its drivers, and the Company should then develop a plan to implement these goals.

Keep wrecked trucks in yard

At one of the carrier sites, there were two truck cabs stored in a garage. These trucks had been in accidents and were damaged beyond repair. The carrier encouraged all of its drivers to take time out of their working schedules to take a look at these trucks, so they could see the potential consequences of unsafe driving.

Raising safety awareness by showing the consequences of unsafe behavior, Zohar, Cohen, and Azar (1980) implemented a program to promote the use of ear plugs among employees who were at risk of the damaging effects of noise in the workplace. Employees were subjected to hearing tests before and after their work shift to show the effects of short-term hearing loss. Two audiograms were generated and posted showing the effects of short-term hearing loss for those who wore ear-plugs and those who did not. This program yielded a 50 percent improvement in ear protector usage.

***Recommendations***

Safety on the road is a full circle concept; it requires work from both the Company and its primary carriers. Currently, each half the circle is only being considered independently; the Company does its half to promote safety and the carriers do their half. In order to complete the circle, both the Company and the carriers need to work together and sponsor cooperative programs, so the message of safety is promoted to the drivers, regardless of where they are in the delivery process. This will allow for a single and coherent message to be communicated to the drivers. Below, we discuss generally what all of the plants and carriers can do to emphasize safety on the road. Following these general recommendations, we discuss how the Company and the carriers can come together to complete the circle of safety.

## The Plants

We developed our methods for data collection around the three main points where the personnel from the Company have direct contact with the truck driver at the plant: 1) the entry gate, 2) the loading station, and 3) the exit gate. We found that there are multiple opportunities during these contact points where the Company can stress safety awareness to the truck drivers who enter their site.

To emphasize the Company's commitment to safety, signs posted at the entry to the site are an effective measure to promote safety awareness. When entering the plant, a pictorial list of rules and map distributed to the driver will help to define the rules of the plant and provide a guide to the site so that the driver can find his/her way to the loading station. Before loading, an inspection should be performed to reduce the possibility that mechanical defects will result in unsafe loading. After loading, another inspection should be conducted to ensure that the tank is properly sealed, so that the product remains inside the tank throughout its journey. These inspections could be performed either regularly or on a random basis by either the driver or by the Company personnel, depending on the unique setup of the plant.

While the driver is waiting for the truck to be loaded, s/he may wait in the drivers' lounge. This is a point of contact where the Company can stress safety awareness to the drivers. By developing posters that can be displayed in the drivers' lounge or utilizing a suggestion box where near-miss reports and comment cards can be deposited, the Company will emphasize the importance of safety. In addition to this practice, plants should work in conjunction with their carriers to develop an awards program to recognize exceptionally safe drivers. Hanging the awards from this program on the walls of the drivers' lounge at the plant will help motivate and inspire the drivers to drive safely. A truck safety awareness day will provide another contact point through which the Company can address safety issues to the driver. For larger sites, holding a truck safety day is feasible, while smaller sites should invite their regular drivers to periodic weekend events.

Another way to make employees aware of safety issues is to make near-miss reports available and to have target goals set for a minimum number of reports per year to ensure that hazards are identified at the plant. When these hazards are identified, proper measures should be taken to reduce and eliminate potential risks. These near-miss reports should be shared amongst the Company's multiple sites. This will enable the sites to learn about the risks present at other sites and from mistakes that others have previously made, so their employees can be better informed of safety hazards.

### The Carriers

Safety awareness at the carriers can be addressed by cognitive tests, drug tests, and intelligent vehicle systems. In-vehicle or in-terminal cognitive tests have been demonstrated to be effective in determining if the driver is fit to safely operate a commercial motor vehicle (United States Midwest Transportation Center, 1997). Random drug testing programs should be established to ensure that the fleet is not driving while under the influence of drugs or alcohol. Intelligent vehicle systems are a

worthwhile investment on trucks the carriers operate. Devices that sense a driver drifting out of the lane or adjust the vehicle's speed based on the speed fluctuations of the surrounding vehicles will improve safety on the road.

To further encourage drivers' awareness of safety, reward programs are a way to provide an incentive to drive safely. There are various programs implemented throughout the carrier industry, which range from pins or plaques to cash incentives as tangible rewards. To demonstrate its commitment to safety, the Company may want to grant a special reward to a driver and/or have a representative present at the carrier awards ceremony. In place of, or in addition to the carrier award programs, the Company may want to implement programs on-site.

Driver education programs are another way to build upon a driver's awareness of safety. By teaching drivers how to drive defensively, it is possible to improve their driving skills. To complement these programs, discussion-based driver training sessions should be implemented to inform drivers about safety-related situations. These programs can be tailored to the carrier's needs and can include topics such as strategies for driving in inclement conditions, route planning, and stress management. These sessions can also be held after an accident to increase awareness of the dangers on the road, as well as to reinforce that safety is both the carrier's and driver's first priority. Also after an accident, the carrier should retain the damaged vehicles to provide the opportunity for drivers to view and reflect upon the consequences of unsafe driving.

## Plants and Carriers

There are seven main ways the plants and carriers can work together to complete the circle of safety: through a cooperative inspection process, actively involving the drivers in the loading process, discussion-based driver training, defensive driving programs, reward programs, sharing of near-miss reports, and various types of safety awareness programs. The Company and its carriers should work together to ensure that inspections are performed uniformly and on a regular basis. The results of these inspections should be tracked in a database and analyzed by both the Company and its carriers. Involving the driver in the loading process ensures that both the driver and loading technician are working together to load the truck safely. In discussion-based driver training sessions, both the Company and its carriers can communicate important issues to their drivers. After these meetings, the Company and its carriers should set goals to address safety concerns and to develop a plan to implement these goals. Defensive driving programs are another type of training program that the Company and its carriers should conduct together. Another way in which the Company can work with its carriers is to become involved in rewarding safe drivers. The Company should not only have a representative present at these carrier reward ceremonies, but should also implement its own reward programs for drivers at each site. Near-miss reports should be shared between the Company and its carriers. Many of these reports could come from the drivers with reports of problems they observe at the plants, the carriers, and on the road. Finally, the Company should develop safety awareness programs with its carriers. Standardized sets of signs and safety posters should be designed for all the sites, creating consistency

among the plant and carrier sites. Working together to hold trucker safety days will improve safety awareness and demonstrate the Company and the carriers' joint concern for the drivers' safety.

***Conclusions***

During our visits to the Company's sites, we observed differences in the safety practices and daily operations of each plant. Similarly, at each of the carriers, we found different safety procedures unique to its location and logistics operation. Despite these differences, there are lessons that all the sites can learn from each other regarding ways to stress safety to their employees and contracted drivers. Similarly, all the carriers we visited have some particular practices that the others could benefit from implementing. In addition to our specific recommendations, our overall finding was that the Company and its primary carriers need to jointly address the issue of driver safety on the road. Our best safety practices and recommendations will help both the Company and the carriers work together to raise driver awareness of safety through unified practices. These unified practices will create an environment in which the Company and the carriers share equal responsibility for improving safety and safety awareness to reduce accidents on the road.

## Introduction

Truck accidents are a worldwide problem. In the year 2000, there were 754 driver fatalities involving large truck accidents in the United States (National Center For Statistics and Analysis, 2002). In 1997, Europe reported 739 fatalities involving heavy goods vehicles ("CARE Community Road Accident Database," 2002).

Over the past several years, one division of the Company has had over 50 accidents, some of which have resulted in fatalities. From the years 1997 to 2000, 82 percent of all of the Company's road incidents that occurred were due to the behavior of the drivers ("Site Safety Improvement," 2002). Because the causes of these accidents were rooted in behavioral factors, a majority of those accidents could have been prevented ("Site Safety Improvement," 2002). By 2005, the Company seeks to eliminate all truck accidents by first investigating its safety inspection procedures, then identifying additional proven procedures, and finally implementing new procedures to increase the level of safety awareness among its divisions and contracted employees.

To determine ways to prevent accidents, we examined studies of accidents to discover what causes were involved. We then analyzed these causes and found that each fell under three main categories: environmental, vehicular, and behavioral. Our reasoning for selecting these three categories was that an accident is caused either by uncontrollable factors set forth by the surrounding environment, a failure in the mechanics of the vehicle, human error, or a combination of these factors. Other study's have taken similar approaches to analyzing this problem and have found comparable results (Crouse and Anglin, 1978). In order to find practices that address these causes of accidents, we performed background research, followed by visits to six of the Company's plants. At these plants, we conducted interviews and observations at the entry/exit gate and product loading station. At the start of our study, it was clear that the Company contracts out transportation logistics; therefore, the safety programs implemented at the Company's and the carriers' sites were independent of each other.

Because of this separation, we also visited four of the primary carriers for these six plants, and interviewed managers from a fifth primary carrier. At the carriers, we conducted interviews with the manager and were given an overview of their business operations. From these visits, we developed a list of potential best safety practices that we found at each of the plants and carriers. We then validated as many of these practices as we could with cited studies, recorded truck accidents, and the Company's Transportation Incident Database. The final outcome of this study is a list of best safety practices for the plants and their primary carriers.

## Key Questions

We framed our study around three main questions that helped guide the direction of the study. These questions will be answered throughout the course of this paper.

The key questions are as follows:

1) What are factors that cause accidents?
   - -Which factors are controllable?
   - -Which factors are uncontrollable?
   - -From these factors, what preventative measures can be taken?
   - -Are there trends in the accidents?

2) What safety practices are in use in the trucking industry to prevent accidents?
   - -What regulations are involved?
   - -What organizations are responsible for developing these regulations?

3) For each plant and carrier, what safety procedures are in practice and what procedures should be implemented?
   - -Are these practices uniform throughout Europe and North America?
   - -Are there patterns in available accident data that suggest the effect of best safety practices?

To answer these questions, we first familiarized ourselves with factors that cause accidents (question 1) to understand the context of our study. With this background, we then examined the safety protocol that is effective in reducing the risk of a specific cause (question 2). Finally, we observed the procedures in place at each individual plant to determine the safety protocol that may be unique to that plant (question 3). We also performed a "gap" analysis that compared the practices a plant implemented and the practices that a site should implement (see Appendix A: Gap Analysis). This process revealed safety procedures that will help to reduce the number of truck accidents on the road.

## Context

To answer the first two key questions, we performed research to identify the causes of accidents and current measures that are in place to prevent the occurrence of accidents. Identifying the cause of an accident is not a simple process, as there are a variety of human, environmental, and vehicular factors that can contribute to the occurrence of an accident (see Appendix B: Concept Map). This wide array of variables makes it obvious that one should focus on more than a few potential factors when trying to prevent accidents. However, one must keep in mind that these variables do not act independently; it is the dynamic interplay of these variables that results in an unsafe driving situation. To prevent an unsafe situation from becoming an accident, it is important to be aware of the associated risks. To identify those risks, one must first define the human, environmental, and vehicular categories of factors involved in the driving task. When these elements are defined, it is then possible to evaluate the risks and develop countermeasures to reduce or eliminate potentially dangerous situations.

### *Driver Cognition and Driving Task Conditions*

To better understand the way in which the driver plays a role in the driving situation, it is necessary to separate the driving task into different elements. As defined by the Australian National Road Transport Commission, the driving cycle consists of four main elements: information, vehicle, decisions, and control ("Medical Examinations of

Commercial Vehicle Drivers," 1997). Factors such as the driver, the natural environment, the legal requirements, the road, the business requirements, and the vehicular equipment are considered in this driving cycle model. The driver's experience, training, and health are also major considerations, since the driver is responsible for making split-second decisions ("Medical Examinations of Commercial Vehicle Drivers," 1997). This model considers the skill level, ability, and personality of the driver in the interaction of the driver with the vehicle and the surroundings.

The driver thought process begins with the receipt of information from both the vehicle and the external surroundings and continues with the interpretation of this information with respect to his/her individual knowledge of the road system, traffic laws, and task conditions. After this information has been processed, the driver must decide how to respond to the situation and implement the appropriate decision by maneuvering the vehicle ("Medical Examinations of Commercial Vehicle Drivers," 1997). If the driver's thought process fails and s/he does not respond appropriately to the situation, an accident is likely to occur.

Psychologically based studies may help to identify and explain the mechanisms by which the driver's thought process fails. The work of Fancher, Bareket, and Bogard (2001) focuses on using the psychological concepts of knowledge, rule, and skill-based behavior to develop a model that represents the driver's behavior according to his/her mental perception, or "minds' eye" coordinates of his/her thought process. The minds' eye coordinates indicate the driver's ability to critically reason throughout a situation. The model can represent driver response to such situations as closing in on a slower-moving vehicle, following a preceding vehicle, accelerating, decelerating, and braking in response to the preceding vehicle's deceleration. This work may help in understanding how the human mind functions and identifying the weaknesses of a driver in a given situation.

***Behavior Based Safety Programs***

In their 2001 study, Hakkanen and Summala considered and evaluated potential causes of accidents. Their study found that the number one and two causes of truck accidents are behavior related: some sort of error in driver attention, such as anticipation or estimation, and driver error in operation of the vehicle. To address safety concerns related to driver behavior and to improve observance of safety procedures, several companies have instituted behavior based safety (BBS) programs. Scott Geller, a professor of psychology at Virginia Polytechnic Institute and a senior partner with Safety Performance Solutions, believes that rewards are better than training for deterring unsafe behavior. He states that taking proactive measures, such as putting up posters and holding training sessions are not as effective as having a specific outcome for a certain action (Geller, May 19, 2000). In two separate reviews of over 120 published evaluations of occupational accident prevention, researchers found that incentives were generally more effective in enhancing safety than engineering improvements, selection of personnel, and disciplinary action (Fox, Hopkins, and Anger, 1987, and McAfee and Winn, 1989).

Behavior Science Technology (BST) developed a behavior safety method that uses observation and feedback (Behavioral Science and Technology, Inc., 1999). In the observation and feedback method of BBS, there are "safety coaches" who use a checklist to keep track of safe and risky behavior and to give feedback to the people observed. Monitoring trends in the data from these lists show when behaviors are changing, so that the necessary behaviors can be focused on, leading to continued improvement (Geller, May 19, 2000). BST helps companies implement its method of BBS. BST has shown that its method improves communications, employee involvement, labor/management relations, teamwork, and morale. These results were not simply short-term fixes to problems, with 93 percent of companies reporting continued success after as many as twelve years (Behavioral Science and Technology, Inc., 1999).

Not everyone believes that BBS is a valid method for reducing accidents. The Transport Workers of America (TWU) sees BBS as a way for employers to put responsibility and

blame on e mployees i nstead of a ddressing p roblems b y us ing s afeguards, pr oper ventilation, and ergonomic designs. TWU believes that if employees feel they will be blamed for accidents and injuries, they will not report problems, erroneously making it appear as if the BBS is working (Transport Workers of America). Geller (April 11, 2000) addresses many of these issues as common myths associated with BBS. Sometimes employees believe that a BBS strategy is simply a way to blame employees for accidents and allow managers to do nothing. However, individuals' names are not specified in reports, so employees do not need to fear being blamed for accidents.

BBS has many benefits. A decrease in the number of accidents can increase employee morale, making employees more productive. Also, when employees feel that they have an active role in preventing accidents, they are more likely to do their part to make the system work. One aspect of BBS that companies need to be aware of is that BBS does not make a change overnight, so expecting too much too soon can make it appear that the system is not causing improvements (Geller, April 11, 2000).

BBS programs are in use in the transportation industry at a national level. The United States Department of Transportation (U.S. DOT) believes that "safe driving recognition or incentive programs should be an integral part of a formal fleet safety program" because these programs recognize superior driving performance, and those superior drivers as models for the rest of the fleet to follow. ("Commercial Vehicle Preventable Accident Manual," 1991).

An example of a BBS program in use in the trucking industry is a driver assessment and reward program employed by Trimac, a motor carrier recognized by both Canada and the United States for excellence in the area of safety. In this quarterly program, drivers who log at least 500 on-duty hours are eligible to receive a $125 cash award. The drivers who receive this reward are rated in 11 areas: customer complaints, untimely product pick-up and delivery, trip log violations, product contamination, product spills, chargeable traffic accidents, U.S. DOT infractions/traffic tickets, preventable product residues, safety gear violations, lost duty time due to preventable on-the-job injuries, and documented

disciplinary actions ("Commitment to Safety," 2001). After a driver receives four consecutive cash awards, a placard with his/her name and "Top Driver Award" designation is placed on his/her assigned tractor. As long as the driver continues to qualify for this reward, the placard remains on his/her tractor. This program serves as both an assessment program for the carrier and as a reward program for the driver. It encourages close evaluation of the driver by the carrier so that awards can be granted. At the same time, it provides incentives for good driver behavior.

Incentive programs have also been studied in research performed by the Division of Highways in California. Approximately 10,000 drivers were contacted who were at-fault for collisions or had violations in the year prior to the study. All had accumulated points on their licenses from the incidents. The drivers were informed through a letter that they would receive a free 12-month extension on their license if they had a clean record the next year. A control sample of the same number of drivers was not contacted, but their driving record was monitored during the study.

In the first year, the study found there were "significantly fewer accident-involved drivers in the experimental group, particularly among . . . those drivers whose license renewal was to come up within one year after receipt of the letter." These results suggest that the incentives provided by the program had a positive effect on driver safety behavior. The accident rate for the drivers whose license renewals were due was 22 percent lower than the controls. The drivers who earned the bonuses also had 33 percent fewer accidents in the follow-up year than the controls (Harano and Hubert, 1974).

***Driver Education***

Safe driving and driver awareness of safety are identified by the U.S. DOT as countermeasures to prevent commercial vehicle accidents from occurring ("Commercial Vehicle Preventable Accident Manual"). In order to reduce accident rates, the Federal Motor Carrier Safety Administration (FMCSA) recommends that commercial vehicle operators be trained in defensive driving techniques. While on the road, the defensive

driver tries "to recognize potentially hazardous situations in advance to allow time to maneuver past them" ("Accident Countermeasures Manual"). If a driver can recognize a risk with enough time to avoid it, an accident will have been prevented.

The purpose of any driver training program is to improve the skill level of the motor vehicle operator so that s/he performs more effectively and efficiently on the road. The work of Hatakka, *et al.* (2002) also suggests that driver education needs to take a multifaceted approach since the task of driving involves responses to a variety of physical, psychological, and environmental factors. To simplify the complicated tasks involved in driving, Hatakka, *et al.* (2002) formulated an adapted model that defined the hierarchical levels of driver behavior. This model suggests driving skills are based on four levels: (1) vehicle maneuvering, (2) mastering traffic situations, (3) goals and context of driving, and (4) goals for life and skills for living. "Vehicle maneuvering" consists of the characteristics of the vehicle and its physical environmental surroundings and the control of the direction and position of that vehicle. "Mastery of traffic situations" includes the driver's awareness of traffic regulations, negotiation of traffic situations and road conditions, the driving path/order, and the ability to perceive risks and anticipate and adapt to the behavior of others on the road and in the traffic environment. "Goals and context of driving" consists of the specific trip goals such as route planning and navigation, as well as the proper estimation of travel time. It is also concerned with the presence of others in the vehicle and social pressures involved in driving. "Goals for life and skills for living" is comprised of the driver's broad and personal motives and goals, lifestyle factors, values, skills in handling a variety of situations, and current developmental stage (see Appendix K for an elaboration of these skill levels and associated risks).

Each of the individual levels of the hierarchy must be addressed for safe driving; however, control of this hierarchy is not necessarily linear. Driving programs must be able to address all levels, as each level has an effect on the model as a whole. This adapted model suggests that driver education programs should not only teach basic skills and knowledge needed for the driving task, but also address the risks present in driving

situations. (Hatakka, *et al.*, 1998). To address these risks in driver training, the U.S. DOT recommends implementing an accident review program. By classifying preventable and non-preventable accidents that have occurred, it is possible to identify specific risks that should be addressed in driver training ("Accident Countermeasures Manual-Defensive Driving"). Besides addressing these risks, self-reflection and self-evaluation should also be included in the training course. If a driver is more aware of his/her personal tendencies and capacities and how they affect his/her driving skills, then the driver will be better able to adapt his/her driving style to real life driving situations (Hatakka, *et al.*, 2002).

While all these elements are important to address in driver training sessions, training is only effective if the skills taught are transferred to the workplace. When planning training, it is important not only to consider the material covered in the sessions, but also the learned knowledge, skills and attributes that will be acquired through the training (Bots and Veldhuis, 1998).

To train a fleet of defensive drivers, the FMCSA recommends that a qualified person ride along with each commercial vehicle operator and evaluate his/her driving skills on the road. To maintain an effective program, the employer should promote and encourage defensive driving, as well as uphold a standard by which to evaluate safety performance (**"**Accident Countermeasures Manual-Defensive Driving"). Evaluation is as important as training, as the two are interrelated. The effects of a driver-training program should be assessed by more than one method of approach. Future instruction should address the gaps found in the transfer of the skills taught in the training sessions to the workplace (Bots, M.J., and Veldhuis, G.J., 1998).

***Driver Fatigue***

Another one of the primary behavior-related concerns in preventing accidents is driver fatigue. To better understand fatigue, Williamson, Feyer, and Friswell (1996) examined three different driving regimens and their effect on driver alertness. The study found that

none of the regimens prevented fatigue and that driver awareness was related to the driver's fatigue level prior to the trip. This study concluded that fatigue is a subjective experience, and as a result, fatigue reduction strategies should be based on the driver's preference and work style.

Since fatigue is a subjective experience, Arnold, *et al.* (1997) performed a qualitative study to determine the perceptions of fatigue among truck drivers and their employers. They surveyed drivers who stopped at roadhouses around the country, and they found that drivers did not perceive fatigue as affecting themselves individually as much as it affected other drivers on the road. To lessen fatigue, a majority of the drivers recommended the use of stimulants such as caffeine, pills, and drugs to increase their alertness and ability to keep driving. However, their employers felt differently. The majority of the company executives surveyed believed that additional driver education would help drivers become more aware of fatigue and how it affects their driving abilities. Less than ten percent of the drivers surveyed agreed with this (Arnold, *et al.*, 1997). To address problems with fatigue, Arnold, *et al.* recommended that "multi-faceted fatigue management programs in the road transport industry" should look beyond just the hours a driver worked, as well as address the difference of opinion between the views of drivers and their employers on fatigue management.

Looking beyond the hours spent on the road, Lenne, Triggs, and Redman (1997) examined driver performance and how it was affected during different times of day. The driver's mental performance and ability to complete secondary tasks was determined by looking at his/her reaction time when presented with other tasks while driving, such as visual and auditory cues. These results measured the level of alertness and the reaction time of the individual driver, and it was found that the driver was most susceptible to accidents during the late night and early morning period. The study concluded that driver schedules should be modified to reduce or eliminate driving during these times.

The Driver Fatigue and Alertness Study analyzed 80 different drivers under four different driving schedules for over 200,000 miles of highway driving. The drivers' performance,

alertness, and physiological levels were measured during driving and off-duty sleeping. The results found that driver performance and alertness were more related to the time of day, rather than the time the driver was on the road. Drowsiness was eight times more likely between 0:00 and 6:00 than other hours. During the drivers' main sleeping period, they typically slept for only five hours. The study also demonstrated that the driver's self-assessment of his/her alertness level was not consistent with the objective performance measures in this study. ("Driver Alertness and Fatigue: Summary of Completed Research Projects, 1995-98," 2001).

A measure to detect fatigued drivers might be to employ "fitness-for-duty testing," which is a series of psychomotor tests administered at the beginning of the job and/or during breaks. A study showed that five- to ten-minute tests were reliable for identifying fatigued drivers ("Research and Technology Program: Driver Alertness and Fatigue R & T," 2000). Another approach to help minimize fatigue of a driver is to reduce the pressure to travel during dusk and dawn. A group comprised of the European chemical industry and trucking companies has proposed "16 Hours Operation" of the loading station. An increase in the open hours of the loading station reduces the pressure on a driver to arrive during a small window of time and also reduces traffic congestion and waiting times to load. In the case of multiple loads, it allows the drivers to load during peak traffic times, so they are not on the road when they are most susceptible to accidents ("Guidelines for 16 Hours Operation," 2002).

***Drug and Alcohol Testing***

Drug and alcohol testing is another approach that may help to ensure driver lucidity. Alcohol has been shown to decrease a driver's reaction time, attention, and concentration. It also increases the amount of error in speed awareness while braking, as well as the number of crashes on simulator tests (Austroads working group, 2000). In a literature review of the effect of marijuana use on driving, Ward (2000) found that psychomotor responses such as motor coordination and control, reaction time, time perception, and dynamic tracking were negatively affected. Stimulants, such as amphetamines and

cocaine generate a sense of well being and cause uninhibited behavior and over-activity, which influence the psychomotor skills needed while driving a vehicle. A National Transportation Safety Board investigation of fatal truck accidents found that stimulants was the most frequently identified (15 percent) drug class among fatally injured truck drivers (Insurance Institute for Highway Safety, 2002). Other drugs have a variety of effects on driving related skills, and when drugs are combined, they can produce unpredictable results (National Road Transport Commission, 2001).

A study performed by the Insurance Institute for Traffic Safety of interstate tractor-trailer drivers determined that 15 percent of all the drivers tested had traces of marijuana, 12 percent had non-prescription stimulants, and two percent had cocaine in their systems (Insurance Institute for Highway Safety, 2002). These numbers are a cause for concern; employers of truck drivers should implement programs to control drug and alcohol related risks. William F. Current (2001), the president of a national consulting firm, feels that drug-testing programs heighten the level of safety and awareness of a corporation's employees. On-site testing is advantageous in getting fast results and also may provide the edge needed to ensure that the employees will refrain from using drugs and/or alcohol at all times (Current, 2001).

***Intelligent Vehicle Systems***

Another possible way to decrease accidents is to reduce or eliminate the human factor in the driving equation through the use of intelligent vehicle systems. Bishop (2000) describes three general types of intelligent vehicle systems: collision warning, driver assistance or collision avoidance, and vehicle automation. Collision warning is generally some type of sound that alerts the driver to hazards, such as stopping vehicles ahead or the vehicle drifting from the lane. Collision avoidance or driver assistance consists of an intelligent system temporarily taking control of the vehicle if the driver responds too slowly to road conditions. Driver assistance takes the forms of precise maneuvering, lane keeping, and adaptive cruise control. Collision avoidance is more active than collision warning and occurs when the system takes over control of brakes or steering. For

example, if the driver does not apply the brakes in time to respond to a stopping vehicle ahead, the intelligent systems would apply the brakes at the necessary pressure to stop the vehicle in time, or to at least slow the vehicle enough to reduce the severity of a collision. Vehicle automation occurs when the intelligent systems take over complete control of the vehicle. These systems can be either fully contained within the vehicle or they can incorporate systems both in the vehicle and on the road.

Vehicle automation and collision avoidance technologies are not yet available, but some collision warning and driver assistance systems have been implemented in trucks. According to Bishop (2000), lane-departure warning systems, other radar-based collision warning systems, and adaptive cruise control have been available in the United States since 1999. Adaptive cruise control in a truck uses radar to determine if there are slower vehicles ahead (Clarke, 1998). It then adjusts the speed of the truck to remain at a safe distance behind the slower vehicle. In studies, truck drivers have reported that adaptive cruise control is helpful, both in saving fuel and in decreasing driver fatigue (Bishop, 2000).

The DaimlerChrysler Company has started to develop and implement both driver assistance and lane-departure warning systems. According to a DaimlerChrysler publication, misjudgment of the weather, the lane, and the speed of the vehicle ahead account for about 50 percent of all accidents, while driver distraction and the driver falling asleep account for almost 38 percent of accidents ("The thinking vehicle - how assistance systems support drivers," 2000). To try to decrease these types of accidents, DaimlerChrysler has developed the PROTECTOR and the Lane Assistant.

PROTECTOR is a driver assistance system that applies the brakes if the driver does not react fast enough to a slow or stationary vehicle ahead. This can either reduce the severity of the accidents by slowing the vehicle or prevent accidents entirely by stopping the vehicle. The Lane Assistant is a lane-departure warning system that makes a washboard sound when it detects that the vehicle is veering out of the lane. The sound is produced through the stereo system on the side of the vehicle that it is moving in the

direction of, so the driver will instinctively steer away from the noise back into the lane. The Lane Assistant has been available in European vehicles since the beginning of the year 2000 ("The thinking vehicle - how assistance systems support drivers," 2000).

Like DaimlerChrysler, Mercedes-Benz has also developed a driver assistance system, though it was originally marketed for luxury vehicles, not heavy trucks. In his description of the system in the *EE Times,* Clarke states, "[t]he Mercedes-Benz system uses a 77-GHz Doppler radar linked into the electronic control and braking systems," so the car can remain at a safe distance behind preceding vehicles. However, Daimler-Benz is being careful to emphasize that the system is not for safety, but for comfort; they do not want to be held liable for any accidents occurring in a vehicle with a driver assistance system.

***Vehicular Inspection***

Driver error plays a major role in contribution to accidents; however, when looking to eliminate accidents, vehicular factors must also be addressed. The U.S. DOT Safety Council emphasizes that worn or failed parts can result in or contribute to an accident. Periodic inspections can prevent failures, as well as ensure that a vehicle is drivable ("Accident Countermeasures Manual- Preventive Maintenance and Inspection Procedures"). In roadside inspections of over 2.4 million commercial vehicles across the United States, the FMCSA found that 31.7 percent of inspected vehicles were considered "out of service" in regard to inspection regulations. Eight percent of the vehicles were rejected due to driver factors and 23.7 percent due to vehicular factors. ("Summary of Program Measures Activity – 2000," 2001). These statistics suggest that random inspections should be performed to ensure both vehicle and driver compliance.

Probability studies have been conducted on both automobile and truck safety inspections to determine the effectiveness of inspections in reducing accident rates. The work of Schroer and Peyton (1979) tried to determine whether or not diagnostic automobile inspections were cost-effective in Alabama. Their results indicated that diagnostic inspections had an effect on reducing accident rates; however, they found a stronger

correlation between higher education and a lower accident rate, which may indicate that educational experience also plays a role in accident prevention.

To further examine the correlation between inspections and the accident rate, Symons and Reinfurt used a mathematical model with an exponential waiting time (1975). In their study, they demonstrated a reduced accident rate immediately following a safety inspection, which decayed slightly thereafter. In a study in New Zealand, White (1986) found that benefits of periodic vehicle inspection on the accident rate were not significant enough to detect. White felt that the reason for these results was that it was too costly and time consuming to thoroughly investigate the causes of accidents, so it was difficult to determine if an inspection had played a direct role in the accident. However, he did note that the brakes and the wheels accounted for most defects in motor vehicles.

On this same note, van Schoor, van Niekerk, and Grobbelaar's (2001) investigation of the mechanical failures of vehicles in South Africa found that irregularity in tire inflation pressure, as well as the age of the vehicle had a substantial effect on the occurrence of accidents. Because the vehicles studied were not well maintained, mechanical problems were often undetected and not repaired, resulting in accidents due to mechanical failures. This study emphasized the importance of preventative maintenance on the serviceability of a vehicle. It also mentioned that human factors and driver error had a significant effect on the accident rate.

The work of Thakuria, Yanos, Lee, and Sreenivasan (2001) represented the effect of inspection on the accident rate more quantitatively by using a linked database of state and federal roadside inspection, crash, and firm records of commercial motor vehicles in the United States. They divided the levels of inspections into varying degrees of stringency and calculated the accident rates separately within those separate degree levels. They found that the strictest inspections resulted in the smallest accident rate.

A FMCSA study that surveyed the inspection procedures across several states established that there were inconsistencies in the uniformity of the inspection procedure. To improve

the effectiveness of the inspection procedures, the FMCSA suggested that all inspections should be performed in a uniform manner. FMCSA also indicates that the inspection program should be supervised, and recommendations continually made to improve the program ( "Uniformity of Roadside Safety Inspections of Commercial Vehicles and Drivers on the National Level," May 2002).

FMCSA and the Volpe National Transportation Systems Center made a combined effort to develop a model that measured the effectiveness of roadside inspections in relation to the number of accidents and injuries avoided. They used an analytical tool called the "Intervention Model," which was based on the premise that roadside inspections directly and indirectly contribute to accident reduction. They assumed direct effects were found when vehicle and/or driver defects were identified and remedied, which suggested that corrected vehicles/drivers were less likely to be involved in future accidents. They assumed indirect effects resulted from the motor carriers' end, where increased awareness of the programs and the consequences of not maintaining stringent practices resulted in higher levels of safety. Therefore, inspection programs not only corrected mechanical defects, but also provided practices that made drivers more aware of safety issues related to their vehicles ("Summary of Program Measures Activity – 2000," Sept. 2001).

***Safety in the Chemical Transport Industry***

To reduce the accident rate in the chemical industry, companies have come together to develop a standardized set of best practices for inspections. The European Petrochemical Association ( EPCA), the European Chemical Transport Association ( ECTA), and the European Chemical Industry Council ( CEFIC) have partnered with both trucking and chemical companies, to establish joint working groups focused on improving the safety of the chemical transport industry. These groups have focused on standardizing equipment, developing a consistent method of evaluation of delivery performance, improving safety conditions in the supply chain, setting stricter regulations on driver working hours, and improving emergency response to accidents in hopes of improving safety in chemical transport ( "Working Groups," 2002) . To improve safe behavior

throughout the industry, these groups have determined that it is necessary to identify and promote best practices of safe behavior to make the organization aware of these practices and to suggest methods by which these practices can be implemented ("Recommendations on Safety, Health and Environmental Management Practices for Logistic Services Providers," 2002).

To assess the safety performance of carriers, CEFIC has established a program called "Safety, Quality and Assessment Systems" (SQAS) ("Safety, Quality and Assessment Systems for the Transport/Storage/Handling of Chemicals," 2000). An independent party can use this method to assess logistic services contracted by a chemical company. This method of evaluation measures the performance of the logistics provider and supplies a rating system that reveals the provider's strengths and weaknesses. It also gives feedback to the logistics provider, which encourages improvement ("Safety, Quality and Assessment Systems for the Transport/Storage/Handling of Chemicals," 2000). The assessment involves the logistics carrier's verbal responses to a questionnaire, as well as evidence observed by the auditor. Based on these results, a report is generated. When available, these reports aid a chemical company in choosing appropriate carriers for its products ("Safety, Quality and Assessment Systems for the Transport/Storage/Handling of Chemicals," 2000).

***Accident Analysis and Investigation***

Progress can also be made by looking at the cause of accidents to identify risk factors in present situations ("Accident Countermeasures Manual-Defensive Driving"). When an accident occurs, a method of analysis that considers the procedures, training, compliance, behavior, and equipment involved in the incident is suggested ("Guidelines For Safety Awareness and Behaviour In The Supply Chain," 2002). This kind of method clearly identifies the primary causes behind an accident. Analysis of a single incident, as well as a trend analysis can help not only to measure current performance and set goals for future performance, but also to correct unsafe behaviors so that similar types of accidents are

not repeated ("Guidelines For Safety Awareness and Behaviour In The Supply Chain," 2002).

For example, one company has implemented an "Incident Reporting Best Practice Network," by which a site can learn about the causes of accidents within the corporation and identify potential risks at their own site ("Element 9: Incident Investigation and Analysis," 2000). A company with similar logistics operations has implemented a database called "Application for Registration for Incidents and Accidents," which documents an incident and describes the measures taken in response to the incident. The system's aim is to improve overall safety by sharing past experiences ("DSM Responsible Care Progress Report 2001," 2002).

***Near-Miss Reports***

Another means by which risks that cause accidents can be tracked is through near-miss reports. A near-miss report consists of a potential safety risk that is identified, but when a minor or no accident occurred. The United States National Safety Council states that approximately 75 percent of industrial accidents are predicted by near-miss incidents ("Near Miss Accident"). By studying the information revealed in near-miss reports, the root causes of accidents can be identified and the chain of reactions that cause accidents can be more clearly understood. By analyzing the causes of accidents, it will be easier to identify the risks involved, as well as develop better prevention methods ("Bureau of Transportation Statistics," 2001). The U.S. DOT Safety Council feels that traditional actions taken to reduce accidents, such as accident investigation, regulation enforcement, and driver education have reduced the number of accidents, but have "flatlined" in that reduction. The U.S. DOT Safety Council also believes it is necessary to take a proactive approach to accident prevention, by utilizing near-miss systems to prevent accidents and spills. Systems such as the International Maritime Information Safety System, the Aviation Safety Reporting System, and the Global Analysis and Information Network have been utilized to recognize the risks present in near-miss situations ("Section 1:What We'll Do to Improve Safety Data," 2002).

## Methods

To answer our third key question, what safety procedures are in practice at each plant and carrier and what procedures should be implemented, we developed a qualitative study to compile a list of "Best Safety Practices" to be implemented at five sites across Europe. These best practices address the environmental, vehicular, and behavioral factors found in our background research, as well as the practices observed at the carriers and the plants (see Appendix B: Concept Map).

Before leaving for Europe, we pilot tested our methods on one U.S. plant, Plant A, and its primary carrier, Carrier A. We then wrote two case studies as documentation of the visits (See Case Studies 1 and 7). We had not originally planned to visit carriers; this was part of the agenda set for us by our contacts at Plant A. However, we found the Company contracts out the logistics to its carriers, which means that responsibility is placed on the carriers for the safety of their drivers. For this reason, we determined that it was necessary to visit carriers as well as plants to learn what safety practices are in place at the carriers.

The rest of the study was then based around visiting five of the Company's plants and four carriers. We visited Plant B during the third week as an entire group to collaborate and revise our methods before dividing into two groups. We then traveled to the remaining plants and carriers in groups of two during weeks three and four. Two team members went to Plants C and E, as well as their joint carrier, Carrier C. Two team members visited Plants D and F, as well as their respective primary carriers, Carrier B and Carrier D.

We allotted two weeks before traveling to secure travel plans to visit the nine sites. During this time we met with our contacts at the Company. From these meetings we obtained the contact information for each plant along with information about each of the plants such as size, number of employees, and yearly production. After obtaining this information, we emailed our contact at each plant with interview questions. Finally, we

developed a travel itinerary for each team of two and created a detailed agenda to be followed at each plant and carrier.

***The Plants***

We developed our methods based upon the three main points where the Company's personnel have direct contact with the truck driver at each of the plants: 1) the entry gate, 2) the loading station, and 3) the exit gate. We focused on these three points of contact because they are places where the Company can stress safety awareness to its drivers. We evaluated these points using two main methods: interviews and interactive observations.

For each site, we contacted the site manager via e mail with interview questions (see Appendices D, E, and F for interview questions). We emailed the questions before visiting the site to try to reduce the language barrier and to allow the interviewee more time to formulate complete answers to our questions. Additionally, we wanted an accurate record of the questions we asked. We had hoped to receive answers to our questions via email to give us an accurate account of each manager's responses and to give us more time at the plant for observations. However, we only received an email response from one of the managers, so the rest of the interviews were conducted in person once we arrived at the plant.

A possible threat of using an interview format, whether by e mail or in person, is the validity of the employees' answers. Because of the nature of this project, we may have been perceived as auditors for the Company. Our primary concern is that this auditor image may have affected the truth of the answers we received. Some employees may have formulated their answers so it appeared that they pay very close attention to safety when, in actuality, they may disregard the safety protocol. We tried to formulate general questions that did not address specific procedures, but asked for overall safety measures used. We also tried to make it clear to each of the interviewees that we were not looking for what each plant was doing wrong, but rather we were looking for the good safety

practices the plant has in place. We felt that by emphasizing the positive nature of this study, and by keeping our eyes open to invalid answers, we limited the effects of this validity threat.

Besides the threat just mentioned, we encountered two other main validity threats for the interviews performed in person. The first threat was the diverse language and cultural barrier we faced. As a group, we tried to ensure that despite this barrier, our interviewees understood all of our questions fully. Additionally, we tried to ensure that we understood their responses to our questions. To help eliminate these threats, we carefully worded our questions and, if needed, obtained a translator to facilitate our conversations.

At four of the five plants, the plant manager did not respond to our e mail interview questions, so we spent the first day conducting the interviews in person. The position of the people we interviewed varied from plant to plant, depending on our contacts there and the jobs people held. We first interviewed the plant manager to determine what safety protocol the plant requires for each one of the three aforementioned points (see Appendix D: Plant Manager Interview Questions). After the managerial interview, we interviewed a technician at each of the points to determine what protocol s/he actually used for each truck and any checklists s/he might use. If a technician was not available due to language barriers, we interviewed a logistics or quality assurance manager who was familiar with the responsibilities and protocol related to the entry/exit gate and loading station personnel. During this first day, we also made preliminary observations of the layout of the plant and obtained the loading schedule, if there was one, so that we could schedule our time to observe as many trucks as possible the next day. In the one case where the plant manager responded to our interview questions via e mail, we spent the first day interviewing the quality assurance manager and performing interactive observations at the site. The second day, we performed more observations and a follow-up interview with the plant and quality assurance managers.

Depending on the truck arrival schedule and the layout of the site, the team either observed numerous trucks go through the entry procedures, loading station, and exit

procedures or followed a series of individual trucks throughout the entire process. The first method was used at Plant B, Plant D, and Plant F, while a combination of the two methods was used at Plants C and E. When a bulk tanker arrived at the entry gate, the team observed any inspection performed by the Company and any interaction between the Company and the truck driver. The team members also questioned the gate personnel about inspection procedures.

At the loading station, the team members again observed any type of safety inspections performed and any interaction between the Company personnel and the driver. The team observed any truck inspection processes performed by the driver or the Company personnel and compiled a list of the safety protocol followed at this point. The team also observed what the driver did during the time while the truck was being filled. The team members noted if the driver remained in the truck during this time or if s/he entered the drivers' lounge. We wanted to observe what each driver did during this loading time because we see it as the best opportunity for the Company to stress truck safety and correct driving behavior. After loading, the team observed and recorded any safety protocol followed before the truck was allowed to exit the site.

While each team was away, we conducted periodic phone conferences to keep each team informed as to what was being seen by the other team. Also, to process the observations made during the day, each night after leaving the plant, we wrote a memo reflecting on our overall impressions of the particular plant we visited. During this time, we also compiled a list of "best practices" we observed at that plant. Using these memos and our observations, each team wrote a case study for the plants they visited (see Case Studies 1-6). These case studies discuss the safety protocol a truck was subjected to as it went through the entire process of being loaded, from entry to exit. These studies include the documented safety practices, in addition to listing what practices were observed.

***The Carriers***

For the carriers, we developed our methods around the main processes a carrier performs: 1) driver assignment, 2) driver dispatch, 3) and driver tracking. We were only able to visit the sites of four of the carriers; for the fifth carrier, we were only able to perform interviews. As with the plants, after visiting each carrier, we wrote a case study listing responses to our interview questions and describing the procedures we observed at the site (see Case Studies 7-11).

For the four carriers we were able to visit, we spent one day at their site, performing interviews and interactive observations. Upon arriving at each carrier, we first interviewed the site manager (see Appendix G: Interview Questions for the Carriers). In each case, these interviews sparked conversations that differed from carrier to carrier. Key points from these conversations are documented in each individual carrier case study (see Case Studies 7-11) After these interviews, we observed the driver assignment process to determine what considerations were taken into account when drivers were assigned to loads, such as the length of trip and hours previously worked. We then examined the criteria involved in route selection to see if consideration was given to the truck's load in relation to the type of roads, traffic, and weather conditions. We also observed the dispatch process and learned what procedures and security considerations were involved before releasing a driver from the site. After the driver was dispatched, we noted the method that the carrier used to track the driver, along with the methods of communication used between the driver and the dispatch. Finally, at each carrier we observed the setup of the truck yard. At one carrier, we also were able to look inside the cab of a truck to see the layout of the instruments.

For the fifth carrier, we interviewed the logistics and QHSE directors at a local hotel (see Appendix G: Interview Questions for the Carriers). The carrier was conducting a training session at the hotel with its local drivers that day, so that was the most convenient location for the interviews. The main site for the carrier was quite far from the plant, so it would not have been feasible for us to visit that site.

***Data Analysis***

After visiting all the sites, we compiled two lists of best practices that we observed at each of the sites we visited, one for the plants and the other for the carriers. The criteria for a practice to be placed on this list were: the practice had to have the potential to prevent truck accidents on the road and the practice was not observed at all the sites. Once the list was developed, we created a matrix showing which sites adhered to each practice. We then validated our proposed best safety practices with tangible evidence in the form of cited studies, reported truck accidents, and near-miss reports. We also included practices that we did not observe at the plants, but that we found in our research. Based on the combined list of practices, we wrote a gap analysis, a site specific explanation of what each plant and carrier needs to do to improve its truck safety protocol (see Appendix A: Gap Analysis). Finally, we made general recommendations for all of the plants and carriers we visited.

## Results and Analysis

The evidence for the practices detailed in this section is based on a combination of the Company's Transportation Incident Database and other research authority, some of which has been restated briefly from our context for the reader's benefit.

During our visits to the Company plants, one of the main problems that we found was a division of responsibility for safety between the carriers and the plants. Because of this separation, we feel that the Company and its carriers need to work together to make safety a shared responsibility. Among our list of best practices, there are several that the Company and its carriers should cooperatively implement. For these practices, we explained how they can work together to make safety a shared responsibility.

*Matrix of Plant Best Practices*

| Plant Practices | Plant A | Plant B | Plant C | Plant D | Plant E | Plant F |
|---|---|---|---|---|---|---|
| | | | | | | |
| Pre-load Inspection | X | | | | | |
| Post-load Inspection | X | | | | | |
| Random inspections with check list | NA | | | | | X |
| Pictorial safety rules and map of plant | | X | | | | |
| Near-miss incident reports | | | X | | | |
| The driver is very active in the loading process | | | X | | X | |
| Safety Awareness | | | | | | X |

## *Description of Plant Practices*

Inspections

### *Pre-load Inspection*

Before entering the Plant A site, each truck was inspected at the Truck Control Center. This truck inspection included a 360-degree walk-around to check the condition of the truck and tires, an internal and external vacuum test on the back valve, and a check of the condition of the gasket lining the inside of the manhole cover.

### *Post-load Inspection*

At Plant A, after each truck was loaded, it returned to the Truck Control Center where it was subjected to a post-load inspection. This inspection consisted of a 360-degree visual check of the truck for leaks, along with a check of the back valve and top manhole to ensure that both were closed and sealed correctly.

Through the analysis of the Company's Transportation Incident Database, we found 64 incidents related to pre- and post-load inspections that occurred between 1999 and 2002. These incidents consisted of items such as loose wash caps and butterfly nuts, which resulted in product spills while driving. All of these near misses could have been avoided if trucks were subjected to a pre-load inspection before entering the plant and a post-load inspection prior to exiting the plant (The Company's Transportation Incident Database).

### *Random inspections with checklist*

Plant F performed inspections on a random basis because it was not feasible to inspect every truck due to the high volume of trucks that entered the site. About 40 percent of the incoming trucks were inspected, with different criteria for dangerous and non-dangerous goods. This practice ensured that, when the inspections were performed properly, the

trucks that failed the inspection based on the criteria of the checklist were not admitted into the plant. This practice is also useful for data tracking and reporting. The employee who performed the inspections had an Excel database in which he input the information from every inspection. He used charts and statistics to analyze where the most problems occurred and what carriers were associated with those particular problems. This database allowed the plant to track the performance level of its respective carriers. With proper analysis, the site can identify the major problems with safety equipment and modify its protocol to reflect the data.

As evidence of the effectiveness of this practice, during our visit to Plant F, a truck was refused admission to the plant because it did not have a fire extinguisher, which was required safety equipment for the product they were transporting (See Case Study 6). Furthermore, Symons and Reinfurt used a mathematical model with an exponential waiting time to measure the effect of safety inspections on the accident rate (1975). Their study suggested that random inspections could help ensure the continuing function of the vehicle (see Context, Vehicular Inspection).

To ensure the continued functioning of their vehicles, the Company and its carriers should work together to establish joint responsibility for the inspection process. In all cases, the Company should establish a checklist of necessary items for both the pre- and post-load inspections. This list should be distributed to all of the Company's carriers and drivers so that they are aware of the Company's expectations. Depending on the size of the plant, the implementation of the inspections will differ. However, at all plants, the results of these inspections should be tracked in a database and analyzed by both the Company and its carriers. Using the results of this analysis, the Company and the carriers should identify problem areas and focus on improving those areas together.

Pictorial safety rules and map of plant

When a driver arrived at the Plant B site, s/he was given a document at the reception desk that explained the safety procedures in place at the site, such as speed limits and

requirements for Personal Protective Equipment (PPE). The procedures were represented pictorially for ease of understanding. This paper also contained a map of the site. Using this map, the receptionist showed each driver how to get to the loading station. Upon receiving the document the driver, had to sign and return it to the receptionist before entering the plant. The driver was allowed to keep the carbon copy, so s/he could refer back to it if s/he had any questions.

An example of an incident that involves the misunderstanding of safety instructions due to a language barrier occurred at a Georgia construction site, where a Spanish-speaking compactor operator lost his leg. The Occupational Safety and Health Administration (OSHA) stated that this accident "could have been avoided had he understood safety instructions" ("Language Barrier Leads to Accident," 2001). The supervisor of the employee did not speak Spanish, and the safety instructions for the machine were only in English. According to Raymond Finney, OSHA Area Director, accidents involving workers improperly trained because of a language barrier are increasing ("Language Barrier Leads to Accident," 2001). Pictorial representations of instructions will help those who do not speak the primary language to understand and follow safety rules.

Symbolic systems are also useful to represent complex systems and conditions. Trotter-Cox (1999) conducted a study on responses to flight situations using two different manuals: one presented in graphic-symbolic form and the other presented in text form. A series of experiments was conducted to obtain a quantitative estimation of the test subjects' responses to the instructions. The accuracy of the long-term retention of those symbols was much greater than those who had only read the text manual. The ability of the crew to respond correctly in an emergency situation, such as when components failed, hazardous conditions existed, and a critical system failed, was markedly improved (Trotter-Cox, 1999).

Near-miss incident reports

Plant C has a goal of reporting at least 200 near-miss incidents each year. A near-miss report tracks an incident caused by risks that could pose a potential problem, but where no serious accident occurred. The purpose of the goal is to encourage employees to observe each other and report anything that could potentially cause an accident if ignored in the future and identify protocol that could be added or changed to reduce the risk of these incidents.

The United States National Safety Council states that approximately 75 percent of industrial accidents are predicted by near-miss incidents ("Near Miss Accident"). By studying the information revealed in near-miss reports, the root causes of accidents can be identified and the chain of reactions that cause accidents can be better understood. By analyzing the causes of accidents, it will be easier to identify the risks, as well as develop better prevention methods ("Safety Data Initiative," 2001). The U.S. DOT Safety Council feels that traditional actions taken to reduce accidents, such as accident investigation, regulation enforcement, and driver education have reduced the number of accidents, but have "flatlined" in that reduction. The U.S. DOT Safety Council feels it is necessary to take a proactive approach by utilizing near-miss systems to prevent accidents and spills ("Section 1:What We'll Do to Improve Safety Data," 2002).

By using near-miss systems, the Company and its primary carriers should work together to share their near-miss reports to increase their knowledge of potential dangers. With this knowledge, local branches of the Company could meet with their respective primary carriers to discuss recent incidents and ways to remedy them. These meetings would help keep the lines of communication open between the Company and its carriers to further improve their safety audits/inspections by making sure they are equal on both the Company's and carriers' ends. This would allow for the same safety message to be continually improved upon and communicated to the Company's and carriers' employees.

Driver active in the loading process

At both Plants C and E, the driver was active in the loading process. At Plant C, the drivers and the Company personnel shared the loading tasks fairly equally and there was a large amount of interaction between the Company personnel and the driver. At Plant E, the drivers did everything except select the storage tank from which to load. By keeping the drivers active in the loading process, the drivers were required to interact with the Company technicians at the loading station. Due to the complexities of loading the product, all the Company sites that implemented driver loading required their primary carriers to teach their new drivers how to load on-site with each site's specific equipment. This ensured that the drivers were trained properly. At Plant C, drivers from other carriers besides Carrier C were allowed to load; however, they were required to learn how to load from reading printed instructions on their own and by being trained by any driver who was around.

Involving the driver in the loading process serves as a non-intrusive way to test the alertness of the driver before s/he starts his/her trip on the road. Although this loading process only involves simple tasks, these are things the driver may not be able to do effectively while under the influence of drugs, in sleep deprivation, or any other condition that may hinder the mental awareness of the driver. Such a test is known as a cognitive test. A 1997 study conducted by the Midwest Transportation Center (1997) tested 62 drivers using a cognitive test for both audio and visual spatial processing and selective attention. Immediately after this test, each driver was then subjected to an on-road driving performance test. The study found that "losses in certain cognitive skills can be identified as being related to increasing potential for driving errors and increasingly of a serious nature" (Mercier, Mercier, O'Boyle, and Strahan, 1997).

When drivers load their own trucks, they interact with the employees at the Company's sites. Drivers who frequent the same site are likely to form a friendship with the loading technicians, which will create an open and safe workplace. During the loading process, the Company employees have the chance to observe the driver's condition and identify

potential danger signs of fatigue and substance abuse. An additional inspection of the driver's PPE can also be conducted at this time by the loading technician before the start of the loading process. This ensures that both the drivers and loading technicians are working together to safely load the truck.

Safety Awareness

Improving safety through increased awareness is a key theme present in the Company's safety program. The Company hopes that by setting a goal of zero accidents, employee and driver safety awareness will be raised, improving behavior on-site and on the road. During our site visits and discussions with managers at the Company, we compiled a list of ways to increase driver awareness of safety on the road.

Driver awareness of safety is identified by the U.S. DOT as a countermeasure to prevent commercial vehicle accidents from occurring ("Commercial Vehicle Preventable Accident Manual"). To raise safety awareness, the OSHA designed seven guidelines for the Voluntary Training of Employees. Guideline number three is "Identifying Goals and Objectives," which is when a clear, attainable goal is set and information is provided as to how to reach that goal (Cohen and Colligan, June 1998). The Company is doing this by stating its goal for obtaining zero accidents by 2005 and providing instruction on how to obtain this goal by making safety programs and material available to drivers and employees. Below, we have listed a set of practices we observed and researched that will reinforce these goals.

*Signs for "Zero truck accident goals" on way into plant*

On the road leading to the Plant F site, there were multiple signs that stressed safety to both drivers and visitors. One sign reminded them that the Company's goal was of zero truck accidents, while another was a time graph of the number of on-site injuries, highlighting the downward trend of the number of injuries over time.

The Company and its carriers should work together to develop signs to be posted at the entry to both the plant and carrier sites. Some of these signs should be the same at each location and should display information about general safety and the Company's goal of zero accidents. Other signs should be site-specific, graphing the site's yearly accident rate over time or showing the number of days since the site last had an accident. Having these signs at both the plants and carriers will reinforce the idea of safety and that safety is important to both the carriers and the Company.

*Trucker safety day*

Plant F held trucker safety days where a pavilion for the drivers was set up outside the front gate. Drivers coming to load that day were invited to spend some time at this event. The pavilion had multiple booths set up showcasing different aspects of truck safety. At the end of each drivers visit, s/he was encouraged to fill out a survey to give his/her thoughts about Plant F. This practice familiarized drivers with new truck and safety equipment. It emphasized the importance of drivers to the Company and provided a venue to communicate current site access info and road safety issues. Free mugs, hats, and hot dogs were also an incentive for drivers to attend.

The Company should have some type of trucker safety day at all its sites, though the implementation of these safety days will differ depending on the size of the site. These events should be held in conjunction with each plant's respective carriers. This way, the carriers could promote the event at their sites to encourage drivers to attend. The carriers could also provide safety information for the Company to display at trucker safety days.

The next three practices are not procedures we observed in our visits to any of the Company's sites. However, we have evidence to demonstrate their validity. We feel that each site should consider implementing these practices to improve the safety awareness of its employees as well as drivers.

*Near-miss report/Driver comment box*

A box placed in the drivers' lounge where near-miss reports can be submitted would serve as a line of communication between the driver and the management of the plant. If a driver notices a safety concern while on- or off-site, s/he can fill out a near-miss report to inform the plant of the problem. Having a box in the lounge shows that the Company is concerned with the driver and his/her input, while the near-miss reports encourage the safety awareness of the drivers.

The information drivers fill out in the near-miss reports or comment forms will be related to both problems the drivers see at the plant and on the road. The plant should share the reports that are related to problems on the road with its carriers. The carriers and the plant should then work together to address the problems that can be fixed and make their drivers aware of all the problems that appear in the reports.

*Driver award programs*

Many of the carriers we visited had driver award programs to recognize drivers who were leaders in safety. These drivers were rewarded in a number of different ways, such as with small gifts or cash rewards. However, the drivers were only rewarded by their carriers, not by the Company.

The Company's individual sites should work in conjunction with their carriers to be a part of these reward programs by sending a representative to each carrier's award ceremony to show the awardee that the Company appreciates the driver's hard work. This program should also be used to improve safety awareness at the plant by hanging plaques in the drivers' lounge that recognize each driver who has won an award. These plaques will be seen by each driver while s/he waits in the drivers' lounge and will serve as a constant visual reminder of the importance of safety. In addition to the carrier programs, the Company should implement its own reward programs for drivers at each

site. The recipients of these rewards could be chosen either by management at the plant or in conjunction with the carriers for that plant.

*Safety posters*

Posters displaying safety issues that drivers should be aware of, such as the proper use of PPE and graphs of causes of on-the-road accidents, should be placed in the loading area and in the drivers' lounge. The United States Naval Education Center advocates the use of posters as a "passive training method" to promote safety in the workplace (The Navy Advancement Center). These posters should be placed in appropriate, high traffic areas, so the most people will see them. Posters should contain a current, relevant idea and be changed often, so people continue to notice and pay attention to them (The Navy Advancement Center).

The Company and its carriers should have a standard set of safety posters to display at their sites. This would create consistency among the plant and carrier sites, so drivers would see the same message regardless of where they were. At the plants, these posters should be placed in the reception area, the loading station, and the drivers' lounge since these are the areas where the drivers are the most likely to notice the posters. At the carrier sites, safety posters should be placed wherever the drivers will see them the most; for example, at a site that has tank cleaning facilities, posters could be hung in the cleaning area.

*Matrix of Carrier Best Practices*

| Carrier Practices | Carrier A | Carrier B | Carrier C | Carrier D | Carrier E |
|---|---|---|---|---|---|
| | | | | | |
| Computer systems in trucks | | X | X | | |
| Planners managed small units of trucks and drivers | | | X | | |
| Discussion-based driver training sessions | | X | X | X | |
| Reward program | | X | | X | X |
| Keep wrecked trucks in yard | | X | | | |
| Driver manual outlines pre-trip inspections | NA | X | | NA | X |
| Inspection check list | X | | | X | NA |
| Defensive driving classes | | X | | | |
| Periodic inspections | X | | X | | X |

***Description of Carrier Practices***

Computer systems in trucks

Carriers A, B, and C implemented computer tracking and communication systems in some or all of their vehicles. These systems allowed communication between the driver and the dispatch without the use of mobile phones. The carrier could communicate information to the driver such as loading instructions, problems with the truck, or weather problems. Carrier B's system is mounted on the passenger side dashboard of the truck, forcing the driver to pull the vehicle to the side of the road in order to send or receive a message.

The Company's Transportation Incident Database recorded three separate reports of drivers who negotiated curves at a speed that was too fast for the conditions, and a rollover of the trailer occurred. (The Company's Transportation Incident Database). These incidents could have been avoided if the computer systems implemented in the trucks were extended to track previous trips and recommend safe speeds to navigate turns, depending upon the current weather conditions. The system could also be used to track driver habits and routes frequently used. The carrier could then analyze these habits and routes and recommend safe driving speeds as well as possible alternative routes. An example of a computer system with similar abilities is adaptive cruise control. In studies, truck drivers have reported that adaptive cruise control is helpful, both in saving fuel and in decreasing driver fatigue (Bishop, 2000) (see Context, Intelligent Vehicle Systems).

Planners managed small units of trucks and drivers

Carrier C assigned planners to manage different areas of its operating region. Each planner was responsible for about 30 to 45 drivers and approximately fifteen trucks. It was the planner's job to assign loads to the drivers and to choose trucks to use that were clean and in good condition. The idea behind this system was that the planner would know his/her drivers well and would be able to keep his/her fleet of trucks running 24

hours a day, seven days a week. Carrier C assigned the responsibility to the planner to track how long each of his/her drivers had been driving and to understand the skills and experience each of his/her drivers had. By using this knowledge, the planner should be able to maximize the use of the drivers and trucks available.

On November 5, 1999, an incident report in the Company's Transportation Incident Database described an accident involving a fatigued driver. This driver was on the road due to poor planning, as no other driver was available to pick up the load (The Company's Transportation Incident Database). This incident could have been avoided if the carrier used planners to match drivers with trucks based on location and hours worked.

Reward programs

Carriers A, B, D, and E had systems in place to reward safe drivers. In Carrier A's reward program, drivers received hats, shirts, and mugs as incentives for safe driving. At Carrier D, drivers could pay to be a part of the reward program. Whenever a driver had an accident-free year, s/he received a silver pin. Each driver at Carrier E was given a set monetary bonus each month; any type of incorrect behavior resulted in a percentage reduction from his/her bonus. At Carrier B, all drivers were automatically included in the reward program. If a driver had no speeding tickets, accidents, or other traffic violations, the insurance return that Carrier B received was given to that driver.

The "Commercial Vehicle Preventable Accident Manual," states that "safe driving recognition or incentive programs should be an integral part of a formal fleet safety program" (Underride Network, 1991). These programs recognize superior driving performance and set those superior drivers as models for the rest of the fleet to follow. In the United States, the National Safety Council and the American Trucking Association sponsor these types of programs (Underride Network, 1991).

In research performed by the Division of Highways in California, approximately 10,000 drivers who were at-fault for collisions or had violations in the year prior to the study were contacted. All had accumulated points on their license from the incidents. The drivers were informed through a letters that they would receive free 12-month extensions on their licenses if they had clean records the next year. The first year, the study found that there were "significantly fewer accident-involved drivers in the experimental group, particularly among the younger drivers and among those drivers whose license renewal was to come up within one year after receipt of the letter." The accident rate for the drivers whose license renewals were due was 22 percent lower than the controls. The drivers who earned the bonuses had 33 percent fewer accidents in the follow-up year than the controls (Harano and Hubert, 1974).

Trimac, a motor carrier recognized with multiple awards in Canada and the United States for excellence in the area of safety, utilizes a driver reward and assessment program. In this quarterly program, drivers who log at least 500 on-duty hours are eligible to receive a $125 cash award. After they receive four consecutive cash awards, a placard with their name and "Top Driver Award" designation is placed on his/her assigned tractor. As long as the driver continues to qualify for this reward, the placard remains on the tractor ("Commitment to Safety," 2001). Another example of the value of reward programs was a review of over 120 published evaluations of occupational accident prevention that found that incentives were generally more effective in enhancing safety than engineering improvements, selection of personnel, and disciplinary action (Fox, Hopkins, and Anger, 1987, and McAfee and Winn, 1989).

The implementation of a reward program is the first step toward working together with the Company. After each carrier has set up a reward program, it can further this program by stressing to the Company and other customers that they need to work together with the carrier. If safety is a shared responsibility, then rewarding safety should also be a shared responsibility. Each carrier should encourage the Company to attend all of its rewarding ceremonies to show the drivers that the Company appreciates their work. Furthermore,

each carrier should give the Company copies of each award to post in the drivers' lounge or check-in area, further showing that the Company appreciates its drivers.

Inspection checklist

On the daily log for the Carrier D drivers, there was an inspection checklist that drivers had to fill out before each day of travel. Each day, the drivers submitted their completed logs to certify that they had inspected their trucks before going on the road. If a driver discovered any mechanical problems during the inspection, s/he submitted a repair request and used a different truck for his/her trip.

In a study on inspection processes in the United States, the FMCSA observed 253 truck inspections in six different states (2000). In discussions following these observations, the FMCSA noted that the process of these inspections varied greatly. Given these results, the FMCSA recommended that all inspections should be performed in a uniform manner and should be supervised in order to improve the effectiveness of the inspection procedures. One way to standardize these inspection processes is to use a checklist during the inspection.

Driver manual outlines pre-trip inspections

Rather than preparing a checklist to be filled out each day, the management of Carrier B included the pre-trip inspection protocol in the driver's manual. The management felt that a checklist was easy to falsify, so these inspections were included as a part of the driver's everyday responsibility. The management also felt that this system eliminated a lot of needless paperwork.

Deborah L. Frailey, a consultant who has developed and managed audit programs and conducted employee training, believes that safety philosophy is "visible only when the policy is demonstrated by managers and supervisors." She suggests one method of communication as an employee/driver handbook, which facilitates communication

between the driver and the management. By establishing clear rules and expectations, the driver will better understand and have a helpful reference to define his/her role in preventing hazards on the road (Frailey).

Defensive driving classes

Carrier D used to have defensive driving classes for its drivers, but over time, this program disappeared. About 60 percent of Carrier D's current drivers are trained in defensive driving techniques. The carrier is planning to resurrect its program, so all its drivers can be trained.

The FMCSA suggests that drivers should be trained in how to drive defensively to reduce accident rates ("Accident Countermeasures Manual-Defensive Driving"). The defensive driver tries "to recognize potentially hazardous situations in advance to allow time to maneuver past them" ( "Accident Countermeasures Manual-Defensive Driving"). To train a fleet of defensive drivers, the FMCSA recommends that a qualified person should ride along with the drivers and evaluate their driving skills. The carriers should promote and encourage defensive driving, as well as have a standard to judge safe driving performance for their drivers. In addition to defensive driving programs, an accident review program to classify preventable and non-preventable accidents should be implemented to identify risks that should be addressed in driver training ( "Accident Countermeasures Manual-Defensive Driving").

Defensive driving programs are another practice that should be a shared responsibility between the Company and its carriers. Although these classes are something the carriers would have to arrange, the Company should encourage its carriers to implement these programs by subsidizing the cost or offering better contracts to those carriers that have defensive driving programs implemented. Furthermore, the Company and its carriers should work together to plan such a program. With the use of teamwork for these defensive driving programs, both the Company and its carriers are addressing the shared responsibility for safety on the road.

Discussion-based driver training sessions

Many of the carriers hold driver training sessions in small groups. Carrier C and Carrier B travel to their different geographic locations to conduct sessions with groups of about 15 to 30 drivers at a time.

Discussion-based small group techniques can be applied to driver training sessions by having carriers organize meetings with up to 25 drivers from an area to meet and discuss safety awareness and procedures. Small groups of this size encourage participation and make it easier for others to share their opinions. During meetings, participants are encouraged to speak openly during the discussion, making these meetings more productive and efficient due to the useful information that can be provided by group participants. Another advantage of small groups is that they "foster dissemination of information to the broader community" (Howard/Stein-Hudson Associates, Inc. and Parsons Brinckerhoff Quade and Douglas, September 1996).

Many small group techniques exist; however, breakout groups, workshops, and seminars are three types of meetings that would be very effective for communicating information about safety to truck drivers. Breakout groups are smaller sections of a larger group that meet to discuss specific issues and then report their findings back to the larger group. Seminars focus on a single topic, allowing drivers to effectively learn a single new safety procedure. The small group setting allows the meeting to be very technical and gives the opportunity for drivers to ask questions and raise discussion. Conversely, workshops intensively focus on multiple topics over a short period of time. Workshops enable drivers to learn a set of new safety procedures with hands-on training, as well as provide the opportunity for drivers to ask questions (Howard/Stein-Hudson Associates, Inc. and Parsons Brinckerhoff Quade and Douglas, September 1996).

Carrier D used two of these small-group meeting techniques to educate its drivers on new safety procedures. Carrier D had three of its top drivers from each of its two divisions

attend a seminar or workshop where management communicated new procedures to these three drivers. These drivers were then responsible for communicating the procedures to the rest of the driving community at the carrier. The three newly trained drivers acted as a breakout group, informing the rest of their peers about what they had learned.

It is in the best interest of both the Company and its carriers to focus on communicating important issues to their drivers, such as in discussion-based driver training sessions. These could be held at either the Company or the carrier sites, and the Company and its carriers should work together to create an agenda for these periodic meetings. After these meetings, the Company and its carriers should set goals to address safety concerns. Together, the carriers, their drivers, and the Company should then develop a plan to implement these goals.

Periodic inspections

*Additional truck inspection besides government requirement*

Some countries have laws requiring all commercial trucks to be inspected by a government official a certain number of times per year. Carriers B and E performed additional thorough truck inspections each year for each of their trucks.

*Periodic inspections en route*

Carrier A requires its truck drivers to stop every 200 miles to perform en route inspections of their trucks. In order to inspect his/her truck en route, the driver must pull over, forcing him/her to take a break from driving and to observe the condition of his/her vehicle. If these inspections are performed properly, the trucks will be kept in good operating condition.

The U.S. DOT emphasizes that worn or failed parts can result in or contribute to an accident. Periodic inspections can prevent failures and ensure the vehicle is drivable

("Accident Countermeasures Manual- Preventive Maintenance and Inspection Procedures"). Symons and Reinfurt (1975) used a mathematical model with an exponential waiting time. In their study, they proved that more inspections performed on a truck will continually decrease the chance of a mechanical defect occurring, as well as help identify future large mechanical problems early (see Context, Vehicular Inspection).

Keep wrecked trucks in yard

Carrier B had two truck cabs stored in its truck yard that had been in accidents. The management encouraged all the drivers to take time out of their working schedules to take a look at these trucks, so they could see a potential result of unsafe driving.

In 1980, Zohar, Cohen and Azar implemented a program to promote the use of ear plugs among employees who were at risk of the damaging effects of noise in the workplace. Employees were subjected to hearing tests before and after their work shift to show the effects of short-term hearing loss. Audiograms were generated from the results of these tests that pictorially explained the amount of hearing loss for those who routinely wore protection and those who did not. Permanent hearing loss was apparent in the employees who did not use ear protection, which further increased the impact of the displayed audiograms. This program yielded a 50 percent improvement in ear protector usage (Zohar, Cohen, and Azar, 1980). Carrier B implements a program similar to this by showing the effects of wrecked trucks to its employees. By employees being able to visually see the damage, they understand the requirement for safety on the job, thus improving their awareness of safety.

## Recommendations

Safety on the road is a full circle concept; it requires work from both the Company and its primary carriers. Currently, each half of the circle is only being considered independently; the Company does its half to promote safety and the carriers do their half. In order to complete the circle, both the Company and the carriers need to work together to sponsor cooperative programs, so the message of safety is promoted to the drivers

regardless of where they are in the delivery process. This will allow for a single and coherent message to be communicated to the drivers. Below, we discuss generally what all of the plants and carriers can do to emphasize safety on the road (see Appendix A: Gap Analysis for a more detailed description). Following these general recommendations, we discuss how the Company and the carriers can come together to complete the circle of safety.

***The Plants***

As previously mentioned, we developed our methods for data collection around the three main points where the personnel from the Company have direct contact with the truck driver at the plant: 1) the entry gate, 2) the loading station, and 3) the exit gate. We found that there are multiple opportunities during these contact points where the Company can stress safety awareness to the truck drivers who enter its sites.

To emphasize the Company's commitment to safety, signs posted at the entry to the site are an effective measure to promote safety awareness. When entering the plant, a pictorial list of rules and a map distributed to the driver will help define the rules of the plant and provide a guide to the site so that the driver can find his/her way to the loading station. Before loading, an inspection should be performed to reduce the possibility that mechanical defects will result in unsafe loading. After loading, another inspection should be performed to ensure that the tank is properly sealed, so that the product remains inside the tank throughout its journey. These inspections could be performed either regularly or on a random basis by either the driver or by Company personnel, depending on the unique setup of the plant.

While the driver is waiting for the truck to be loaded, s/he may wait in the drivers' lounge. This is a point of contact where the Company can stress safety awareness to the drivers. By developing posters that can be displayed in the drivers' lounge or utilizing a suggestion box where near-miss reports and comment cards can be deposited, the Company will emphasize the importance of safety. In addition to this practice, plants

should work in conjunction with their carriers to develop an awards program to recognize exceptionally safe drivers. Hanging the awards from this program on the walls of the drivers' lounge at the plant will help motivate and inspire the drivers to drive safely. A truck safety awareness day will provide another contact point through which the Company can address safety issues to the driver. For larger sites, holding a truck safety day is feasible, while smaller sites should invite their regular drivers to periodic weekend events.

Another way to make employees aware of safety issues is to make near-miss reports available and to have target goals set for a minimum number of reports per year to ensure that hazards are identified at the plant. When these hazards are identified, proper measures should be taken to reduce and eliminate potential risks. These near-miss reports should be shared amongst all the Company's sites. This will enable the sites to learn about the risks present at other sites and from mistakes that others have previously made, so their employees can be better informed of safety hazards.

***The Carriers***

Safety awareness at the carriers can be addressed by cognitive tests, drug tests, and intelligent vehicle systems. In-vehicle or in-terminal cognitive tests have been demonstrated to be effective in determining if the driver is fit to safely operate a commercial motor vehicle (United States Midwest Transportation Center, 1997). Random drug testing programs should be established to ensure that the fleet is not driving while under the influence of drugs or alcohol. Intelligent vehicle systems are a worthwhile investment on trucks the carriers operate. Devices that sense a driver drifting out of the lane or adjust the vehicle's speed based on the speed fluctuations of the surrounding vehicles will improve safety on the road.

To further encourage drivers' awareness of safety, reward programs are a way to provide an incentive to drive safely. There are various programs implemented throughout the carrier industry, which range from pins or plaques to cash incentives as tangible rewards.

To demonstrate its commitment to safety, the Company should grant a special reward to a driver and/or have a representative present at the carrier awards ceremony. In place of, or in addition to the carrier award programs, the plants should implement programs on-site.

Driver education programs are another way to build upon a driver's awareness of safety. By teaching drivers how to drive defensively, it is possible to improve their driving skills. To complement these programs, discussion-based driver training sessions should be implemented to inform drivers about safety-related situations. These programs can be tailored to the carrier's needs and can include topics such as strategies for driving in inclement weather conditions, route planning, and stress management. These sessions can also be held after an accident to increase awareness of the dangers on the road, as well as to reinforce that safety is both the carrier's and driver's first priority. Also after an accident, the carrier should retain the damaged vehicles to provide the opportunity for drivers to view and reflect upon the consequences of unsafe driving.

***Plants and Carriers***

There are seven main ways the plants and carriers can work together to complete the circle of safety through 1) a cooperative inspection process, 2) actively involving the drivers in the loading process, 3) discussion-based driver training, 4) defensive driving programs, 5) reward programs, 6) sharing of near-miss reports, and 7) various types of joint safety awareness programs.

1) The Company and its carriers should work together to ensure that inspections are performed uniformly and on a regular basis. The results of these inspections should be tracked in a database and analyzed by both the Company and its carriers.

2) Involving the driver in the loading process ensures that both the driver and loading technician are working together to load the truck safely.

3) In discussion-based driver training sessions, both the Company and its carriers can communicate important issues to their drivers. After these meetings, the Company and its carriers should set goals to address safety concerns and to develop a plan to implement these goals.

4) Defensive driving programs are another type of training program that the Company and its carriers should conduct together.

5) Another way in which the Company can work with its carriers is to become involved in rewarding safe drivers. The Company should not only have a representative present at these carrier reward ceremonies, but should also implement its own reward programs for drivers at each site.

6) Near-miss reports should be shared between the Company and its carriers. Many of these reports could come from the drivers with reports of problems they observe at the plants, the carriers, and on the road.

7) The Company should develop safety awareness programs with its carriers. Standardized sets of signs and safety posters should be developed for all the sites, creating consistency among the plant and carrier sites. Working together to hold trucker safety days will improve safety awareness and show the Company and the carriers' joint concern for the drivers' safety.

## Conclusion

During our travels to five European sites and one North American site, we observed differences in the safety practices and daily operations of each plant. Similarly, at each of the carriers, we found different safety procedures unique to its location and logistics operation. Despite these differences, there are lessons that all the plants can learn from each other regarding ways to stress safety to their employees and contracted drivers. Likewise, all the carriers we visited have some unique practices that the others could

benefit from implementing. We recorded these differences in the case studies we developed for each plant.

From our case studies, we developed a list of practices and justified their validity with research and accident data. The practices we could validate with tangible data were considered as best safety practices, which are shown below.

| Plant Practice | Evidence | Page |
|---|---|---|
| | | |
| Pre-load Inspection | Transportation Incident Database | 42 |
| Post-load Inspection | Transportation Incident Database | 42 |
| Random inspections with check list | Observations, Studies | 42-43 |
| Pictorial safety rules and map of plant | Studies | 43-44 |
| Near-miss incident reports | Studies | 45 |
| The driver is very active in the loading process | Studies | 46-47 |
| Safety Awareness | Studies | 47-50 |

| Carrier Practice | Evidence | Page |
|---|---|---|
| | | |
| Computer systems in trucks | Transportation Incident Database, Studies | 52 |
| Planners managed small units of trucks and drivers | Transportation Incident Database | 52-53 |
| Reward program | Studies | 53-54 |
| Inspection check list | Studies | 55 |
| Driver manual outlines pre-trip inspections | Studies | 55-56 |
| Defensive driving classes | Studies | 56 |
| Discussion-based driver training sessions | Studies | 57-58 |
| Periodic inspections | Studies | 58-59 |
| Keep wrecked trucks in yard | Studies | 59 |

For each plant and carrier, we have detailed how our best practices can be implemented in each particular setting. In addition to these specific recommendations, our overall finding was that the Company and its primary carriers need to work together to address the issue of driver safety on the road. Our best safety practices and recommendations will help both the Company and the carriers to work together to raise driver awareness of safety through unified practices. These unified practices will create an environment in which the Company and the carriers share equal responsibility for improving safety and safety awareness to reduce accidents on the road.

## References


"Accident Countermeasures Manual-Defensive Driving." Retrieved November 25, 2002 from http://www.fmcsa.dot.gov/factsfigs/accidenthm/Driver.htm/

"Accident Countermeasures Manual- Preventive Maintenance and Inspection Procedures." Retrieved November 25, 2002, from http://www.fmcsa.dot.gov/factsfigs/accidenthm/vehicle.htm/

Arnold, Hartley, Corry, Hochstadt, Penna, and Feyer. (1997). "Hours of Work, and Perceptions of Fatigue Among Truck Drivers." *Accident Analysis and Prevention, 29*, 471-77.

Austroads Working Group. (2000). "Drugs and Driving in Australia: First Report of the Austroads Working Group."

Baker, D., Bushman, R., and Berthelot, C. (2001). "Effect of truck rollover warning systems." *Transportation Research Record, 1779,* 134-140.

Bureau of Transportation Statistics. "Safety Data Initiative." (2001). Retrieved November 25, 2002, from http://www.bts.gov/sdi/

Behavioral Science and Technology, Inc. (1999). "BST®'s Ongoing Studies of Behavioral Safety and the Behavioral Accident Prevention Process® Technology." Retrieved October 22, 2002, from http://www.bstsolutions.com/s-index.htm/

Bots, M.J., and Veldhuis, G.J., (1998). "Transfer of Training: a review of the literature." Retrieved November 28, 2002, from http://www.tm.tno.nl/research/index.html/

CARE Community Road Accident Database. (Last updated 2002, October 31). Retrieved November 26, 2002, from http://europa.eu.int/comm/transport/home/care/reports/t_vehgroup_all_en.htm?category=3&country=0

Clarke, P. (1998, October 20). "Adaptive cruise control takes to the highway." *EE Times.* Retrieved September 21, 2002, from http://www.eetimes.com/story/OEG19981020S0007/

Cohen, A. and Colligan, M.J. (June 1998). Assessing Occupational Safety and Health Training. Retrieved December 5, 2002, from http://www.cdc.gov/niosh/98-145-b.hml/

"Commitment to Safety." (2001). Retrieved November 25, 2002 from http://www.trimac.com/about/safety/commitmentToSafety.htm

Crouse, W.H. and Anglin, D.L. (1978). *Motor Vehicle Inspection.* New York: McGraw-Hill.

Current, W.F. (2001, August). "Drug and Alcohol Testing: Screening for Safety." *Occupational Health and Safety*, 24-26.

"Driver Alertness and Fatigue: Summary of Completed Research Projects, 1995-98." (Apr. 2001). Retrieved November 25, 2002, from http://www.fmcsa.dot.gov/safetyprogs/fatigue/fatigue.htm

"Drivers Training." (2000). The Company Slide Presentation, 1-26.

"DSM Responsible Care Progress Report 2001" (2002). Retrieved October 25, 2002, from http://www.dsm.com/care/2001/~down/rcpr_2001_en.pdf

"Element 9: Incident Investigation and Analysis" (2000). Retrieved October 26, 2002, from http://www.exxonmobil.com/news/publications/c_she/c_page11.html/

Entry/Exit Gate Manager at Plant A, interview by authors, 15 October 2002.

Entry/Exit Gate Manager at Plant B, interview by authors, 4 November 2002.

Entry/Exit Gate Manager at Plant D, interview by authors, 7 November 2002.

Entry/Exit Gate Personnel at Plant F, interview by authors, 12 November 2002.

Entry/Exit Gate Receptionist at Plant C, interview by authors, 7 November 2002.

Fancher, P.S., Bareket, Z., Bogard, S. (2001). "Modeling Driver Behavior by Using Mind's Eye Coordinates." *Transportation Research Record*, 1-12.

Fatal Accident Rate Down By Nearly One-Third Over Past 10 Years. (2001, December 19). Retrieved October 29, 2002, from http://www.truckline.com/insideata/press/121801_fatality_rate.html/

Federal Highway Administration: Office of Motor Carriers. (1998). *Drug and Alcohol Testing Survey* (FHWA-MCRT Publication No. 98-003). Washington, D.C.

Finn, Jeremy. "Class Size and Students At Risk: What is Known? What is Next?" (1998) Retrieved November 24, 2002, from http://www.ed.gov/pubs/ClassSize/academic.html

Fox, D.K., Hopkins, B.L. and Anger, W.K. (1987). The long-term effects of a token economy on safety performance in open pit mining. *Journal of Applied Behavior Analysis*, *20*, 215-224.

Frailey, Deborah. "A Safety Philosophy Begins With Management Responsibility." Retrieved November 25, 2002, from http://www.ecsinc.com/riskctrl/hot/focsafdf.htm/

Geller, Scott. "Surveying behavior-based safety experiences." (May 19, 2000). Retrieved October 22, 2002, from http://www.ishn.com/CDA/Article_Information/BehavioralSafetyItem/0,3563,3200,00.html/

Geller, Scott. "The ten myths of behavior-based safety." (April 11, 2000). Retrieved October 22, 2002, from http://www.ishn.com/CDA/Article_Information/BehavioralSafetyItem/0,3563,1091,00.html/

Groeger, J.A., Rothengatter, J.A. (1998). Traffic psychology and behavior. *Transportation Research Part F*, *1(1),* 1-9.

"Guidelines of 16 Hours Operation." (2002, April). Retrieved October 22, 2002, from http://www.epca.be/Pages/workshops/download/16Hours.pdf

"Guidelines for Safety Awareness and Behaviour in the Supply Chain." (2002, April). Retrieved October 22, 2002, from http://www.epca.be/Pages/workshops/download/Safety_awareness.pdf

Harano, R.M. and Hubert, D.E. (1974). *An evaluation of California's `good driver' incentive program*. Report No. 6, California Division of Highways, Sacramento.

Hatakka, M., Keskinen, E., Gregersen, N. P., Glad, A., and Hernetkoski, K. (2002). From control of the vehicle to personal self-control; broadening the perspectives to driver education. *Transportation Research Part F*, 201-215.

Howard/Stein-Hudson Associates, Inc. and Parsons Brinckerhoff Quade and Douglas. (September 1996) *Transportation Decision-making.* Retrieved December 4, 2002, from http://www.fhwa.dot.gov/reports/pittd/smlgroup.htm)/

Federal Motor Carrier Safety Administration: Analysis Division. "How Effective are Roadside Inspections and Traffic Enforcement?" (Dec. 2001) Retrieved November 25, 2002 from http://ai.volpe.dot.gov/CarrierResearchResults/HTML/ProgramEffectiveness/intmodel.htm/

General Manager at Carrier B, interview by authors, 6 November 2002.

Insurance Institute for Highway Safety. "Q&A:Drugs (Other than Alcohol)." (2002). Retrieved November 29, 2002 from www.highwaysafety.org/safety_facts/quanda/drugs.htm

"Language Barrier Leads to Accident." (2001). Retrieved November 25, 2002, from http://www.wls-law.com/newsletters/jan2001/language_barrier.htm

Lenne, Triggs, Redman. (1997). "Time of Day Variations in Driving Performance." *Accident Analysis and Prevention, 29*, 431-37.

Logistics Director at Carrier C, interview by authors, 12 November 2002.

Logistics Manager at Plant E, interview by authors, 11 November 2002.

Logistics Manager at Plant F, interview by authors, 12 November 2002.

"Medical Examinations of Commercial Vehicle Drivers." (1997). Retrieved Nov 20, 2002, from www.nrtc.gov.au/publications/assessment.pdf/

McAfee, R.B. and Winn, A.R. (1989). The use of incentives/feedback to enhance work place safety: A critique of the literature. *Journal of Safety Research*, *20*, 7-19.

Mercier, C.R., Mercier, J.M., O'Boyle, M.W., and Strahan, R.F. (1997). Validation of relationship of cognitive skills losses to driving performance. Retrieved December 3, 2002, from http://www.ctre.iastate.edu/reports/mercier.pdf/

National Center for Statistics and Analysis. (2002). "Fatality Analysis Reporting System (FARS) Web-Based Encyclopedia." Retrieved November 29, 2002, from http://www-fars.nhtsa.dot.gov/finalreport.cfm?title=Trends&stateid=0&year=2001&title2=Large_Truck_Related

National Road Transport Commission. "Medical standards: drugs other than alcohol." (2001). Retrieved November 26, 2002 from http://www.nrtc.gov.au/publications/med-c.asp?lo=public

"Near Miss Accident." Retrieved November 25, 2002 from http://www.slosipe.org/TRAIN/santabarbara/Mod39/pg3.htm/

Plant Manager at Carrier D, interview by authors, 11 November 2002.

Plant Manager at Carrier E, interview by authors, 4 December 2002.

Plant Manager at Plant B, interview by authors, 4 November 2002.

Plant Manager at Plant C, interview by authors, 7 November 2002.

Plant Manager at Plant D, interview by authors, 7 November 2002.

Plant Manager at Plant F, interview by authors, 12 November 2002.

Quality Assurance Manager at Plant C, interview by authors, 7 and 8 November 2002.

QHSE Director at Carrier C, interview by authors, 12 November 2002.

"Q Safety." Retrieved November 25, 2002 from http://www.qsiinteriors.com/city/regina/safety

Ranney, T. A., Simmons, L. A., Masalonis, A. J. (1999). "Prolonged exposure to glare and driving time: effects on performance in a driving simulator." *Accident Analysis and Prevention, 31,* 601-610.

"Recommendations on Safety, Health and Environmental Management Practices for Logistic Services Providers." (2002, April). Retrieved October 22, 2002, from http://www.epca.be/Pages/workshops/download/Safety_SHE.pdf

"Research and Technology Program: Driver Alertness and Fatigue R & T." (2000). Retrieved November 25, 2002, from http://www.fmcsa.dot.gov/safetyprogs/research/driverfatigue.htm

Road and Warehouse Leader at Plant A, interview by authors, 15 October 2002.

Safety/Logistics Manager at Plant D, interview by authors, 7 November 2002.

Safety Manager at Carrier B, interview by authors, 6 November 2002.

Safety Manager at Carrier C, interview by authors, 11 November 2002.

Safety Supervisor at Carrier E, interview by authors, 4 December 2002.

Sales Manager at Plant E, interview by authors, 11 and 12 November 2002.

"Safety, Quality and Assessment Systems for the Transport/Storage/Handling of Chemicals" (2000). Retrieved October 26, 2002, from http://www.cefic.be/activities/logistics/sqas/sqas.htm

Schroer, B.J., Peyton, W.F. (1979). "The Effects of Automobile Inspections On Accident Rates." *Accident Analysis And Prevention*, 11, 61-68.

"Section 1: What We'll Do to Improve Safety Data." (2002). Retrieved November 25, 2002, from http://www.bts.gov/sdi/section1.html#nearmiss http://ai.volpe.dot.gov/ProgramMeasures/Intro/ProgramMeasuresMain.asp

Site Logistics Manager at Plant A, interview by authors, 15 October 2002.

Site Logistics Manager at Plant B, interview by authors, 4 November 2002.

Site/Production Manager at Plant E, interview by authors, 11 November 2002.

"Site Safety Improvement." (2002, February). The Company Slide Presentation, 1-4.

"Standard Company Intranet Presentation." (2002, August). 1-107.

"Summary of Program Measures Activity – 2000." (2001, September). Retrieved November 25, 2002, from http://ai.volpe.dot.gov/ProgramMeasures/Intro/ProgramMeasuresMain.asp

Symons, M.J., Reinfurt, D.W. (1975). "A Model For Evaluating The Effectiveness Of Motor Vehicle Inspection Programs." *Accident Analysis And Prevention, 7* 281-288.

Terminal Manager at Carrier A, interview by authors, 15 October 2002.

Thakuriah, P., Yanos, G., Lee, J.T., Sreenivasan, A. (2001). "Motor Carrier Safety: Crash Patterns of Inspected Commercial Vehicles." *Transportation Research Record*, 150-156.

The Company's Transportation Incident Database (2002).

The Navy Advancement Center. Safety program promotion and attitudes. Retrieved December 3, 2002, from https://www.advancement.cnet.navy.mil/products/web-pdf/tramans/bookchunks/14167_ch2.pdf/

"The thinking vehicle - how assistance systems support drivers." (2000, November 13). Retrieved September 12, 2002, from http://www.daimlerchrysler.com/index_e.htm/

Transport Workers of America. "The Origin and Fallacies of Behavior Based Safety -- A TWU Perspective." Retrieved October 22, 2002, from http://www.twu.com/HealthSfty/HlthSfty.Fact9.html/

Trotter-Cox , Anita. "Intelligence Support System (ISS)- Research technology attempts to solve flightdeck information presentation challenges." (1999). Retrieved November 25, 2002 from http://www.aviationmanuals.com/articles/article5.html

Underride Network. "Commercial Vehicle Preventable Accident Manual." (1991). Retrieved November 25, 2002, from http://www.underridernetworkorg/managmnt.html/

"Uniformity of Roadside Safety Inspections of Commercial Vehicles and Drivers on the National Level." (2000, May). Retrieved November 25, 2002 from http://www.fmcsa.dot.gov/Pdfs/tb00-010.pdf

van Schoor, O., van Niekerk, J.L., and Grobbelaar. (2001). "Mechanical failures as a contributing cause to motor vehicle accidents – South Africa." *Accident Analysis And Prevention, 33*, 713-721.

Ward (2000). "Cannabis and Driving: A Review of the Literature and Commentary" Retrieved November 25, 2002, from http://www.dft.gov.uk/roads/roadsafety/cannabis/index.htm

White, M.T. (1986). "Does Periodic Vehicle Inspection Prevent Accidents?" *Accident Analysis And Prevention, 18(1),* 51-62.

Williamson, Feyer, and Friswell. (1996). "The Impact of Work Practices on Fatigue in Long Distance Truck Drivers." *Accident Analysis and Prevention, 28,* 709-19.

"Working Groups." (2002, June). Retrieved October 22, 2002, from http://www.epca.be/Pages/workshop.html/

Zohar, D., Cohen, A., and Azar, N. (1980) Promoting increased use of ear protectors in noise through information feedback. Hum Fact 22:69-79.

*Case Study 1: Plant A*

Visited on October 15, 2002

## Introduction

Plant A was used as a test case for our study that was carried out at five European plants and 4 European truck carriers. We spent one day at Plant A and observed one truck undergo the entire loading process. Our key findings at this plant allowed us to refine our methods and develop daily schedules for the plants the team visited in Europe.

The day's agenda was as follows:

The Company Plant

- Truck Control Center
    - Driver check-in
    - Pre-Fill inspection
- Loading Station
    - Observed start up procedure
    - Demonstration of fill-up procedure
    - Observed truckers` lounge
    - Observed closing procedure
- Truck Control Center
    - Observed post fill up inspection
    - Observed truck check-out

## Key Points from Interview with the Road and Warehouse Mode Leader

1) **Do you perform safety inspections on inbound and outbound trucks? If yes to either, when and where do you perform these safety inspections?**
    a) Yes, perform random inspections on incoming and outbound trucks
    b) Inspections are performed at the weigh station

c) If an inspection is failed it is performed a second time. If the truck passes either inspection it is allowed to enter the plant.
d) The findings from random inspections are tracked in an Excel document

**2) What do these inspections entail?**

a) Check Tires and inside protectors
b) Pump Valve
c) Vacuum check
d) Check cleanliness of tank

**3) Do you reward safe driving? If so, how?**

a) No
b) Carriers may do this, but the Company is not involved

**4) What type of certification do you require the drivers to have?**

**a)** A commercial driver's license

**5) If you could improve upon any current inspections or add new items to your safety protocol, what would you improve or add?**

a) Improve spot check frequency on self-cleaned tankers

**<u>Key Points from Interview with Entry/Exit Manager</u>**

**1) What is your protocol for interacting with the truck drivers?**

**a)** Driver presents The Company identification card for receptionist to scan
**b)** If a driver does not have an identification card s/he must go watch a video and then take a test after the video to show competence of the local safety procedures. If the driver passes the test, s/he is awarded a Company identification card
**c)** Verify paperwork and put the driver and load into the Diamond System
**d)** Print truck weight on back of bill of laden

2) **What exchange of paperwork do you require prior to entry?**
    i) Bill of laden
    ii) Drivers receive visitor identification badge for the site
3) **What exchange of paperwork do you require prior to exit?**
    i) Bill of laden
    ii) Weight ticket
    iii) Return of visitor identification badge
4) **When and where do you perform safety inspections on inbound trucks?**
    i) In the Truck Control Center
5) **What do these inbound truck inspections entail?**
    **a)** Check cleanliness of tank
    **b)** Check tires and inside protectors
    **c)** Pump valve
    d) Vacuum check

6) **When and where do you perform safety inspection on outbound trucks?**
        (1) At the truck control center

7) **What do these outbound truck inspections entail?**
    i) 360 degree walk around
        (1) Check for leaks
        (2) Check for condition of truck
    ii) Check back valve
        (1) Tighten if necessary
    iii) Check all wash caps and manholes
        (1) For leaks
        (2) Tighten if necessary

8) **If you improve upon any current inspections or add new items to your safety protocol, what would you improve or add?**

a) Increase the amount of random inspections performed

## Observations at the Entry Gate

The driver entered the site and parked his truck at the weigh station. Next, the driver left his truck and entered the truck control center. In the truck control center, a Company employee collected from the driver his bill of laden and commercial driver's license. On the bill of laden, the Company employee printed the tare weight of the truck and then gave the Bill of Laden back to the driver. The drivers' Company identification card was then scanned, to record his entrance to the site. The driver then received an identification card that recognized him as a guest on site.

While the driver was checking in a pre-load inspection was performed on the truck. This inspection included a check of the cab in the truck, which was normally performed at random; however, due to September 11th the plant was on yellow alert, which required an inspection of every cab for weapons and narcotics. After the cab inspection the Company employee did a 360-degree check of the condition of the truck. During this inspection the Company technician looked at the condition of the tires and for any loose equipment.

After this, a vacuum test was done on both the internal and external valves in the rear of the truck, to ensure they could hold a vacuum. Next, the technician climbed to the top of the truck to make sure that all the wash caps were tightened and wired shut and the loading cap gasket was in good shape. Finally, a paper towel was clipped to a long pole; this pole was used to swab the inside of the tanker to ensure there was no residue inside the truck. This final step was conducted randomly on two trucks per carrier each week; this test is performed to ensure that the carriers were following the cleaning procedure set by the Company. After the inspections, the Company technician went back into the truck control center to let the receptionist know that the truck was fit to load. Once the procedures were complete, the driver was allowed to proceed to the loading station.

While we conducted our observations at the entry gate we discovered that two of the three technicians working there had background in security work. The technicians with the security background were the personnel responsible for performing the cab inspections and dealing with the drivers in the Truck Control Center.

## Observations at the Loading Station

At the loading station we were guided through the steps of loading the product into a tanker. Due to the time it took to move from the truck control center to the loading station, we missed the chance to observe the starting procedure at the loading station. However, we were able to see a demonstration of the steps necessary to start the loading procedure and begin loading the product into the tanker. For live loading the tanker usually took about 90 minutes to load. During this time the truck driver would either wait in his/her truck or go to the truckers' lounge on-site. The truckers' lounge at this plant contained a phone, 4 chairs and an accessible soda machine. The walls were bare of safety procedures and Company advertisements.

We spoke with the driver while his truck was loading and asked him what he typically did during that time. He explained to us that he would usually sit in the truckers' lounge and wait. While he was waiting, he would call his carrier company to see if any changes have occurred with the delivery.

After the truck was loaded with the correct amount of the product, we observed the capping procedure. This involved the removal of the hose from the tanker and removal of the plastic sleeve. The driver then sprayed down the area with water to wash away any spilled product. This water was washed away into a recycling area, where the water was used for future products. Once the top of the truck was capped off we observed the truck return to the truck control center to complete the bill of laden.

## Observations at Exit Gate

When the driver finished loading his tank he proceeded to the weigh station to determine the final weight of his truck, which was printed on the bill of laden. At the weigh station the driver left his truck and entered the Truck Control Center (TCC). In the TCC one technician printed the loading slip for the driver, while another technician took the keys from the driver and proceeded outside to perform a post-load inspection. The post-load inspection included a 360-degree visual inspection for leaks. Next, the valve in the back of the truck was checked to make sure it was secure. The technician then climbed to the top of the truck to check the tightness of the wash caps on the top of the truck and the wing nuts holding the manhole shut. After the manhole inspection was completed, the technician returned to the truck control center and gave the truck keys to the driver. The driver then returned his badge to the technician and retrieved the final paperwork.

*Case Study 2: Plant B*

Visited on November 4th-5th, 2002

## Introduction

Truck traffic for the Plant B site is directed by the truck control center. The plant is open from 6:00 to 22:00 for loading during weekdays, with the heaviest hours of loading occurring from 7:00 to 10:00 and 12:00 to 14:00. If needed, the plants will load Saturday mornings.

The entire plant is equipped with an accident response center, which handles emergencies. Their phone number is printed on all of the safety forms given to the truck driver; this number can be called from anywhere in Europe. Plant B has partnered with the local fire brigade and local emergency clean-up personnel so that they can respond to accidents and spills that occur within 200 to 300 kilometers of Plant B. They contract out the remaining area of service in Europe to other organizations that are capable of providing an urgent response to emergencies.

Our first day at the plant, we interviewed the plant manager and the site logistics manager, observed several trucks go through the truck control center, and observed two trucks being loaded. The second day, we observed five additional trucks go through the loading process.

## Key Points from Interview with the Plant Manager

1) **What is the percentage breakdown for how your products are shipped (tankers, trailers, intermodal, etc.)?**
   a) About 80 percent is shipped as intermodal cargo

2) **Do you do live or non-live (pre-) loading?**

a) Mostly pre-loading
b) Container terminal where tanks are stored before they are loaded and after they are loaded before they are picked up by a truck

3) **Do you perform safety inspections on inbound and outbound trucks? If yes to either, when and where do youperform these safety inspections?**
   a) Inspections are done at the entry and exit gate

4) **What do these inspections entail?**
   a) Plate on the truck is checked at entry
   b) Visual inspection of the truck's instruments prior to entry

5) **Do you reward safe driving? If so, how?**
   a) No
   b) Carriers may do this, but the plant is not involved

6) **What type of certification do you require the drivers to have?**
   a) No certification specifically required by the Company for shipping the product, which is non-hazardous
   b) If any certification is needed by drivers, it is up to the carrier to make sure their drivers have this certification

7) **Do youhave driver training sessions and driver safety awareness training?**
   a) No
   b) Responsibility of the carriers

8) **Have you implemented any new truck driver safety procedures in the past 2 years?**
   a) No new safety procedures
   b) Modifications may have been made to previously existing protocol

9) **If you could improve upon any current inspections or add new items to your safety protocol, what would you improve or add?**
    a) Improve some of the relations between drivers and the plant loading personnel
        i) Loading personnel have specific instructions for when a driver can or cannot leave the site after loading
        ii) Sometimes, the driver does not agree with the loader's decision, and arguments may ensue

<u>Key Points from Interview with the Site Logistic Manager</u>

1) **What is your protocol for interacting with the truck drivers?**
    a) Truck arrives at gate
    b) Check-In
        i) Truck number
        ii) Status of shipment
    c) Loading Station
        i) Phone communication
        ii) Load List
        iii) Dispatch Number
        iv) Field Access Form
    d) Truck loaded
        i) Shipment paper
        ii) Load List
        iii) Product Ready for loading
    e) Container terminal
        i) Tank containers
        ii) Bring into loading if needed
        iii) Sign up for timeslots
    f) Driver Certification from cleaning station
        i) At entry: physical paper, proclaiming "fit for loading"
    g) Driver waiting during loads

i) Can stay in cab
ii) Can go in driver's lounge

2) **Do you exchange paperwork with the truck driver at the loading station?**
   a) Yes

3) **If so, what do you exchange?**
   a) Load List
   b) Dispatch Number
   c) Field Access form

4) **When and where do you perform safety inspections on trucks in the loading station?**
   a) Yes

5) **What do these inspections entail?**
   a) Checklist in the native language of Plant B

6) **If you could improve upon any current inspections or add new items to your safety protocol, what would you improve or add?**
   a) Would like to change times trucks can arrive for loading to make longer hours open

<u>Key Points from Interview with Entry/Exit Manager</u>

1) **What is your protocol for interacting with the truck drivers?**
   a) Give driver appropriate paperwork
   b) Enter shipment number into system
   c) Issue security badge for entrance to the site
   d) Ensure proper personal protective equipment (PPE) is worn
   e) Communicate with driver and loading station throughout the loading process

f) Handle return of security badge
g) Process and issue necessary paperwork for transport and destination

2) **What exchange of paperwork do you require prior to entry?**
   a) Bill of Laden
   b) Signed Safety form

3) **What exchange of paperwork do you require prior to exit?**
   a) Return of security badge
   b) Billing information
   c) Load truck is carrying
   d) Customs forms

4) **When and where do you perform safety inspections on inbound trucks?**
   a) Safety inspections are not performed on non-hazardous materials; responsibility of carrier to ensure truck is "fit for loading"
   b) Hazardous materials inspections performed at separate checkpoint

5) **What do these inbound truck inspections entail?**
   a) Hazardous materials shipments are checked for appropriate equipment
   b) Driver's license and hazardous materials certification is checked
   c) If the driver is loading or unloading hazardous materials, the dispatch coordinator also assesses the driver's condition and a separate checkpoint is required after entry

6) **When and where do you perform safety inspection on outbound trucks?**
   a) Safety inspections are not performed

7) **What do these outbound truck inspections entail?**
   a) Safety inspections are not performed

8) **If you improve upon any current inspections or add new items to your safety protocol, what would you improve or add?**
   a) No comment to this question, language barrier made it difficult to ask this question

<u>Observations at the Entry/Exit Gate</u>

When the driver first arrived at the site, the dispatch coordinator collected the Bill of Laden from the driver and, from this, obtained the shipment number. The dispatch coordinator then entered the number into the computer database system and from the software obtained the truck number. S/he then wrote this number on the access permission form that s/he handed to the driver to sign. The driver filled out the form and handed it in to the entry/exit personnel in addition to a document from the carrier stating that the truck had been inspected and was fit for loading. The personnel took the original copy of the access permission form and handed the driver the carbon copy of the sheet, which contained pictorial instructions for the site. This list of instructions included a site map and explanations of speed limits on-site, Personal Protective Equipment (PPE) requirements, and the alarm signals. If the driver was hauling dangerous goods, the person at the entry gate checked to make sure the driver had the necessary licenses. The driver were required to wear eye and head protection while on the site. If the driver did not have such protection, it was issued to the driver.

When the paperwork was completed, the dispatch coordinator either issued the driver a security badge to enter the site, or s/he issued the driver a pager if the plant was not ready for the driver to enter the site. When the plant was ready for loading or unloading, the dispatch coordinator paged the driver to signal that s/he may enter the site. The dispatch coordinator also indicated on the map where the driver needed to go to load or unload.

The badge that the dispatch gave the driver accomplished two tasks. First, it was an electronic key that allowed the driver to gain access to the plant through the main truck entrance. Second, after entering the site, the truck drove onto a scale, and the tare weight

of the truck was recorded temporarily on the tag, as well as in the truck control center. This weighing process was done again after the tanker was loaded, and the two weights were subtracted to determine the exact weight of the product loaded.

The dispatch coordinator utilized a board with slots to show where trucks were at any given time. Bright, color-coded headings indicated in which part of the site the trucks were located. There were specially coded forms that the dispatcher used to show whether the job was a load or unload; green forms were used for unloading and pink forms were used for loadings. Slips that represented drivers waiting in the parking lot were placed in a separate section of the board, and the dispatch coordinator moved these slips as the driver moved throughout different sections of the plant.

When the driver exited the site, s/he had to return the badge s/he was issued. The dispatch coordinator used the computer database system to signal when the job was completed. The computer system processed the necessary paperwork, which was dependent upon the route as well as the materials being transported. This paperwork included information such as customs forms, hazardous goods safety sheets, the loading bill, and the net weight of the load. It was packaged in a folder and handed back to the driver for transport.

## Observations at the Loading Station

During our two days at the plant, we observed seven trucks go through the loading station. The trucks seemed to follow the same set of procedures, except when noted. When the driver arrived at the loading station s/he presented the paperwork that s/he received at the entry gate. The technician at the loading station compared this paperwork to the load list to the certificate the customer would receive. Some of the items that were compared were type of material, truck number, destination, and material specification. Next, the technician put yellow ties on the truck to let the customer know that, before the Company loaded the vehicle, everything was sealed properly. If there were no problems, the driver was allowed to begin the loading process.

The driver started the process by opening the gates at the top of the walkway that allowed access to the top of the truck. The driver than proceeded to open the hatch to the tanker and hang the high-level shut-off probe on the side of hatch. After the hatch was prepared, the technician moved the loading arm to the hatch and lowered the hose into the tanker truck. The arm was mechanical and was attached to a beam on the roof; the beam allowed the arm to move horizontally along it, so it could reach any hatches on the top of the truck. The mechanical arm was moved along the walkway by a joystick; this reduced the amount of time the driver had to spend on top of the truck. Attached to this arm was a spotlight, which clearly lit up the hatch of the tanker truck and allowed the technician to easily see what s/he was doing.

As the tank was being loaded, the driver had a few options for what s/he did during this time. There was a room with a table, some chairs, and a coffee machine where the driver could sit while his/her truck was being loaded. The driver could also sit in the cab of his/her truck or wait in the loading control center. We observed one driver who sat in his cab and wandered around the loading station. Another driver chatted with us and the technicians. During our time at the loading station, we observed two drivers enter the loading control center to sit in more comfortable chairs and talk with the technicians.

All the trucks observed had two tank compartments; each compartment took about thirty minutes to load. Near the end of the loading process, the technician took a sample of the product to be tested to make sure it met the Company's and the customer's specifications. S/he stirred the product at the top of the tank and took a sample to the lab in the loading control center. After the truck finished loading, the technician moved the loading arm out of the way so the driver could lay a sheet of plastic over the entire opening into the tanker; the driver then closed the hatch and tightened the bolts. This plastic sheet was used to keep the inside of the hatch clean from residue. Out of the seven trucks observed, five of the trucks did this process; the other two drivers did not place a plastic sheet over the hole before closing the hatch. Next, the driver and technician either started loading the second compartment of the truck or moved on to post-loading procedures.

After the sample was tested, the plastic placed properly, and the hatch was closed, the technician closed and locked the loading area. The driver then had his/her access permission form signed and received a copy of the customer certificate. Next, the driver removed the chock from underneath the tires, started the truck, passed over a control strip in the area for a green light, and drove off to the exit gate.

*Case Study 3: Plant C*

Visited on November 7th-8th, 2002

## Introduction

Our first day of the plant visit, we interviewed the quality assurance manager and the receptionist at the entry gate. We also observed three trucks begin the loading process. We observed one of these trucks go through the entire process of checking into the plant, loading, and checking out of the plant. On the second day, we conducted a follow-up interview with the plant manager and observed three trucks start the loading process.

## Email Interview with the Plant Manager

1) **How are the majority of your products shipped (i.e., tankers, trailers, intermodal)?**
   **a)** Tank trucks only

2) **Do you do live or non-live loading?**
   **a)** Live-loading

3) **When and where do you perform safety inspection on inbound and outbound trucks?**
   **a)** At loading station

4) **What do those inspections entail?**
   **a)** See loading procedures

5) **Do you reward safe driving? If so, how?**
   **a)** No, purchased service

6) **What type of certification do you require the drivers to have?**
   **a)** As by logistics contract for the product shipments

7) **Do you have programs, such as driver training sessions or safety awareness training, in place to keep accident rates low?**
   **a)** Yes, for the truck drivers visiting the Plant C site

8) **Have you implemented any new safety procedures in the past 2 years?**
   **a)** yes

*Questions Relating to the Entry/Exit Gate*

9) **What is your role in interacting with the driver of the truck?**
   **a)** See loading procedures

10) **What exchange of paperwork do you require prior to entry?**
   **a)** See loading procedures

11) **What exchange of paperwork do you require prior to exit?**
   **a)** See loading procedures

12) **When and where do you perform safety inspections on inbound trucks?**
   **a)** Prior to loading

13) **What do these inbound truck inspections entail?**
   **a)** Clean tank, properly working valves

14) **When and where do you perform safety inspections on outbound trucks?**
   **a)** After loading, manhole closed, valves closed

15) **What do these outbound truck inspections entail?**

**a)** See above

*Questions relating to the loading station*

**16) What is your role in interacting with the driver of the truck?**

**a)** Prepare loading, ensure connection to loading arm etc.

**17) Do you exchange paperwork with the truck driver at the loading station?**

**a)** Yes

**18) If so, what do you exchange?**

**a)** Pick-list via computer database system, certificate of analysis

**19) When and where do you perform safety inspections on trucks in the loading station?**

**a)** see answers above

**20) What do these inspections entail?**

**a)** see procedures

<u>Key Points from Interview with the Quality Assurance Manager</u>

1) **How are the majority of your products shipped (tankers, trailers, intermodal, etc.)?**

a) Mostly sent by tanker trucks

**2) Do you do live or pre-loading?**

**a)** Like to do driver loading, which is live

**b)** Driver loading is not always possible

**c)** Some non-live loading of small amounts

3) **Do you perform safety inspections on inbound and outbound trucks? If yes to either, when and where do you perform these safety inspections?**
   a) Random audits at the entry gate
   b) Done in response to perceived problems, such as if people at Plant C start seeing problems with cleaning or incorrect labeling

4) **What do these inspections entail?**
   a) Checking specific things, such as the cleanliness of the truck or making sure it is correctly labeled for the type of material it is carrying (i.e. hazardous or not).

5) **Do you reward safe driving? If so, how?**
   a) No reward for safe driving; done at the carrier's end

6) **What type of certification do you require the drivers to have?**
   a) The country where Plant C is located has a law requiring truck drivers to have a special license
   b) The Company does not check for this license
   c) Carrier is responsible for making sure drivers have the necessary licenses and certifications

7) **Do you have driver training sessions and driver safety awareness training?**
   a) Again, this is the carrier's responsibility

8) **Have you implemented any new truck driver safety procedures in the past 2 years?**
   a) Yes, new procedures come out fairly regularly
   b) Generally in response to incident reports

9) **If you could improve upon any current inspections or add new items to your safety protocol, what would you improve or add?**
   a) Trucks with incorrect labels are becoming a problem

**b)** Sometimes a truck was previously carrying dangerous materials, and the label is not removed. If there is an accident, authorities will believe that there is hazardous material in the truck, when, in fact, there is not.

**c)** To address this issue, the plant will be conducting random audits next week to check truck labels to see if incorrect labeling is indeed a problem

***Questions Relating to the Entry/Exit Gate***

**10) What is your protocol for interacting with the truck drivers?**

**a)** Receptionist gets shipment number from the driver and finds it in the computer database system

**b)** Receptionist calls loading station to find out if there's a spot for the truck to load at in the loading station

**c)** If there is a spot and the driver has not been to the site before, the driver receives a card that identifies him/her. Driver keeps this card for return visits.

**d)** Driver enters site and drives truck onto the scale to be weighed

**e)** Truck is loaded and reweighed

**f)** Scale prints out a weight slip

**g)** Office next to the reception area; contains the invoice forms and a printer. After loading, the driver prints the weight and other information on an invoice, which goes to the customer.

**h)** Reception is open from 08:00 until 16:00, but trucks can continue to load after this time

**i)** For loading when the reception area is not open, driver must let the receptionist know ahead of time, so s/he can prepare the identification card for the driver

**ii)** ID card is left in the office with the invoice forms, along with loading procedures for the drivers

**11) What exchange of paperwork do you require prior to entry?**

**a)** No paperwork exchanged at entry

**b)** Driver must present the shipment number, which the receptionist uses to make sure the truck is on the list for loading

**12) What exchange of paperwork do you require prior to exit?**

**a)** Driver prints out the invoice form, which contains information for the customer, such as the weight of the truck and the material it is carrying

*Questions Relating to the Loading Station*

**13) What is your protocol for interacting with the truck drivers?**

**a)** Driver helps with loading

**b)** Plant C personnel make sure that the correct products are loaded from correct storage tanks

**14) Do you exchange paperwork with the truck driver at the loading station? If so, what do you exchange?**

**a)** Certificate of Analysis, which lists the material and specifications, is printed out at the loading station

**b)** Certificate is given to the driver

**15) When and where do you perform safety inspections on trucks in the loading station? What do these inspections entail?**

**a)** No safety checks are done on the truck

**b)** Cleanliness of the truck is always checked prior to loading

**c)** If the truck is not clean, it is sent away

**16) If you could improve upon any current inspections or add new items to your safety protocol, what would you improve or add?**

**a)** Would like to see loading process become fully automatic

**b)** Currently, a Plant C technician must manually select which tanks to load the product from

**c)** Fully automated system would help prevent accidental mixing and contamination in the storage tanks

**Key Points from Follow-up Discussion with the Quality Assurance Manager**

**Incident Reports**

The Plant C site has production meetings every morning to discuss any issues from the previous day, such as accidents or near-misses. Any incidents that occur are written up in a report, which is then sent to the other Company plants in Europe, so the other plants can learn from mistakes made at Plant C. They even write up incident reports about accidents that do not directly reflect on the plant's procedures. For example, there was an incident in which a load from the Company had delivered to the wrong place. The technicians there did not pay attention to the labels on the truck and paperwork and began unloading the truck. It was not until partway through the unloading process that the technicians discovered that the substance did not look, smell, or taste like the correct product and as a result, checked the labels. Plant C wrote up an incident report to remind other plants to always check labels before unloading. Plant C has an annual goal of at least 200 near-miss incident reports a year. This keeps employees on the look out for possible problems and allows for continual improvement of safety procedures. Management encourages employees to observe their colleagues and remind them to do certain things if they seem to be relaxing on safety concerns. Plant C has no problem with firing people or turning drivers away who refuse to follow basic safety rules, such as speed limits and wearing protective helmets and glasses.

**Improving Safety**

Plant C has annual training sessions with the local fire brigade, so the fire fighters will be prepared for any incidents that may happen on site.

The Company also helps other companies improve safety. In the city where Plant C is located, there was a paper mill that was having problems. Representatives from the paper mill went to the Company to learn about the Company's safety procedures as a way to improve the safety procedures for the paper mill. The Company provided the paper plant with its contractor handbook. This handbook gave specific instructions for how to load and unload Company products.

**Site Setup**

There were two offices for the drivers to visit: one at the entry point and one at the loading station. The office at the entry point contained the invoice forms the drivers must complete prior to departure from the site, and it also contained a notebook with the important loading and safety procedures in the two most common languages the drivers speak. The office at the loading station was for drivers to sit in while they were waiting for their trucks to load. This office contained a coffee machine, refrigerator, chairs, table, telephone, fax machine, and a computer terminal. This office encouraged drivers to stay in the loading area, so they could watch their trucks. In case of emergency, the Company would also know the driver's location.

Drivers who come to the site regularly were given an entry card. If a driver was new to the site, s/he received a temporary card. Drivers helped with the loading/unloading process. For drivers who were new to the site, a Company technician or an experienced driver helped them learn the procedures.

**<u>Key Points from Interview with the Entry/Exit Gate Receptionist</u>**

1) **What is your role in interacting with the driver of the truck?**
   - **a)** Gets information from driver

2) **What exchange of paperwork do you require prior to entry?**
   - **a)** There is no paperwork

**b)** Receptionist gets shipment and registration numbers from driver and checks them with information in the computer database system

**3) When and where do you perform safety inspections on inbound trucks?**

**a)** No inspections are performed

**4) When and where do you perform safety inspections on outbound trucks?**

**a)**No inspections are performed

**Additional Information**

Experienced drivers help new drivers by telling them where to go and what to do to load their trucks. There was also a printed set of procedures in the drivers' office in the reception area. The receptionist had never seen any drivers that appeared tired or under the influence of drugs or alcohol, but if she did, she said she would not let them into the site.

<u>Observations at the Entry Gate</u>

First, the driver went into the reception area and gave his shipment number to the receptionist, who checked this number against the data in the computer database system to make sure the truck was scheduled to come in. If the driver had never been to the site before, s/he received a card or identification number. The receptionist called the loading station to see if there was a place for the truck to load. If space was available, the driver proceeded to the scale, where he entered his identification number, and the weight of the truck was stored in memory in the computer system. Then the driver went to the loading station. If there was not space available for the driver to load, s/he waited in the parking lot or returned at a later time.

At Plant C, drivers did not schedule loading times prior to their arrival; they simply showed up during open reception hours. However, if a driver planed to arrive at the plant

outside of the times when the reception was open, the driver had to notify the receptionist ahead of time, so an entry card could be prepared and left in the office for the driver when s/he arrived at the plant.

## Observations at the Loading Station

When a truck came in to be loaded, the Company personnel made sure the storage tank wells were open to make sure the correct product was loaded. The driver aligned the tank underneath the loading arm. The driver opened the hatch, positioned the loading arm above the hatch, and lowered the arm. The Company personnel then began the loading. The driver was not allowed to initiate the loading. After the loading had began, the Company technician printed out the pick-list via the computer database system and matched it to the Certificate of Analysis, which was then sent with the driver to the customer. If there were any discrepancies between these two documents, loading was halted until the problem was straightened out.

While the truck was being loaded, the driver could sit in the lounge, which contained a table, chairs, refrigerator, microwave, coffee maker, computer, telephone, and printer/fax machine. Most of the drivers we observed sat in this lounge and read newspapers. On a table in the loading area, there were laminated copies of the loading procedures in the two most common languages of the drivers to read if they were unsure about any procedures. We observed one driver reading through these procedures while the first tank in his truck was loading.

When the loading was completed, the driver put on rubber gloves and took a sample of the product from the top of the tank. This sample was stored for six months, and the specifications of the sample were retained in a database for three years. Every two weeks, a sample was taken from the storage tanks and watched for five days to check for bacterial growth. After taking the sample, the driver removed the loading arm from the tank and closed and sealed the hatch. At Plant C, they previously had two accidents when drivers began to drive off without raising the loading arm to remove it from the tank.

The loading station at Plant C was heated. This was for three reasons. First, the product could freeze if it sat for too long in low temperatures. Second, a person's reflexes were slower when he/she was cold, so if there was a problem, they may not react quickly enough. Also, having a heated loading area kept drivers from leaving the loading area to sit someplace warmer.

**Observations at the Exit Gate**

After the truck was loaded, the driver took the truck back to the scale by the entry/exit gate, reweighed the truck, and printed the weight slip listing the full weight. The driver then brought the weight slip into the entry office and printed the delivery note, which was sent with the driver to the customer. The delivery note contained information about the truck, such as the shipment number and weight, and about the load, such as the type of product and all its specifications. The receptionist checked the delivery note against the weight slip and the information in the computer about what is supposed to be loaded. The receptionist then allowed the driver to leave.

*Case Study 4: Plant D*

Visited on November 7th-8th, 2002

## Introduction

The loading station at Plant D was open from 8:00 to 17:00; however, nearly all loading was pre-loading, so driver pick-up was allowed 24 hours a day, seven days a week. Carrier B was the primary carrier for Plant D and had both dedicated drivers and tanks for the product they carry for Plant D. Because of this dedication, Carrier B drivers were the only drivers given access to the plant to pick up a pre-loaded tank outside the operating hours.

There were different types of products shipped from Plant D. Because the product we were mainly interested was nearly all pre-loaded at this plant and our study was based upon live loading, we also decided to observe a live load of a different product, in addition to our other loading station and entry/ext gate observations.

## Key Points from Interview with the Safety/Logistics Manager and the Plant Manager

1) **What is the percentage breakdown for how your products are shipped (tankers, trailers, and intermodal)?**
   a) 100% of the product is shipped by truck
   b) Raw materials are received via harbor, rail car, and truck

2) **Do you do live or non-live loading?**
   a) Non-live loading occurs at this plant

3) **Do you perform safety inspections on inbound and outbound trucks? If yes to either, when and where do youperform these safety inspections?**

a) Not for non-hazardous materials
b) Yes, a signed checklist is used for hazardous materials before they are allowed to enter gate

4) What do these inspections entail?
   a) Hazardous Goods
      i) Check permits for Dangerous Goods
      ii) Check Tank
      iii) Check Trailer
      iv) Dangerous goods placards
      v) Fire extinguisher in tractor/trailer
      vi) Chocks (tires)
      vii) Correct Label/Product Number
      viii) Platform on top of truck
      ix) Driver Participated in Dangerous Goods training
      x) Personal protective equipment
      xi) Driver signature
      xii) Signature of personnel who administered inspection

5) Do you reward safe driving? If so, how?
   a) No, responsibility of carrier

6) What type of certification do you require the drivers to have?
   a) Contracted with Carrier B
   b) Dedicated drivers for Plant D
   c) New drivers for Carrier B must go through training program and shadow an experienced truck driver for four to five days

7) Do you have driver training sessions and driver safety awareness training?
   a) Driver training for new drivers
      i) Carrier B trains new drivers

ii) New driver is sent out with an experienced driver for approximately a week

b) Mandatory driver training sessions held

i) Carrier comes to Plant D

(1) Most drivers live nearby to site, easier to attend

ii) Review of driver safety behavior

iii) Train in small classes 15-25 drivers

8) **Have you implemented any new truck driver safety procedures in the past 2 years?**

a) Driver training sessions in response to accidents

b) New truck drivers go out with the Company drivers

9) **If you could improve upon any current inspection or add new items to your safety protocol, what would you improve or add?**

a) Response to an accident

i) Analyze cause of accident

ii) Develop procedures to address cause

iii) Implement procedures

<u>Key Points from Interview with the Logistics Manager</u>

1) **What is your protocol for interacting with the truck drivers?**

a) Almost no interaction with truck drivers

i) Nearly all trucks are preloaded

ii) Drivers come on site, hitch up to tanker, and leave

2) **Do you exchange paperwork with the truck driver at the loading station?**

a) No paperwork exchange is done

i) Logistics Center prints out necessary paperwork

ii) Paperwork is attached to loaded tank in lot

3) **If so, what do you exchange?**
    a) There is no paperwork exchange with the driver, only the necessary paperwork is sent with the truck.

4) **When and where do you perform safety inspections on trucks in the loading station?**
    a) Safety inspections are not performed on trucks in the loading station

5) **What do these inspections entail?**
    a) Safety inspections are not performed on trucks in the loading station

6) **If you could improve upon any current inspections or add new items to your safety protocol, what would you improve or add?**
    a) No suggestions

<u>Key Points from Interview with Entry/Exit Gate Manager</u>

1) **What is your protocol for interacting with the truck drivers?**
    a) Non-Carrier B Drivers
        i) Exchange of Paper
            (1) At Front Gate
                (a) Check documentation
                (b) Issue visitor's security badge for entry to site
                (c) Ensure return of security badge
            (2) At Logistics Center
                (a) The weight certification
                (b) The inventory sheet
                (c) The load list
                (d) Certificate of cleaning (if applicable)
    b) Carrier B Drivers

i) Have security badge allowing entry to site 24/7

ii) Tankers are pre-loaded and left in on-site lot for pick up.

2) What exchange of paperwork do yourequire prior to entry?

a) Shipment order for the Company

3) What exchange of paperwork do you require prior to exit?

a) Return of security badge

4) When and where do you perform safety inspections on inbound trucks?

a) Safety inspections are not performed on the product trucks

b) Hazardous materials inspections performed before truck enters the gate

5) What do these inbound truck inspections entail?

a) Hazardous materials

i) Check driver's license and hazardous materials license

ii) Driver's license and hazardous materials certification is checked

iii) Check List

iv) Vehicle must pass all items on check list to enter site

v) Some items on list include

(1) Protective equipment

(2) Safety equipment for transport

(3) Fire extinguishers

6) When and where do you perform safety inspection on outbound trucks?

a) Safety inspections are not performed on outbound trucks

7) What do these outbound truck inspections entail?

a) Safety inspections are not performed on outbound trucks

8) **If you improve upon any current inspections or add new items to your safety protocol, what would you improve or add?**
   a) No comments made

## Observations at the Entry/Exit Gate

Access to the site was controlled at an entry/exit gate. Upon a truck's arrival, the security guard asked for identification, and in the case of a non-Carrier B truck driver, a shipping order or other documentation. After the documentation was checked, the truck driver was issued a visitor badge which allowed them temporary access to the site. After the driver was finished with loading, the badge was returned and they were allowed to exit.

In the case of a dedicated Carrier B driver, the driver had already been issued a security badge, which gives them access to the site. They simply swiped their badge and entered through the door and turnstile into the site. From here they could open the gate for themselves so that they could drive their trailer through. The badge recorded the date, time, and duration of the visit, so that management knew when the driver had picked up a load.

## Observations at the Loading Station

There were three bays in the loading station where a tanker could be filled with the product. All were equipped with scales so that weight could be measured before and after loading. The weight prior to loading and after loading, as well as the net loading weight, was printed on a weight slip inside the loading station. The invoice was also printed here, and it was attached to the weight slip and the certification of cleaning. In the case of live loading, these documents were given to the truck driver. In the case of non-live loading, they were placed on the tanker so that the driver had access to the documents when s/he picked up the tanker.

During our time at the plant we observed three live loads that were scheduled for the day, two of which were for the primary carrier, Carrier B. The Carrier B trucks observed were not subjected to any type of pre- or post-load inspection. The non-Carrier B truck however, was subjected to an inspection of the back valve to ensure it was up to the loading standard.

## Observations of Other Product Loading

When the truck first entered the site, it was inspected to ensure that the inside of the bulk container was clean. After the inspection, the logistics personnel cross-checked the order the driver presented with the order in the system to ensure that they matched. After this, the truck was weighed, and the tare weight was printed on the order sheet. The truck and the logistics personnel then proceeded to the loading station.

At the loading station, the truck was partially loaded with the product. The amount of product loaded was determined using by an estimation system; the logistics personnel timed the loading and used the approximate flow rate of the product to determine the amount loaded in that amount of time. After the partial loading, the truck was brought back to the weigh station to determine the mass of the load. The load was slightly lower than the order requested, so the truck was brought back to the loading station to be filled with more of the product. After this final loading, the truck went back to the weigh station so the logistics personnel could determine the final weight of the load. The final load list was exchanged, and the driver left the site.

*Case Study 5: Plant E*

Visited on November 11th-12th, 2002

## Introduction

The first day of our visit, we interviewed the sales manager, the site/production leader, and the logistics manager. We also observed two trucks being loaded. The second day, we conducted follow-up interviews with our three contact people and observed two trucks being loaded, one of which was a new driver being trained by an experienced driver. Of the four trucks we observed, we saw two trucks undergo the entire process of entry, loading, and exit.

## Key Points from Interview with the Site/Production Leader and the Sales Manager

1) **How are most of your products shipped (tankers, trailers, intermodal, etc.)?**
   a) Most of the product shipped by tank trucks

2) **Do you do live or non-live loading?**
   a) All live loading
   b) Driver loads truck, not Company personnel

3) **Do you perform safety inspections on inbound and outbound trucks? If yes to either, when and where do you perform these safety inspections?**
   a) No safety inspections are performed
   b) Inspections are the job of the carriers; Carrier C is SQAS certified
   c) Company performs one random inspection a week to check that the tank of the truck is clean

4) **Do you reward safe driving? If so, how?**
   a) No rewards for safe driving

b) Cash rewards for safe behavior at the Company site, such as reporting leaks or other problems

**5) What type of certification do you require the drivers to have?**

a) Carrier's responsibility to make sure drivers have the necessary licenses
b) Drivers must be certified to load before they are allowed to load at the Plant E site
c) Carrier C takes care of training drivers for loading
   i) Done by hands-on learning with experienced loader/drivers
   ii) Carrier C notifies the Company that a new driver is certified
   iii) Driver's name is added to list kept in the control room at the Company site of drivers that are allowed to load
   iv) If a driver comes whose name is not on the list, that driver is not allowed to load
d) When a driver comes to the plant for the first time, the Company personnel go through Safety Handbook for Contractors with the driver, so s/he is aware of the rules that must be followed at the plant

**6) Do you have driver training sessions and driver safety awareness training?**

a) They do training one to three times a year. These trainings generally focus on how to do loading and safety. Only once has Plant E received the "Company philosophy" on what these trainings should entail. The main interest of the Company is the drivers' behavior at the Company site and at the customer. Carrier C sends drivers in groups of ten to thirty to attend the training sessions at Plant E. Carrier C also does a separate training focused on driving safety

**7) Have you implemented any new truck driver safety procedures in the past 2 years?**

a) No new procedures have been implemented
b) Modifications due to updated equipment have been made

**8) If you could improve upon any current inspections or add new items to your**

**safety protocol, what would you improve or add?**

a) Sales Manager
    i) Would be good to have more training sessions and follow-ups on drivers' behavior at the customer
b) Site/production Leader
    i) Operations at the plant are good how they are
    ii) Interested in any recommendations we would make

<u>Key Points from Follow-up Discussion with the Sales Manager</u>

1) **Have there been any truck accidents where the truck originated from your plant or occurred on site? If so what was the situation?**
    a) Accident about a year ago with a truck going from Plant E to another country
        i) Truck was driving in a roundabout and rolled over
        ii) Driver was going too fast for the curve
        iii) Maximum weight allowed on roads in the destination country is about 40,000 kilos
        iv) Maximum weight allowed in Plant E's country is 60,000 kilos

2) **If an incident did occur on the road, what are the guidelines you follow to remedy the incident?**
    a) Driver contacts his/her supervisor
    b) Supervisor may or may not contact the Company, depending on the severity of the accident and if any Company product was damaged
    c) Supervisor contacts sales manager
    d) sales manager reports the accident to the people in charge of supply chain issues
    e) Safety area at the Company obtains a root cause analysis from the carrier and gives recommendations to the plant about anything that could be improved
    f) Emergency contact number for dangerous goods

3) **Why do you feel most trucking accidents happen in the transport industry?**

a) Quoted the Company number that about eighty percent of accidents are related to the behavior of the driver
    i) Probably around 75 percent of drivers wear their seatbelts
    ii) Fatigue not a major factor because law says that drivers must rest for eight hours after driving a maximum of ten hours
        (1) For long trips, Carrier C often uses multiple drivers, so they can switch off driving and get more rest
    iii) Speeding not a problem
        (1) Carrier C's trucks have devices that do not allow the trucks to go over 80 or 85 km/hr
        (2) Only possible problem related to speeding would be that the trucks may be too nice and comfortable of a ride, so drivers do not realize how fast they are going when coming to stop signs/lights
b) Drivers may not be as of as high a quality as they used to be
    i) Carrier C has been growing quite a bit, so the owners are no longer able to personally interview all new drivers
c) Differences in driving in different countries in Europe
    i) In Plant E's country, there is not much traffic, but in other countries, roads can become quite congested
    ii) Difference in driving culture between Eastern and Western Europe
        (1) In Russia, people tend to drive down the middle of the road because the roads tend to be quite poorly kept up
        (2) Drunk driving in Russia is extremely prevalent

**4) The Company expects their carriers to perform safety inspections and employee safe drivers, however, if an incident occurs on the road the Company is in the spotlight. Where do you feel the Company's responsibilities are in ensuring their product is being transported safely?**

a) The Company's responsibility extends from the loading station until the product is unloaded at the customer
b) Driver usually unloads the product at the customer, instead of the customer's

employees doing the unloading

c) As far as the insurance companies are concerned, the Company's responsibility continues all the way until the product is used in the paper mill, for example

**5) With this end-to-end responsibility in mind, do you think the Company should double-check that the carrier is performing the expected inspections?**

a) The Company should not perform safety checks
   i) The Company does not have the technical knowledge to do such inspections
b) The Company could do more training for their side of the procedures

**6) If the Company owned and operated a carrier do you think that would improve driver performance as well as increase safety while on the road? What would you be able to control that you cannot control now?**

a) Things would probably improve a little bit
b) Improvements would only happen if the Company followed the same procedures for building or buying their trucks as they do for building plants
   i) No concern about cost. He believes that trying to decrease costs is part of the problem with safety
c) The Company has been trying to drive down transportation costs
   i) Partly for this reason, Carrier C has started hiring more drivers from other countries, who may not be as good as drivers native to Carrier C's country, but will drive for lower pay
d) Would be a good idea if the Company paid the carriers more or gave them bonuses to improve safety

**7) Have you ever had a driver slip while loading or unloading a tanker due to ice or snow on top of the trailer?**

a) Never had this type of accident at the Plant E site or with trucks from the Plant E site
b) Does happen one to two times each year at customer sites
c) Loading site at Plant E is best in the country it is located in

d) Accidents from slipping on ice on top of the truck mainly occur during cleaning
e) Ideas of how this risk could be reduced
    i) Could be some mechanism that would enable drivers to clean the tank from the ground, instead of needing to climb on top of the truck.
    ii) If drivers did not need to clean the tanks as often.
        (1) Sometimes carriers have "dedicated trucks"
            (a) Always carry the same product
            (b) Do not need to be cleaned between every load
            (c) To drive down costs, carriers are reducing the number of dedicated trucks, so they can always keep the trucks full

**Additional Information**

The Company has written some unloading procedures for drivers when they are at the customer sites. He also mentioned that Carrier C has about 100 trucks that have laptops connected to cell phones through which the drivers can request and receive information, such as reminders about loading or unloading instructions and special rules.

<u>Key Points from Interview with the Logistics Manager</u>

*Questions relating to entry and exit*

**1) What is your protocol for interacting with the truck drivers?**
a) Driver calls into site to gain entrance
    i) Calls the receptionist during normal business hours
    ii) Calls control center during non-business hours

**2) What exchange of paperwork do you require prior to entry?**
a) Driver gets pick-list from the control center

**3) What exchange of paperwork do you require prior to exit?**

a) Paperwork turned in to basket in drivers' office at entry gate
    i) Pick-list
    ii) Certificate of Analysis
    iii) Driver statement

**4) When and where do you perform safety inspections on inbound trucks?**

a) No inspections are done regularly
b) Random inspections once a week

**5) What do these inbound truck inspections entail?**

a) Check cleanliness of the truck
b) 360-walkaround inspection to check for any obvious problems

**6) When and where do you perform safety inspections on outbound trucks?**

a) No inspections are performed

**7) If you could improve upon any current inspections or add new items to your safety protocol, what would you improve or add?**

a) Add outbound checks to look at the tires and other equipment to make sure it is in good condition

*Questions relating to the loading station*

**8) What is your protocol for interacting with the truck drivers?**

a) No need for protocol for interaction with the drivers at the loading station
b) Correct storage tank is selected by the Company personnel in the control room
c) Driver does rest of loading procedures on his/her own

**9) Do you exchange paperwork with the truck driver at the loading station?**

a) Paperwork is not exchanged with the driver
b) Driver fills out paperwork

**10) If so, what do you exchange?**

a) Driver fills out the driver statement
    i) Verifies the truck was clean before loading

**11) When and where do you perform safety inspections on trucks in the loading station?**

a) No inspections are performed

**12) If you could improve upon any current inspections or add new items to your safety protocol, what would you improve or add?**

a) Add safety inspections at the loading station after loading to make sure the hatch is securely fastened and check other mechanical, safety-related parts

<u>Observations at the Entry Gate</u>

When a driver entered the site, s/he first weighed the truck. The driver then went into the main building with the shipment number. The driver obtained the pick-list and showed it to the technician in the control room. From the information on the pick-list, the technician selected the storage tank from which to load and told the drivers which loading arm to use. Then the driver went to the loading station.

<u>Observations at the Loading Station</u>

At the loading station, the driver first selected the loading arm and drove the truck into place beneath it. The loading arms could not move much, so the driver had to be quite accurate in his/her placement of the truck. The driver turned on a light above the loading arm, put the high-level switch in the tank, positioned the loading arm, and began loading. After s/he began loading, the driver went up to a desk in the loading area to fill out some paperwork. S/he entered information such as the truck number, storage tank ID, and loading arm number into a computerized shipment entry form. S/he also filled out the

driver statement, in which the drivers entered the facts about the truck such as the carrier, truck's license plate number, and what product the truck last carried. The driver then signed the form, stating that the truck was properly cleaned before loading began.

The loading area and drivers' lounge were heated, which is good since drivers were not allowed to wait in the main building during the loading process. The loading area contained instructional signs telling drivers to close the load area doors and the correct way to take the product samples. When the driver was loading multiple compartments in his/her truck, the sample was taken after one tank had been completely loaded. For example, one truck we observed had three compartments being loaded, and the sample was taken after the second compartment was loaded. After taking the sample, the driver cleaned the cup and bucket used for obtaining the sample by spraying them out with water. The drivers did not wear protective gloves while taking the sample. Each sample that was taken was stored at the plant for about six months.

While waiting for the truck to be loaded, the driver either waited by the truck or in the drivers' lounge. This lounge contained a table, six chairs, a coffee maker, refrigerator, and microwave. There was also a tiny room with two chairs where drivers were allowed to smoke. The smoking room and the lounge had no windows looking outside or towards the loading area. In the room, it was impossible to know the status of the truck's loading progress.

After the tank was loaded, the driver raised the loading arm. S/he sprayed down the loading arm and top of the manhole and hatch with water. The driver then closed and sealed the hatch and drove to the scale.

## Observations at the Exit Gate

When the driver was done loading, s/he weighed the truck again. The driver then took the Certificate of Analysis, pick-list, and driver statement to the control center, where the technician compared the documents to make sure the product was in specification and

that there were no discrepancies. Next, the driver went to the drivers' office in the main building where s/he entered information from the pick-list, such as identification numbers and the delivery quantity, into the computer database system and printed out the delivery note. This delivery note contained information about the product, such as the grade and the amount loaded in the truck and was sent with the driver to be given to the customer. Then the driver turned in the Certificate of Analysis, the pick-list, and the driver statement to boxes in the office area.

At the exit gate, the sample taken from the tank was not tested for quality. Plant E takes samples from their storage tanks periodically to make sure it is up to their standards. This seems to expedite the loading process because the driver does not have to wait for test results.

*Case Study 6: Plant F*

Visited on November 12th-13th, 2002

## Introduction

Truck traffic for the site was directed by the truck control center. During weekdays, the plant scheduled loading slots from 07:00 to 23:00. The driver signed up for a loading time slot the day prior to the scheduled loading; however, due to the nature of the traffic patterns in the country, drivers did not always show up for loading at the scheduled time.

## Key Points from Interview with the Plant Manager

1) **What is the percentage breakdown for how your products are shipped (tankers, trailers, intermodal)?**
   a) 4% boat
   b) 4% railcars
   c) 92% truck

2) **Do you do live or non-live loading?**
   a) Both live and non-live loading

3) **Do you perform safety inspections on inbound and outbound trucks? If yes to either, when and where do youperform these safety inspections?**
   a) At front gate
      i) Check documentation
      ii) Check safety gear
   b) Loading Station
      i) Check valves
      ii) Check cleanliness of tank
   c) No outbound inspections, drivers are free to go

d) See site logistics for more detailed information

4) What do these inspections entail?
   a) Inspections done at entry, see site logistics for more detailed information
   b) Tires
   c) Valves
   d) Empty truck
   e) Clean
   f) Leaks
   g) Odorless
   h) Send back two to three trucks per year for re-cleaning

5) Do you reward safe driving? If so, how?
   a) Verbal rewards- "good job" "excellent," etc.
   b) Sometimes monetary award, no specifics given

6) What type of certification do you require the drivers to have?
   a) Contracted with carriers- Carrier D
   b) Require drivers to have certification based on national law
      i) Commercial
      ii) Hazardous
      iii) Non-hazardous

7) Do youhave driver training sessions and driver safety awareness training?
   a) "Safety Awareness Week" (one time event)
      i) Exhibition on driver safety outside of the gates
      ii) Give feedback to companies, but not a method of driver training

8) Have you implemented any new truck driver safety procedures in the past 2 years?
   a) Trucker's day exhibition

b) Continuous checks for proper safety equipment
    i) Difficult with drivers who do not share a common language
    ii) Language barrier
    iii) Non-uniform standards throughout all plants in the Plant F site
c) New loading center; will be much more safe and new protocol will be developed as of January

**9) If you could improve upon any current inspection or add new items to your safety protocol, what would you improve or add?**

a) Try to make safety protocol/equipment consistent throughout Plant F site
b) Insufficient fall protection on the types of trucks loaded; will be addressed with the new loading station
c) Compliance to all procedures, especially PPE must be continually monitored
d) The Company must continue to push the carriers to stress safety issues among drivers

<u>Key Points from Interview with the Logistics Manager</u>

**1) What is your protocol for interacting with the truck drivers?**

a) Truck arrives at gate
b) Completes inspection form to prevent safety incidents and spills
    i) Cleanliness
        (1) Check residue
        (2) Check cleaning certificate
    ii) Valves
        (1) If unfamiliar driver, will physically check valves
        (2) If familiar driver, will ask if valves were checked
        (3) Driver may open and/or close manhole
    iii) PPE Requirements
c) Driver waits during loads
    i) Drivers' lounge nearby where driver can sit

ii) Driver is paged on the intercom when the loading is finished

iii) If the staff are busy, the driver may need to help with loading

d) Depends on familiarity/language of driver

i) Driver may close the truck

ii) Driver may otherwise assist with loading

2) **Do you exchange paperwork with the truck driver at the loading station?**

(1) Yes

3) **If so, what do you exchange?**

a) "Pick list"

i) Date/time of loading

ii) Reference number

iii) Linked to inventory management system

iv) Indicates special regulations if a product is classified

v) Signifies approval to carry the Company goods

b) Certification of analysis

4) **When and where do you perform safety inspections on trucks in the loading station?**

a) Random checks

i) "Fit for loading"

ii) ADR (hazardous goods) certificates

b) Spot checks- if truck is not clean will send back to be cleaned properly

5) **What do these inspections entail?**

a) Checklists

6) **Have you implemented any new truck driver safety procedures in the past 2 years?**

a) Updates to checklist to address legal requirements

b) Reclassification of materials

7) **Do you have driver training sessions and driver safety awareness training?**
   a) Safety Awareness Week
      i) Developed with driver in mind
      ii) Demonstration of safe storage
         (1) emergency/rapid braking with load
         (2) showed how load moved in response to emergency braking

8) **If you could improve upon any current inspections or add new items to your safety protocol, what would you improve or add?**
   a) Driver comes fully equipped to loading station; nine times out of ten driver behavior needs to be corrected
   b) Consistent application of the on-spot checklist procedure
      i) Reminds one to check all items
      ii) Keep procedures up to date
      iii) Make the checklist a required form of written documentation

<u>Key Points from Interview with Entry/Exit Personnel</u>

1) **What is your protocol for interacting with the truck drivers?**
   a) Complete check-in list
   b) Obtain shipment number
   c) Perform random inspection checklist (approx 40% of trucks)
      i) Exterior check performed
      ii) Results tracked and reported by carrier

2) **What exchange of paperwork do you require prior to entry?**
   a) Pick List
   b) Check-In List

3) **What exchange of paperwork do you require prior to exit?**
   a) None

4) **When and where do you perform safety inspections on inbound trucks?**
   a) Outside the gate to the plant
   b) Before trucks are allowed to enter the site
   c) Trucks cannot enter site unless the checklist is complete

5) **What do these inbound truck inspections entail?**
   i) Non-Hazardous
      (1) Driver appears to be okay to drive
         (a) no drugs
         (b) no alcohol
         (c) fatigue
      (2) Tires are in good condition
      (3) The lighting is functional
      (4) The screens are complete
      (5) The hoses are well fastened
      (6) The outside is clean, no spilled product
      (7) Handrail is present (on trailer models made after 1995)
   ii) Hazardous (Non-hazardous inspection as well as):
      (1) ADR Certificate, Driver
      (2) ADR Certificate, Truck and Trailer
      (3) Tank container is valid, approved for use
      (4) Personal Protective Equipment (PPE)
      (5) Eyewash bottle with water
      (6) Reflective Safety Vest
      (7) Wheel blocks
      (8) Two self-standing warning signals
      (9) Headlamp
      (10) Fire extinguisher

(11) Special Intervention Equipment, if necessary (for more hazardous materials)

6) **When and where do you perform safety inspections on outbound trucks?**
   a) Safety inspections are not performed on outbound trucks

7) **What do these outbound truck inspections entail?**
   a) Safety inspections are not performed on outbound trucks

8) **If you improve upon any current inspections or add new items to your safety protocol, what would you improve or add?**
   a) Controls performed 100% of the time (presents a difficult problem due to busy times at check-in gate)
   b) If necessary, controls performed inside plant by technicians

## Key Points from Discussions with European Logistics Manager/EHS and the Safety Manager

### Incident Analysis/Investigation Techniques In Use

The incident analysis and investigation technique that was currently in place at the Company is primarily a root cause investigation system. This method was used for accidents that are classified either as "serious" or "moderate," on a case-by case basis. "Acts of God" did not undergo analysis. The root causes of the accident were identified through an extensive analysis system.

### Transportation Safety in the Chemical Industry

The Safety and Quality Assessment System (SQAS) was implemented in 1994 to measure the performance of carriers. The Company found that the implementation of SQAS decreased the number of incidents globally. However, the Company found an

increase in accidents is 1998. They were uncertain exactly why the increase occurred, but they noted that this increase was observed globally.

## Taking an Industry Approach to the Safety Problem

The Company would like to take an industry approach to addressing the safety problem. In the first quarter of 2003, they anticipate working with other chemical companies such as Cefic, Exxon, Bp, DuPont, and also the European Chemical and Transport Industry to take measures to improve safety in chemical transport. These organizations would like to include the European Transport Association (URI); however, it has been difficult to get them involved.

The focus of this industry-wide approach is to reduce the number of incidents, fuel consumption, maintenance cost and insurance premiums. The Company anticipates accomplishing this by establishing European standards for a defensive driving program. Defensive driving programs teach drivers how to be have appropriately on the road. However, the quality of these programs vary, as the program depends on the driving instructor, whether or not the instructor possesses good driving skills, is able to teach, is credible, and if the drivers are able to accept what the instructor is telling them.

## Defensive Driving Programs

These programs are typically a one-day training session, which are repeated periodically. During the program, the driver goes on the road with the driving coach and the coach identifies and corrects the mistakes the driver is making. Within 10 minutes, a typical driver has already made four to seven mistakes. The Company surveyed their carriers to determine who was implementing these programs, and they found that only 24% of their carriers were fully implementing defensive driving programs.

The Company would like to see a behavior based safety program based on defensive driving courses, and would like to structure this same program throughout Europe for use

in the chemical industry. They would like to establish a standard mean of reporting as well as determine benchmarks by carrier.

The program is an investment for the carrier; typically the programs cost $500-1000 per driver. The European commission has a budget to sponsor these types of programs, and individual countries may provide funding. The price may be reduced to around $200-300 per driver with this funding. Although the program may be expensive to implement, there is an immediate return on this investment. The carrier will have more skilled drivers and fuel consumption will be reduced.

### Accidents during loading/unloading

An element of safety which the Company feels important, but is not addressed by the Company specifically is accidents during unloading and discharging at the customer's end. There are a significant number of incidents that occur on that end. It is difficult to address this problem because three levels of interaction are present: the driver's needs vs. the customer's needs, the Company's needs versus the customer's needs, and the Company's needs versus the driver's needs.

If a driver training program was implemented, it might improve the interaction between the driver and the customer. The Company and the customer have a sensitive relationship; as a result, the behavior based safety program to remedy this situation must be addressed with the customer's needs in mind. This presents difficulties, as the Company's many customers each have different needs that must be addressed by one program. There are also difficulties in defining the duties that both the driver and customer are responsible for doing, as currently, the level of interaction between the driver and customer varies from site to site. The Company also feels it is necessary to define who takes the responsibility for the incidents that occur.

### Trucker Safety Day

The Company partnered with carriers and supply and equipment companies to create a "Trucker Safety Day" in order to communicate with the drivers on a personal level. "Trucker Safety Day" consisted of a pavilion with stands from several companies: supply and equipment, securement, the Company, and carriers.

This event occurred in September of 2001 at Plant F. Drivers were invited to attend while their trucks were loading. The Company's aim in creating this day was to change the behavior of drivers through positive influence and to stress to the driver that their job was indeed an important one. They tried to inform and involve the driver about safety in the displays and exhibits. The average driver spent about twenty to thirty minutes in the tent, and it was estimated that 500-100 drivers attended this event. A questionnaire was distributed for the drivers to fill out at the event. The benefits cannot be tangibly measured, but the safety day programs obviously improved the drivers' awareness of safety.

## Communication

### The Company and Driver

The Company and the driver have both direct and indirect contact at the sites. Direct contact between the Company and the driver occurs during checks of personal protective equipment and hazardous materials checks or random inspections. Indirect contact occurs through the signs posted as well as the photographs of accidents at the check-in window.

### The Company and Carrier

Each year, a questionnaire is sent to the carriers evaluating safety measures. The Company has previously emphasized safety belts and also encouraged the carriers to set Incident Targets and methods to measure their targets. The Company addresses the management of the contracted carriers with these questionnaires.

The Company believes that the management must see the importance of safety measures, and that the carriers are responsible for the drivers.

### The Company and the Company Sites

Communication between the Company Headquarters and the Company sites occurs during modal team meetings. The supply chain managers from each site attend. During this meeting, safety is always the number one issue on the agenda. In relation to safety, they typically highlight significant accidents, the steps to prevent accidents from occurring, and the goals that must be set to improve safety at the Company. At each site, logistics is responsible for the direct exchange of information within their site. These meetings, whether formal or informal, are not organized by the Company Headquarters.

## Carrier Contracts

Standards for carrier contracts are set by the Company's European Headquarters. There are equipment specifications for bulk, dry and packaged products. All of the contracts require the carrier to present a truck that is "fit for loading." They also require the carriers to be assessed by the SQAS system. In the site-specific contracts, the price for transport is negotiated. The contracts typically last three years, but volumes are never guaranteed. This means that a site can penalize a carrier by taking away business; however, this is more the exception than the rule.

## Observations at the Entry/Exit Gate

When a truck first entered the site, the driver filled out a "Check-In List," which included the Company reference number, the product name, the driver name, the container number, the truck number, the nationality of the driver, and the transport company the driver is working for. The driver had to sign a form stating that his truck, tank, and personal licenses were all up to date. The rules of the site were also on this form.

Random inspections are performed on trucks before they enter the gate. These inspections, comprised of a paper checklist with specific guidelines, were performed when staff is available, during the hours 08:30 to 16:30.

We observed a random inspection of a truck that was parked outside the site. The check included all the items on the random inspection check list. A visual check was performed to see if the driver was fit to drive. The tires were visually checked for any deformities. The lights on the front and rear of the truck were tested for functionality. A 360 degree check was done to see if the truck was clean and free of any leaks or cracks. This information was recorded into a database, which is analyzed by the carrier.

We observed a second random inspection, which was a truck to be loaded with dangerous goods. This inspection covered all the points in the dangerous goods random inspection protocol. During this inspection, it was noted that one of the fire extinguishers was not sealed, and therefore, the truck was not allowed to enter the site. The driver was told that he could not enter the site until he fixed the problem with the fire extinguisher.

## Observations at the Loading Station

The loading station at Plant F is comprised of two terminals. These terminals are completely enclosed inside a building, and rectangular slots allow the Company technician access to the top of the tanker. There is a viewing window made of plexiglass and a bright spotlight shines above the opening, which allows the technician to observe the loading while s/he is testing the product or entering information in the computer.

This filling station fills approximately 32 trucks a day, 40 percent of which are non-live loading. The filling apparatus can only move up and down. The truck must be parked underneath the loading station in perfect alignment with the apparatus, so that the apparatus can be lowered into the tank. Trucks are loaded according to what time slot the driver chose the day before, but trucks are often late for their time slots. During our

observations, one truck arrived nearly eight hours early, and the technicians told the driver that he would have to wait until there was a time slot open for him.

After a truck parked underneath the loading station, the driver walked up the stairs to the loading station and opened the hatch for the Company personnel. The Company then loaded the truck, and during this loading time, the truck driver went to the driver's lounge, which contains a coffee machine, as well as an area to smoke cigarettes.

There were three systems that prevented the truck from overloading. The first was the high-level shut-off apparatus observed at all the Company plants thus far. The second was the computer automatically shutting off the flow of the product once the correct volume had been added. The third and final safety shut-off was a shut-off point that was entered into the computer according to the height of the tank. Before inserting the filling apparatus fully, the technician stopped the apparatus just below the top of the tank, where a sensor indicated to the computer to shut off the system when the product reached that level. The probe was then fully inserted into the tank, and as it filled, it rose in small increments.

After the truck was loaded, the Company loading station employee called the driver via intercom from the truckers' lounge. The driver then came to the loading station to seal the top of the truck. The driver first placed a plastic cover over the manhole, so that no film would be deposited on the inside surface of the manhole cover. The driver then closed the hatch and tightened all the butterfly nuts. With the current loading station, the process was very difficult because there was very little room above the truck to close the hatch. During one of the observed loads, the driver had to use a reaching rod in order to screw the butterfly nuts atop his truck. After the manhole had been closed and sealed, the truck driver weighed in again at the weigh station. The driver then returned to the loading station to exchange paperwork with the loading technicians, which included a pick list, weight ticket, and analysis of the product. After the documentation was completed, the driver was free to go.

The non-live loadings we observed were entirely done by the Company personnel. When the loading bay was ready for a truck to come in, the Company technician radioed the person responsible for bringing trailers to the loading station. This person then backed the trailer into the loading station and the technician at the loading station began to load the truck. The Company technician performed the entire loading process, which included opening and closing the manhole on the truck. During the waiting time, the technician tested the product samples and also completed paperwork on the computer.

When the load was finished, s/he closed the manhole and secured the bolts. A difference we noted between non-live and live loading was that no plastic cover was placed over the manhole on the truck after non-live loading. When the loading was finished, the technician radioed the person responsible for picking up the trailer, and s/he picked up the trailer and brought in a new one.

*Case Study 7: Carrier A*

Visited on October 15, 2002

## Introduction

Carrier A was not only the operations center for this area, but the terminal we visited also included an on-site cleaning facility for the tankers.

The day's agenda was as follows:

- Demonstration of load and driver assignment
- Tour of operation
- Demonstration of cleaning process
- Qualcomm introduction
- Driver log analysis
- Post-delivery inspection

## Key Points from Interview with the Terminal Manager

1) **Do you reward driver safety; if so what programs have you implemented?**
   a) Drivers with incident free years are rewarded with:
      i) Carrier A National Awards
         (1) Gold Award
         (2) Silver Award
         (3) Bronze Award
      ii) Hats
      iii) Shirts

2) **How do you promote driver safety at the workplace and on the road?**
   a) One safety meeting a month for drivers
      i) Each driver must attend at least six meetings a year

3) What criteria do youconsider when you assign loads to drivers?
   a) Driver eligibility
      i) Number of hours of rest
      ii) Number of hours worked
   b) Seniority

4) How do you monitor how many hours a truck driver has worked in a given week?
   a) Driver Logs

5) What are you protocols for the following?
   a) Driver Check-in
      i) Driver must do inspection of truck
         (1) Checklist included in daily driver's log
   b) Driver Check-out
      i) Driver must do inspection of truck
         (1) Checklist included in daily driver's log
      ii) Fill out repair report if any problems are noted
   c) Cleaning the Tanker
      i) Driver returns tanker to be cleaned
      ii) Carrier A uses cleaning facility to clean tanker
         (1) High pressure sprinkler head is inserted in tanker to clean
         (2) Process takes about two hours
         (3) After cleaning, a vacuum test is done on the back valves of tanker.

6) How do you track your driver's route/progress?
   a) Qualcomm system tracks driver's progress via computer.
   b) Drivers also enter "macros" into the system to identify when they have completed certain tasks:
      (1) Finished loading

(2) Arrived at customer

(3) Finished Unloading

7) **How do you plan the assigned routes?**

a) Up to the driver to decide his route

8) **If you could improve on the way you currently communicate with your drivers en route, what would you improve?**

a) More use of the Qualcomm system

i) Currently 92 percent of drivers use the "macros"

(1) Goal is to improve to 100 percent usage

b) Use more of the features of the Qualcomm system

i) Track driver's hours

ii) Audit driver's logs for cheating

9) **How do you ensure a truck is fit for loading? Do you provide any certification/paper documenting that that the truck is fit for loading?**

a) Properly filled out Bill of Laden

i) Driver initials certifying the tanker is fit for loading

<u>Key Discussion Topics Following Interview with Terminal Manager</u>

Qualcomm System

The Qualcomm system is a cell phone system that can easily send text messages from the truck to the base of operations, and monitor the speed and location of the truck. The Qualcomm System allows for "macros" to be sent to the carrier. These "macros" are numbers that symbolize specified tasks that are completed by the driver. The Carrier A division we visited currently uses the system to identify the location and status of the truck while out on the road. They have tried to use the data from the Qualcomm system in conjunction with a computer software program to "flag" instances that indicate a

violation on the part of the driver, such as driving too many consecutive hours without a break. Due to software limitations this has not worked correctly for Carrier A.

The integration of the Qualcomm System into the driver's daily routine allows the carrier to have a much better idea of what the driver is doing and where s/he is going. Carrier A is currently using the Qualcomm System to track the whereabouts of a truck, and record the number of hours a truck is on the road. Carrier A is trying to educate their drivers to use "macros" to signal the completion of required safety procedures. Currently 92% of Carrier A's drivers are using the "macros" to signal their arrival at the consignee ("5"), unloading ("1") and leaving the customer ("6").

### Auditing of Driver's logs

Prior to the Qualcomm System the drivers logbooks were used to provide the number of hours the driver worked and the logbooks were audited for illegal driving violations. Now, with the Qualcomm System slowly being implemented Carrier A tried to have both the number of logged hours and driving violations be computed automatically by J. J. Keller, a company that specializes in safety and regulatory compliance solutions. However, the software that J. J. Keller used would "flag" driving violations that were not actually violations, so Carrier A had to go back to auditing the driver logbooks by hand for driving violations. Currently the numbers of hours a driver worked are taken from the Qualcomm System and not the manual driver's log the driver produces. While, the driving violations are coming from the manual driver log and not the automated results reported from the Qualcomm System.

## Observations

### Cleaning Facility

During the tour of operations we were able to observe the truck cleaning facilities at Carrier A. The facilities allowed for quick cleaning of the tanker trucks and hoses. This

cleaning process started at the drop off of a tanker after it was used for a previous shipment. The cleaning process took approximately two hours, and involved the use of a sprinkler head that entered the tanker, and sprayed high-pressure water in all directions. The wastewater from this cleaning process is stored, and then shipped to the Company for incorporation into the product formation process. While the tanker was being cleaned, the plant also cleaned all the hoses used for pumping the product. At the end of this process, a pressure test was done on both the internal and external valves in the back of the truck to ensure they can both hold a vacuum.

### Post-Cleaning Inspection

The inspection included a valve pressure check as mentioned before, as well as a check of all the valves and seals on top of the tanker. At this point Carrier A sealed each of the wash caps on top of the truck with wire ties, so if the tie is broken, the customer knows the quality of the product may be in jeopardy. The inspection process concluded with a check for moisture in the tanker.

In addition to the post cleaning inspection, we were given the bulleted list that each trucker must follow to inspect his/her tanker each time it is picked up or dropped off. This process put the bulk of the mechanical inspection responsibility on the trucker, rather than the cleaning employees.

*Case Study 8: Carrier B*

Visited on November 6th 2002.

## Introduction

Carrier B has shipped a certain product for Plant D for 15 years, and are considered Plant D's primary carrier for that product. The Carrier B site that we visited is the location that is responsible for billing and logistics.

## Key Points From Interview with the General Manager, and the Safety Manager

1) **Do you reward driver safety; if so what programs have you implemented?**
   a) Do not specifically implement programs for driver safety
   b) If a driver has an incident free year, the insurance return Carrier B receives is forwarded to the drivers.

2) **How do you promote driver safety at the workplace and on the road?**
   a) Annual meeting
      i) Approximately four hours in length
      ii) No more than 15 drivers per session
      iii) Topics include:
         (1) customer information
         (2) news on political/social events that have affected the trucking industry
         (3) new documents that have surfaced in the past year
         (4) problems of clients during the year
         (5) safety issues
      iv) Safety manager responsible for agenda
   b) Have sent letters to drivers informing them about accidents that have occurred and stressed the need to prevent it
   c) Letter written to drivers that discusses what goes on during the meetings

d) Will send out driver evaluation questionnaire to improve accident awareness

3) **What criteria do youconsider when you assign loads to drivers?**

a) Type of order

i) Spot traffic (rush orders)

ii) Intermodal/Tanker

iii) Dedicated customers

b) Driver location

c) Location of destination

d) Location of nearest cleaning station

e) Driver trained to operate equipment

i) Experienced drivers have priority with special materials

ii) New drivers are trained to be able to transport these materials

f) Driver eligibility (number of hours worked)

4) **How do you monitor how many hours a truck driver has worked in a given week?**

a) Required by law:

i) No more than 12 hrs./day working

(1) No more than 9 hrs./day driving

ii) No more than 90 hours/2 weeks

b) Tachometer

i) Records number of hours

(1) driving

(2) working

(3) sleeping/personal time

(4) waiting

ii) Records speed of driver at given points

iii) Can be altered; computerized system will be implemented by 2004

c) Computer system

i) Tracks driver location
ii) Tracks when ignition is on/off (resting/sleeping)
iii) Driver must send location electronically at 0900 each day

5) What are your protocols for the following
   a) Driver check-in
      i) Tank is clean
      ii) Tire Pressure
      iii) Electronic Systems
      iv) Discharging Systems
      v) Driver protocol- responsible for checking each time the driver starts out for the day
   b) Driver check-out
      i) Certification of Clean Tank placed in cab of truck
      ii) Maintenance checklist (if repairs are needed)
   c) Cleaning the tanker
      i) Contracted by outside group
      ii) Outside group provides certification
      iii) Driver signs certification

6) How do you track your driver's route/progress?
   a) Computer satellite system attached to truck
   b) Messages sent between driver and carrier
      i) Physical keyboard installed in truck
         (1) Attached to passenger's side of cab
         (2) Driver must stop the vehicle when using the system
      ii) Computer terminal allows carrier to track a driver's location at any time
   c) Mobile Phone
   d) Tachometer

7) How do you plan and assign routes?

a) Receive the orders
    i) Fax
    ii) Phone
    iii) Computer system (the Company submits orders 3 times/day)
b) Select truck
c) Select trailer
d) Determine drivers available to load/unload
e) Determine location of drivers
f) Assign drivers to route
g) Route Selection
    i) Political climate
    ii) Weather
    iii) Countries traveled-
    iv) Method of transportation
    v) Location of nearest cleaning station

8) **If you could improve upon any current ways you manage your drivers, what would you improve?**
    a) Risk assessment
        i) Example: Driver injuries
            (1) Problem: Three times in the past year drivers have slipped and fallen while exiting the cab of their truck
            (2) Solution: Placed signs in all truck reminding drivers to watch their step.

9) **If you could improve upon the way you currently communicate with your drivers en route, what would you improve?**
    a) Computer system will be implemented in 2004
        i) Card placed in truck
        ii) Eliminates reliability issues with accuracy of tachometer

10) **How do you ensure a truck is fit for loading? Do you provide any certification/paper documenting that the truck is fit for loading?**
    a) Cleaning is a subcontracted responsibility
    b) Driver signs certification

**Key Topics of Follow Up Discussion With the General Manager, and the Safety Manager**

**Inspections**

National law in the country where Carrier B is located requires one annual inspection for all tank trucks conducted by governmental personnel. Carrier B requires one additional inspection per year, which is done by their personnel.

**European Carrier Organization**

There is a European carrier organization with international ties that is comprised of carriers that have the common interest of improving the transport industry. Carrier B was added to this organization in early 2002. The carriers in the organization have worked together to inform and educate each other about issues in the industry, as well as have pooled resources to maximize the amount of empty loads between transports. The European carrier organization emphasizes quality of service in the transport industry by sharing information related to current issues affecting the industry. This information is shared in the form of written newsletters in addition to periodical email newsletters.

**Tachometer**

As part of European requirements, each Carrier B truck must be outfitted with a tachometer to log the amount of road hours for each driver. The tachometer disc is made of a carbon paper product that is scratched by a device in the speedometer to log the speed of the truck and the driving time. Because the driver is responsible for loading

each disc for each day s/he is on the road, s/he can easily change the number of hours s/he has driven or the speed s/he was traveling by scratching the disc. To prevent this, Carrier B will be implementing computer logging systems in the future. Each driver will have an identification card s/he must insert into a computer system on the truck before any trip s/he makes. This computer system will then record the speed s/he travels and the number of continuous hours s/he drives throughout his trip.

## Key Observations

### Logistics room

On the day of our visit, four people were staffed in the logistics room. They focused on three key areas of operations: spot traffic (rush orders), intermodal/road transport, and dedicated carriers transport. In the past, driver assignment, tank assignment, and truck assignment were all done on paper. Carrier B has since changed to a computer system. Most non-Company orders were faxed to Carrier B and contained the dates and the locations of the loading and delivery sites, product specifications, and special instructions. Orders from the Company were received three times during the day via the computer database system.

When an order was received, the logistics technician decided upon a method of transportation for the load, as well as which tanker and trailer to use for delivery. All the tankers and trucks operated by Carrier B have been assigned an identification number that is catalogued in the computer system. Information about the specifications of the trucks and tanks was obtained by inputting these codes into the system. This system made it possible to determine important information such as the location of a truck or tanker in a certain area, and what goods that tanker was eligible to carry. When scheduling a driver, the technician considered the truck drivers available for the trip, as well as the hours worked by the available drivers. The material transported, the weather, the distance of the trip, and the numbers of countries contained in the route were also considered. If Carrier B could not handle the demand for transport due to busy times, it

was possible to redirect orders to other local carriers; however, in this instance dedicated clients would get priority.

The driver tracking system was also entirely computerized. From the logistics room, the technician had contact with the truck driver via satellite. The technician could send and receive messages via the computer system, as well as track a driver's ground location at any given moment. This system could be used to send driver assignment orders for the next day, report mechanical problems back to Carrier B, or update the driver on weather or traffic conditions that may change the route.

### Destroyed Tractors and Tankers

In their back garage, Carrier B had two damaged truck cabs from two accidents that have happened in the past year. Though the trucks were only there for storage until they could be disposed of properly, it was stressed to the drivers that they should take time out of their schedule to take a look at the trucks to see the consequences of unsafe driving.

### Tachometer

In the truck we observed, the tachometer was located underneath the speedometer in the cab of the tractor. A key was used to insert or remove the circular recording disc. The driver would write the date and his or her name on the card and insert it beneath the speedometer. The tachometer would use a needle to record the speed of the truck while in motion. While the truck was stopped, the tachometer would record the amount of time the driver spends waiting for a load, working, or sleeping. This difference was distinguished by a dial the truck driver would turn, signifying whether he was waiting, working, or sleeping.

### Satellite/Messaging Transmitter in Truck

In approximately 70 percent of Carrier B's fleet, there are keyboards attached to the passenger side of the cab that allow the driver to communicate with the logistics center. We observed one truck outfitted with this technology. The system was located on the passenger side dashboard, with a transmitter/receiver mounted on the roof of the cab. It was designed like this so the truck driver cannot possibly use the system without pulling the truck to the side of the road and stopping. We were told it took about ten minutes for a message to be sent.

*Case Study 9: Carrier C*

Interviewed on November 12th, 2002

## Introduction

Carrier C is the carrier for both Plants C and E. Unfortunately, we were unable to visit either the headquarters or a local depot for Carrier C. We interviewed the logistics director and the QHSE director at the hotel where earlier in the day they gave a safety tutorial to their local drivers. One of our contacts from Plant E was also present during our meeting to help with translating.

## Key Points from Interview with the Logistics Director and the QHSE Director

1) **What are the working hours for drivers?**
   a) Set by European legislation
   b) Maximum driving time allowed is twelve hours, which must be followed by eight hours of rest

2) **How do you monitor how many hours a truck driver has worked in a given week?**
   a) Tachometer in truck
      i) Records the truck's speed and operating time
      ii) Tachometer is sealed in the truck
      iii) Cannot be falsified
   b) Driver writes report for each trip,
      i) States his/her time on the road
      ii) Turned in when the driver returns to the Carrier C depot
   c) Some trucks now have an electronic terminal
      i) Software to record the amount of time a driver spends on the road
      ii) Information is immediately transmitted to the truck depot

iii) System will be in all trucks by the end of this year, 2002

iv) Will eventually replace paper reports filed by drivers

**3) How are the drivers paid (by the hour, mileage, trip, etc.)?**

a) Two types of drivers

i) About thirty percent paid by the hour

ii) About seventy percent paid by mileage

b) Drivers choose which way they are paid

**4) If you could improve upon the way you currently communicate with your drivers en route, what would you improve?**

a) Complete implementation of computer system in all trucks

b) Ensure this system is functioning properly

**5) What criteria do you consider when you assign loads to drivers?**

a) All drivers have a planner who makes the load assignments.

i) Each planner is in charge of a group of about 30 to 45 drivers and approximately fifteen trucks.

ii) Since the planner is in charge of a fairly small group of people, s/he knows the drivers well

b) The planner looks at many different factors before assigning loads

i) Product to be carried

ii) Driver location,

iii) Weather as it relates to driver location and time it will take driver to reach pickup area

iv) Number of hours driver has previously worked

v) Special skills

(1) Training in loading certain materials

(2) Training in loading at sites that require special training, such as at Plant E

**6) How do you plan and assign routes?**

a) Drivers plan their own routes
b) Generally choose the shortest route, unless they know of areas of rush hour
    i) Rush hour is not a major problem in the areas where Carrier C mainly travels

**7) How do you track your drivers' route progress?**

a) Starting to use their new computer system
b) Before this system was in place, used cell phones
c) Not much communication except if there is a problem or if the driver does not know where s/he is supposed to go next

**8) What type of technology do you use to communicate with drivers when they are on the road?**

a) Computer system
    i) Tracks driving time of truck
    ii) Communicate with driver
        (1) Driver can receive and request transport order and loading/unloading instructions
b) Before computer system, used cellular phones
    i) Drivers tended to be on phone trying to write down instructions while continuing to drive
        (1) Driving risk
        (2) Possibility for missing important instructions
    ii) With the introduction of the computer system, hope to limit or completely avoid use of cell phones for communication with drivers

**9) What are your protocols for each of the following:**

**a) Driver check-in? Driver check-out?**

    i) No check-in or check-out procedure
    ii) Trucks on the road almost constantly, so drivers rarely go to Carrier C depot
    iii) Usually change drivers at unconventional places, like at customer or in parking lots

**b) Cleaning the tanker?**

i) Tanks usually cleaned either at customer's site or at cleaning station

ii) Carrier C ow ns a f ew cl eaning s tations; m ost of s tations ar e r un by a contracted company

iii) Tank cleaned at customer's site or one of Carrier C-owned stations

(1) Driver cleans truck and fills out a certificate

(2) Driver signs certificate, stating that tank is clean

iv) Tank cleaned at contracted station

(1) Employees at station clean tank and fill out the certificate

(2) Driver signs certificate, stating that tank was cleaned

v) Planner's job to choose trucks that are fit for loading

**10) How do you promote driver safety at the workplace and on the road?**

a) Defensive or "echo" dr iving pr ograms s imilar t o t he C ompany's be havior ba sed safety programs

i) Used mainly to teach d rivers t o dr ive s lower t o r educe e missions a nd f uel consumption

b) Training sessions once a year

i) Hoping to increase this number to two or more times a year

c) New drivers requirements:

i) Have an ADR license

ii) Spend two weeks training with an experienced driver

iii) After t wo-week t raining, go t hrough a ny f urther t raining r equired b y s pecific customers, like the Company

d) All drivers are required to wear a seatbelt, but this is difficult to enforce

**11) Do you reward driver safety? If so what programs have you implemented?**

a) No reward programs in place

b) Trying to develop such a program

i) Perhaps will buy better equipment for drivers with no accidents

**12) Do you do any combined safety training with the Company?**

a) The Company does training with drivers one to three times each year

**13) Are you involved with the European carrier organization that Carrier B is involved in? If so, what is your involvement?**

a) No involvement

14) **Why do you think most accidents in the trucking industry occur?**

a) Driver fatigue
b) Weather
c) Gets very cold in the winter, and roads become icy
d) Animals, such as moose
e) People who commit suicide by driving head-on into trucks
    i) Carrier C generally has around three to five accidents of this type per year

**15) What are the details of accidents you have had?**

a) Accident at the end of May 2002
b) Driver went too close to the edge of the road
c) Trailer rolled on its side
d) Sodium hydroxide leaked out of a hole punched in the side when the trailer flipped
e) Determined accident caused by a combination of factors:
    i) Road was narrow
    ii) Road curved slightly
    iii) Driver failed to follow the curve
    iv) Driver was speeding
f) Local environmental company cleaned up the spill
g) Some of the soil had to be taken to a disposal area for hazardous waste

**16) How do you determine the root cause analysis?**

a) If driver is able to give account of accident
    i) Driver's report
    ii) Police report
b) If driver is unable to give account of accident
    i) Police Report

**17) Do your drivers typically take the same routes?**

a) Yes
b) Sometimes, there is only one road that goes to a certain location

*Case Study 10: Carrier D*

Visited on November 11th 2002

## Introduction

Carrier D is one of the primary carriers for Plant F. Carrier D services a local range of customers. Because of this local business setup, the majority of the shipments done by Carrier D take less than one day of travel.

## Key Points From Interview with Plant Manager and Safety Manager

1) **Do you reward driver safety: if so what programs have you implemented?**
   a) Safe Driving Reward System
      i) Sponsored by insurance company
      ii) Drivers pay an annual fee to be a part of the program
      iii) Drivers receive a silver pin for each year they are "incident free," indicting how many consecutive years they have been without an accident or violation.

2) **How do you promote driver safety at the workplace and on the road?**
   a) Four safety meetings each year
      i) One for each division
         (1) Packed Goods
         (2) Bulk liquids
      ii) Three representatives from each division attend each meeting with the management
         (1) Representatives are leaders in their field
         (2) Representatives are responsible for setting up meetings with the rest of the driving fleet to share the topics discussed.
      iii) Typed copy of the minutes from each meeting is given to every truck driver
   b) "Safety Driving Schedule"

i) Defensive Driving class for drivers
ii) Currently not active; used to be implemented more consistently
iii) Approximately 60 to 65% of Carrier D drivers have been trained using this program
iv) Management plans to reinstate this program in the future

3) **What criteria do you consider when you assign loads to drivers?**

a) Drivers own their tractors
   i) Driver assignment is done during truck assignment
   ii) Drivers are trained according to what goods their truck is equipped to ship
b) Experienced drivers deliver dangerous goods
c) Newer equipment is sent on longer hauls
d) Location of the driver
   i) Where is the loading?
   ii) Where is the unloading?

4) **How do you monitor how many hours a truck driver has worked in a given week?**

a) Dual check system
b) Drivers Log
   i) Drivers must fill out every day
   ii) Indicate what they are doing during every hour
      (1) Driving
      (2) Loading/Unloading
      (3) Resting
c) Tachometer
   i) Records number of hours:
      (1) Driving
      (2) Working
      (3) Sleeping/personal time
      (4) Waiting for loading

5) What are your protocols for the following:
   a) Driver check-in
      i) Driver receives order via phone
      ii) Picks up truck and does pre-inspection
   b) Driver check-out
      i) Drop off truck and tanker
      ii) Fill out maintenance form if necessary
   c) Cleaning the tanker
      i) Check-in to cleaner
      ii) Report product last loaded in tank
      iii) Drop off tank and pick up a clean one

6) How do you track your driver's route/progress?
   a) Mobile Phone
      i) Easiest way; drivers call during
         (a) Loading
         (b) Unloading
         (c) If there are any problems
   b) Tried computer system
      i) Too complicated given that their range of delivery is typically 100 to 300 km

7) How do you plan and assign routes?
   a) Receive the orders
      i) Fax
      ii) Phone
      iii) Computer system (the Company submits orders 3 times/day)
   b) Select truck
   c) Select trailer
   d) Determine drivers available to load/unload
   e) Determine location of drivers

f) Assign drivers to route
g) Route Selection
    i) Shortest Distance
    ii) May be changed due to extreme weather conditions such as strong winds
    iii) Will not ship to customer hazardous goods if foggy conditions (as per national law in Carrier D's country)

**8) If you could improve upon any current ways you manage your drivers, what would you improve?**

a) Re-implement the "Driver Safety Schedule"
b) Train drivers on a regular basis

**9) If you could improve upon the way you currently communicate with your drivers en route, what would you improve?**

a) Would not change anything
    i) Continue to use mobile phones
        (1) Quickest way to reach drivers
        (2) Easiest because of the short delivery distances involved.

**10) How do you ensure a truck is fit for loading? Do you provide any certification/paper documenting that the truck is fit for load?**

a) Clean inside and outside
b) Bottom Valves
    i) Working
    ii) Clean
c) Butterfly Valves
    i) Working
    ii) Clean
d) Pressure gauges working
e) Back valve dust cap is secured
f) Manhole

i) Gasket is in place and working
ii) Nuts are working

g) Pressure relief valve is working
h) Driver signs form
i) The Company signs form

## Key Topics of Discussion

### Hiring of New Drivers

When new drivers are hired for Carrier D, a background check is performed to ensure that the drivers are ADR trained. Carrier D also contacts past employees for references to make sure they are hiring reputable drivers. They do not, however, base their decision on past accidents. After a driver is hired, s/he must first ride along with a veteran driver for one to two weeks, depending on the experience of the new driver. This is so the driver becomes accustomed with the equipment and vehicles, and more importantly, they understand their role in linking the needs of the supplier, the provider of the product, and the final customer.

### German Packed Goods Regulations

In the interview with the plant manager, the new regulations Germany has put into legislation regarding the shipment of packed goods were mentioned. In the manager's opinion, these new regulations are the most stringent and up to date of their kind, and he thinks other European countries should adopt these regulations.

### Communication

We also talked about Carrier D's reasoning for the use of only mobile phone communication, as opposed to trying to implement some sort of a satellite communication system. Carrier D had tried to implement such a system, but the phone

proved to be quicker and easier with regards to their logistics set-up. This is because the majority of their trucks only travel short distances that can be covered in less than a day, so any type of a satellite tracking system would be too cumbersome for such a small scale operation.

## Key Observations

### Logistics Center

The orders for the carrier come in via fax, phone, and for the Company, via ADI. For each day, there is a planning list that consists of the drivers and containers available for transport that day, as well as a blank list of all the jobs. As jobs are received throughout the day, they are penciled into the master job list, and tentative drivers and containers are assigned. Drivers and tanks are switched around based on location and time of delivery to save time and effort on the driver's end. By the end of the day, the list is completely filled in. Once this list is complete, it is entered into the computer system, and the drivers are called via phone with their assignments for the next day.

### Truck yard

In the truck yard, we saw the various types of bulk containers that Carrier D uses. In addition to this, we were shown the floor of a packed goods truck used for the shipment of paper reels. The addition of a track to the floor surface allowed braces to be locked in place to the track, which stabilized the rolls of paper during shipment. This change was the result of a recent accident, where the shifting of the paper load caused the truck to overturn.

### Carrier D Terminals

We also took a drive across the area of Carrier D Terminals, which ships paper, the product, and other products via sea. The terminal includes a port, which unloads about

three ships a day. We were shown this terminal to demonstrate the power of the Carrier D name, as they are not merely a trucking logistics center; but offer many other services, such as storage and vehicle maintenance. Since multiple companies depend on the reputation of the Carrier D name, truck safety is a priority for Carrier D Logistics. Any accident involving Carrier D has the potential to taint their name and, consequently, affect the reputations of all of their businesses.

### ADR kit for drivers

We were shown the ADR kit that is given to each driver who is to transport dangerous goods and does not own his/her own kit. This kit included items such as a fire safety blanket, a first aid kit, a flashlight, and proper footwear.

*Case Study 11: Carrier E*

Visited on December 4th, 2002

1.) Do you reward driver safety; if so what programs have you implemented?

Each driver receives a 100 Euro bonus each month

a) Money is deducted from this bonus for mistakes
    (1) Breaking internal rules
    (2) Violation on the road

2) How do you promote driver safety at the workplace and on the road?

a) Blackboard in lounge for driver posts
    i) News from Carrier E
    ii) News from customers
    iii) New driving regulations
b) Monthly newsletter
    i) 1-2 pages long
    ii) Circulated with salary
    iii) Given to every employee
c) Carrier E News
    i) Circulated 3 times a year to every employee
    ii) 8 pages long

3) What criteria do youconsider when you assign loads to drivers?

a) Training of the driver
    i) Dangerous goods training
    ii) Experienced drivers take special loads
b) Size of tank container
c) Location of nearest cleaning station
d) Type of truck

4) **How do you monitor how many hours a truck driver has worked in a given week?**
   a) Tachometer
   b) Driver's responsibility to log and report hours correctly
   c) Carrier E uses railcars and boats to primarily transport products, therefore their few drivers rarely work too many hours
   d) Drivers primarily do short day trips and only work Monday through Friday unless special circumstances arise

5) **What are your protocols for the following:**
   a) **Driver check-in**
      i) Pre-inspection protocol are outlined in the drivers manual
         (1) Driver checks:
            (a) Water
            (b) Oil
            (c) Tire pressure
      ii) Subsidiary manager audits if these checks are carried out, if not a deduction in the driver's monthly bonus is a consequence
   b) **Driver check-out**
      i) If the driver experienced any problems while on the road the driver reports them at this time
   c) **Cleaning the tanker**
      i) Carrier E's own cleaning station is used when available, otherwise a third party cleaning station is used
      ii) When the tanker is cleaned a cleaning certificate is put in the tanker

6) **How do you track your driver's route/progress?**
   a) Drivers call the dispatch to report that his/her truck has been loaded or unloaded
   b) Sky Eye is used to track the location of the truck if needed
      i) GPS based system
      ii) Reports are generated every two hours

c) A satellite system is used to track a truck's location when trucks travel to Eastern Europe, where Sky Eye does not work

7) **How do you plan and assign routes?**
   a) The driver decides which route he will take
   b) Assistance is available if requested. Drivers can contact dispatch and request instructions via telephone
   c) Routes are assigned based on:
      i) Driver's experience and training
      ii) Truck location
      iii) Driver location

8) **If you could improve upon any current ways you manage your drivers, what would you improve?**
   a) Behavior of drivers must be improved to respect safety
      i) All technology is in place to track drivers
      ii) All procedures are laid out to protect drivers

9) **If you could improve upon the way you currently communicate with your drivers en route, what would you improve?**
   a) Put more computer systems into the trucks similar to the satellite system they have in place for trucks that go to Eastern Europe
   b) Extend computer system so drivers can type in when they have loaded, unloaded, how much weight they are carrying
   c) Want to maintain personal communication even with technology advances

10) **How do you ensure a truck is fit for loading? Do you provide any certification/paper documenting that the truck is fit for loading?**
   a) Driver's responsibility
   b) When tanks are cleaned at Carrier E or a third party cleaning facility a cleaning certificate will be put in the tank
   c) Tank is fit for loading if a driver presents a re-order form at pick up location

d) Checklists at plants should determine if tank is not clean
    i) Carrier E should not double check

## Observations at Logistics Center

After our interview we toured the logistics center. In the logistics center there were eight departments, one department for each country in which Carrier E had a subsidiary. Each department was responsible for planning pick-ups and deliveries for the area for which it was responsible. On the walls were three magnetic boards per department. The boards represented the orders from one week prior, the current week, and one week in the future. Magnets were put on these boards to signify orders; the placement of these were confirmed every night by a call to the local subsidiaries to make sure no mistakes were made.

## *Appendix A: Gap Analysis*

After compiling our list of best practices, we looked at how each of the plants and carriers we visited should implement these practices. Due to the differences in the layout of the plants and in their operations, some of the practices we found are not applicable for every plant. For this reason, we have written explanations for how each plant and carrier can meet the items on our list of best practices that apply to its site.

### *The Plants*

**Plant A**

Pictorial safety rules and map of plant

Given the size of the Plant A site and the fact that there are multiple other plants in the same facility, a detailed map of the site would be helpful to drivers. Since Plant A had many unique traffic rules, a pictorial version of these rules would be very useful for the driver. This document should be explained and given to each driver at the Truck Control Center while his/her truck is undergoing inspection.

Near-miss incident reports

Incident reports encourage the employees to observe each other and look for ways to improve current safety procedures. Because the drivers are not active in the loading process at Plant A, making incident reports available to them may not be very beneficial. However, we would recommend putting comment forms in the drivers' lounge to allow the driver an easy and possibly anonymous way to communicate with the plant management about problems s/he observes or things s/he likes.

Driver active in the loading process

Plant A does almost entirely live-loading. During the loading process, the driver either waits in the cab of his/her truck or in the drivers' lounge. This results in almost no interaction between the loading technician and the driver. Requiring the driver to be active in the loading process would accomplish two things. First, it would force the driver to take one final look at the top of the truck before loading to identify any defects, and second, it would give the Company technician a chance to interact with the driver to ensure s/he is fit to be on the road.

Safety Awareness

*Signs for "Zero truck accident" goals on way into plant*

Before a truck arrives at the Truck Control Center, there is an open strip of road between the security gate and the Truck Control Center. This would be an ideal location to place signs about truck accident goals because it is in a safe, on-site area where the drivers could read the signs easily without having to worry about surrounding traffic. Signs should also be posted at the same location facing in the opposite direction, so each driver can be reminded about the zero truck accident goal one last time before leaving the site.

*Trucker safety day*

Plant A deals with many carriers and all methods of transportation, so it would be an ideal place to hold a trucker safety day. By having a trucker safety day at a large site such as Plant A, many drivers will have the opportunity to attend the event. This event may make the drivers feel more valuable as representatives for the Company, as well as inform the drivers about issues vital to safe driving.

**Plant B**

Pre-load Inspection

At Plant B, each driver had to stop and park his/her truck in order to exchange paperwork with the logistics personnel at the entry gate. The Company personnel should conduct a quick visual inspection of each truck during the time the driver is checking in.

Post-load Inspection

Each driver must also stop and park his/her truck before leaving the site to exchange the final paperwork with the logistics personnel at the front gate. Similar to pre-load inspections, this time should be used to perform a quick post-load inspection of each truck to ensure that the truck is sealed correctly.

Random inspections with check list

This practice may be more feasible for Plant B than the pre- and post-load inspections because Plant B does not have a Truck Control Center. For this reason, there may not be enough personnel available to perform inspections on every truck that enters the site. Plant B should designate one employee to perform random inspections at the front gate.

Near-miss incident reports

This practice encourages employees to observe each other and look for ways to improve current safety procedures. It also creates a way for employees to easily communicate with the managers at the plant. Since the Plant B site is comprised of many different plants, the reports should be shared between plants so they can learn from each other. Opening these incident reports to the drivers would also help provide a channel for drivers to communicate to plant management about problems they observe.

Driver active in the loading process

The driver is already somewhat involved in the loading process at Plant B. The driver begins the loading process by opening the hatch and inserting the high-level shut-off device. S/he also finishes the process by closing and sealing the hatch. The driver could be more active in the process; for example, at Plants C and E, the driver also positions and lowers the loading arm.

Safety Awareness

*Signs for "Zero truck accident goals" on way into plant*

After each truck entered the Plant B site, it drove onto the scale to be weighed. This area would be ideal for posting signs about the Company's goal of zero truck accidents. The driver could notice these signs while stopped on the scale. The messages on these signs should consist of pictorial reminders of the Company's emphasis on safety, including graphs of the downward trend of the number of annual truck accidents in the past few years.

Similarly, the driver stops on the same scale before exiting the plant to obtain the final weight. During this time, the driver would see these signs again as a final reminder of safety awareness. Signs are not a large investment, but will positively reinforce the Company's goals and encourage adherence to safety regulations.

*Trucker safety day*

Having a trucker safety day will make the drivers feel more valuable as representatives for the Company, as well as inform them about issues vital to safe driving. The Plant B site has approximately 150 trucks coming in each day for loading, and a trucker safety day would be a good way to reach those drivers about safety issues. It would also give drivers something to do during long waiting periods.

**Plant C**

Pre-load Inspection

At the Plant C site, drivers must park their trucks and enter the reception area to give their shipment numbers to the receptionist. At this time, the Company personnel should perform a quick inspection of the truck. Due to the site layout and the fact that drivers can enter the site and load during times when the reception is not open, it might be more feasible for these inspections to be performed by the technician at the loading station before loading the product. Since the driver already helps by opening the hatch and positioning and lowering the loading arm, s/he has contact with the loading technician. During this time, the technician should assess the driver's condition. Pre-load inspections may require some additional training and/or a checklist for the technicians to be able to properly assess the condition of the truck.

Post-load Inspection

These should be performed by the technician at the loading station after the truck is loaded and the driver has sealed the tank.

Random inspections with check list

Random inspections could be performed instead of inspecting every truck at the loading station. This should only be considered an option when a plant receives too many trucks per day for it to be feasible to inspect every truck. Plant C does not usually load more than ten trucks per day, so unless many trucks arrived at the same time, it would be possible to inspect every truck entering the site.

Pictorial safety rules and map of plant

When we talked with the receptionist at the Plant C site, she mentioned that it is sometimes a problem when she does not share a common language with the drivers. In this circumstance, it is very difficult to explain safety procedures and give directions to the loading station. A pictorial description of safety rules and a map of the area would be quite helpful in these types of situations by alleviating possible misunderstandings.

Safety Awareness

*Signs for "Zero truck accident" goals on way into plant*

Signs should be placed along the road that leads to the site entrance. Safety signs stressing the Company's commitment to achieving its goal of zero accidents reinforce the importance of safety to the drivers and encourage them to drive safely.

*Trucker safety day*

Only about eight to ten trucks come in to load at Plant C per day. Therefore, having a trucker safety day at the plant would not be cost- and time-effective. Instead, Plant C could hold regular safety sessions with its primary carrier, so a larger number of drivers could be reached.

**Plant D**

Pre-load Inspection

Due to the layout of Plant D and the manner in which it is run, implementing a pre-load inspection of a tank trailer would be more difficult than at some of the other sites we visited. Since almost all of the tanks are pre-loaded, any inspection conducted on tanks would have to be performed by the contracted Carrier B employee who moves the tankers to and from the loading station. This employee should be trained by both Carrier B and

the Company to conduct an inspection of each tank truck before loading. The main part of the inspection, including everything but a check of the top of the truck, should be performed in the lot. After performing these inspections, the technician should then move the tank to the loading station to check the top, as the loading station is the only location on-site where a person can safely walk across the top of a tank truck. Performing the bulk of the inspections in the lot would reduce the hassle of returning a truck to the yard should it fail any inspections.

Post-load Inspection

Again, because nearly all tanks are pre-loaded, this safety practice would have to be implemented differently than at the rest of the plants. The same Carrier B employee who is trained in the pre-load inspection protocol should also be trained to carry out a post-load inspection on each tank. This inspection would need to be performed in the loading station, so the employee could check the top of the truck.

Random inspections with check list

Due to Plant D's small operating size, an inspection of every tanker is certainly feasible. Therefore, random inspections are not necessary.

Pictorial safety rules and map of plant

This practice does not apply because the majority of the tanks are pre-loaded and then picked up from the lot directly inside the front gate. Plant D should still print a small number of copies of a site map for the few live loads that they complete. This map should be given to the drivers by the security guard at the front gate.

Near-miss incident reports

This practice would benefit the operations at Plant D because it opens up a clear line of communication between the management and the employees. It also ensures that any problems seen are reported, which makes it possible to prevent similar accidents from happening in the future. However, because Plant D does nearly all non-live loading, drivers do not spend much time on-site and, therefore, could probably not contribute much to the near-miss incident reports.

Eliminate 24-hour pick up of preloaded tanks

Research has shown that drowsiness is eight times more likely between the hours of 0:00 and 6:00. This study also demonstrated that drivers do not accurately assess their alertness levels, according to objective performance measures ("Driver Alertness and Fatigue: Summary of Completed Research Projects, 1995-98," 2001). The current setup of Plant D allows drivers to show up at anytime to pick up a loaded tank. We suggest limiting this to the open hours of the plant when personnel see the driver enter the site. This ensures that the driver's condition is assessed before s/he picks up the load, reducing the chance of a driver leaving the plant who is unfit for driving.

Driver active in the loading process

Again, due to the non-live loading operation of this plant, the driver does not have the opportunity to be active in the loading process.

Safety Awareness

*Signs for "Zero truck accident" goals on way into plant*

The road into Plant D is in the middle of a busy industrial harbor, and because of this, any signs directly outside of the plant could be a distraction to drivers. These signs, however,

could easily be placed on-site, just inside the front entry gate. There is plenty of open space for signs between the front gate of the site and the parking lot where the tanks are picked up. This area of the plant is also free of other distractions, so any signs would be very obvious to the truck drivers.

*Trucker safety day*

Plant D is small, with only 15 to 20 load pick-ups per day. Due to this small traffic flow, a trucker safety day of the proportion of the one at Plant F may not be worthwhile. However, a small-scale truck safety day would be a good investment. Such an event should be co-sponsored by Plant D and Carrier B, and should be held on a Saturday or Sunday when the plant is not open for loading. This event would not only stress safety to the drivers, but also show that the Company and Carrier B appreciate the drivers.

**Plant E**

Pre-load Inspection

At Plant E, the pre-load inspection would be easiest to implement once the driver is in the loading station. This is due to the layout of the plant and the generally cold weather, which would make it difficult for the receptionist to walk to the entry gate for every truck that requests entry to the plant. The Company loading personnel should then go over a short checklist with the driver to assess the truck's condition and the driver's alertness before the driver is allowed to start the loading process. Adding a pre-load inspection may require an additional staff member to be assigned to this task, or a checklist could be provided to the driver at the loading station. The driver could then be required to assess the condition of his/her own truck on-site and vouch for its condition. This checklist would then be turned in upon exiting the plant, when the driver picks up the customer receipt from the receptionist. When the reception area is closed, the checklist would be turned in at the loading station prior to departure.

Post-load Inspection

Company personnel should also perform a post-load inspection in the loading station before the driver takes his/her truck to be weighed. If the Company chooses to have the driver perform inspections instead of the Company personnel, a checklist should be provided to the driver at the loading station to ensure that the proper close-up procedure has been performed.

Random inspections with check list

The small number of trucks that are loaded at Plant E makes it feasible to inspect every truck, so random checks are unnecessary.

Pictorial safety rules and map of plant

Plant E is a very small plant and only works with Carrier C. This means that all drivers that load on-site have had site-specific training through the carrier; because of this, a map of the plant is not necessary. Drivers would benefit from having to sign a sheet that displayed the proper safety equipment and loading procedures for the plant, stating that they know and understand the safety protocol.

Near-miss incident reports

As at Plant C, near-miss reports encourage staff members to observe each other and look for ways to improve current safety procedures. This practice also opens a channel for employees to easily communicate with managers at the plant. Opening these incident reports to the drivers will also provide a channel for drivers to communicate to plant management about problems they observe.

Safety Awareness

*Signs for "Zero truck accident" goals on way into plant*

Signs should be added along the road towards the entrance of Plant E that re-state the Company's vision of zero truck accidents by 2005. Signs could also state how long it has been since a truck leaving the plant has had a near-miss or incident while on the road.

*Trucker safety day*

The small size of Plant E and the low number of drivers that it uses on a regular basis make it difficult to reach many drivers at a trucker safety day at the plant. A trucker safety day for the drivers of both the Plant C and the Plant E sites would be a good idea. Since Carrier C is the primary carrier for both plants, drivers could meet somewhere halfway between the sites for an offsite trucker safety day.

**Plant F**

Pre-load Inspection

The Plant F site currently performs random inspections at the entry gate. However, if a truck entering the site was not already randomly inspected, the truck should be inspected prior to loading to ensure that all of the valves are tightened and the truck is fit to load.

Post-load Inspection

A quick inspection after loading the truck is beneficial to ensure that the truck is ready to exit the plant and safely proceed with delivery of the load. This inspection would have to be conducted at the same point as the pre-load inspections. Due to the size of the plant, this inspection process may need to be at random, similar to the pre-load inspections. Drivers would be informed while exiting the site to pull over for a post-load inspection. This process may require the hiring of another employee.

Pictorial safety rules and map of plant

Since Plant F is such a large site and many of its drivers speak different languages, it would be helpful to have a more detailed map of the plant, as well as pictorial rules. Several Plant F employees stated that there are sometimes difficulties in communicating with drivers, and pictures and symbols would help them to reinforce the safety rules at each plant. Also, developing a format for the regulations at the entire site would help implement the safety equipment policy uniformly throughout the site. This would solve the PPE issues that Plant F is currently having.

Near-miss incident reports

Plant F is a large site, and it would benefit from analyzing near-miss situations. It would be advisable to share the reports among the many plants on the site to better inform the managers and employees about risks on-site and then make corrective actions to reduce or eliminate the risks.

Driver active in the loading process

The Company personnel are responsible for loading the trucks, while the driver is responsible for opening and closing the manhole. At the current loading station, it is not advisable for the drivers to be active in the loading process. The opening over the truck in the loading station is in a small, confined space. Injury may result to a driver that is not familiar with the careful maneuvers needed to load the tanks. However, when the new loading station is implemented, the driver should be active in the loading process.

***The Carriers***

**Carrier A**

Computer systems in trucks

Carrier A currently communicates with drivers using a cell phone system. This system allows its drivers to alert Carrier A's main office of their progress before loading and while delivering a load. By installing computer systems similar to the systems being installed in the Carrier B and Carrier C trucks, the communication level between the drivers and Carrier A's main office would be increased, and relaying information to the drivers could occur in a safer manner.

Reward programs

Carrier A should offer some type of reward program similar to Carrier B's insurance return program. If an insurance return is not an option, an annual cash reward based on driving performance should be offered.

**Carrier B**

Defensive driving classes

Currently, Carrier B collaborates with Plant D to schedule periodic safety meetings at Plant D. They should expand upon this program by holding driver classes more frequently and incorporating defensive driving lessons into these classes. Though this would be an investment of both Carrier B's time and money, the return would justify the investment. Drivers trained in defensive driving would not only be safer drivers on the road, but would also reduce the amount of fuel used for each trip, thereby cutting Carrier B's costs. Therefore, this practice is not only beneficial from a safety point of view, but also from an economic standpoint.

Inspection checklist

Currently, Carrier B's drivers perform an inspection before each trip. This process is outlined in the driver's manual, and it is expected that each driver conducts this inspection. A detailed checklist, other than the procedures outlined in the driver's manual, will accomplish two things. First, it will ensure that a driver will not forget a particular item on the checklist, and second, it ensures that the driver performs the inspection each time s/he is required to. This checklist should be part of a driver's log that each driver must fill out before his/her trip each day. This checklist should require a signature from the driver, certifying that s/he performed the inspection.

En route inspections

Carrier B delivers products for a broad range of locations, some of which require long trips. During such a trip, a mechanical default could occur en route. To prevent this from occurring, periodic stops to check for problems should be implemented. The driver should be required to stop the truck at a specific mileage on each trip to perform a quick inspection before continuing to drive.

**Carrier C**

Reward programs

Carrier C does not currently reward safe driving, though the management mentioned that the carrier is in the process of developing a reward program. The type of program discussed would be similar to Carrier B's insurance return plan. However, instead of cash, Carrier C is considering giving drivers upgrades or improvements to their trucks. This would have two benefits; first, it would be a reward to give drivers an incentive to drive safely, and second, it would improve the quality of the fleet.

Driver manual outlines pre-load inspections

The Company currently supplies Carrier C with a "Safety Handbook for Contractors" that outlines procedures at the Company sites. Although this book gives information specific to the Company sites, it should also contain a section about what items to check during safety inspections.

Inspection checklist

Carrier C places a large amount of responsibility on the driver to make sure his/her truck is in good condition and fit for loading. Carrier C should help the driver better understand what inspections are required by providing a checklist for pre-trip inspections.

Periodic Inspections

*Additional truck inspection besides government required one each year*

The laws in the country in which Carrier C is located do not require vehicular inspections each year. Carrier C currently requires inspections every 40,000 miles, as mandated by an agreement with the truck dealership at the time of purchase of the trucks. Since these inspections do not occur very often, Carrier C should require inspections to be performed more frequently, either by the dealer or the driver, in addition to the currently required dealer inspections.

*En route inspections*

As previously mentioned, Carrier C currently requires the minimum number of inspections set by the truck dealer when Carrier C purchases trucks. It is the driver's responsibility to perform any safety inspections before driving the truck. Most of the trips that Carrier C drivers make are fairly short, so periodic en route inspections may not be a

feasible practice. Instead, driver inspections should be required each time the driver leaves a customer and when passing off the truck to a new driver for a new trip.

Defensive driving classes

Carrier C currently implements a program called "eco driving." This program focuses on teaching drivers to use their seatbelts and reduce their speed in order to save fuel. The program could easily be modified to include other important aspects of safe driving, such as appropriate driving for various weather conditions, fatigue awareness, and getting the proper amount of rest.

**Carrier D**

Better reward programs

Currently, Carrier D has a safe driver rewards program in which drivers have the option to be involved. Drivers who participate must pay a fee to be part of the program, after which they receive silver pins for each incident-free year they drive. This program could be improved into a program similar to Carrier B's program, such that each driver is automatically included in the program, with no fee required. Drivers could be rewarded with money, such as an insurance return, instead of silver pins. This would be less of an investment for the company, as the reward money is simply an insurance return, and it will give the drivers a more desirable incentive to drive safely. If Carrier D wants to include a way to publicly recognize safe drivers, a placard placed on the cab of the driver's truck for each award earned would be an easy and inexpensive way to identify safe drivers.

Computer systems in trucks

Given the size of the region that Carrier D services, a computer system implemented in each truck may not be the best investment. The majority of its trips are day trips, so a computer system is not an efficient way to communicate with the drivers. The

management at Carrier D feels that communication via cell phone is quicker and easier. However, Carrier D should implement computer systems in a few of its newer trucks for the occasional long trips it handles. With computers in only a few trucks, Carrier D maintains the ease of cell phone usage for all its short range trips, but still has the option to use a computer tracking system for its occasional long trips.

Periodic inspections

*Additional truck inspection besides government required inspection(s) each year*

Carrier D should inspect its trucks one or two times per year in addition to the one time required by national law. These inspections would be relatively easy to perform, as one of its partner companies has a garage facility less than 100 meters away from the carrier's main terminal. These extra inspections would ensure that each truck is fit for the road.

*En route inspections*

Due to the fact that the majority of Carrier D's drivers make multiple short-range day-trip deliveries, this inspection may not prove very useful. Carrier D should modify this, so that each driver must perform an inspection at each stop of his/her trip, such as when s/he is departing from a customer, arriving at the loading area, and arriving at a second customer.

In addition to this, Carrier D should require its drivers to stop for periodic inspections in the case of the occasional long-distance delivery. The combination of these two techniques would ensure that each truck is checked more than once per day. These multiple checks would help ensure that each truck on the road is fit for driving and, furthermore, that any truck not fit to be on the road is taken out of service and repaired.

**Carrier E**

Computer systems in truck

Carrier E has two types of computer systems set up in its trucks for tracking only; one system is GPS-based, while the second is satellite-based, due to the fact that the GPS-based system does not work in Eastern Europe. The satellite-based system does have messaging capability; however, Carrier E handles all communication with the drivers via cell phone. In our di sucssion with the management of Carrier E, the safety manager indicated that he would like to include messaging technology in all of the trucks, in addition to the cell phone, in order to keep up with technology, but still maintain a personal relationship with the drivers. Carrier E should update its system further to include computer systems that can track the speed of the truck, as well as reccomend speeds for common routes the truck travels on.

Planners manage small groups of trucks and drivers

The majority of Carrier E's transportation is intermodal transport; that is, a truck only transports the tank to the nearest railway, where the tank is transported to its destination via train. Because of this setup, drivers are only driving short distances, and therefore, the implementation of a group of planners managing small groups of drivers would not be worthwhile.

Discussion-based driving training sessions

Carrier E has a very intensive driver training program that must be completed by each driver before driving alone on the road. Carrier E should build upon this rigorous driver training program to include periodic discussion-based classes held at each one of their subsidaries. Such classes could be very informal and should be held every few months to inform drivers of any changes in government or company regulations, or inform them of any commonly noticed problems.

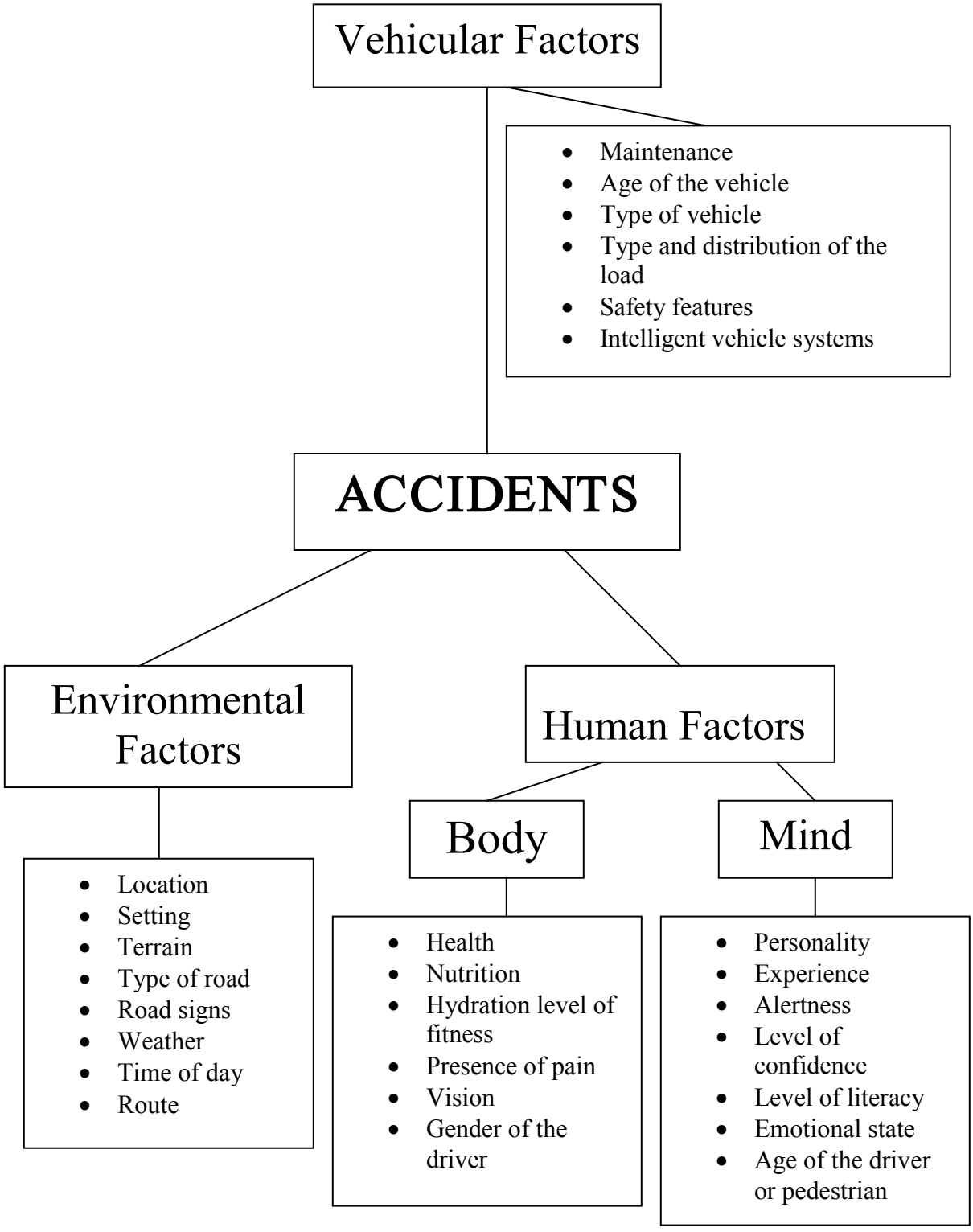
Keep wrecked trucks in yard

Carrier E is a large trucking coorperation serving many locations across mainland Europe. Because of this, it would be very difficult to display a wrecked truck at each one of these locations. However, we feel that Carrier E should take advantage of its training program that requires each driver to first be trained at the carrier's headquarters. We suggest that Carrier E keep at its headquarters a few examples of truck cabs and tanks that have been involved in accidents. These wrecks can be shown during a section of the training program, demonstrating the consequences of unsafe driving.

Defensive driving classes

Carrier E has a very intensive training program that involves up to two months of training at its company headquarters, followed by an additional month of training at the specific satellite branches. Furthermore, Carrier E has a department dedicated to driver training, so that it can organize a training session at anytime. These spontaneous training sessions may be held for an entire group due to change in regulations, or for a single driver who has been performing duties incorrectly. Carrier E should build upon this training program to include periodic training sessions in defensive driving. Carrier E already has the department and facilities to arrange these programs; it can use its current training department to conduct the classroom portion of the defensive driving programs. Carrier E should hire a driving coach to implement the second portion of defensive driving classes, on-road observation. Drivers should be trained in defensive driving upon being hired, and then on a periodic basis throughout their careers at Carrier E.

***Appendix B: Concept Map***



***Main Body***

The purpose of our project is to eliminate truck accidents. We see three main factors that contribute to accidents: vehicles, the environment, and human factors. To help eliminate accidents, vehicles can be inspected and preventative measures can be put in place to monitor the environment and drivers.

***Vehicles***

Vehicles have six main factors that can affect their likelihood of being in an accident and the severity of damages in an accident: maintenance, age, type, load, safety features, and technology. Maintenance to the mechanical, electrical, and computer systems of the vehicle is important to keep it in good working order. Type of vehicle is important since motorcycles, trucks, and their drivers will suffer different amounts of damage if involved in an accident. Weight and number of trailers attached can affect the maneuverability of a vehicle and how quickly it can stop. Safety features, such as airbags and antilock brakes can decrease damage suffered in an accident. Finally, new technologys uch as preventative warning systems and intelligent vehicles can reduce the likelihood of an accident.

***Environment***

We identified several environmental factors that affect the potential to be in an accident: location, setting, terrain, type of road, road signs, weather, the time of day, and the route. The location of the vehicle determines its likelihood of being in an accident. The setting (urban, rural, suburban) and terrain (mountains, ocean) often determines the speed limits and the type of traffic encountered. The type and condition of road on which the vehicle is driving determines the traffic patterns. Road signs are important, as they indicate where essential places are located, as well as providing information about distance and direction. The weather can affect how fast the vehicle can travel safely. The time of day is an important consideration, as things are more visible when it is light outside. The route and direction that the vehicle is traveling can determine if the sun gets into their eyes and also if the trip will take a longer amount of time.

***Human Factors***

There are various human factors that affect the probability of being involved in an accident. Firstly, it is dependent upon the people driving the vehicles involved, and pedestrians affected in the incident. Mainly, the human factors that contribute to accidents can be divided into two separate, but not distinct categories: body and mind. Mental factors that may affect the chance of being involved in an accident are the personality, experience, alertness, level of confidence, level of literacy, emotional state and age of the driver or pedestrian. Physical factors, such as health, nutrition, hydration level of fitness, presence of pain, vision, and the sex of the driver also play a role in the way the person behaves. Factors related to both mind and body, such as the influence of drugs, sleep, reaction time, depth perception, and the hierarchy of needs determine the proneness to being involved in a mishap.

## *Appendix C: Checklist for Observation of the Company Sites*

Entry Point:

- Key Visual Observations
    - First impression of driver's alertness
    - Is the driver wearing proper attire?
    - Is the driver wearing a seat belt?
    - Are there passengers in the truck?
    - What documents are exchanged?
    - Communication between driver and the Company personnel during exchange of documentation
    - Is spot check of truck performed at entry point?
        - If spot check is performed, will ask questions
        - Will document what is done during spot check

Loading Station:

- Key Visual Observations
    - Observe layout of loading area
    - Are safety signs posted around loading area?
    - Observe driver's alertness
    - Observe driver interactions with loading manager
    - Observe driver's role in loading/unloading the truck
    - Are checks made to ensure that the truck is loaded/unloaded properly?
    - Are there supervisors present while the truck is being loaded/unloaded?
    - Are the products inspected prior to load/unload?

Exit Point:

- Key Visual Observations
    - Observe procedures before the truck leaves the plant.

## *Appendix D: Interview Questions for Plant Manager at the Company Sites*

1) What is the percentage breakdown for how your products are shipped (tankers, trailers, intermodal)?
2) Do you do live or non-live loading?
3) Do you perform safety inspections on inbound and outbound trucks? If yes to either, when and where do you perform these safety inspections?
4) What do these inspections entail?
5) Do you reward safe driving? If so, how?
6) What type of certification do you require the drivers to have?
7) Do you have driver training sessions and driver safety awareness training?
8) Have you implemented any new truck driver safety procedures in the past 2 years?
9) If you could improve upon any current inspection or add new items to your safety protocol, what would you improve or add?

## *Appendix E: Questions for Technician at Entry/Exit Gate*

1) What is your protocol for interacting with the truck drivers?
2) What exchange of paperwork do you require prior to entry?
3) What exchange of paperwork do you require prior to exit?
4) When and where do you perform safety inspections on inbound trucks?
5) What do these inbound truck inspections entail?
6) When and where do you perform safety inspection on outbound trucks?
7) What do these outbound truck inspections entail?
8) If you improve upon any current inspections or add new items to your safety protocol, what would you improve or add?

### *Appendix F: Questions for Technician at Loading Station of the Company Sites*

1) What is your protocol for interacting with the truck drivers?
2) Do you exchange paperwork with the truck driver at the loading station?
3) If so, what do you exchange?
4) When and where do you perform safety inspections on trucks in the loading station?
5) What do these inspections entail?
6) If you could improve upon any current inspections or add new items to your safety protocol, what would you improve or add?

## *Appendix G: Interview Questions for the Carriers*

1) Do you reward driver safety: if so what programs have you implemented?
2) How do you promote driver safety at the workplace and on the road?
3) What criteria do you consider when you assign loads to drivers?
4) How do you monitor how many hours a truck driver has worked in a given week?
5) What are your protocols for the following:
    a) Driver check-in
    b) Driver check-out
    c) Cleaning the tanker
6) How do you track your driver's route/progress?
7) How do you plan and assign routes?
8) If you could improve upon any current ways you manage your drivers, what would you improve?
9) If you could improve upon the way you currently communicate with your drivers en route, what would you improve?
10) How do you ensure a truck is "fit for loading"?
11) Do you provide any certification/paper documenting that the truck is "fit for loading".

## *Appendix H: Adapted model for hierarchical driving*

| Hierarchical Level | Elements of level | Risks present in level | Ways driver education can address level |
|---|---|---|---|
| (1) Vehicle maneuvering | • Control of direction and position of vehicle<br>• Vehicle characteristics<br>• Physical and environmental surroundings | • Inadequate technical skills to control vehicle<br>• Inappropriate adjustment of speed<br>• Difficult driving conditions | • Repetition of skills needed for maneuvering<br>• Awareness of typical mistakes that lead to loss of control of vehicle in both hazardous and non-hazardous conditions<br>• Accurate self-evaluation |
| (2) Mastery of traffic situations | • Anticipation and adaptation to the behavior of others on the road and in the traffic environment<br>• Ability to perceive risks in problem situations<br>• Awareness of traffic rules<br>• Negotiation of traffic situations and road conditions<br>• Driving path/order | • Driving style (i.e. aggressive)<br>• Erroneous expectations<br>• Disregard for traffic rules<br>• Inappropriate adjustment of speed<br>• Overload of information<br>• Difficult/risky driving conditions | • Awareness of personal driving style<br>• Awareness of strong and weak points in basic traffic skills<br>• Awareness of personal skills and limits in driving situations<br>• Accurate self-evaluation |
| (3) Goals and context of driving | • Specific goals of trip, context of driving<br>• Navigation of and planning routes<br>• Proper estimation of travel time<br>• Social pressures of driving<br>• Presence of others in vehicle | • Driver's mood or condition (blood alcohol content)<br>• Driving environment (highway/rural)<br>• Social context and company<br>• Purpose of driving<br>• External motives (competition) | • Address planning skills<br>• Address typical goals of driving<br>• Inform driver about typical motives which produce risky driving |
| (4) Goals for life and skills for living | • Broad motives and goals of driver<br>• Lifestyle factors and values<br>• Driver's motives<br>• Personal skills in handling life situations<br>• Developmental stage of driver | • Use of drugs/alcohol<br>• Values and attitudes towards society<br>• Elevated need for sensation<br>• Social pressures<br>• Acceptance of risks<br>• Self-enhancement through driving | • Self-evaluation and awareness of risky tendencies<br>• Personal skills for impulse control<br>• Motives that negatively address safety<br>• Personal risky habits |