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Effects of Loading and Unloading Cargo on Commercial Truck Driver Alertness and Performance

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16. Abstract

This report describes Phase I of a two-phased assessment of the effects of loading and unloading cargo on truck drivers alertness and performance. The report, which documents work done on three Phase I tasks, contains:

a) a comprehensive behavioral and physiological sciences literature review regarding sustained performance and operator fatigue, with a focus on the effects of expending physical work energy on operator fatigue.

b) a characterization of commercial motor vehicle industry procedures, methods and practices concerning drivers who load and / or unload their vehicles (trucks/buses). This was accomplished by examining trucking industry trade literature on loading/unloading procedural matters, then conducting a questionnaire survey of over 300 truck drivers, followed by sixteen focus group interviews to understand driver loading/unloading requirements across the country, and

c) a behavioral task analysis assessment of various driver loading and unloading scenarios in four cargo commodity groups: moving household furniture and goods, tank truck carrier operations, fast food supply delivery, and beverage delivery operations

Phase II of the overall study involved a truck driver simulator-based experiment to assess the effects of physical activity on loading /unloading cargo on subsequent driver alertness and driving performance. The Phase II experiment is described fully in a companion report, No. FHWA-MC-99-140, Effects of Operating Practices on Commercial Driver Alertness.

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Prepared for:

Robert J. Carroll, Project Manager
U.S. Department of Transportation
Federal Motor Carrier Safety Administration
400 Seventh Street, SW
Washington, DC 20590

American Trucking Associations Foundation
Trucking Research Institute
2200 Mill Road
Alexandria, Virginia 22314

Prepared by:

Gerald P. Krueger, Ph.D.
Susan B. Van Hemel, Ph.D.
Star Mountain, Inc.
3601 Eisenhower Avenue, Suite 450
Alexandria, Virginia 22304-6496

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Preface

The Federal Motor Carrier Safety Administration (FMCSA), formerly the Federal Highway Administration (FHWA) Office of Motor Carrier and Highway Safety (OMCHS), conducts a multifaceted Research and Technology (R&T) Program with a high priority on human factors research. Throughout the remainder of this report we will use the former agency name (OMCHS) which was in effect at the time this research was conducted. The FMCSA program places special emphasis on assessments of commercial driver fatigue and studies pertinent to hours-of-service rules. As part of the R&T Program, this document reports driver fatigue research specifically addressing an assessment of the activities of commercial motor vehicle (CMV) drivers loading and unloading cargo in their trucks and what effects that physical work has on their subsequent levels of driving alertness, or the possible development of driver fatigue.

The project was conducted in two phases. Phase I of the study (conducted in 1996-97 and reported in this technical report) involved: a) a comprehensive literature review on the effects of expending physical energy on development of operator fatigue, b) a questionnaire survey of over 300 truck drivers, and sixteen focus group interviews to understand driver loading/unloading requirements across the country, and c) a behavioral task analysis assessment of various driver loading and unloading scenarios.

Phase II of the project, conducted in 1997-98, involved a truck driver simulator-based experiment as an assessment of the effects of physical activity in loading/unloading cargo on subsequent driver alertness and driving performance. This experiment measured and documented truck driver's performance on a daily schedule of 14-hours-on-duty (with 12 hours simulator driving) followed by 10-hours-off-duty for two successive workweeks of 5 days each. The study also examined the "weekend" rest/recovery process over the 58-hour off-duty period between the two successive weeks. Details of the simulator experiment and the test results are described by O'Neill, Krueger, Van Hemel, & McGowan, and contained in the September 1999 FHWA Report No. FHWA-MC-99-140.

The two-phased project was conducted as part of a 1996 Cooperative R&D Agreement between FHWA-OMCHS and the American Trucking Associations Foundation - Trucking Research Institute (ATAF-TRI), Alexandria, Virginia. TRI's project officers for oversight management of the project were Clyde E. Woodle and William C. Rogers, Ph.D. The entire project was conducted on a TRI subcontract to a team of human factors researchers at Star Mountain, Inc. in Alexandria, Virginia: Timothy R. O'Neill, Ph.D., Gerald P. Krueger, Ph.D., Susan B. Van Hemel, Ph.D., and Adam L. McGowan. Gerald Krueger and Susan Van Hemel did the bulk of the work for Phase I of this project and prepared this report. Robert J. Carroll, project manager, and Ronald R. Knipling, Ph.D., Chief, Motor Carrier Research and Standards, Research Division, served as the Federal Highway Administration's project monitors.

Table of Contents

List of Figures and Tables

Executive Summary

The Federal Motor Carrier Safety Administration (FMCSA), formerly the Office of Motor Carrier and Highway Safety (OMCHS), at the U.S. Department of Transportation, sponsors a multifaceted research program examining commercial motor vehicle (CMV) driver fatigue. One research project is to analyze the potential fatigue effects of CMV drivers loading and unloading cargo onto their own vehicles and trailers. That research topic is addressed in this report.

The principal research question posed was: *what effect does loading or unloading a truck, or a commercial bus, have on driver alertness, performance, and/or driver fatigue during subsequent driving?* The American Trucking Associations Foundation's Trucking Research Institute (TRI) and Star Mountain, Inc. (SMI) began this loading/unloading project in mid-summer 1996 with the hypothesis that the physical labor (i.e. the physical energy expended) in loading and unloading CMVs is an important contributor to subsequent driver fatigue and therefore may adversely affect driver alertness and safety.

In a two-phased study approach, Phase I (consisting of four tasks) was designed to define the problem:

In Phase I, Task I of the project, human factors researchers reviewed and evaluated behavioral and physiological sciences literature regarding sustained performance and operator fatigue, with an aim to define the physiological impact of doing sustained physical work prior to equipment operator extended performance on the job.

Phase I, Task 2 of the project characterized CMV industry procedures, methods and practices concerning drivers who load and/or unload their vehicles (trucks or buses). Task 2 accomplished three goals: 1) examined the trucking industry trade literature on loading/unloading procedural matters in the CMV cargo transport industry, 2) conducted driver focus group interviews to determine how frequently drivers engage in cargo loading/unloading activities, and 3) determined drivers' perceptions of the likelihood that performing physical labor associated with loading-unloading influences driver fatigue.

In Phase I, Task 3 of the project a behavioral task analysis was performed on drivers loading and unloading trucks in several cargo commodity groups. From the results, a behavioral task taxonomy of loading and unloading tasks was developed for several cargo commodity groups. The first three tasks of Phase I of the project are documented in this report in three sections, respectively, one for each of the three tasks.

At the conclusion of Phase I of the study, Star Mountain and the Trucking Research Institute presented FHWA-OMCHS with research recommendations (Phase I, Task 4) containing options for consideration as to how to proceed in Phase II of the project. The recommendations were incorporated into the Phase II study, which included a set of generic loading and unloading tasks

interspersed with a two-week long extended driving experiment in a truck simulator that collected measurable driver performance data regarding facets of the problem. Task 4 and the driving experiment were reported in FHWA Report No. MC-99-140 by O'Neill, Krueger, Van Hemel, and McGowan (September, 1999).

Literature Review. The scientific literature clearly establishes that sleep deprivation, circadian bodily rhythms, and sustained work are the principal determiners of vehicle operator fatigue, as these factors affect a driver's mental alertness and can lead to degradations in attention-demanding performance required for safe vehicle operation. In sustained performance studies it is clear that cumulative fatigue effects lead to decrements in operator performance on mental tasks earlier than they degrade performance on physical tasks. For the converse however, the literature draws a less clear connection between physical energy expended and subsequent general mental fatigue as it affects operator performance. Whether doing substantial physical work hastens or slows development of general-mental fatigue is not well defined.

Some truck drivers, especially those in industries like the household goods movers, or in the grocery delivery business, and others, do considerable amounts of loading and unloading of freight or cargo. Questions remained concerning the contributions to driver fatigue by the amount of on-duty but non-driving work done by drivers while loading and unloading their trucks. That is, does a certain amount of physical exercise associated with loading/unloading energize drivers as some of them contend; or does expending a large amount of such energy make drivers more fatigued and subsequently more drowsy at the wheel, and more likely to fall asleep? The literature review lead to an interest in determining what impact such non-driving activities have on truck driver alertness and highway safety.

Industry procedure documents. Very little literature was located to describe CMV industry procedures, methods, and practices of driver involvement in loading and unloading cargo. Available truck training manuals, handbooks, and workbooks present general training information and guidance for anyone who handles, loads, secures, covers, or unloads freight or cargo, and provides safety procedures for dealing with hazardous cargo. This guidance includes instruction on how to properly lift items without injury, to stack and distribute load weight in a van, and to secure specialized rigging for large bulky items on flatbeds. Manuals on handling of hazardous materials are also available. That documentation is helpful for describing how *anyone* should load cargo onto or into trucks; but by itself it does not convey whether or not truck *drivers* become involved in the actual loading and unloading process.

There is a paucity of other literature involving studies performed for and by the trucking industry to provide solid information on drivers' involvement in loading and unloading, or their attitudes toward loading and unloading issues.

Surveys, interviews, focus groups. Star Mountain researchers administered questionnaires, and conducted focus group meetings as well as individual structured interviews with drivers, and with safety managers and other company officials in various segments of the trucking and bus industries. A driver survey (questionnaire) distributed at the National Truck Driving

Championships yielded useful results. Sixteen focus group and structured interviews were accomplished with drivers and trucking industry officials in nine freight/cargo categories, ranging from produce and refrigerated cargo to household furniture, steel pipe, and hazardous chemicals in tank trucks, and included interviews of bus drivers. Considered together, the questionnaire and interview data help determine the extent to which drivers participate in the loading-unloading process, and describe other activities that drivers do while they are on duty, but not driving.

Industry loading and unloading practices. The frequency and amount of CMV driver loading and unloading varies across trucking industry segments (defined by cargo type) and even within segments. As for bus drivers, generally their cargo is mostly handled by others, and therefore loading and unloading is not a significant fatigue-related factor. It is true for most truck cargo categories as well, for it appears that most truck drivers do not do substantial amounts of cargo loading and unloading of their own trucks. In many settings, people other than drivers (e.g. shipper and receiver personnel, dock workers, hired lumpers, helpers, and others) do most of the actual loading and unloading of trucks. Much of the loading is done with mechanical assistance in the form of fork lifts, electric pallet jacks, hydraulic cranes, gravity and pneumatic suction feed mechanisms (e.g. at grain elevators, petroleum refineries), and is accomplished by personnel trained to operate that specific equipment. Truck drivers then, very often supervise the cargo handling for their trucks, and in some cases merely pick up or drop off trailers of cargo and are not even present for the cargo handling process.

When truck drivers are involved in handling cargo, they are more likely to be involved in the unloading than the loading process. In several trucking industry segments, drivers drive trucks or trailers pre-loaded and prepared by others. Upon reaching the delivery point, some drivers become involved in the unloading process; in some cases they accomplish all the unloading themselves.

Primarily drivers frequently involved in handling freight and actually performing significant amounts of loading and unloading of their trucks were identified in two commodity groups: 1) household goods moving van drivers who do both loading and unloading, and 2) grocery haulers who tend to do more unloading than loading. In the movement of household goods and other furniture, large numbers of van drivers are involved almost daily in actual loading and unloading of substantial amounts of cargo. Many, but not all, grocery industry drivers occasionally unload, breaking out items from pallets and re-palletizing to fit store or warehouse requirements, or even completely unloading pallet contents, one carton at a time, at grocery stores without delivery docks.

From the focus group interviews it appears that when drivers discuss "loading and unloading," they often refer to it in a general sense, not only to their own physical labors associated with moving freight onto or off of a truck. They are really thinking of the whole general process of loading and unloading, including meeting dock appointments, waiting and moving the truck in queues, counting loaded items, processing cargo shipping or receiving paperwork (e.g. bills of lading, or chemical cargo analysis results etc.). By far, many more complaints were encountered

from drivers regarding the fatigue effects of frequent lengthy "waiting periods" for loading - unloading than were complaints of getting tired from actually physically performing the loading and loading of cargo. Many drivers suggested the amount of time expended in doing loading and unloading noticeably cuts into their time for rest between drives.

Physical fatigue. Truck drivers, when asked specifically whether the amount of physical labor associated with loading and unloading plays a role in driver fatigue, gave mixed responses. Some drivers indicated a certain amount of physical activity during periodic loading and unloading of trucks gives them a physiological boost, akin to an adrenaline rush, and therefore helps them to be more alert on subsequent drives, at least, they claim, for about one to two hours. Many drivers suggest that regularly scheduled physical activity associated with loading and unloading helps them to stay in good overall physical shape, and therefore from a simple wellness or physical fitness standpoint, they contend it is good for drivers to do such work.

Other drivers, particularly those whose jobs require considerable amounts of loading and unloading (e.g. household goods moving and grocery delivery) claim they routinely expend large amounts of physical energy in loading and unloading cargo or freight. They claim they become fatigued during and after the task because of the amount of physical work they perform. In some cases they claim this affects their driving alertness. Drivers described how their long bouts (2-6 hours commonly reported) of physical work make them acutely tired, and how they must be careful not to over-extend themselves when they drive over-the-road after such physical work. Sometimes their schedules do not permit much choice but to begin their long drives shortly after expending large amounts of physical energy in the loading/unloading process. These are the drivers most at risk that physical fatigue contributes to their general mental fatigue behind the wheel of the truck.

Thus, the effects of large amounts of physical labor preceding long haul driving were reported to vary, depending upon the cargo commodity being delivered, and upon other factors (e.g. delivery procedures, time of day of driving etc.).

Behavioral task analysis. The behavioral task analysis of drivers loading and unloading trucks studied household goods moving activities; grocery delivery; beverage delivery; fast food supply delivery; and tank truck carrier operations; each was chosen to represent work settings where loading and unloading are significant parts of truck drivers' jobs. Video recordings and behavioral observations were analyzed and narrative descriptions of all driver loading/unloading tasks analyzed are presented in this report. A behavioral taxonomy of loading and unloading tasks and activities was developed. Estimates of frequency and duration of these tasks and activities and approximations of the amount of physical energy expended in their performance were made to permit characterization and comparison of a variety of loading/unloading situations across commodity types and trucking industry segments.

Implications for further research. The overall results of the industry characterization study (Phase I, Tasks 1, 2, & 3) suggested:

a) It would not be fruitful for FHWA-OMCHS to expend large funding resources for field experimentation to examine long haul driver fatigue effects as a function of the physical labors of drivers loading and unloading trucks across most of the long haul trucking industry, because they simply do not engage in that activity very much; and

b) On the basis of the behavioral task analysis data collected, if FHWA-OMCHS chooses to explore further the relationship between the physical labor of loading and unloading and driver fatigue, then the grocery and household goods moving industry segments should offer a clear test case for exploring the extent to which loading and unloading contribute to driver fatigue.

At the conclusion of Phase I of the study research recommendations were presented to FHWA-OMCHS (Phase I, Task 4, O'Neill et al. 1997) containing options for Phase II of the project. The recommendations were incorporated into the Phase II study which was reported in FHWA Report No. MC-99-140 by O'Neill, Krueger, Van Hemel, and McGowan (September, 1999).

Section I. Review and critique of the literature: Effects of physical work and sustained performance on driver fatigue, alertness, and driver safety (Phase I, Task 1)

Introduction

Safety concern over truck driver fatigue

Safe highway driving requires conscientious drivers who: a) are continually alert and attentive to driving tasks on the road; b) have unimpaired judgment and quick reactions to dynamically changing highway and traffic situations; c) follow the "rules of the road;" and, d) adhere to safe practices in interacting with other drivers, vehicles, and the physical environment. Fatigued or drowsy drivers, who are unable to maintain high levels of driving alertness because they are physically or mentally tired, will likely compromise some or all of the four safety considerations above. Fatigued drivers typically have slower reactions, are less attentive, exhibit poorer driving judgment, and may become involved in highway accidents because they are not fully alert.

Fatigue research and countermeasures program

Current U.S. Department of Transportation's Federal Highway Administration (FHWA) motor carrier safety programs increase government and industry attention to the topic of *driver fatigue* and address concerns over vehicle operator wakefulness, alertness and attention to safe driving on our highways. The FHWA's Office of Motor Carrier and Highway Safety i(OMCHS) Research and Standards Division sponsors a multifaceted R&D program on *Driver Fatigue*. The driver fatigue program focuses on identification of operational and environmental factors that affect commercial motor vehicle (CMV) operator alertness and readiness to drive; and develops countermeasures to ameliorate commercial truck driver fatigue as a major safety concern on the nation's highways. FHWA research projects include studies of driver over-the-road performance, simulator studies of varying sleep schedules, epidemiological surveys of the incidence of driver sleep disorders, survey assessments of the availability of trucker rest stops, evaluations of fatigue management technologies, etc. (Knipling, 1999).

One of OMCHS's initiatives: "*Effect of Cargo Loading and Unloading on Driver Fatigue*" is a research project which strives to determine the relationship between CMV driver non-driving duties, such as loading and unloading activities, and subsequent driver alertness or fatigue when he/she drives. This notion presumes there is a relationship between driver duty time spent performing physical labor involved in loading/unloading truck cargo (i.e. expending energy) and development of general mental fatigue which can adversely affect driving alertness and performance. The principal question posed by OMCHS and other interested parties is: *What effect does loading or unloading the truck have on truck driver alertness and/or fatigue during subsequent driving, and how does it affect performance*?

Driver loading/unloading project

To study driver loading/unloading issues as they pertain to America's long haul trucking operations FHWA-OMC issued a research grant to the American Trucking Associations Foundation's Trucking Research Institute (ATAF-TRI). TRI subsequently sub-contracted human factors researchers and ergonomists at Star Mountain, Inc. (SMI) in Alexandria, Virginia to conduct much of the work at various stages of the project. The TRI-SMI project on driver loading and unloading began in mid-summer of 1996.

The methods, practices, and procedures of driver involvement in loading and unloading trucks differ across various segments of America's trucking industries. The project therefore aimed to identify and assess some of those differences, especially in terms of the physical labor requirements for drivers who load and/or unload their trucks before driving. The principal concern was to determine whether or not driver loading and unloading practices contribute to driver fatigue, and subsequently affect driver alertness on the highway. If driver loading and unloading does contribute to fatigue and adversely affects driver alertness, then the goal is to propose and test countermeasures.

Goals and procedure

The project goals included delineating the behavioral and physiological impact of commercial drivers loading and unloading their trucks prior to driving those vehicles for extended periods on the highway. The literature review and critique presented here constitute Task I, an initial portion of the fact-finding segment of the project. The focus of this review concerns the relationship of physical fatigue to development of general mental fatigue and its importance in driver alertness and driving safety.

SMI researchers screened several technical literature data bases, accomplished library and on-line searches, and reviewed numerous technical articles and reports examining physiological and behavioral approaches to the study of physical fatigue, particularly that which develops from activities like loading and unloading. SMI reviewed and critiqued the scientific literature (physiological and behavioral) relating expenditure of physical energy in work tasks similar to loading and unloading trucks to anticipated physiological and behavioral effects on operator alertness and performance.

This literature review was conducted in 1996-97 and a report submitted by ATAF-TRI to FHWA-OMCHS in March, 1997 (Krueger & Van Hemel, 1997). Thus the references cited here are current through 1996.

Topics covered in this review

The literature review focuses on describing the relationship among the amount and intensity of physical work (e.g. those activities which may be similar to loading and unloading trucks) and its

contribution to subsequent operator fatigue in performance of job tasks. Attempts are made to draw parallels from the scientific literature to the tasks of truck drivers who load or unload before highway driving. Topics covered in this report include such considerations as:

1) the relationship of physical work (activities or exercise of varying intensity and duration) to operator fatigue and performance.

2) the workers' state of physical fitness for doing such labors; the relationship of physical fitness to general-mental fatigue, and parallels to truck drivers.

3) the amount of loading and unloading (frequency, intensity, duration) accomplished by a worker during a workday or a workweek; parallels to work by long haul, over-the-road truck drivers.

4) the worker's schedule mix, including the work/rest schedule, the amount of sleep obtained, time of day of working/sleeping etc.; parallels to long haul truck drivers.

Before beginning the presentation of the research literature, the following section reviews some aspects of loading and unloading as they relate to truck driver fatigue, and illustrate some of the varying opinions on the issues.

Relationship of loading/unloading to driver fatigue

Issues of commercial driver fatigue involve many behavioral and physiological variables, among them: the truck driver's daily and weekly work schedule (on- and off-duty time and activities); the amount of driving per day and during an entire work-week; the time-of-the-day of the driving; the driving environment (terrain, road type and condition, traffic, lighting, weather); the amount of previous rest and sleep obtained by the driver; and the driver's psychological frame of mind or state of alertness (as affected by stress levels or motivational factors) at the wheel.

Although reports presenting highway accident statistics implicate truck driver fatigue as a highway safety concern, there is little published information showing whether or not one of the prevalent non-driving activities, i.e. drivers loading and unloading cargo/freight in their trucks, contributes significantly to development of driver fatigue on our highways. In many work settings across America a substantial (but not quantified) number of long haul or "over-the-road" truck drivers, and most assuredly many short-haul/local delivery drivers, do considerable amounts of loading and unloading of cargo onto, into, or out of their trucks as part of their job duties delivering the bulk of our nation's goods and products.

Truck driver loading and unloading activities

In portions of the long haul trucking industry many truck drivers manually lift and carry numerous boxes, crates, sacks, bags, or other containers of such items as perishable produce, tins of groceries, flour, fertilizer, miscellaneous goods and freight of all sorts and place them into

truck trailers. In some delivery arrangements drivers often unload their own trucks at delivery stops, where they move the cargo to the tail end of the trailer, or set the cargo onto a warehouse dock, on the ground, or carry it inside a building. Some drivers operate hand-towed electric pallet jacks to load/unload pallets of freight from their trucks. In some instances they operate the shipper or receiver's fork or pallet lifts to do these tasks. Drivers who operate tank trucks to haul fuel, chemicals, other liquids, and bulk materials often heft and hook up heavy hoses while climbing about tank trailers to load or unload hazardous materials, to perform equipment and load safety checks, or to extract cargo samples for chemical verification tests.

Drivers working with cargo loads requiring specialized carriers and riggers must secure heavy tarpaulins or ratchet chain tie-downs over bulky loads of pipe, lumber, construction materials, heavy or bulky machinery. Truck drivers who deliver automobiles regularly use chains and leverage crank bars to secure the automobiles on car carrier trailers. Drivers for van lines pack high value products such as electronics equipment and instrumentation and then deliver such heavy equipment into tall buildings by using dollies and freight elevators. Countless other van line drivers pack and secure household furniture loads onto trucks. They drive cross country, and often carry bulky boxes and furniture items up several flights of stairs to deliver them to customers' new residences.

In short, much of what gets delivered in our country gets delivered by truck, and a sizable but undefined proportion of the cargo at both pick-up and delivery is handled by the truck drivers themselves.

Truck driver opinions differ on loading/unloading

As an initial inquiry into these topics (during Phase I, Task 2) Star Mountain's human factors team administered questionnaires, interviewed numerous truck drivers, and conducted focus group discussions in several different settings (August-December 1996) to ask hundreds of drivers about their experiences and opinions regarding loading and unloading trucks. The driver interview and questionnaire data produced very mixed reviews of the impact or effects of loading and unloading trucks on subsequent driver fatigue (Van Hemel & Krueger, 1997).

Generally, *two groups of driver opinions* were encountered. There are those drivers who think a moderate amount of loading and unloading associated with their jobs makes them more physically fit and alert. These drivers contend it is desirable to do some loading-unloading on a regular basis because it helps them maintain personal physical fitness and driver alertness. On the contrary, drivers who complained that they do a large amount of loading and unloading, much of it physically demanding work, claim it makes them pretty tired, even fatigued. They indicated that depending upon when in their work schedule this loading and unloading activity took place, it could make them fatigued to the point of degrading their alertness for driving.

A common belief which drivers seem to hold is that the physical activity associated with loading the truck stimulates the body, and stimulates driver alertness for the first hour or two of subsequent driving. Then this heightened alertness slackens off, perhaps because the physical

stimulation has "worn off" while the driver sits in the truck cab on the highway; and they say fatigue then sets in with a vengeance.

TRI-SMI administered a questionnaire about loading and unloading trucks to over 350 drivers at the ATA-sponsored National Truck Driving Championships in Columbus, OH (August, 1996). One of the questions asked was: *does the physical activity in loading and unloading make you more or less alert for subsequent highway driving?* Numerous truck drivers who stated that loading and unloading *makes one more fatigued* answered the question in the following ways:

> ...it makes me less alert when loading or unloading, especially in the summer; the trailers are extremely hot, so naturally, along with the physical work is the exhaustion from being in the extreme heat.
>
> ...too many big boxes can make you tired and weak.
>
> ...you get tired from working the dock, then have to drive 400 miles.
>
> ...after loading my runs for each day, my general physical condition is not the same as I had when I reported for work.
>
> ...in many cases we are required to be suited in full chemical protective gear. It takes a lot out of one's body on hot summer days due to dehydration (tank truck driver).
>
> ...if you unload a truck at multiple stops and you physically unload the load, it takes away from you mentally and physically after working 12 hrs or more.
>
> ...10 hours of sorting and segregating is a lot of exercise for one person and will cause fatigue or exhaustion.
>
> ...we are unable to rest due to the need to move the truck in lines (queues) constantly as trucks await their turn to be loaded.

By contrast, many drivers who touted *some advantage in terms of driving alertness* to doing some amount of loading and unloading answered the question this way:

> ...when you unload you get your blood going a little faster. It helps you get motivated.
>
> ...wakes me up, gets the blood flowing after a 2-hr drive to the first stop (usually at 1 or 2 AM in the morning).
>
> ...when you make as many as 30 stops per day, you don't get fatigued as you would if you had a lot of idle time. We are constantly on the move (short haul driver).
>
> ...it breaks up boredom and keeps you in shape more physically.

...the more you use your muscles the better you feel and the stronger one becomes. A weak person is less alert, because he is fatigued from straining his muscles.

...it doesn't matter. I am always alert because my job depends on it. If I do become tired or fatigued I will stop my vehicle and rest.

Preliminary assessments of the questionnaire and interview data make it clear that driver responses differ along at least *three identifiable dimensions* which portray considerable experiential differences across our nation's diverse trucking industry. Driver opinions about loading/unloading differ as a function of the:

a) ***type of cargo/freight commodity*** being hauled: e.g. perishable produce, meats, frozen goods, processed canned groceries, heavy bulky equipment, machinery, bulk freight, furniture, construction supply materials, hazardous chemicals, liquids, etc.;

b) ***type of truck or equipment being driven***: e.g. flatbeds, refrigerator trucks, dry vans, tank trucks, car carriers, etc.

c) ***procedural and methodological features of particular loading situations***: e.g. shipper or receiver expectations of driver involvement or non-involvement in the actual loading and unloading process; the use of shipper or receiver staff personnel or lumpers to do the physical labor; the availability and permissive use (by carrier drivers) of loading and unloading equipments such as forklifts or electric jacks; whether or not delivered load pallets must be broken down and re-palletized by the driver; or the particular configuration of unloading docks or other delivery locations (e.g. delivering upstairs inside a building vs placing loads on a warehouse floor, vs gravity feed of bulk materials into a storage tank or grain elevator, etc.).

The above descriptions point out a *diversity of dimensions for subject matter* pertaining to driver issues on loading and unloading. A more complete analysis of the questionnaire data is presented in the report for Phase I, Task 2: Characterization of loading/unloading procedural differences in segments of the trucking industry (Van Hemel & Krueger, 1997) covered in detail in Section II of this report.

Before exploring many of the dimensions of loading and unloading identified above, it seems useful to describe some of the basic behavioral and physiological science literature on *operator fatigue*, its development during *sustained work* conditions and how it is affected by substantial amounts of *physical work* such as loading and unloading trucks. Additional dimensions of the issues then can be examined to determine how they affect work and fatigue on the job and their relationship to driver safety on the highway.

Physical and General-Mental Fatigue and Loss of Alertness

Defining fatigue: subjective and inferred?

Fatigue (physical or mental) is predominately subjective, and it is hard to measure or quantify; rather, *it is an inferred physiological and psychological state.* Holding (1983) indicates that "fatigue" may be regarded as an *intervening variable or a hypothetical construct*, similar to hunger or associate strength. Just as hours of food deprivation operationally define hunger, then hours since the last period of sleep, hours on the job, or hours of performing work are often operationally used in research reports to specify the "amount of fatigue."

Researchers operationally define and manipulate the "fatigue state" of individuals in terms of independent variables such as: how much sleep they have missed (*sleep debt*); how long they have continuously worked at particular tasks (*time-on-task*); the mix of physical or cognitive demands of work (*workload*); how long it has been since they have had a work break or an opportunity to go away from the work place for a rest, or sleep (*sustained performance, or sustained operations*); the non-stop team approach to accomplishing a goal whereby teams of operators spell one another in work stations until the goal is reached (*continuous operations*); and subjectively, the degree to which individuals report they are tired or fatigued (*subjective fatigue*) usually on a self-report rating scale (for a review see Krueger 1989, 1991).

The inferred physiological or psychological state of fatigue is of interest to us mainly because of its potential to affect task performance. The dependent performance variables that have been used to evaluate this effect in a research participant include: his/her alertness, attentiveness, quickness to respond correctly, other measures of performance goodness (quality and quantity) or accuracy, and his self-report of subjective fatigue. How fatigued an operator must be is usually inferred from how well or poorly he is performing. That is, typically *an operator's level of fatigue is operationally defined in terms of how poorly he/she performs as a function of time-on-the-task, the time of the day of the testing (i.e. circadian rhythms), the length of time since the last quality sleep, and other independent experimental variables.*

From the scientific literature on the subject, it is clear that "fatigue" is not a simple unitary hypothetical construct. It is a complicated psychological and physiological state of operator readiness to perform well at sustained task requirements. In this literature review the specific concern is: *what effect does this physical work, especially in conjunction with sleep loss, sleep disruption, or sustained performance requirements, have on general-mental fatigue, subsequent driving alertness and performance? Specifically does performance of physical work (i.e. loading/unloading) relate to the development of fatigue - especially general-mental fatigue which might be detrimental to a driver's alertness at the wheel?*

To address this topic as it pertains to CMV drivers, it is important to differentiate among several forms of fatigue that affect operators of transportation vehicles and other equipment. Broadly considered, fatigue can imply: 1) muscular tiredness (*physical fatigue*) because of sustained

strenuous physical activity; 2) feeling and acting tired or weary (*mental fatigue*) after repeated performance of routine tasks (usually mental or cognitive tasks rather than physical ones), or because of boredom at the lack of novel stimuli; 3) feeling sleepy because of the effects of sleep deprivation (because usual amounts of sleep were missed, or insufficient quantity or quality of sleep required to maintain alertness was obtained and is now needed) which often leads to intermittently poorer cognitive performance (*phasic mental fatigue*). These three facets of fatigue together can make up what is commonly called "*general fatigue,*" which when accompanied by loss of alertness in driving is of concern regarding driving safety (Krueger, 1989, 1991).

Physical fatigue

Physical fatigue may be thought of as the temporary reduction or loss of power to respond, induced in a sensory receptor or motor end organ by continued stimulation. It is the muscular tiredness and soreness one feels after sustained vigorous exercise or performance of demanding physical tasks such as repeated lifting, carrying and moving heavy objects, or digging, climbing etc. Most physiologists describe *physical fatigue* as a decrease in physical performance tied to developing oxygen debt and accumulating lactic acid[1] in the muscles (Simonson, 1971; Simonson & Weiser, 1976). Kroemer et al. (1990) define physical or muscular fatigue in terms of a state of reduced physical capacity associated with a change in the response of the biomechanical or physiological subsystems.

Other physiologists are less certain in their definitions of physical fatigue. Christensen (1960) for example defined physical fatigue as a state of disturbed homeostasis[2] due to work and to the work environment which gives rise to objective as well as subjective symptoms (the latter are seldom considered by physiologists). Astrand and Rodahl (1977) stated physiologists do not fully understand fatigue but they are certain the fall in the blood sugar observed in a fasting subject engaged in prolonged submaximal work lasting several hours causes disturbed homeostasis in the central nervous system, leading to a feeling of fatigue as a symptom of hypoglycemia[3]. It is also clear the accumulation of lactic acid in muscles engaged in intense work involving anaerobic[4] metabolic conditions is a sign of disturbed homeostasis leading to symptoms of local fatigue (Astrand & Rodahl, 1977).

When a person is *physically fatigued*, he/she subjectively feels physically expended, unable any longer to perform desired physical tasks, accompanied by claims that "I am physically exhausted." Generally, someone who is physically fatigued will encounter feelings of task aversion, and will likely strive to be allowed to stop performing the fatiguing work (Pearson, 1957; Grandjean & Kogi, 1971); or will just quit on his own volition. Bartley and Chute (1947)

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[1] Lactic acid: metabolic products of anaerobic muscle exertion; a build up of lactic acid in muscle causes discomfort and loss of capacity for further activity

[2] homeostasis: maintenance of normal internal biological stability in an organism

[3] hypoglycemia: feelings of weakness, hunger, dizziness resulting from reduced blood glucose

[4] anaerobic: using of predominately short term high intensity muscular power

and other behavior theorists attribute such reluctance to perform physically during continued exercise to "reactive inhibition" and thus avoid invoking the more complex idea of fatigue.

Cameron (1973) suggests many stressful situations, including those of extensive use of the muscles, are accompanied by high arousal. Since many forms of sustained physical effort are consistent with high arousal, as individuals attempt to respond to task demands, increased effort is generally necessary to maintain adequate performance over a prolonged period of time. Cameron suggests "anxiety levels" or expectations to perform motivate a person to continue even in the face of acute fatigue (on both physical and mental tasks).

Other behavioral scientists are also quick to point out that physical fatigue, prior to actual measurable muscular exhaustion, seems to be partially controlled by cognitive (mental) components such as motivation, instructional set, and the individual's tolerance of pain or discomfort (Holding, 1983). Thus, it is not uncommon for a person claiming to be physically exhausted on the job, when offered an opportunity to participate in a team sporting event at a lunch time break or after working hours, to subsequently perform vigorously, and seemingly painlessly, in a very physical game (e.g. volleyball or softball). In fact, they may use the very muscles they claimed were tired and on the job at least, could do no more. Likewise, when marathon runners run about 18 miles of their race and hit the so-called "physiological wall" (when much of the intramuscular glycogen stores in the legs have been expended, resulting in muscular fatigue), continue their race for another 8 miles because of their high levels of conditioned training and motivation to succeed.

Mental or cognitive fatigue

Mental or Cognitive Fatigue, two terms often used interchangeably, refer to the subjective feeling of weariness which accompanies repeated performance of almost any nonphysical task. Sustained performance requiring one to repeat similar tasks often brings on feelings of monotony and boredom, which can be accentuated by tiredness or drowsiness, especially that attributable to missing sleep. Mental fatigue may be the consequence of continuously high levels of information load (Hockey, 1986), and is typically a by-product of hours of continuous cognitive work (mental tasks entailing vigilance, attention, logical reasoning, and judgments).

Mental fatigue results in decreases in functioning of our cognitive (as opposed to physical) processes, and thus can directly affect mental task performance. After prolonged cognitive activity the symptoms of mental fatigue are manifested through a general slowing of response time to stimuli, poorer and decreased performance in the form of irregularities in timing, speed, and accuracy (usually more errors of omission), restricted field of attention, poorer conceptualization or planning of activities than when fully alert, decreased motivation, and subjective feelings of fatigue (Bartlett, 1953; Grandjean & Kogi, 1971; Krueger, 1989, 1991).

General mental fatigue

General-mental fatigue is sometimes viewed as a "whole" symptom felt throughout the body and mind, an interrelationship that governs the consciousness of tiredness (Bartley, 1965). Bartley said fatigue includes physiological changes in internal organs reflected as an overt behavior disorder in work decrement, or as psychological changes manifested in personal dissatisfaction. Alternatively, Grandjean (1968) interpreted *general fatigue* simply as a consequence of reduced afferent impulses or reduced feedback from the cortex to the reticular activating system in the brain. Cameron (1973) highlights the importance of elapsed time and activity engaged in at the time. Cameron broadly conceptualizes *fatigue* as a generalized response to psychological and/or physiological *stress* over a period of *time*, with effects that may be either *acute or chronic*, or both. These effects may be confined to the subjective state of the individual (I feel tired) or may extend into measurable aspects of his or her performance (cognitive performance gradually degrades). He also indicates there is often an emotional state, such as *anxiety*, present during the experience of general mental fatigue.

Boredom

Boredom is not considered to be fatigue per se, but it is often considered to be a major contributor to development of general-mental fatigue. Boredom is sometimes described as the result of a requirement to maintain attention, especially vigilance attention, in the absence of relevant task information. Boredom often occurs when doing inherently uninteresting tasks in which the stimuli do not change in appearance very much or very frequently, such as watching a computer screen of radar or sonar data, or perhaps repeatedly driving on the same road and viewing the same roadside scenery. Boredom can become apparent within minutes of the onset of a task thought to be monotonous (O'Hanlon, 1981), and in visual monitoring tasks in which the viewing display does not change much, plays a part in vigilance decrements typically observed after twenty minutes on task (Mackie, 1977).

Phasic fatigue

Phasic fatigue, a special case of general-mental fatigue, is a phrase sometimes used to refer to fundamental changes in the level of system efficiency in human attentiveness. Hockey (1986) describes phasic fatigue as short term fatigue resulting from prolonged vigilance work in which the worker occasionally exhibits an unusually long response time, misses signals, exhibits brief interruptions in performance (due to lapses in attention), or merely slows down, makes more errors of choice, or maintains accuracy but sacrifices speed of performance, and consequently accomplishes less work per unit time (see seminal work on this topic, especially sleep lapses, by Williams, Lubin & Goodnow, 1959). Sleep deprivation has been studied in relation to phasic fatigue. The intermittent lapses in performance associated with phasic fatigue generally occur more frequently, and are more pronounced, the longer the duration of sleep deprivation (Babkoff et al., 1985). When performance lapses become more frequent in severely sleep-deprived individuals the evidence of a lack of alertness becomes more obvious.

Perception of physical fatigue and motivational determinants

The importance of "perception of fatigue" was illustrated in two studies with physically fit marines working two 20-hour workdays. In the first study the marines carried 48.5 lb (22-kg) packs and walked on treadmills at 4 miles/hour up to 40% of their VO_2max[5] in sixteen 30-minute sessions, each of which was alternated with 30 min. cognitive test batteries. The remaining 4-h of the work day involved two 30-min meal periods, a 45 min break and hook up of instrumentation etc. The two continuous work days were separated for one group of subjects by a 4-hr sleep period and for another group by a 4-hr of (non-sleeping) rest (Ryman, Naitoh, & Englund, 1989).

Most subjects could not maintain the 40% VO_2max workload past the first eight sessions, and the treadmill grade and speed had to be adjusted downward to a rate subjects could maintain for an entire 1/2 hr treadmill walk session. Half the participants in either group could not maintain the 40% VO_2max workload through half of the second continuous work day. The subjects' ratings of perceived exertion (RPE) correlated positively with increased ratings of fatigue, sleepiness, and negative mood, and correlated negatively with vigor in most periods on the first workday. RPEs decreased at the beginning of the second day but showed no greater recovery by subjects who had 4-hr sleep the night before than by those who had only 4 hr rest. That is, the 4-hr of sleep did not reduce subjective perception of fatigue to less than that reported by subjects who had no-sleep.

In the second experiment, the treadmill grade and speed were reduced (to approximately 30% of their VO_2max). One group of subjects began their work at 1300 hr while another group started at 2400 hr; each group was permitted 3 hrs of sleep between the two continuous work days. Almost all subjects working at this lower oxygen consumption rate completed two full days of continuous work. Subjective ratings of perceived exertion (RPEs) increased linearly through each day with submaximal exercise, even though the workload was decreased from Study 1. At this lower work intensity, RPE correlated poorly with actual workload and the generally lower heart rates, but seemed more helpful in reflecting the subjects' psychological factors such as mood and sleepiness. In this second study, the afternoon start vs midnight start conditions produced no changes in the pattern of perceived exertion. Any circadian effects were obscured.

Ryman et al., (1989) concluded: "initial increases found in RPE the first day with repeated exercise appear to reflect the workload and physiological conditions only at higher workloads. At lower levels of workload, RPE reflects psychological fatigue and sleep loss perceptions after some initial continued repeated exercise." As an aside, in these studies, treadmill walking did not accentuate or attenuate sleep-loss effects on the cognitive performance tests (Englund et al., 1985).

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[5] VO_2max: a standardized reference measurement of a person's maximum oxygen uptake capacity which reflects a person's overall fitness and is used here to define an intensity level of work.

When we feel physically tired, or are especially muscularly fatigued from sustained physical effort, we generally decide to stop working to take a *break or a rest.* A repeated question of interest to those who study muscular fatigue is: *when does physical (muscular) fatigue actually occur?* Eventually in sustained arduous physical work the worker reaches a point at which he/she decides muscular work is uncomfortable or painful to continue, or is no longer possible, or simply the motivation dissipates and they do not want to continue. This point of *decision to stop working often occurs well before the measurable physiological limit of muscular fatigue has been reached.* People are apt to claim to be exhausted and "quit" doing muscular work long before the muscles (electrophysiologically) indicate they should be physically fatigued.

There is clear indication that central, cognitive control (*motivation*) often prevails over peripheral "end organ" control of physical fatigue. For example, Caldwell and Lyddan (1971) showed that the "maximal pull" of a dynamometer handle was greater if subjects "expected" longer rest pauses between trials. Feeling tired does not necessarily correlate with physiological impairment, nor with reduced efficiency in work output for other kinds of human performance. Physical fatigue, and even discomfort or pain, can be quickly ignored to respond to an emergency or while acting out an excess of enthusiasm for some situation (Holding, 1983). Fatigued workers can be seen to vigorously participate in some sporting activity "on break." Thus, *personal motivation* plays an important role. However, peripheral physical fatigue is not so likely to be a factor in everyday performance, since physical fatigue effects are not often observed outside very high workload conditions, such as endurance athletics (Holding, 1983).

Cognitive (*motivational*) influence over general-mental fatigue

As with motivational variables associated with physical fatigue, the issue of central cognitive control versus peripheral "end organ" control arises with regard to *general-mental fatigue* as well. In an attempt to define fatigue, Cameron (1973) points out that many people fail to recognize what a complex biological phenomenon it is. He writes that humans are both adaptive and purposive in our behavior: if the demands of the task are high, a worker can respond with greater effort; if the incentives to continue working are high, he/she can maintain this effort over a very long period (motivation). The worker also responds to the stimulation provided by interesting and challenging tasks even when he/she must put himself under some stress resulting from prolonged efforts to adapt to abnormal circumstances (Cameron, 1973).

Bartley and Chute (1947) contend that fatigue represents a form of conflict between the demands of the task situation and the subject's aversion to effort. After 24-32 continuous hours on a multiple-performance battery (by necessity accompanied by significant sleep loss) fatigued subjects are more likely to choose a *strategy* of low effort/low probability of success even when probability of success corresponds to effort exerted (Holding, 1974). Hockey (1986) says prolonged periods of cognitive overloading put individuals into states where any further effort to meet task demands is aversive. This normally leads to shortcuts and inconsistent application of task-related behavior, and is considered by Hockey to be a *strategic change* rather than a fundamental reduction in operating efficiency. Some researchers would simply describe this phenomenon as changes in *motivational state.*

Haslam (1985) showed that sleep deprived soldiers in an *anticipatory way* improved both their physical and their cognitive performance after merely being told that a nap would soon be permitted. Thus the centralized notions of "aversion to effort," and "motivation," and the influence of "individual strategies" for performing are pertinent to both physical and general-mental fatigue.

In addition to the more direct effects of physical and cognitive fatigue described above, studies of skilled performance (like driving) over prolonged periods show that workers may also *change their patterns of attention* during sustained work. As early as the 1940s, Bartlett (1942) noted that as fatigued pilots got more tired, even though they seemed to be "flying okay," they began making larger control movements (scored as errors), different from the fine motor control movements they made when they were alert, though the large movements were generally less frequent than the fine movements. Bartlett's tired pilots also exhibited less accurate timing of coordinated movements and maneuvers. Infrequently attended instruments and actions were more likely to be ignored, as if the pilot had chosen not to look at them. Marked irritability in the pilots was another concern mentioned by Bartlett. These early aviation findings by Bartlett have been supported by more recent studies with military helicopter pilots (Lees et al., 1979, Krueger et al., 1985).

In early research on truck drivers, Herbert and Jaynes (1964) demonstrated that performance of Army truck drivers on psychomotor tasks declined after they drove only one hour, and such degradation progressed somewhat for periods up to nine hours, except for performance on the ninth hour itself, no doubt an end spurt effect. Ellinstad and Heimstra (1970) used a general laboratory psychomotor tracking device to examine paced contour tracking performance with variable tracking target speeds (Poulton, 1954) over a 15-hour session (3 blocks of hrs each separated by 15-minute breaks). Secondary tasks, including reaction time (RT) to vigilance stimuli and two measures of mental alertness (mental multiplication and digit span) were incorporated in the subjects' workload. Two separate measures of tracking performance were available. Ellingstad and Heimstra found a relatively steady decrement in performance for each of the two measures on the primary tracking task for about the first eight to nine hours; whereas performance on the subsidiary tasks was variable with no apparent decrement - rather on vigilance and RT there were improvements in performance. Then after the 15-min. break after 10 hours of work there was a general leveling of tracking performance through the 15th hour. The subjects seemed to change strategies and make tradeoffs in terms of increasing the "number of times on the target" vs the "time duration off tracking targets" over the course of the fifteen hours. As time in the experiment progressed, control movements were less smooth, and even involved some "dither." Ellingstad and Heimstra (1970) concluded their work illustrates the complex relationship between the "fatigued" state of the organism and performance. The effects of fatigue on performance are differential and may be dependent upon task characteristics such as task type, level of complexity, whether the task is primary or subsidiary, and what strategy the operator takes in approaching his/her task load.

Mackie and Miller (1978) demonstrated that Bartlett's observations on timing of coordinated movements relate to truck driver steering wheel movements on sustained drives, too. They found drivers on irregular work schedules exhibited lower levels of fine steering during late night trips and significant decreases in fine steering after only 5 hours on late night trips, as compared to 8.5 hours when operating on regular schedules. They also found earlier appearance of coarse steering after 4-5 hours compared to 8.5 hrs; with significant increases during late night/early morning trips. Mackie and Miller's (1978) truck drivers also demonstrated the importance of circadian rhythms in time-of-day effects and cumulative fatigue over 4-5 days of driving.

Such studies of general-mental fatigue effects on vehicle operator performance are obviously directly pertinent to questions of truck driving performance in OMCHS's sequence of studies of truck driver fatigue.

Sleep loss, fatigue and sustained performance

Driving a truck hundreds of miles on our nation's highways, or in busy city traffic, involves significant amounts of sustained sensorimotor, psychomotor, and cognitive activity. Truck drivers must continually be concerned with their ability to respond quickly to changing stimuli, to quickly anticipate, recognize and correct deteriorating driving situations (e.g. responding to other drivers' movements). Our principal concern is the effect general-mental fatigue has on these activities. It is the truck driver's ability to dynamically change the situation to be more favorable for highway safety and his/her own safety that can be threatened by driver fatigue.

Since even partial sleep loss has a marked effect on operator performance, especially the cognitive performance aspects of vehicle operation, it is paramount to understand the relationship between sleep loss and decrements in performance. Sleep loss effects on general-mental fatigue are important because many long haul truck drivers experience substantial amounts of sleep loss. Such partial sleep deprivation may be due to long working hours which include lengthy drives, non-restful waiting time at docks and terminals, frequent irregular work and sleep schedules, and unsuccessful attempts to sleep at times of day when the body is not attuned to sleeping.

Through much laboratory research the relationship between sleep loss and performance decrements on various cognitive tasks is well established. There are three mechanisms by which fatigue attributable to sleep loss causes decrements in performance: a) by causing brief "lapses" (microsleeps of 1-10 sec. duration) in EEG defined wakefulness, b) by causing a steady state of reduced arousal during EEG defined wakefulness (i.e., between "lapses") manifested by a reduced capacity for sustained selective attention, and c) by lowering mood and motivation levels, thereby reducing morale and initiative (Belenky et al., 1987). Each of these phasic fatigue mechanisms includes factors that differentially contribute to impaired performance on all tasks with sleep loss. However, the degree to which each of these mechanisms affects performance depends upon the nature of the task.

The reduced arousal and decreased capacity for sustained selective attention resulting from sleep deprivation imply a diminished capacity for efficient performance of higher level cognitive tasks

(Kjellberg, 1977). Performance on cognitive tasks requiring calculations, creativity, and the ability to "plan ahead" effectively are especially sensitive to sleep loss. However, the nature of the high-level cognitive task determines the extent to which performance will be impaired by sleep loss. For example, performance on an addition task that is externally paced (expected response speed is not under control of the performer) degrades rapidly with extended sleep loss (Williams & Lubin, 1967), but under similar sleep loss conditions, accuracy of arithmetic calculations can be maintained at the expense of "speed of calculation" in self-paced (performer determines the work pace) arithmetic tasks (Thorne et al., 1983; Babkoff et al., 1985, 1989).

Task sensitivity to fatigue

Truck drivers are faced with mixtures of self-paced and situationally-paced tasks. The truck driver can usually choose his/her driving speed on the highway within limits, making some driving tasks self-paced; if driving slow enough the driver's reaction time may be less affected by fatigue. However, most highway driving situations require maintenance of a moderately high rate of speed most of the time, and frequent perturbations in the form of rapidly developing traffic situations (e.g. another driver pulling too closely in front of the truck to exit the highway) tax the reactions of a tired truck driver, calling for rapid complex decision making and quick responses to take evasive maneuvers. In this sense, frequent situationally-paced task requirements necessitate a continued high state of alertness, quick reflexes, and accurate, timely responses from the truck driver.

Within the realm of primarily cognitive tasks there are differential susceptibilities to the effects of general fatigue attributable mostly to sleep loss. Borrowing from Johnson (1982) who catalogued aspects of tasks sensitive to sleep loss, we present here a list of truck driver task aspects which are sensitive to the general-mental fatigue attributable to combinations of sleep loss and other stressors:

- **Duration** of the task: the longer the task the more sensitive it will be to fatigue effects. Those tasks which take a long time to complete or by their very nature require sustained concentration and effort are especially affected by fatigue. Thus long stretches of attending to oncoming traffic or with-the-flow traffic in crowded high speed driving conditions can constitute long duration driving tasks. *This should be recognizable as resembling many long haul truck driving tasks.*

- **Task difficulty**: the more cognitively demanding the task, the greater its sensitivity to fatigue. A truck driver's driving tasks predominately involve continuous visual and auditory vigilance, and psychomotor tracking skills; they are not inherently difficult in the cognitive sense; but decision making aspects of driving become slightly more difficult in denser city traffic, or during rapidly changing emergency driving situations. Determining if and when to pass slower traffic in the face of oncoming traffic in the opposing lane, and on changing slopes in terrain, would be considered a difficult cognitive task while driving a loaded truck. *Truck drivers' task difficulty increases when rapid decision making is required in traffic, or*

evolving traffic and highway dynamics threaten an impending accident if evasive action is not taken.

- **Feedback**: tasks which provide immediate feedback to the operator on his or her task performance (i.e. being able to immediately recognize how well or poorly one is performing his or her work) are more resistant to effects of fatigue than those which provide no feedback. Automobile and truck driving give instantaneous visual feedback of how well the driver is doing by virtue of seeing the terrain, successfully passed, or other traffic fading away in the rear view mirror. Feedback is obtained by witnessing the accumulation of progress over the intended miles of the trip. Kinesthetic feedback is obtained from the vibration of the engine and vehicle suspension and shock absorption system when shifting gears or accelerating and the lateral acceleration when negotiating curves. Much auditory feedback (engine and cab sounds) is provided to confirm correctness of driving speed, and other immediate feedback is occasionally given when other drivers on the road honk their horns or flash their headlights to indicate displeasure at some poor driving action. Some of the feedback needed to safely operate a truck is subtle. Fatigue may reduce attentiveness to such feedback, allowing the driver, for example to be far off-center in lane tracking before noticing and correcting; or a driver may creep up in following a vehicle without awareness that he/she is doing so. *Truck drivers receive constant instantaneous sensory feedback while driving.*

- **Practice**: those tasks which have been well-learned and repeatedly practiced are more resistant to fatigue effects. This would seem to apply to most truck driving and to most accomplished truck drivers who are skilled at timing and executing control actions. *Experienced truck drivers possess highly honed driving skills involving psychomotor tracking and visual vigilance scan patterns; the first of these, "staying in lane," should be highly resistant to fatigue effects.*

- **Complexity**: those tasks which are more complex by virtue of requiring a *sequence of mental operations* or *division of attention* are especially sensitive to fatigue and particularly to sleep loss. Truck drivers regularly encounter *rapidly changing traffic situations* which at times can become quite complex, and require rapid problem solving, calling for almost instantaneous correct decision making and evasive action or dynamic changes to the direction of the truck's travel. In instances where many highway drivers are traveling at high speeds, changing lanes, and bringing about the interactive highway dynamics that only a wide variety of drivers seem capable of generating, crash-likely events usually require one hundred percent of the driver's attention focused on several simultaneously changing events. It is these complex situations to which drivers must respond perfectly, and if they are not fully alert because they are fatigued, especially when they have experienced considerable sleep loss, they can get into trouble. *Truck drivers' highway driving tasks are frequently complex and require alert driving with quick reaction times, and clear effective decision making unaffected by fatigue.*

- **Learning and memory**: those tasks which require utilization of short term memory are very sensitive to sleep loss and general fatigue. The driver's ability to learn new information will be compromised with sleep loss - therefore it may affect the driver's ability to learn and remember new directions for navigating his truck to the next delivery point; or affect his/her memory of what was just seen in the side or rear view mirrors. Sleepy drivers often report not remembering passing terrain landmarks or roadside mile markers. They frequently mention knowing they are fatigued when suddenly another vehicle "appears out of nowhere" in the lane alongside their truck and they do not remember that vehicle approaching from behind -- an indication that their rear view mirror scan patterns are waning. *Truck drivers must maintain constant alertness, including being ready to learn from evolving roadway situations, and to call upon memory for important aspects of their jobs.*

- **Work/rest schedule**: It is clear that "workload" interacts with general-mental fatigue and sleep deprivation. The degree of performance impairment depends not only upon the amount of sleep loss, time of day, and the type of job being performed, but also on the degree to which the operations being performed truly require continuous concentration and attention by the driver. Liberal use of rest breaks during long drives, whether they include sleep or simply rest, helps to maintain safe performance levels, even if only temporarily. *Truck drivers work-rest-sleep schedules vary according to job situations, but in general many truck drivers have irregular and disrupted schedules; planning for rest stops and naps is important.*

- **Circadian lulls**: Generally, performance on most tasks tends to be slightly less effective in the mid-afternoon (about 1 to 4 PM) and is even more degraded during night operations (about 1 to 4 AM; the circadian nadir) simply due to normal physiological circadian periodicity of bodily and brain functioning. These dips in performance can be significantly worsened if the operator is very sleep-deprived. *Truck drivers must learn to anticipate these circadian lulls in performance and take countermeasures to cope with them or avoid them by not driving during these hours; they are good times to take a rest break from driving, to sleep, perchance to take a nap.*

- **Other factors**: a) high levels of interest in a task will partially offset the deleterious effects of fatigue; b) high levels of motivation can improve performance under fatigued conditions; c) a noisy environment, brief exercise breaks, splashing cold water on the face, and d) consuming stimulating substances, e.g. caffeine, can all help maintain alertness, but only on a temporary basis. Performance on some tasks is more susceptible to degradation as a function of sleep deprivation than for other tasks.

Regardless of the susceptibility of particular task performance to fatigue, as a minimum, fatigue at least divides a driver's attention. That is, in addition to safely following the road on a long drive, the truck driver can be expected to devote part of his/her personal physiological and psychological resources to *fighting fatigue, and especially sleepiness*. Motivation to perform becomes weakened by the conflicting *motivation to sleep. Reductions in driver motivation and mood due to fatigue can have deleterious effects on virtually any driving task; and no amount of*

interest, motivation or personal effort of any kind will be completely effective in counteracting the effects of large amounts of sleep loss.

Truck Driver Fatigue: Physical, Mental, Or Both?

Physical and general-mental fatigue interact to affect truck driver alertness

The distinction between physical fatigue and mental fatigue is not as important in this context as is the interaction of the two. A driver's on-the-road task performance can be affected by *both* these stressors, and it is likely that they both affect driving alertness. Excessive muscular usage in loading and unloading, or just operating for long working hours doing combinations of various physical tasks, especially being seated in a truck cab for hours at a time, or working for a length of time in a hot, humid climate, all contribute to a subjective sense of physical fatigue. Cognitive fatigue, whether accumulated from lengthy vigilance tasks associated with long drives or dealing with heavy traffic, or accentuated by lack of quality sleep, contributes to the feeling of general-mental fatigue that many drivers recognize so well. Long haul truck driver fatigue undoubtedly involves *elements of both the tiredness from the expenditure of physical energy and the general-mental fatigue* which develops with extended performance requirements.

General-mental fatigue affects the ability of a driver to maintain attentiveness and to maximize use of one's cognitive processes in adhering to safe driving practices. The primary question of interest in this project is: *what impact does the amount of physical activity, expenditure of muscular energy (at the extreme - muscular fatigue) in loading and unloading of trucks have on a driver's subsequent general-mental fatigue and alertness while driving?*

Physical fatigue affects general-mental fatigue

Along with sleep loss, boredom and other variables, physical expenditure of energy and development of muscular fatigue are important contributors to development of general fatigue. Physical fatigue which develops from arduous or strenuous work (i.e. much loading and unloading of trucks) is important in as much as it contributes to the onset, development or accentuation of the general-mental fatigue experienced by truck drivers and ultimately affects their alertness and safe driving performance.

Physical fatigue takes on significance when one considers the extensive physical energy expended by van line drivers in loading or unloading household furniture; or by grocery drivers who spend hours moving heavy boxes at a myriad of delivery situations; or those who load automobile and truck tires, or compressed gas cylinders one at a time, by hand; or by a variety of other truck drivers who mention how tiring loading many types of cargo can be in hot, humid summers.

Such physical fatigue of truck drivers is dependent upon factors associated with different loading and unloading practices, methods and procedures throughout the trucking industry. The issue of

how much impact the physical work involved in loading and unloading has on subsequent general mental fatigue in the truck cab is not easily answered from existent research literature.

What does the literature tell us about doing extensive amounts of physical activity (work/exercise) and its subsequent effects on general-mental fatigue? Does such activity stimulate us, arouse us, and make us more mentally alert, as some drivers contend? Or as others have suggested does it make us physically and mentally tired, so that we become fatigued more quickly? *How much loading and unloading therefore, is too much because it makes drivers fatigued at the wheel?* If physical fatigue is impactful, what can be done to ameliorate its negative consequences? What are the break points in determining the desirable amount of such physical activity versus the amount of physical work which begins to add to the driver's subsequent general-mental fatigue during driving? Is there an optimum amount of physical activity before long drives? Are there important individual differences (such as physical fitness levels) that enter into all of these questions?

Work Physiology and Fatigue

The focus of this section of the report is to review the relationship among the amount and intensity of physical work akin to loading and unloading trucks. Such baseline information, mostly from other research communities, can be extrapolated to the contribution physical energy expenditure of drivers makes to subsequent driver fatigue on our highways. The literature reviewed here describes what is known about these topics, identifies data gaps and important issues as they pertain to loading and unloading activities of truck drivers, and specifies research objectives that should be addressed. Topics include such considerations as:

a) the relationship of physical activities (work or exercise of varying intensity and duration) to vehicle operator fatigue;

b) characterization of physical activity which is similar to that of long haul, over-the-road truck drivers, and its contribution to fatigue;

c) the state of physical fitness of the worker (e.g. driver) when doing such labors; the relationship of physical fitness to fatigue; and

d) work/rest schedule mix variables, including the amount of sleep obtained, time of day of performing work, etc.

A few basic notions regarding *work and exercise physiology* are reviewed first to assist in clarifying the relationship between: a) physical energy expended in loading and unloading a truck, or in driving one, and b) development of physical fatigue, especially as it may relate to development of general-mental fatigue which may affect driving safety.

Daily physical energy expenditure

A person's daily total expenditure of energy includes the sum of three energy forms:

1) in a person with an average activity level, approximately 60-75% is energy involved in basal and resting metabolism,

2) about 10% is thermogenic expenditure attributable to eating and consuming food; and

3) about 15-30% is energy generated during physical activity (work or exercise) and recovery.

At the low end of the energy expenditure scale, the energy baseline, the basal metabolic rate (BMR) is the minimum energy required to maintain vital bodily functions in the waking state (in this near vegetative state lying down, O_2 consumption is between 160 to 290 ml per minute). The BMR is proportional to the surface area of the body. BMR generally is 5 to 10% lower in women than for men, largely due to variation in body composition, i.e. women tend to have more body fat and less lean body mass. Generally, as we age past 40 years, BMR drops about 2% per decade, attributable to increases in body fat and decrease in lean mass (McArdle et al., 1991).

Our *resting metabolism*, e.g. sitting up awake, but not engaging in any activities, is only slightly higher than our BMR. The resting metabolism is usually measured at least 3-4 hours following a light meal. Above the BMR and the resting metabolism, a person's daily functioning metabolic rate is principally affected by four factors: physical activity, dietary-induced thermogenesis, climate, and the special case of pregnancy. The greatest influence on our daily metabolic rate is from physical activity in the form of work or exercise performed (e.g. standing, walking, running, manipulating things etc.).

Thus, the activity of *driving a truck, and especially loading or unloading one, can markedly affect a person's metabolic rate* and is important in a discussion of work activities related to driver fatigue.

Each day, many people spend as much as 7 or 8 hours sleeping or lying down, and approximately another 12 hours sitting or standing; 19-20 hours of these kinds of activities (for more than three-quarters of the day) therefore is spent in activities requiring less than a total of 2000 kcal of energy (Astrand & Rodahl, 1977): a *light expenditure of energy,* actually not much more than our resting metabolic rate (>BMR). If in our 24-hr day we add in about 2 hours of miscellaneous walking and perhaps 2 hours of other moderately busy recreational activities, our total daily energy expenditure only would be between 2200 and 2600 kcal. If this is a typical pattern of activity, such individuals, on the average are leading somewhat sedentary lifestyles, since their daily energy expenditure rarely climbs significantly above the resting level (Astrand & Rodahl, 1977; McArdle et al, 1991).

Classification of strenuousness of work

Humans are not ideally suited to be a source of mechanical power (Astrand & Rodahl, 1977) and in this respect cannot compete with modern mechanical devices such as a bulldozer, a truck, or for that matter, a forklift. The power output of an average man engaged in prolonged work over an 8-hour working day may amount to little more than 0.1 horsepower.[6] A horse may yield 7 times that amount, and an ordinary farm tractor, 70 horsepower.

Astrand and Rodahl (1977) claim that practical experience in several measured work situations indicates a workload taxing 30 to 40 percent of an individual's maximal oxygen uptake is a reasonable average upper limit for physical work performed regularly over an 8-hour working day. Similarly, Banister and Brown (1968) say that no more than 40 percent of maximal muscle strength should be applied in repetitive muscular work in which the time of each muscular contraction is about one-half the time of each period of relaxation.

The physiological and psychological effects of a given energy output (per minute, per 8 hour, per day) are determined by an individual's maximal aerobic power, size of the engaged muscle mass, working position, whether work is intermittent at a high rate or continuous at a lower intensity, and environmental conditions (i.e. high heat and humidity are impactful). In general, a person's subjective experience of a particular work load or rate of work is more closely related to heart rate than to oxygen uptake during the performance of the work/exercise, since the work pulse reflects emotional factors, heat, the size of the engaged muscle groups, etc. in addition to the actual work load (Astrand & Rodahl, 1977).

Work physiologists rate the difficulty of sustained physical activity in terms of its *strenuousness*. Work tasks are frequently rated in terms of *the ratio of work energy required to that of either the person's resting or, (depending upon the authors) the basal energy requirement (BMR),* (McArdle et al., 1991; Astrand & Rodahl, 1977; Patton et al. 1995; & numerous USARIEM reports). Various authors and different physiology textbooks differ slightly on how many work categories they list, and how they determined to label them. For our purposes, the five work levels in the table below suffice. Generally, *Very Light Work* can be defined, for men, as that eliciting oxygen consumption from a range of about 105 to 170 watts[7] of metabolic energy expenditure - amounts just slightly above the resting requirement. This equates roughly to about 0.5 liters of oxygen consumed per minute, and would be accompanied by a heart rate up to about 90 beats per minute. As the workload increases, *Moderate Work* is classed as that which expends from 325 to 500 watts of energy - a range of about four to five times the resting requirement, equating to about 1.0 to 1.5 liters of oxygen consumed per minute, and the heart rate would be about 110 to 130 bpm. *Heavy Work* is that requiring over 500 watts of energy - a range of from six to eight times the resting metabolism, and consuming from 1.5 to 2.0 liters of oxygen per minute with a heart rate of about 130 to 150 bpm (see Table 1).

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[6] 1 horsepower equals ~ 750 watts of energy, or about 645 kcal per hour (or slightly above 5,000 kcal per 8-hr day)

[7] watts are an energy rate measure: 1 watt x 0.8605 = kilocalories per hr

Table 1. Categorization of work or physical activity levels for men

Work Level	Multiple of Basal Metabolic Rate	O_2 consumption	Energy expenditure	Heart rate
Very light	1+ x BMR	~0.5 liters/min	105-170 watts	~90 beats/min
Light	~3 x BMR	0.5-1.0 liters/min	170-325 watts	90-110 beats/min
Moderate	4-5 x BMR	1.0-1.5 liters/min	325-500 watts	110-130 beats/min
Heavy	6-8 x BMR	1.5-2.0 liters/min	>500watts	130-150 beats/min
Maximal	>9 x BMR	>2.0 liters/min		150-170 beats/min

[Note: sources include: McArdle et al., 1991; Astrand & Rodahl, 1977; others. The five categories listed in the table are essentially from McArdle et al.; the cited oxygen consumption and heart rates are from Astrand & Rodahl; some authors do not refer to all five categories listed in the table.]

Generally, due to the smaller size of women and their lower level of aerobic capacity (maximal oxygen uptake and ability to transfer O_2 to muscles), work classifications in terms of units of resting metabolism are slightly lower for women compared to men (Vogel et al. 1986).

Many industrial jobs (e.g. easy assembly line tasks) and household tasks (e.g. cooking, light cleaning) require energy expenditures no more than three times our energy expended at rest; and by the above classification are therefore categorized as "light work." Other industrial job assignments which involve lifting, especially repeated lifting of big or heavy items above shoulder height, or carrying numerous heavy items for long distances, may range from "moderate" to "heavy work."

Occupational energy expenditure

Considering our daily activities, an "average" U.S. man between 23 and 50 years of age normally expends between 2700 and 3000 kcal of energy per day (5 kcal is approximately equal to one liter of oxygen consumed); whereas females generally expend less, roughly about 2000 to 2100 kcal of energy per day (Passmore & Durnin, 1955; Durnin & Passmore, 1967; Astrand & Rodahl, 1977; McArdle et al., 1991). These population "average" energy expended figures, collected 30-40 years ago, sound rather low. Such figures serve as a commentary supporting the notion that "average people" lead a rather sedentary life style.

Various energy expenditure surveys indicate differences in energy expended by workers in different occupational groups. British data from Durnin and Passmore (1967) suggest male

laboratory technicians expend an average of 2840 kcal per day, steel workers 3280 kcal, farmers 3550 kcal, and forestry workers 3670 kcal per day. In the extreme, Lundgren (1946) measured lumber workers as sometimes expending as much as 6000 kcal per day performing heavy work, prompting Astrand and Rodahl (1977) to declare that lumber work is probably the hardest form of physical work. More recently, extensive occupational medicine research determined that U.S. Army soldiers in the 8-week Ranger candidate school expend upwards of 4000 kcal per day in field exercises, and during the mountain training phase frequently expend over 6000 kcal per day (Shippee, 1993).

Thus while participating in various forms of physical activity there is a large variation in energy expenditure according to the tasks undertaken, and therefore significant variation in different jobs or occupations as well. Average caloric (energy) expenditures on different jobs vary considerably depending on such factors as the physical requirements to perform particular tasks associated with the job; individual workers' physical fitness level; worker skill in doing the tasks; the pace (intensity and duration) at which work is performed; and the duration and timing of the work day.

Comparative energy expenditure data on long haul truck drivers were not located. Almost no published figures on truck driver activities were located. It is likely that *driving a truck* would be categorized as light work; *waiting* to be loaded or unloaded in many instances probably ranges from very light to light work; while actual *loading and unloading* cargo and freight may range from moderate to heavy work depending upon the situation (i.e. how much physical work is done by hand vs using mechanical devices such as forklifts or pallet jacks). Conceivably, drivers who expend considerable effort in loading heavy, bulky furniture and household goods in large dry vans are at times working in the heavy work category.

Factors Affecting Work Physiology

Influence of body mass (mass x distance)

The energy cost of a particular exercise is generally greater for weight-bearing exercises for which a person must transport his/her body mass during the activity, e.g. walking or running. The effect of added *mass* on energy metabolism and exercise performance occurs whether a person gains weight "naturally" as added body fat or bulk, or in the form of an acutely added load, as for example, when wearing strap-on ankle weights used by physical fitness buffs. Heavier people, those with a taller, larger frame, or especially those who might be considered over-weight and not physically fit, expend a larger number of calories than a lighter weight person to accomplish the same task. This is simply because transporting their larger body mass in the exercise or work activity requires proportionately more total energy. Thus within limits, lifting or moving packages of equal weights over equal distances requires more energy expenditure by heavy workers than by lighter-weight or more physically fit workers.

Mass is also added when a worker lifts or carries cargo/freight items (e.g. boxes, etc.) associated with loading and unloading a truck. Lifting or carrying larger, heavier boxes or cargo items generally requires more energy expenditure than does moving smaller, less heavy items. Manually moving the items above chest and shoulder height requires more energy than moving packages about on the floor. The energy expended is a function of a *mass* **x** *distance* equation. Repeatedly lifting heavy packages from the floor to place them on a shoulder height pallet or onto a truck trailer bed would constitute energy-demanding work.

While truck drivers are seated in the cab and driving, their body weight is supported by the seat and the cab structure itself. The influence of body mass on energy cost in actual driving for a heavy- vs light-weight driver is probably less pronounced than it is during non-driving tasks such as loading or unloading the truck. We located no measures of energy expended while drivers drove trucks.

Intensity and duration of work

Two important factors in rating the difficulty or strenuousness of physical work for particular tasks are the *intensity* and the *duration* of task performance. The same number of calories may be expended by two workers in accomplishing the task of loading a truck, even though they work at different speeds, or *rates* of energy expenditure. For example, one worker might work quickly to completely load his/her truck in two hours (duration), thus burning calories quickly. Another worker of comparable physical fitness might work at a slower more comfortable pace and take two and a half hours to accomplish the same task, and thus burn calories at a slower rate (intensity) than the first worker. If the two workers burned an equivalent number of calories in accomplishing the task of loading the truck, then both the *intensity* of the exercise (effort expended per unit time) and the *duration* (how long one sustained a particular work rate) are

factors distinguishing the manner in which the specific task is completed, and together they determine the energy expended (calories burned).

Physical fitness, exercise and work

Many truck drivers interviewed in the ATA August 1996 National Truck Driving Championship competition in Columbus, Ohio commented on the benefits of the regular physical exercise associated with loading and unloading activities - they expressed a sense of weight control, of well-being, and pride in their personal physical fitness (Krueger & Woodle, interviews with truck drivers, August, 1996).

In the late 1990s much of the loading and unloading of trucks was seemingly done by people other than the truck drivers (see Section II of this report). There are observable differences in driver physical work expenditure. Driver loading/unloading situations may be more prevalent for short haul pick-up and delivery drivers than for long haul over-the-road drivers, but in either case, there is concern for the health, fitness and safety of drivers accomplishing such physical work, as well as a question of the impact such work has on driver fatigue.

Older drivers who are generally slightly slower and who have a reduced physical working capacity may be hard-pressed to keep pace with the younger drivers in team-driving situations. In truck driver interview sessions, many husband and wife teams painted out that it is still expected that the husband will accomplish the largest share of the loading/unloading chores. In any event, large individual differences exist in physical working capacity of individuals.

The physiological effects of exercise on the human body are well known. The changes that occur in the cardiovascular, respiratory, skeletal and other organic systems during and after exercise are described in almost any physiology or sports medicine book (e.g. Astrand & Rodahl, 1977; McArdle et al., 1991). Generally, regularly scheduled performance of moderate amounts of physical exercise helps an individual maintain good biological homeostatic balance, develops good muscle tone, and contributes to overall personal health and fitness. A person's physical condition (fitness) directly affects major physiological variables such as heart rate and VO_2max, which normally are used to measure work tolerance or work rates.

Consequently, physical condition (i.e. general physical fitness, or a compromised state of fitness such as having a physical disability, or even having a temporary illness such as influenza) has a clear and direct impact on the amount of physical work that can be accomplished. In performance of arduous physical tasks, the energy expended by two different individuals may be similar, but the person who is *more physically fit* is likely to experience an easier time of the task, is apt to demonstrate better endurance, and will probably recuperate more quickly from such physical labor.

Generally, if the size and weight of individuals are matched, drivers who personally maintain better *physical fitness*, i.e. aerobic (heart/lung-oxygen) and anaerobic (muscular) fitness, will have an easier time of loading and unloading trucks.

In any subsequent physical measurement research on loading and unloading, *test participants should be measured for their overall level of physical fitness* at the beginning of experimentation (e.g. both a VO_2max test and an incremental lift test could be used to gauge level of fitness) to permit proper *categorization of the drivers physically.* It is also important to *characterize the nature of the physical tasks performed by means of standard workload measurement* techniques (i.e. physical measurement task analyses), so that different work settings studied can be properly categorized and compared across segments of the trucking industry.

Anaerobic vs aerobic exercise and physical fitness

All physical activities place demands for energy upon the body. The energy output from working muscles for swimming or sprint running may be as much as 120 times higher than that expended in the simple resting state. Less intense but sustained exercise such as running a marathon requires increases in energy of about 20 to 30 times above that of resting. Depending upon the intensity and duration of exercise, and the fitness of the participant, the relative contributions of the body's various means for energy transfer differ markedly (McArdle et al., 1991). The physical work we perform is generally classified according to two types of intramuscular energy transformation which take place during exercise: *anaerobic and aerobic energy production.*

Anaerobic exercise (predominately muscular activity) consists of relatively high physical work levels. Examples of anaerobic exercise include lifting and holding heavy weights, squeezing a hand dynamometer, and full-speed sprints such as the 100-meter dash, or other activities requiring a high burst of energy. Sustained high rates (intensity) of strenuous anaerobic exercise produce lactic acid in the muscles at a faster rate than it is removed, and it quickly diffuses into the bloodstream where it is buffered and carried away from the site of energy metabolism. This leads to localized muscular fatigue that limits the duration of physical exertion (Simonson, 1971; Mainwood & Renaud, 1985).

Aerobic exercise (oxygen consuming activity) is characterized by the ability of a person to maintain a constant level of exercise for an extended period of time. Common aerobic activities are walking, swimming, running, and bicycling. Aerobic energy production involves the supply of oxygen to the muscle cells to assist in metabolism of free fatty acids into sources of energy for muscle contractions.

Under normal conditions, almost all exercise involves a *combination* of anaerobic and aerobic energy production. The duration and intensity of exercise determines which of the two systems plays the more dominant role in producing the energy necessary to maintain ongoing levels of physical exertion.

When considering continuous materials-handling tasks (e.g. lifting of cargo items, especially lifting heavy items or moving them repeatedly) as drivers might do in loading and unloading trucks, *anaerobic power* (muscular prowess, or fitness level) may be important. Maximal

aerobic power, the maximal rate of a person's oxygen consumption (overall physical fitness) may also be a limiting factor, especially if items repeatedly are to be carried any distance, such as from one end of a loading dock to the other. In subsequent experiments on loading and unloading, various physical tasks undertaken by drivers should be categorized in terms of their anaerobic or aerobic requirements.

VO_2max as overall indication of fitness.

Exercise physiologists usually rate a person's general level of physical fitness overall by citing a measure of one's maximal oxygen consumption or uptake capability. A person's maximal oxygen uptake capability is usually measured in a simple lab test involving blowing into a closed-circuit spirometry resistance tube. The aerobic capacity score referred to as VO_2max is a measure of the body's level of readiness to consume oxygen at a high rate. VO_2max reflects the maximum volume of oxygen (maximal aerobic power) that can be transferred to skeletal muscles during exercise and represents a person's capacity for aerobic re-synthesis of adenosine triphosphate (ATP), the primary energy source for muscle contraction. VO_2max then is a general indication of our oxygen uptake and transport capacity. It serves as an excellent measure of overall aerobic fitness, providing a quantitative statement of an individual's capacity for aerobic energy transfer. It is one of the more important factors that determine one's ability to sustain high-intensity exercise for longer than 4 or 5 minutes.

Research participants in subsequent studies of loading and unloading should have their physical fitness categorized in terms of their VO_2max.

Exercise intensity, muscular fatigue or exhaustion

As is readily demonstrated by athletes, when one "warms up" to compete in a sporting event, marked physiological changes occur. These include stretching of muscles, increased heart rate, blood flow, change in hormonal secretions. Importantly, oxygen consumption rises rapidly during the first minutes of exercise until it reaches a steady rate of consumption, a readiness to supply energy for exercise. These *warm-up effects* can provide a physiological advantage in preparation for greater exertion (as in preparing for anticipated competition).

Short duration, high intensity work rates (e.g. repetitions of a 100 yard dash, or a 25 yard swim, and weight lifting repetitions) which can only be maintained for 15 minutes or less, require an immediate and rapid supply of energy. Muscular fatigue in these instances is related to depletion of adenosine triphosphate (ATP), and creatine phosphate (CP) stores in the specific muscles activated, as well as to accumulation of hydrogen ions in the muscle cell resulting from lactic acid formation (Simonson, 1971).

Different bodily organs use different amounts of oxygen during rest and exercise. At rest, muscles require about 20% of our body's total oxygen uptake. However, during exercise, the oxygen uptake of skeletal muscle increases 100 times above rest, and more closely approximates 85% of the body's oxygen uptake. In performing physical work, the period over which one can

sustain physical exercise before experiencing muscular fatigue is mostly determined by the rate (*intensity*) of doing work - the more intensely one works, the more rapidly one develops muscular fatigue. Lifting very heavy loads (e.g. 50-80 lbs. or more) for sustained periods may lead to muscular fatigue fairly quickly.

Physiologists also cite a person's exercise intensity level in term of one's VO_2max as an indication of the approximate oxygen consumption rate of a particular set of exercises performed. For most people, exercise at an oxygen consumption rate below 55 to 60% of their own VO_2max can generally be performed at a steady rate with little lactic acid buildup. However, when exercise intensity exceeds about 55 to 60% of VO_2max a steady rate of aerobic metabolism is no longer maintained, lactic acid formation exceeds its rate of removal, and lactic acid accumulates. As work intensity increases, the level of lactic acid rises sharply and the exerciser soon becomes fatigued even to the point of exhaustion (McArdle et al., 1991).

Petrofsky and Lind (1978) determined that if the work rate is maintained at less than 40% of VO_2max, physical fatigue does not ordinarily occur over the course of only one hour. However, it is not just the rate which matters, for the amount of weight lifted and the lifting rate generally interact with each other. Thus for example, lifting a 50 lb. (22.7 kg) box at a rate requiring 30 or 40% of VO_2max led to no rise in arterial lactate concentration; while lifting an 80 lb. (36.4 kg) box at a rate requiring 25% VO_2max resulted in elevated lactate levels over one hour. In another study, the endurance time for isometric forearm contraction was decreased following one hour of lifting at all VO_2 levels (Williams, Petrofsky & Lind, 1982).

Various authors estimate the rate at which work can be continued for long periods of time. Astrand (1960) reported aerobic work can be continued for one work day (7 hours of work, on a schedule of 50 minutes work with 10 minutes rest each hour, and one hour off for lunch), if the work rate is maintained at approximately 50% of the maximal rate of oxygen consumption. Continuance of work beyond 8 hrs (one normal work day) requires that the work rate be maintained below 50% VO_2max. In Astrand's experiments, VO_2 and heart rate rose and the respiratory exchange ratio (O_2 inspired to CO_2 expired) fell over the course of the work day; changes consistent with development of fatigue (Simonson, 1971). If the work rate is maintained nearer 40% of VO_2max, physical fatigue is generally not encountered (Hughes & Goldman, 1970; Soule & Goldman, 1973).

Exhaustion. Accomplishing high rates of physically fatiguing work over a period of from 1 to 6 hours can lead to exhaustion of intramuscular glycogen stores, although other factors such as dehydration due to thermal stress, ion shifts between body cellular compartments, or depletion of metabolic substrate in other compartments are also important contributors to *exhaustion* (Gibson & Edwards, 1985; Stone & Conley, 1994). When work is continued beyond 5 or 6 hours, physical fatigue appears to be related to shortage of fuels, particularly carbohydrate in the muscles, plasma, or liver, to shifts in metabolic hormone levels, and to musculature intracellular damage resulting from physical activity (Simonson, 1971).

Muscular recovery. Both intensity and duration of exercise affect how fast the normal homeostatic level of the exerciser is regained after physical exertion. Physiological recovery from intense but brief anaerobic exercise is relatively rapid, occurring within a few minutes, whereas recovery from low-intensity, long duration aerobic exercise may take several hours (Tomporowski & Ellis, 1986). An athlete who participates in a high aerobic power activity, such as running a marathon, usually requires several days to recover physiologically from the effects of the race.

Patton et al. (1995) published important data citing measures of energy cost (in terms of oxygen uptake) for men performing 42 well-defined physical tasks, and for women performing 36 tasks, from the U.S. Army's Military Occupational Specialty Physical Task List. This classic task-related energy expenditure study produced baseline energy expenditure data for 58 physically fit soldiers (32 male and 26 female) wearing everyday utility uniforms in thermoneutral conditions. They performed such tasks as lifting boxes and crates to varying heights (including truck bed heights), carried artillery projectiles, ammunition and ammo charges, lifted and carried litter patients, and unloaded and stacked paper stock. Many of the tasks measured are similar to the work normally involved in loading and unloading trucks.

Some of Patton et al.'s tasks that are similar to those of truck drivers required considerable energy and would be categorized as moderate (325 to 500 watts) or heavy work (>500 watts). Three such heavy work tasks, each requiring in excess of 500 watts of energy, were measured in terms of the percentage of the soldiers' maximal oxygen uptake capability (VO_2max) required to do the tasks: a) carrying two 13.6 kg (about 65 lbs.) chemical smoke pots a distance of 30 meters and repeating this carry 4 times in 10 minutes was measured to require an average of over 76% of VO_2max for men; b) lifting 105mm projectiles (25 kg or about 60 lbs.) and carrying them 15 meters and lifting to a height of a 2½ ton truck (1.32 meters) and repeating this carry 4 times in 15 minutes required men an average of almost 45% of VO_2max; whereas, c) carrying TOW missile equipment (24.5 kg or about 59 lbs.) up a 20% grade at 0.89 m/s for 10 minutes while wearing full combat clothing and equipment required an average of almost 75% VO_2max. Such VO_2max measures above 45% suggest the above three tasks require considerable work output, and probably are not likely to be sustained very long without frequent rest breaks.

Descriptions of all 42 tasks and detailed tabular data (including measures of oxygen inspiration and exhalation, heart rate, and subjective ratings of perceived exertion) are presented in Patton et al. (1995). These important data serve as an excellent reference base for comparison to similar energy expenditure measures which might be collected in studies of truck drivers loading or unloading trucks.

To provide a proper frame of reference, discussions of truck loading and unloading tasks should include measurement and categorization of the amount of metabolic energy expended in performance of physical work (i.e. in loading or unloading) in a manner similar to that of Patton et al. (1995). This will permit quantifiable comparisons of measured driver energy expenditures (in standard terms of VO_2max) on non-driving physical work to those of drivers accomplishing slightly different loading and unloading tasks in other segments of the trucking industry. Such

comparisons of energy expenditure measures then will be possible even when the cargo commodities they load, or the equipment they use to do the work, vary significantly.

Selecting a work pace

Over-the-road truck drivers frequently spend weeks at a time on continuing irregular work-rest schedules involving mixes of loading and unloading activities and long haul drives. The only published data we located on the work pace of truck drivers loading and unloading are those of Mackie and Miller (1978). Therefore it may be instructive to consider information concerning work pace from other communities.

Astrand and Rodahl (1977) indicate practical experience shows that we do not usually tax more than 30 to 40 percent of our maximal aerobic power during an 8-hour working day without developing subjective or objective symptoms of fatigue. Therefore one of the most obvious problems is to determine the ratio between work load and work capacity. If the burden placed upon the worker is too high in relation to the person's capacity for sustained physical work, fatigue invariably will develop. Astrand and Rodahl say this is true whether the work involves the entire body (large muscle groups) or only part of it (small muscle groups). They contend the ideal way to perform physical work is to perform it dynamically, with brief work periods *interrupted by brief rest pauses* That way the worker may avoid fatigue and exhaustion and be able to leave the workplace with sufficient vigor left over for enjoyment of leisure (Astrand & Rodahl, 1977).

U.S. Army biomedical modeling data estimates the average soldier, a 70 kg (155 lb) man has a VO_2max equal to 53 ml/kg-min. At an energy expenditure rate of 40% VO_2max (21.2 ml/kg-min or 7.2 kcal/min) the average soldier should be able to march continuously over several successive days (with some rest pauses). Carrying a 25 kg (55 lb) pack, such an average soldier could maintain a pace of 5.6 km/hr (about 3.4 miles) along a blacktop road, 5.3 km/hr through light brush, or 4.8 km/hr through heavy brush (Pandolf, Givoni, & Goldman, 1977). The important point of these data might be that fit men *should be able to sustain reasonable amounts of work at a pace of 40% VO_2max for several days at a stretch.*

However, the work rates soldiers actually select if permitted to do so are considerably less than 40% VO_2max. For example, Myles et al. (1981) found that French infantry soldiers marching an average of 34 km per day for 6 days tended to select a marching pace requiring energy expenditure rates equal to 31.6% of VO_2max. The suggestion is that workers who are permitted to select their own work rate generally select a comfortable pace requiring considerably less than their own 40% VO_2max, even less than physiologists modeling estimates indicate they can readily produce. In fact they select rates closer to 30% VO_2 max.

Examining data more closely related to truck driver loading and unloading, Mital (1983; 1984) studied industrial workers in manual lifting tasks for both 8-hour and 12-hour shifts. Males selected weights that, on average, resulted in metabolic energy expenditure rates of 23% of their aerobic capacity for *12 hours* of lifting; which demonstrated fatigue effects in heart rate measures

and in the amount of work accomplished. The rate of work for 12-hr shifts was significantly lower than the weight acceptable to them (about 29% average VO_2) for the 8-hour shift (Mital 1984; Snook, 1978). It is likely the acceptable work rate for loading trucks is close to 30% VO_2max, but this yet remains to be measured. Most truck loading is likely to be accomplished in three hours or less. The exception may be the 8-10 hour household furniture loading periods the van lines industry experiences.

Physical effects on psychological readiness to perform work

Although the physiological effects of exercise are readily recognized, *effects of exercise on psychological variables* are talked about much less. Individuals who exercise routinely report changes in mental states during and after physical exertion. The psychological variables most often reported to be altered by exercise are *mood and affect.* Many exercisers report enhanced feelings of well-being and euphoria, often referred to as "runner's high," probably attributed to brain neuropeptides such as endorphins. Numerous studies have attempted to assess the effects of exercise on personality and mood variables (for a review see Tomporowski & Ellis, 1986).

Exercisers report the physical arousal associated with all forms of exercise influences their *ability to perform motor tasks*. Considerable research has assessed effects of various levels of physical arousal on psychomotor tasks such as pursuit-rotor tracking, maze tracing, and those employing various athletic skills. Tomporowski and Ellis (1986) cite three reviews of such work.

Another class of psychological variables believed to be affected by exercise are those relating to *information processing and cognition*. Many exercisers report subjectively that physical exertion affects their mental abilities, but the direction of the reported effect is not consistent. Some exercisers report physical exertion facilitates their thinking processes, whereas others report a debilitating effect of exercise on mental ability. See Tomporowski and Ellis (1986) for review of effects of exercise and physical arousal on cognitive tasks. Additional aspects of this topic will be covered later in the section of this report on sustained behavioral and physical performance effects and sleep loss.

Physical conditioning, shift work and sustained operations

Does increasing one's overall physical fitness make one more apt to adapt well to the frequent changes necessitated by shift work? Does physical fitness help one to perform well in situations of extended or sustained operations? It would be useful to determine if increases in truck driver physical fitness training might be helpful as a countermeasure to fatigue effects.

Few studies specifically report physical assessments of long duration sustained work (e.g. longer than 8-10 hours), but of interest are reports suggesting improved physical condition can either increase tolerance to shiftwork (8-hour shifts) or increase the rate of adjustment to shiftwork. For example, Harma et al. (1982, 1988) found physically fit day shift workers had lower heart rates, less perceived exertion, and faster recovery of heart rate during both day and night than did workers of only average physical fitness. These differences, along with a larger amplitude

circadian rhythm, led Harma's team to conclude that *physically fit people can tolerate shiftwork better than workers who are less fit.*

Building upon those findings, Harma et al. (1988) implemented a physical training program for female hospital nurses who work a 3-shift schedule. After 4 months of from 2 to 6 physical training sessions per week, the exercise group had a 5-beat decrease in heart rate and a 5% increase in VO_2max. The non-exercising control group had no such changes. The exercise group reported decreased general fatigue (particularly during the night shift), decreased musculoskeletal symptoms, and increased sleep length after the evening shift. The nocturnal decrease in subjective fatigue is important because fatigue is highest at night. Harma et al. suggested the most important factors in determining tolerance to shiftwork for these women were maximal oxygen consumption (VO_2max) and muscle strength (i.e. good overall fitness).

However encouraging the work of Harma et al. (1988) might seem, Rosa, Bonnet, Bootzin et al. (1990) point out that even with such studies, it is not clear whether physical activity (either self-scheduled or work-scheduled) truly increases adjustment to shiftwork, or merely demonstrates overall increases in strength and more positive subjective reports. Important variables such as the amount of training and the exact placement of the exercise in relationship to the work/rest cycle remain to be examined. Such studies should also control the placement of sleep and rest periods (to further facilitate the re-adaptation of the circadian rhythm).

After a decade of research on sleep deprivation and sustained performance Hegge (1981) speculated that physical fitness of soldiers may play a particularly valuable role in slowing the rate of performance decline during sustained operations. Hegge stated the greater the aerobic and anaerobic capacities of the individual (better physical fitness), the lower the relative rate of resource utilization at work, and the higher the relative rate of resource recovery with rest. This suggests fit workers might experience less fatigue from a given amount of work than unfit ones. Although these relationships have been thought to hold mainly for tasks involving muscular effort, there is some reason to believe that they influence cognitive work capacity as well.

In a study piggy-backed onto a complex Army Ranger training schedule, Pleban, Thomas and Thompson (1985) examined how *physical fitness* may attenuate decrements in cognitive work capacity for certain tasks requiring prolonged mental effort. Cumulative effects of sleep loss and the overall increased stress levels of the arduous around-the-clock training course began to mount over the seven days of their study. Physical fitness seemed to have a beneficial effect in moderating the rate of the development of general-mental fatigue; but on days 5 and 7, some of the more fit cadets reported the greatest levels of fatigue. Fitness did not enhance the recovery process with respect to cognitive work capacity (Pleban et al., 1985). Partly because of a lack of experimental control, this study produced some inconsistencies, and it calls for more controlled research on the subject.

Effects of sleep loss and sustained physical effort on performance

Truck drivers encounter many situations where, for a mix of reasons, they experience significant amounts of sleep loss. They miss sleep while waiting for their trucks to be loaded, or by spending time loading them themselves; they drive long hours, have extended work schedules, and get much of their sleep in the form of naps grabbed when they can. In effect, many of the schedules truck drivers keep are much like those of soldiers who participate in sustained or continuous operations exercises which typically go around-the-clock for days, even weeks at a time, leaving precious little time for sleep. Some of the studies of military continuous operations illustrate that the stresses of doing significant amounts of physical work, even when combined with partial sleep loss, do not so quickly impact performance of physical tasks, as much as they degrade performance on cognitive or mental tasks. Thus *the combination of significant physical work interacting with considerable sleep loss does have a general-mental fatiguing effect on cognitive performance.* These would seem to extrapolate in meaningful ways to many long haul trucking situations. Descriptions of a few of these studies follow.

Tasks that require primarily physical performance are relatively immune to the effects of sleep loss. It is fairly well established that sleep loss does not impair the capacity for physical endurance to a measurable extent (Martin, Bender & Chen, 1986). The principal effect of sleep loss on physical capability seems to be a subsequent need for a slightly longer recuperative period following physical exertion (McMurray & Brown, 1984).

Many studies of sustained physical performance, especially those which also involve significant amounts of sleep loss, were produced by various military laboratory field studies of continuous military operations. Two British Army field trials (Exercises Early Call I & II) have become classic studies of sustained performance and sleep deprivation (Haslam, 1978, 1985; Haslam & Abraham, 1987). Infantrymen in the field undertook conditions of substantial amounts of sleep loss over a nine-day period. These trials required subjects to engage in large amounts of physical activity and lost sleep before being measured on both physical and cognitive tests, and they seem particularly pertinent to truck driver loading and unloading questions. There were sizable differences in early degradation of cognitive and vigilance performance, compared to relatively unaffected physical performance over the duration.

In Early Call I, Haslam and Abraham (1987) subjected three platoons of infantrymen, one each to a schedule of either 0 hrs, 1.5 hrs or 3 hrs block sleep in each 24-hr period, over a 5- to 9-day span. Soldiers were required to perform a mix of physical activities each day, including digging trenches for 3 hours prior to midnight, and a 2-hr simulated casualty exercise from 0530-0730 h. Afternoons included rifle shooting, grenade throwing and running. All members of the 0-hrs sleep platoon (totally sleep deprived) withdrew from the exercise after four nights without sleep; 39 percent of the 1.5-hrs sleep platoon had withdrawn after five nights. Fifty-two percent of the 1.5-hrs sleep platoon and 91% of the 3-hrs-sleep platoon completed the nine-day exercise.

Haslam and Abraham (1987) indicated that in terms of military *effectiveness on mainly physical tasks*, the "survivors" of the 1.5 hrs sleep platoon *remained effective* for six days; the "survivors"

of the 3-hrs sleep platoon were effective on physical tasks for nine days. Haslam and Abraham stated *the main effect of sleep deprivation was psychological rather than physiological*; because mental ability and mood deteriorated, whereas physical fitness or physical performance, according to the assessments made, did not. Vigilance and the more difficult and detailed cognitive tasks deteriorated most, whereas simple and well-learned tasks, like weapon-handling tests (more physical tests), suffered little (Haslam & Abraham, 1987).

Performance on a 20-min. *vigilance* shooting task at nine randomly appearing targets of opportunity deteriorated markedly, while shooting performance varied little over the nine days on a *self-paced* five-round shot grouping task, demonstrating the importance of time pressures on performance of sleep-deprived subjects. In general, there was a *rapid decrement in performance on cognitive tests* over the first four days of sleep loss, after which time performance tended to level out for those subjects remaining in the field, with sometimes an upturn in performance on the last sleep-deprivation day, a phenomenon in knowledgeable subjects called the "end-spurt effect" (Haslam & Abraham, 1987).

Exercise Early Call II, a slightly different nine-day field study, involved an initial 90 hours of total sleep deprivation, followed by six days permitting only 4 hrs sleep in every 24 hrs. Again the *effects of sleep loss were psychological rather than physiological*. Results indicated that tasks with a cognitive and vigilance component began to deteriorate after one night without scheduled sleep. After three nights without sleep, performance on these tasks deteriorated to approximately 50 percent of control values (Haslam & Abraham, 1987). Four-hour blocks of sleep had a marked beneficial effect in that cognitive performance on the following day was considerably improved (recovering 30 percent); mood also improved considerably.

Interestingly, these same soldiers were also studied in a psychophysical method paradigm during the study to establish if maximal acceptable loads (MALs) in repetitive lift tasks were affected by the major variable of sleep loss (Legg & Haslam, 1984). The test necessitates continuous reassessments of decisions concerning MAL based upon perceptions of the load weight, a cognitive task which might be easily degraded by sleep loss. However, Legg and Haslam's assessment concluded MAL was not significantly influenced by sleep deprivation.

These two data-rich large field experiments (Haslam et al.'s) are often cited in the sustained performance literature to indicate *performance of physical activities is highly resistant to sleep loss effects*; *but performance of the more cognitive tasks degrades sooner* as a function of combinations of long periods of physical and mental work, and substantial sleep loss daily. The importance here is that the "keep the soldiers awake" activities in these two experiments consisted largely of physical activities which parallel somewhat many trucking situations where drivers encounter a mix of arduous physical activity (loading and unloading) followed by driving, followed by unloading activities, perhaps a short rest, and then beginning the process again as they progress throughout the work week.

Haslam's work is repeatedly cited for demonstrating that *mental performance degrades before physical performance in sustained operations*. Alternatively, Patton et al. (1989) concentrated

on assessing changes in physical fitness as a function of sustained artillery operations. Patton et al. (1989) studied the effects on physical fitness capacity and performance of 24 soldiers during an 8-day continuous field artillery scenario simulating combat. Artillery gun crews were required to move their equipment from 5 to 7 times per day, accomplish re-supply missions each day, emplace camouflage twice daily, perform frequent fire missions (20 to 65 per day) which required much handling and loading of 45 kg (about 100 lbs) artillery shells, and other tasks associated with artillery operations.

Body composition and measures of fitness (isokinetic strength of the arms and legs, isometric handgrip strength, dynamic lifting, and upper body anaerobic power) were determined before and immediately following the scenario. The researchers made estimates of the intensity of physical activity and of the amount of sleep obtained by use of continuous heart rate monitoring during the 8-day scenario. Physical performance was assessed by daily ratings from senior noncommissioned officers experienced in artillery operations.

Patton et al. (1989) reported no changes occurred in the soldiers' body weight or upper body anaerobic power from pre- to post-scenario. However, measures of muscular strength and lifting capacity *increased* by 12-18% post-scenario. Physical performance scores were significantly higher on Days 1 and 8 compared to the other days but no differences were seen from days 2 through 7. Soldiers averaged 5.3 hrs of sleep daily. Their heart rates were at 50% of their maximal heart rates for an average of 22 min. per day, and as high as 75% of maximal HR slightly less than 3 min. per day (not an overly strenuous scenario). Patton et al. (1989) concluded that soldiers who are allowed 5+ hrs sleep per 24-hr day and who are required to perform at relatively moderate levels of physical intensity show no decrements in physical fitness capacity or evidence of physical fatigue for up to 8 days of continuous operations.

Unfortunately, Patton et al. (1989) did not report behavioral performance effects in this report, and thus one cannot discern the impact such a schedule had on the soldiers' cognitive/mental performance. Knapik et al. (1986) reporting on the same field trial indicated that team artillery crew performance was at an acceptable level, but the data of interest here were confounded with many uncontrolled variables and it is difficult to make definitive statements about them. *Methodologically however, there are practical lessons to be gleaned from the Patton et al. (1989) study for planning experimentation with truck drivers who load and/or unload their trucks prior to driving.*

In another set of USARIEM studies of Army Ranger candidates, Mays (1993) administered four measures of cognitive functioning (decoding, logical reasoning, short term memory, and camouflaged pattern recognition) at the beginning, middle and end of four 2-week training phases (forest, desert, mountain and jungle phases). The 8-week arduous Ranger training course demanded very significant output of physical energy daily, allowed very low caloric intake (Shippee, 1993), accentuated sleep deprivation (average less than 4 hours of fragmented sleep per 24 hrs; Popp, 1993), and psychologically stressed the soldier students in the course.

Students maintained high levels of motivation to perform well on cognitive function tasks. Whenever possible, they traded speed for accuracy to maintain baseline levels of accuracy (i.e. accomplished fewer correct test items per unit time). All students showed substantial impairment of cognitive function. Mays (1993) summarized by stating that there was a 33% decrement in mean speed on the decoding task, a 20% decrement in mean speed on the reasoning task, a 7% decrement in mean accuracy on the memory task, and a 15% decrement in mean speed and accuracy on the camouflaged pattern task during the 8-week ranger training course. Although there were some differences in the pattern of impairment across the four tasks tested, the degree of impairment indicates a general inability to attend to detail and to concentrate. Student soldiers showed some brief periods of recovery of function, but *deficits appeared to be cumulative over the course*. Mays' overriding recommendation was to expand the Ranger training schedule to allow longer periods of recovery sleep between phases of the course, and to augment the sparse meal schedule offered in the course.

In a simulated armor tank driving experiment, Drucker, Cannon, and Ware (1969) studied Army tank drivers during a 48-hour experiment. Subjects worked either 24 or 36 hours and periodically had 1-hr, as well as 15-minute rest breaks. Experiment start times differed for various groups of subjects. Performance on a laboratory driving simulator and on a vigilance target detection task both gradually deteriorated during the darkness of night, with greatest deterioration occurring between 0530 and 0700 hrs just prior to dawn during the first test night, and between 0200 and 0700 hours the second night. Thus, these authors were early determiners of the effects of circadian rhythms and sleep deprivation on driving performance.

Ainsworth and Bishop (1971) conducted a 48-hr experiment to determine the effects of sustained activity on the performance of Army tank crews in communications, driving, surveillance, gunnery and maintenance activities. Although the report cites few measurements of the physical effort expended, which did not involve physical activity like the loading or unloading, the test did combine sustained work and sleep loss in a manner directly relevant to truck driving. Moving surveillance and some driving activities showed statistically significant performance deterioration over a 48-hr period of work without sleep, but the decrements were not deemed of practical significance. The results do not unequivocally support the conclusion that driving performance was affected by the prolonged period of activity. Only results for a log obstacle and slalom driving exercise showed clear, but small performance decrements. Slalom drivers were slightly less accurate, and in the log obstacle exercise drivers took more time but were as accurate as those in a control group. Thus, these drivers too, like participants in other sustained operations studies, made *a trade-off of time or speed of performance, choosing to work more slowly to maintain accuracy*, a common response of subjects performing self-paced tasks under conditions of sleep loss and fatigue.

Cargo loading effects on driver physiology (repetitive lifting studies)

The single scientific report which most closely addresses the issues proposed in this FHWA-ATA loading and unloading project is the work of Mackie and Miller (1978). Their extensive truck driver study regarding hours of service, regularity in schedules, and cargo loading included a physiological analysis of the effects of repetitive cargo lifting on subsequent truck driving performance. They used a realistic simulated truck loading task which could be carried along on the truck during long drives and used for regularly scheduled tests of on-the-route loading activity.

Physiologists have implicitly assumed linear relationships among energy expenditure rate, pulmonary ventilation, heart rate, and workload based on studies of activities such as continuous leg or arm-cranking (Andrews,1967; Astrand & Rodahl, 1977; Bobbert, 1960). Mackie and Miller (1978) hypothesized that [between-subject] variables such as maximum lifting capacity and efficiencies of frequency of repetitive lifts (Jorgensen & Poulsen, 1974; Salvendy & Pilitsis, 1971; Snook, 1971) might invalidate this relationship in real-world repetitive lifting activity.

In a package lifting/loading roller rack simulated work station, Mackie and Miller (1978) had 11 commercial long-haul drivers and 7 research staffers do repetitive lifting of boxes, 12 x 12 x 18 in. (30 x 30 x 46 cm), weighing from 6.7 to 20. 4 kg (roughly 16 to 50 lbs), and representative of produce containers used in southern California in 1975. Work sessions were of 15-, 30-, or 40-minutes duration. All the drivers were relatively unused to performing such physical work.

Light work was defined by Mackie and Miller as a lifting rate of 6 lifts/min. (about 8 watts); *heavy work,* at a rate of 10 lifts/min. on boxes weighing from 6.2 to 21.6 kg., ranged from 7.8 to 50.6 watts; (*note* that by McArdle et al.'s 1991, or Patton et al., 1995 definitions, these work rates would range in the *light to moderate work* category).

For Mackie and Miller's subjects, steady-state inspired, pulmonary-ventilatory flow rate (V_I) was attained in nearly all work sessions. The elapsed time of work required to reach steady-state V_I ranged from 1 to 11 min. during light work, and from 3 to 24 min during heavy work. Steady state heart rate was reached in 80% of the sessions with V_I plateaus within 16 min. for light work and after a range of 3 to 27 min of heavy work; heart rate plateaus did not occur in the absence of steady-state pulmonary-ventilatory flow rate (V_I). Steady state values of V_I were highly correlated ($r = 0.90$) with energy expended rates (EER), the strongest relationship among any two variables measured; EER was highly correlated ($r = 0.86$) with workload; steady state V_I and heart rate were correlated ($r = 0.78$ and 0.72) with workload and with each other ($r = 0.78$).

Mackie and Miller concluded that the linear relationships between these variables, as cited in the previous exercise physiology literature, appear to be justified. In general, linear relationships exist between EER and workload, and among EER, V_I and heart rate. Additionally, cardiopulmonary functions respond to repetitive lifting in a manner qualitatively similar to

responses triggered by treadmill, bicycle, and arm-cranking work, i.e., with high correlations as well as linear functions (Mackie & Miller, 1978). By comparing their data to bicycle ergometer work, Mackie and Miller concluded that in terms of general cardiopulmonary response, lifting boxes from floor level to knee height is comparable to lifting from knee height to shoulder height.

From their assessments, Mackie and Miller came to two important conclusions: 1) that linearity and high correlation are maintained among the four variables: a) workload, b) energy expenditure rate, c) pulmonary ventilation, and d) heart rate during moderate levels of repetitive box lifting work; and 2) that general concepts of laboratory exercise physiology apply sufficiently well to assessing real-world tasks of repetitive lifting during loading and unloading trucks. Although in the past 20 years there have been several refinements to these general statements of exercise physiology relationships (e.g. see biomechanics and exercise respiratory coverage of Stone & Conley, 1994, and Williams, 1994), Mackie and Miller's implications for studies of truck driver loading and unloading activities still hold up well.

Much can be gained by adapting some of Miller and Mackie's methodological approach using such simulated loading tasks in analyses of truck driver loading and unloading activities.

Loading and unloading effects on driver performance (Mackie & Miller, 1978)

Mackie and Miller (1978) subjected long haul drivers to combinations of irregular work schedules and varying amounts of loading and unloading of cargo into their trucks, over a four-day driving schedule. They concluded that: *participation in moderately heavy cargo loading to the extent engaged in by many relay truck drivers increases the severity of fatigue associated with irregular working schedules*. Specifically they observed:

a) systematically greater feelings of fatigue as reflected by the drivers' ratings when they engaged in moderate as opposed to light cargo loading on all trips after the first 2 days of operations;

b) less fine steering and more coarse steering on most trips involving moderate as opposed to light cargo loading;

c) significantly greater lane tracking variability on late night and early morning trips when moderate cargo loading was done; greater tracking variability on all shorter, irregular trips when moderate cargo loading was done;

d) systematically poorer performance on a critical tracking task when moderate work was done;

e) systematically greater subjective feelings of fatigue (with moderately heavy loading) after the first two days of a five-day operation;

f) higher heart rate when moderate work was done, indicating greater physiological stress (though they state this could have beneficial effects on alertness);

g) less theta and more beta in the EEG brain wave patterns in the moderate-work condition, suggesting that despite any possible benefits of physical work, greater cortical activation was required to maintain performance (Mackie & Miller, 1978).

The analysis of large amounts of data in this classic study made the questions even more complicated. In summarizing relevant points from this study, Wylie et al. (1997) state that Mackie and Miller's (1978) work also found that engaging in moderately heavy cargo loading had mixed effects on the subjective feelings, physiological status, and performance of drivers who had access to truck sleeper berths. Performing the loading task appeared to have some beneficial activating effects that persisted for much of the driving periods, especially during late night and early morning trips. It appeared that periodic interruptions of the driving task to participate in cargo loading could have a beneficial though not lasting effect on the subsequent alertness of the driver as he resumed the driving task. However, when combined with subsequent long periods of driving, physical work can have adverse effects on driver fatigue and performance.

The work of Mackie and Miller (1978) is the only published work directly aimed at the current driver loading and unloading issues. Their study serves as baseline information both in terms of methodological approaches and its rich pertinent findings for subsequent work on this topic.

Measuring energy expended driving a truck

Just as in any other physical activity, a truck driver expends a certain amount of energy while driving a truck. The amount of physical activity and energy expended in driving a truck have been inferred from heart rate (HR) measures on drivers. Many researchers interpret moderate to sizable increases in heart-rate as evidence of physical workload. However, driver heart rate may not always be a suitable indicator of metabolic energy expenditure, as the measure is easily affected by many factors and may actually be reflecting something else as well. HR can vary with attentional factors and emotional factors as both are likely to play a role in heart-rate changes during driving as well (McDonald, 1984).

One of the most common findings with automobile drivers is that HR increases when driving begins, as if there is an initial stimulating effect, provoking HR response when one first begins a trip, but then tends to level off. That is, after an initial period of slightly elevated heart rate, as the time on driving tasks continues, the heart rate usually settles back to a level only slightly above baseline. Riemsersma et al. (1976) suggest as time-on-task continues the gradual decline in heart rate from "surge levels" represents not so much "fatigue" or significant de-arousal as adaptation to the task (i.e. decreasing stress, habituation to sensory stimuli).

Driving in different road and traffic conditions produces different magnitudes of HR response; as traffic conditions intensify, perceived stress levels rise and the heart rate can be noticeably

affected. Helander (1976) summarizes: generally, driving on urban highways without much interference of traffic produces heart rate increases of the order of 10 beats per minute (bpm) over baseline in a sedentary non-highway setting. Increases of 30 bpm are typical under more restricted conditions (e.g. town driving with traffic, rural roads, driving on mountain roads), and during operational events of short duration (e.g. overtaking, stopping, etc.) transient increases in HR of 45 bpm might be observed. Harris and O'Hanlon (1972) provided evidence that both time-on-task and diurnal variation have such effects on driver heart-rate levels.

McDonald (1984) pointed out that over short periods of driving, changes in heart-rate levels often reflect variation in: a) maintenance of the body's balance and posture, b) the emotional stress of driving, particularly in traffic, and c) the attentional and cognitive demands of the task, for which measures of heart rate variability are often used as indications of task attentiveness.

For any of these reasons, exclusively relying on HR to estimate energy expenditure may confound assessments of how hard a truck driver is working while driving. In the absence of alternative measures, HR currently appears to be the best inference of driving workload available. Accordingly, Mackie and Miller (1978) reported truck driver heart rates ranged from 81 to 93 bpm across most trips, but averaged as high as 120 bpm during portions of irregular schedules. They also recorded obvious variance in heart rate measures during circadian rhythm low points (mid-afternoon and after midnight).

Most other reported increments in automobile driver heart rate have been of the order of 10 bpm above baseline while driving on highways without much traffic interference, which is not a very large change, especially when a proportion of this increase could be attributable to emotional or attentional factors.

Combination physical measurements of workload and fatigue

There seem to be no reports describing "driver energy expended" during actual truck driving. To gain such baseline information it would be desirable for researchers to collect indirect measures of calorimetry through oxygen consumption measurements (i.e. measure the driver's oxygen consumption in the cab via portable open-circuit spirometry), while simultaneously collecting heart rate indications and then by calculating appropriate energy calorific transformations (personal communication with John F. Patton, Ph.D., Director of Occupational Health and Performance Research at USARIEM at Natick, Massachusetts. It was initially proposed to collect such data (in the form of oxygen consumption measures) during the course of this project; but the idea was shelved as being too intrusive and impractical here.

Driver fatigue and non-driving performance

In considering cumulative fatigue over a work week it is reasonable to ask about performance of fatigued truck drivers in the non-driving portions of their on-duty time. If they accumulate fatigue due to irregular sleep and driving schedules, and interspersed activities of loading and

unloading, or waiting at warehouse docks, etc., they might be asked about their performance on non-driving tasks. Is their performance of on-duty but not driving tasks satisfactory or not?

Performance on tasks that have a large physical component (e.g. loading or unloading cargo into/out of trucks), though perhaps boring and monotonous, should not be readily susceptible to fatigue and sleep loss effects as driving the truck might be. This may in part be attributable to the fact that the physical activity of such tasks is antithetical to falling asleep and not much cognition is required in loading boxes. As Haslam and Abraham (1987) and others have shown, *a person who is in the act of loading his/her truck should be able to withstand long periods of sleep deprivation and fatigue without behavioral or performance consequences of note.* The most notable effect may be a generalized slower level of activity; the driver takes longer to accomplish his/her loading and unloading tasks.

What might be expected from a fatigued driver on the dock is evidence of physical errors or mistakes, as he/she might become involved in accidents of the slips, trips and fall type around loading docks (Milliman & Robertson, 1994). Other errors (mental ones) might manifest themselves in the driver making mistakes regarding the selection or inventorying of items to be loaded; or later by delivering incorrect items in the unloading process; or perhaps making invoice and billing errors for loads he/she must sign for or have the consignee sign for upon delivery.

Section I Summary, Conclusions, and Recommendations

This literature review presents various definitions of fatigue, covers operational definitions of physical fatigue, mental fatigue, boredom, and phasic fatigue, and describes relationships among these definitions. It illustrates the complexity of the influences of cognitive and motivational factors that may sometimes override physical fatigue, and notes that fatigue effects may vary with task characteristics.

The literature illustrates there is a relationship between physical labor and development of general mental fatigue, but it is not very well defined. Cognitive-mental performance is likely to degrade earlier than performance on more physical tasks, especially with substantial amounts of sleep loss (e.g. Haslam & Abraham, 1987). However, only a paucity of literature specifically addresses the relationship between substantial amounts of physical work or exercise and subsequent general-mental fatigue. No definitive studies clearly illustrate how much performance of physical work, without accompanying sleep loss, affects general-mental fatigue. Most of the studies were designed to study fatigue effects on performance as it is affected by continuous time-on-task, with at least partial sleep loss. The physical workload variables were embedded into the scenarios in various ways that precluded determining what portion of the ensuing fatigue measured was at least in part attributable to the physical work directly.

The work of Haslam and Abraham (1987), of Patton et al. (1989), of Mays (1993), of Ainsworth and Bishop (1971), Mackie and Miller (1978) and others definitely supports an inference *that performance of hard physical work in conjunction with long work schedules promotes the development of general-mental fatigue.* The influences of such fatigue, although varied and mixed, adversely affect cognitive performance, especially reaction time, speed of performance in cognitive processing, amount of work accomplished per unit of time, and in a general way, have negative effects on mood and motivation.

The military subjects studied in cited research tended to maintain accuracy (they are taught to do so) at the expense of slower speed of performance (the classic speed accuracy tradeoff found in sustained performance studies). Psychological tests that researchers chose to investigate require cognitive processing, reasoning, decision making, vigilance, target detection and selection, and also some psychomotor and sensorimotor performance (e.g. rifle shooting). Only Ainsworth and Bishop (1971), who studied military armor tank drivers, and Mackie & Miller (1978), who studied truckers, measured performance on tasks involving driving.

Tasks in driving a truck generally are self-paced. Although a driver can determine what speed he or she will drive, and therefore is able to maintain accuracy, to do so for any length of time risks compromises in productivity measured in miles driven to make on-time deliveries. At any speed, but particularly at high speeds, slowed response time to dynamic decision-making situations compromises a driver's safe performance. With the exception of the classic study by Mackie and Miller (1978) it appears no one has directly addressed this topic. The question concerning the

amount of physical energy expended by drivers loading or unloading their trucks before subsequent over-the-road driving, remains an unanswered research issue:

> *What influence do significant amounts of physical exercise, (e.g. in loading or unloading a truck) muscular fatigue, or even generalized fatigue attributable to physical components of the job and other stressors, have on the task behavior (e.g., psychomotor tracking, road vigilance, decision making in traffic) involved in truck driving?*

Section II. Characterization of on-duty non-driving activities: Relationship to driver fatigue, alertness, and driving safety (Phase I, Task 2).

Background

The principal research question posed in the overall project is: *what effect does loading or unloading the truck have on truck driver alertness, performance, and/or fatigue during subsequent driving?* This notion presumes there is a relationship between the time and physical labor (energy) expended by drivers in loading/ unloading and driver alertness or fatigue.

When truck drivers are asked about this subject, some drivers insist a certain amount of physical activity during periodic loading and unloading of trucks gives them a physiological boost, akin to an adrenaline rush, and therefore helps them to be more alert on subsequent drives, at least, they claim, for about one to two hours. Many drivers suggest that regularly scheduled physical activity associated with loading and unloading helps them to stay in good overall physical shape, and therefore from a simple wellness or physical fitness standpoint they contend it is good for drivers to do such work. Alternatively, other drivers, particularly those whose jobs require considerable amounts of loading and unloading, claim they routinely expend large amounts of physical energy in loading and unloading, and that they become fatigued during and after the task because of the amount of physical work they perform; in some cases they claim this affects their driving alertness. Many of these drivers suggest the amount of time expended in doing such loading and unloading noticeably cuts into their time for rest, and sleep, between drives.

Section I of this report (Phase I, Task 1 of the project) reviewed and critiqued the scientific literature (physiological and behavioral), relating expenditure of physical work energy in tasks similar to loading and unloading trucks to anticipated physiological and behavioral effects on operator alertness and performance.

Task 2: Characterization of trucking industry loading/unloading practices and procedures

Phase I, Task 2 of the Commercial Driver Loading and Unloading Study characterized U.S. trucking industry CMV driver methods, procedures, and practices concerning drivers who load and/or unload their vehicles (trucks or buses). Task 2 had three objectives, to: 1) examine the loading/unloading procedural literature of the CMV cargo transport industry, 2) conduct driver focus group interviews to determine how frequently drivers engage in loading/unloading activities, and 3) learn about drivers' perceptions of the likelihood the physical labor associated with loading-unloading influences driver fatigue. The information in this Section includes a description of the Task 2 project methodology, the resultant data collected, and conclusions.

Methodology for Task 2

The plan for the information gathering process was to search for documentation and to obtain first hand descriptive information on the procedures, methods and practices of commercial motor vehicle (CMV) drivers loading and unloading their own trucks. The work of commercial long haul bus drivers was also considered, because they are subject to many of the same OMCHS regulations, with a particular interest regarding hours of service (HOS) rules. Secondarily, the plan was to identify other non-driving activities of commercial drivers that might affect driver fatigue and alertness on the highway.

The plan included identifying distinct segments of the nation's trucking industries, and then conducting several focus group discussion meetings and individual and group interviews with drivers and safety personnel in those industry segments to determine differences in procedures, practices, and loading/unloading requirements for drivers across the trucking industry. Similar information was also to be gathered on the inter-city bus industry.

Trucking industry literature search and review

Star Mountain researchers searched a variety of sources for trucking industry documentation to describe CMV industry procedures, methods and practices of driver involvement in loading and unloading. This search included the Department of Transportation and American Trucking Associations libraries, as well as requests to industry leaders for any documentation their organizations might be able to provide. The amount of industry documentation obtained was fairly small. Available truck training manuals, handbooks, and workbooks present general training information and guidance for anyone who handles, loads, secures, covers, or unloads freight or cargo, and provides safety procedures for dealing with hazardous cargo. This guidance includes instruction on how to properly lift items without injury, to stack and distribute load weight in a van, and to secure specialized rigging for large bulky items on flatbeds. Manuals on handling of hazardous materials were also available. That documentation is helpful for describing how *anyone* should load cargo onto or into trucks; but it does not by itself convey whether or not truck *drivers* become involved in the actual loading and unloading process.

Very little other literature was located. A few scattered reports of studies performed for and by the trucking industry, provided some information on drivers' involvement in loading and unloading, and their attitudes toward loading and unloading issues. The results are discussed in the findings section of this report.

Surveys, interviews, focus groups

With expectations that little documentation would be readily available on current industry practices related to loading and unloading, SMI researchers planned other means of acquiring information about current practices regarding driver loading/unloading.

A driver survey (questionnaire) distributed at the National Truck Driving Championships yielded very useful results. SMI researchers then conducted focus group meetings as well as individual structured interviews with drivers, and with company safety directors or managers and other company officials in various segments of the U.S. trucking and bus industries. About a dozen focus group interviews were accomplished with drivers and trucking industry officials in nine different freight/cargo categories, ranging from produce and refrigerated cargo to household furniture, steel pipe, and hazardous chemicals in tank trucks, and including interviews of bus drivers. In this portion of the study, driver and safety manager focus group meetings discussed specific topics of driver loading/unloading and other activities drivers do while they are on-duty, but not driving. The questionnaire, interview, and focus group data, considered together, are very helpful in determining the extent to which drivers participate in the loading-unloading process, and in describing other activities drivers do while they are on duty, but not driving. Those portions of the project are described in this section of the report.

Preparatory trucking industry information gathering

Discussions with industry organization leaders.

In August and September 1996, TRI and SMI held initial discussions on the loading and unloading topics with trucking industry representatives with a goal of determining how best to choose the invited membership of the focus groups to be conducted and how to plan such meetings. Discussions were held with the following industry organizations:

- American Trucking Associations (ATA) Safety Management Council: Ms. Jai Kundu, et al.;
- National Private Truck Council: Mr. Dave Barry, et al.;
- National Tank Truck Carriers, Inc.: Mr. Clifford J. Harvison, et al.;
- Interstate Truckload Carriers Conference: Ms. Lana R. Batts, et al.

In addition, telephone discussions were held with a select number of trucking company safety managers/directors at ATA regional sites, as well as at trucking companies around the country that employ large numbers of drivers.

More discussions on the above topics, and some planning sessions, were held with representatives of various other trucking organizations in October and November, 1996 as follows:

- Specialized Carriers & Rigging Association: Mr. William P. Rieck, Vice Pres.;
- American Movers Conference: Mr. George Bennett, Mr. Michael C. Myer (Dunbar Armored Car), Mr. Brent Greek (North American Van Lines);
- California Trucking Association (CTA): Ms. Karen Rasmussen, Vice President, et al.;
- CTA Produce Conference: Mr. Mike R. Conrotto, Chairman;
- CTA Agricultural Conference: Ms. Lynn Hoagland, Chairman;
- Agricultural Transporters Conference: Mr. Kent Van Amburg;
- Georgia Trucking Association: Mr. Ed Crowell et al.;
- National Motor Freight Traffic Association, Inc.: Mr. Jerry Stone;

also with a number of additional trucking company safety managers/directors, and other shipper, carrier and trucking company officials in various locations around the country.

Additional conversations on these topics were held in January 1997 with members of:

- The American Bus Association: Ms. Susan Perry, Pres., and Mr. Norman Littler;
- International Safe Transit Association: Mr. Ed Church;
- Chemical Manufacturers Association: Mr. Richard Doyle and Mr. Randy Speight;
- Association of American Railroads (AAR): Mr. Gary Held.

Those industry organizations that are concerned chiefly with short-haul carriage, or whose long-haul drivers are known not to be involved in loading and unloading (LTL carriers, for example), were not included in this information-gathering effort.

National Truck Driving Championships.

The discussions listed above led us to coordinated efforts to conduct focus group meetings and structured interviews in conjunction with several scheduled national and regional trucking safety manager, regulatory and driver professional meetings. The first of these, a national meeting of truck drivers for ATA's National Truck Driving Championships (NTDC) in Columbus, OH, became formative for our strategy to determine focus group membership, and so it is described here in some detail.

Survey and interview procedure. Mr. Clyde Woodle of Trucking Research Institute and Dr. Gerald P. Krueger, of Star Mountain, Inc. attended ATA's 1996 National Truck Driving Championships in Columbus, Ohio (August 22-23rd, 1996). SMI and TRI developed two Loading/Unloading Questionnaires for administration at this truck driver assembly:

1. a questionnaire concerning personal experiences in loading and unloading one's own truck, to be completed by truck drivers participating in the national driving competition;

2. a questionnaire for safety managers and other trucking company officials to be completed by such attendees at the national meeting. This questionnaire asked for information from the safety managers about driver loading and unloading practices and methods within their companies or within their industry segments.

Copies of the survey forms are presented in Appendices A and B. Additionally, at this driving championship meeting, Messrs. Krueger and Woodle conducted short structured interviews with over 60 of the truckers who participated in the competition, and interviewed 10 safety managers at an ATA Foundation (ATAF) trade show booth established for the purpose.

Over 350 driver questionnaires were distributed in the registration packets to all drivers who were to participate in the driving competition. The drivers' names, work affiliation, the state he/she represented, and the category of truck equipment to be used in the competition were all

pre-stamped on a cover letter attached to each questionnaire. This coded identification permitted us to identify the responses by driving competition group as the completed questionnaires were turned in to the study team.

The drivers' cover letter (see Appendix A) indicated that the respondent's written responses would be treated in confidence and would not be seen by others outside the immediate research staff. The cover letter was configured as a tear-off sheet to permit the drivers to separate it from the questionnaire if they preferred their identity and responses on the questionnaire to remain anonymous. As a practical matter, no one requested that confidentiality, and only a handful tore off the cover sheet before handing in the forms.

There was space on the questionnaire for drivers to list their addresses and phone numbers if they wanted to volunteer to participate in subsequent focus group discussions. About 1/4 of the drivers completed this section.

The questionnaires for the safety managers and other company officials were also distributed via the registration process, but were not pre-addressed. Many people who completed this questionnaire served as competition coordinators, judges, and convention operating support personnel. Most also filled in their names and addresses on the response sheets.

At the ATAF trade show booth, additional blank copies of the driver and safety manager questionnaires were readily available for other non-competing convention attendees who approached the booth and who also voluntarily completed the questionnaire. Fewer than 10 non-competing drivers completed questionnaires in this manner. After short discussions with these persons to establish their current predominant driving status, we added their replies to the most appropriate grouping. Many interested judges, company officials and other non-drivers requested and completed surveys at the booth, but because of time demands placed upon them to judge the competition few were able to devote time for interviews at the booth.

As an incentive to participate in our survey, the drivers and safety managers who submitted a completed questionnaire were offered a token gift (e.g. a hand calculator, or computer mouse pad, etc.) in appreciation of taking time to complete the survey and interview with the study team members.

Driver survey returns. The returns for the driver questionnaires provide data helpful in characterizing loading/unloading procedures practiced in portions of the U.S. trucking industry. Approximately 350 truck drivers from 49 states and the District of Columbia competed in eight different classes of driving competition at Columbus. The drivers each were either State or Regional Champions in their respective competitive driving class, having won local competitions to become eligible for the National Competition in Columbus. Additional eligibility criteria for competing included having an accident-free record of at least one year, and meeting qualifications relating to physical condition and employment. Thus, our questionnaire survey, and the many short interviews conducted in Columbus, were with very capable, highly

experienced truck drivers. The competing drivers represented a wide variety of trucking companies, private carriers and independent owner-operators from all over the USA.

The eight classes of professional driver competition included driving: straight trucks, three-, four- and five-axle trucks, flatbeds, twins, tank trucks, auto transport trucks. Completed questionnaires were obtained from a total of 308 of the approximately 350 competitors, close to a 90% return rate in each of the eight categories of competition. Table shows the number of surveys returned in each category.

Table 2. Driver Survey Returns

Vehicle Category	Number
Straight truck	46
Three-axle	31
Four-axle	43
Five-axle	48
Flatbed	43
Twins	44
Tank truck	45
Auto transport	8
Total	**308**

Short (5-10 min) structured interviews were conducted with about 60 drivers. Generally, these interviews were conducted as drivers submitted their completed survey forms near the rooms where they awaited their competitions, or while they stopped by the ATAF booth to talk with us. The interviews permitted us to obtain amplifying comments to the information drivers wrote on the questionnaires.

Safety manager and company official survey returns. We obtained completed questionnaires from 82 safety managers or company officials at the Columbus competition. Because most of these personnel were busy conducting the competition as coordinators, judges, etc. we were only able to interview about 10 of these people.

Survey results used in designing focus group/interview study. One of the principal reasons for designing and administering this particular survey was to assist in determining how best to identify and select subsequent driver membership for the focus group meetings and interviews. The survey returns assisted us to delineate the following points:

1. The National Championship drivers came almost proportionately from each state in the union because after drivers have successfully competed at the local level, each state sends its champions in each category to the national finals. To his/her credit, most drivers had lengthy and diverse driving careers, ranging from as short as 5 years experience to as long as 30 years or more of driving. Most of the drivers' answers relied on those years of experience. Over time, many of the drivers have lived and worked in many locations around the country; have driven many different kinds of trucks; and have developed

experience working with various loading and unloading equipment; as well as having handled many types of cargo.

2. From the driver responses it became apparent that making choices for focus group membership by concentrating on regional or state-to-state differences, would probably not be very helpful. Specific questions about the type of truck often netted responses like "several years ago when I was driving....with this or that type of truck, we did it this way..." or, "when I was driving in this or that part of the country I experienced ..." or "when I formerly worked for this or that company we would do the following,..." etc. It also did not appear useful to categorize drivers on the basis of age, experience, or newness to the job of trucking

3. What made better sense was to structure our focus group inquiry around CMV industry categories based upon the *type of cargo* the drivers haul. The reason is that if one specifies the type of cargo being moved, this usually implies the *type of truck* that will be used to haul it, what *type of loading situation* will be encountered, and often the *type of equipment and procedures* used to load or unload the cargo. For example, liquid fuel will almost invariably be carried in a tank truck, and the procedures and equipment used to load any such cargo are typical of that cargo but distinct from most other cargo types. Specifying produce as cargo usually implies a dry van, often a refrigerated ("reefer") van, and implies a set of loading and unloading conditions typical of that cargo type (palletized cargo, unloading at grocery warehouses, etc.). *Thus the cargo type usually defines most of the important variables associated with loading and unloading operations.*

Focus group planning

Membership selection by cargo types.

After meeting with the drivers and reviewing the questionnaires from the Columbus driving championships, we determined to structure the selection of focus group membership primarily around categories of *type of cargo* (or freight) the drivers haul, which are highly correlated with the type of truck being driven. We determined to obtain driver members, and also company safety directors, for the focus groups in as many as possible of the nine categories of cargo listed here:

1. "Dry" groceries and related items: boxed, bulk loose, or in bulk containers carried to and from manufacturers, wholesale and retail warehouses, retail stores, and other businesses;

2. Non-refrigerated agricultural products: vegetables, fruits, nuts, grain, etc.;

3. Produce, dairy products, meat, frozen foods, other cargo carried in refrigerated vans (reefers);

4. Heavy construction materials, pipe, large equipment items, bulky loads which require specialized rigging and are carried on flatbed trucks;

5. Gasoline, petroleum products, chemicals and hazardous materials, bulk foodstuffs (dry or wet), other dry bulk materials, such as plastic pellets, carried in tank trucks and hoppers;

6. Bulky goods, large commercial and industrial equipment, office furniture, large appliances, large electronics items, etc., carried in vans;

7. General freight (mostly cases or pallets of a mixed variety of products) carried in vans;

8. Household furniture, household goods, or high value products (electronic equipment, medical instrumentation etc.) carried by van lines;

9. Commercial passengers, their baggage, shipped cargo carried by buses.

Regional distribution. Secondarily, we attempted to arrange our driver focus group sessions on a regional basis. We arranged for driver interviews on both the Atlantic and Pacific coasts, in the Southwest, the Southeast, and the Midwest. In this way, we ensured representation for most areas of the country. However, it is worthy of note that in focus group meetings and especially in interviews on one coastline of the country, we often encountered drivers who had just recently come from the opposite coast. We also encountered drivers who had previously lived and worked in other regions of the country, or who had at least spent time in several regions in their long-haul work, and were able to speak knowledgeably about different regions of the country.

Topics for discussion

In the focus groups and interviews, drivers were asked about the type of cargo they ordinarily move, or had moved in previous work assignments. They were asked questions about the type of truck they normally used to haul various cargoes, how much loading and unloading they do, how they feel loading and unloading affects fatigue and alertness, the type of loading dock situations encountered (including the procedures for queuing up to load or unload, the physical arrangements of loading docks and delivery locations, and the type of equipment and procedures used to load or unload cargo).

The drivers were asked also about their notions of driver fatigue and alert driving, how they recognize fatigue on the highway, how they cope with it or prevent it. In addition, we inquired about their usual work schedules, schedule changes, whether they were single or team drivers, effects of hours of service regulations (HOS) on their jobs and work lives. As well, we usually asked about the drivers' sleeping habits, nap-taking strategies, use of stimulants or sleep aids, health and fitness issues, as well.

The safety directors, dispatchers, truck driver managers, and other company officials were asked similar questions regarding loading and unloading activities, and also about driver fatigue, job, lifestyle and safety issues concerning their drivers.

Conduct of focus groups and interview sessions

Eleven focus group discussions were held with drivers, covering each of the nine different cargo commodity types, and in several different geographical regions of the country. For eight of these focus groups the members were drivers only, one group was with safety directors only, and two groups were with a mix of drivers and safety personnel. Additionally, individual interviews or discussions were held at numerous locations. When these were with truck drivers, they were held either individually or in groups of two to three at a time, and were conducted in less formal settings: while drivers waited in driver rest area cafeterias; in driver ready rooms at carrier facilities; standing and waiting with their trucks near loading docks or in parking lots. Table 3 lists the meetings, focus group sessions, interviews, and industry inquiries, and other specific activities accomplished for this task.

Table 3. Interviews, Meetings and Focus Groups for Task 2

Date/Subjects	Location, event	Details
Sept. 30, 1996 Safety managers	Los Angeles, CA Safety managers focus group at ATA's National Safety Management Council Meeting	TRI and Star Mountain, Inc. conducted a 90-min focus group meeting with nine safety managers from a variety of trucking industry carriers across the nation; and separately interviewed four others. This focus group meeting was conducted by Drs. Krueger and W.C. Rogers. Both then attended the full session of the national safety meeting, Oct 1-3, 1996.
Oct. 3, 1996 Tank truck drivers	Houston, TX Southern Bulk Carriers Conference and Exposition	SMI's Dr. Krueger conducted a 75-min focus group meeting with five tank truck drivers, and separately interviewed four other tank truck drivers.
Oct. 4, 1996 Safety directors	Houston, TX National Tank Truck Carriers Western Region Safety Directors Meeting	Dr. Krueger attended this 1/2 day meeting; while there he interviewed four safety directors associated with the tank truck driving community in the South and Southwestern U.S. Points of contact were established for subsequent work.
Oct. 11-12, 1996 Safety directors	Alexandria, VA National Private Truck Council Safety Committee Meeting	Attended by Drs. Krueger and Van Hemel. Interviewed six safety directors; talked to about a dozen other attendees; a questionnaire (Appendix C) similar to the one used with safety directors in Columbus, OH (Appendix B) was administered to all attendees (11 completed questionnaires were obtained). Established points of contact for subsequent work.

Table 3. Interviews, Meetings and Focus Groups for Task 2		
Date/Subjects	**Location, event**	**Details**
Nov. 19, 1996 Produce and grocery drivers; dispatchers; managers; company officials	Los Angeles, CA Los Angeles Wholesale produce market; nearby companies: State Wide Sales Co., Inc., Coast Produce, Valley Produce, & Reliable Transportation, Inc.	Drs. Krueger and Van Hemel interviewed drivers, dispatchers, managers and other company officials at several different California Trucking Association produce carriers, companies and locations in the Los Angeles wholesale produce market.
Nov. 19, 1996 Produce drivers; company officials	Oxnard, CA Boskovich Farms, Inc.	Drs. Krueger and Van Hemel interviewed about 4-5 produce (reefer) drivers and two company dispatchers/dock managers at Boskovich. Toured the produce processing plant.
Nov. 20, 1996 Produce, grocery, and general freight drivers; company officials	Commerce, CA Pathfinder Trucking, Inc.; Progressive Produce distribution center; Gelson's Super Market distribution center	Drs. Krueger and Van Hemel interviewed 4-5 drivers, Progressive's chief dispatcher, and toured the facility. Interviewed Gelson's grocery warehouse manager/dispatcher.
Nov. 21, 1996 Agricultural drivers; port officials; grain company manager	Stockton, CA Port of Stockton Continental Grain Co.	Drs. Krueger and Van Hemel conducted a small focus group meeting with California Trucking Association Agricultural Conference drivers. Site visits were made, and interviews conducted with the Manager of Port Operations and the Port Commissioner. Interviewed the Area Manager at Continental Grain Co.
Nov. 21, 1996	Stockton, CA California Trucking Association (CTA) Regulatory Reform Workshop	Drs. Krueger and Van Hemel attended CTA's ½-day workshop on Public Law 103-305 (Federal Administration Authorization Act of 1994); on the California Deregulation Task Force - CA Governor's Executive Order No. W-115-95 to recommend a new regulatory system; and on the CA Assembly Bill 1683 (Conroy) to revise CA state law to reflect federal preemption under PL 103-305. Other regulatory subjects also were covered.
Nov. 21, 1996 Safety managers; household goods drivers	Alexandria, VA American Movers Conference (AMC) Safety Directors Meeting	SMI's Dr. T.R. O'Neill conducted a focus group meeting with ten AMC participants (7 safety managers; 3 drivers). Mr. Sean L. Cassidy, OMCHS's Project Monitor for this work, attended.

Table 3. Interviews, Meetings and Focus Groups for Task 2

Date/Subjects	Location, event	Details
Dec. 27, 1996 Flatbed drivers; Safety director; company president	Harvey, IL Cresco Lines, Inc.	Dr. Krueger conducted a focus group session with three drivers who haul pipe and fencing from Allied Tube, Inc., and haul large bulky machinery and equipment out of Chicago area for other clients. Interviewed Cresco Lines' safety director and the president of Cresco regarding long haul driver fatigue issues.
Jan. 9, 1997 General freight drivers; company manager	Atlanta, GA Ryder Integrated Logistics International, Inc.	Drs. Krueger and Van Hemel conducted a focus group discussion with several general freight drivers at Ryder; and interviewed Ryder's director of regional customer logistics.
Jan. 9, 1997 General freight drivers; (some HazMat)	Atlanta, GA Custom Carriers, Ltd. (Coca Cola affiliate)	Drs. Krueger and Van Hemel interviewed about 10 drivers who deliver bulk food products for the Coca Cola Southeast regional distribution center. Toured Coca Cola's production center, warehouse, and loading docks.
Jan. 10, 1997 Grocery drivers, Dispatchers, Driver Managers	Lawrenceville, GA Company A Super Markets, Inc. distribution center & manufacturing facility	Drs. Krueger and Van Hemel conducted a driver focus group with from 15 to17 grocery delivery drivers at the Company A central dispatch office and driver waiting room. Interviewed Company A's central dispatch department head and the grocery warehouse supervisor. Toured distribution center.
Jan. 15, 1997 Various drivers	Secaucus, NJ Vince Lombardi rest area, New Jersey Turnpike Exit 17	Dr. Krueger conducted a truck driver focus group session with 8-10 drivers carrying a variety of cargoes as they rested at the public rest stop on the New Jersey Turnpike, not far from New York City's Lincoln Tunnel.
Jan. 22, 1997 Drivers for household goods and high value products; safety, training, and standards officials	Ft. Wayne, IN North American Van Lines (safety committee meeting)	Dr. Krueger conducted a focus group session with six owner-operator NAVL drivers and eight other NAVL safety, training and driving standards representatives. Individual interviews were also conducted with twelve other NAVL owner-operator moving van drivers, in groups of 2-3 at a time, at the NAVL transient cafeteria and rest stop in Ft. Wayne. Toured NAVL's loading and unloading training center, and the truck driving simulator trainer.
Feb. 5, 1997 Over-the-road bus drivers; driver manager	Washington, DC Greyhound Lines, Inc.	Drs. Krueger and Van Hemel held a focus group meeting with 9-10 bus drivers at Greyhound; interviewed the bus driver manager
Feb. 5, 1997 Safety director; terminal personnel	Washington, DC Peter Pan Trailways Bus Lines,	Drs. Krueger and Van Hemel visited the Trailways terminal, interviewed terminal personnel, and telephonically interviewed Peter Pan Bus Lines, Inc. director of safety, in Springfield, MA.

As site visits were made, interviews also were held with various trucking officials when they were available. These people included presidents of companies; safety directors; managers of drivers, carrier operations, docks, warehouses; and dispatchers. Usually the company representatives were interviewed in their offices or normal workplaces; some were interviewed at the regional or national trucking industry gatherings attended during this project.

Data collection and processing

Questionnaire responses were tabulated and analyzed for recurring themes and trends. Pertinent information and comments were extracted from each of the focus group meetings and interviews performed during this task. Most driver interviews and focus group meetings were audio recorded. These were transcribed or summarized to a sufficient level of detail to extract desired information. Some interviews with drivers could not be tape recorded because of high ambient noise environments; for those we took notes.

Focus group meetings with trucking safety managers were generally recorded and later transcribed for use in this analysis. Interviews with individual safety managers, and with other high level company officials, were ordinarily not recorded, as the presence of a recorder was deemed to inhibit free flow of conversation; in those cases we took notes either during the interviews or immediately afterwards.

Findings

The findings of this task are presented separately for each major area of interest: the literature review; the information gathered through interviews and surveys at the NTDC; the driver focus groups and interviews, organized by cargo types; and the focus groups and interviews with safety managers and other industry officials and managers. Then the findings are integrated across groups and the major themes emerging from the work are described.

Trucking Industry Literature review

This section of the report reviews trucking industry trade journal literature and available documentation describing America's trucking industry practices concerning commercial truck drivers loading or unloading trucks, and the procedures and methods by which they accomplish such non-driving activities as part of their jobs. Pertinent questions include:

- How do American truck drivers currently load or unload commercial vehicles?
- How much physical labor do drivers actually perform in the loading/unloading process?

- Does thc amount of physical labor differ as a function of the type of cargo/freight commodity? Does it differ because the kind of truck being loaded/driven or the loading equipment used (e.g. forklifts etc.)?

- What are the usual levels of driver work *intensity* and *duration* in the conduct of normal delivery operations?

- With what frequency do the drivers load or unload their trucks during a typical work week in conjunction with long haul trucking operations?

- Are there particular work shift scheduling considerations which impact loading and unloading and other non-driving activities which might lead to driver fatigue?

- How do these trucking industry procedures, practices, methods relate to driver fatigue, alertness, and driver safety on the highway?

Information from industry training and procedures manuals

Description of loading/unloading equipment used in trucking. Drivers and dock workers, lumpers, swampers, or other loading and unloading helper personnel use a variety of materials handling equipment. Many of these equipment items can be found at large warehouses where freight is shipped or received, and may be owned by the shippers, carriers, or receivers. Some drivers carry such equipment on their trucks, and in the case of many independent owner-operators, may actually own such materials handling equipment.

A partial list of materials handling equipment commonly used in the trucking industry can be found in Gilliland and Millard's *Trucking: A truck driver's training handbook* (1989), and includes the following items, many of which are illustrated in the photographs in Appendix E:

- **Johnson pry bar:** large flat wooden bar with a small set of wheels and a small steel lip on the end. The lip reaches under the edge of a crate giving leverage to lift the crate, tip it so it rests on the bar, and roll it.

- **Hand truck, two-wheeler, or dolly:** these permit one to move several cartons at once on a wheeled platform, and to do so without straining one's back Cargo must be lifted onto these by hand, or the flat steel lip of the hand truck is slid under the cargo, and the hand truck is tilted back to engage the load.

- **Pallet jack:** a low (few inches off the ground) wheeled platform with wide forks for insertion under a pallet; through either an electric or hydraulic lifting mechanism, lifts a pallet a few inches above the floor so that the pallet can be moved around; and sets the pallet down on the floor once it is moved into a chosen location. The motorized pallet jacks are self-propelled, normally electric, whereas the worker must pull non-motorized jacks. Usually pallet jacks have a 4-foot towing bar with a T-bar handle housing the

controls mounted on it. By operating the handle, operators can either push or pull the jack with the pallet on it and directionally control movement of the pallet.

- **Forklift:** small truck-like, self-propelled driver-operated device for lifting, stacking heavy objects. It consists of projecting prongs to be slid under the load (e.g. a pallet containing cargo/freight) and then raised or lowered to permit removal from a stack, or addition to a stack of other pallets. Fork lifts come in different sizes; the size usually determines the size of the load which can be moved, and the height to which a pallet can be machine lifted. Various widths and strengths of forks also determine the type of load which can be moved, stacked or loaded. Fork lifts are usually powered by electricity (battery) for indoor use or by small gasoline engines if used outdoors.

- **Platform truck:** a small truck-like flat platform upon which a load of cargo can be set, and can then be moved around a dock or warehouse by means of the gasoline or electrically powered vehicle. Platform trucks do not have forks and thus are only used to set loads onto, not to lift them.

The training handbook outlines several methods for use of each of the items above, and also provides tips on how to properly use and when not to use these items. A sample piece of advice presented in the handbook is: "When using mechanical handling equipment, work steadily and smoothly. Sudden bursts of speed are hard on you, your equipment and others working nearby" (Gilliland and Millard, 1989).

There are of course other training materials available to teach truckers and dock or warehouse personnel how to use such equipment, and how to properly load a truck and secure the load in particular applications. We obtained a variety of such documents from various trucking firms and shipping industry groups; the documentation we were able to obtain is summarized here.

Shipping/trucking industry manuals on loading/unloading procedures

The Specialized Carriers & Rigging Association offers an hour-long training video on their Load Securement Program (1995) including coverage of the 1994 load securement regulations. The video is a how-to-do-it-right manual on many aspects of loading large bulky items (machinery, equipment, tools, bulky loads, steel, etc.) on flatbed trucks. It depicts a step-by-step approach to planning out specialized loads; safety inspection and proper use of equipment; positioning loads on the truck; load securement through use of cables, chains, rigging procedures; use of tarps; cranes and other lifting devices; performing regular inspections of the load while in transit, etc.

North American Van Lines (NAVL), Ft. Wayne, Indiana offers drivers a course on loading and unloading household goods and furniture, and also a course concerning high value products (HVP) such as computers, electronic equipment, medical instrumentation and other large, expensive and hard to ship items. NAVL requires all their drivers, including Independent Owner

Operators who drive trucks with NAVL's logo on them, to successfully complete these courses (about a week long).

NAVL's courses offer a cargo manual (Gillett, 1997) outlining procedures for handling, packing, loading, transporting, and delivery of customers' furniture and household goods. The manual includes guidance regarding the preparation of goods; strategies and principles for loading and stacking items in the van; stacking boxes in the van or in a residence at delivery; packing and securing furniture; lifting and carrying; servicing and moving appliances; large furniture items; use of dollies and other loading equipment; do's and don't's for walkboard use; etc.

A second NAVL manual, the Relocation Services Division Guidelines Manual (Gillett, 1996) covers company operating procedures; billing forms; cargo damage claim procedures; packing and cargo marking procedures; use of equipment; special transportation programs for select shipments; etc. Policies and procedures for NAVL's High Value Products (HVP) Division are also covered.

Association of American Railroads (AAR) offers publications and training programs (AAR, 1997) in video and document formats. Major categories of videos available include: intermodal damage prevention; loading on or in railroad cars of flat and roll paper and pulpboard stock; lumber; household appliances and furniture; barrels, drums and kegs; case goods; food products. Videos also cover handling and shipping fresh fruits and vegetables by rail; grain car loading; machinery in closed cars; steel products; coiled steel, or aluminum on skids; motor vehicle damage prevention and loading and unloading; safety aspects of loading facilities.

The AAR also publishes an Intermodal Loading Guide for Products in Closed Trailers and Containers (AAR, 1995). This comprehensive manual describes methods and practices for loading closed truck trailers or intermodal containers with a wide variety of cargo/freight load types, and provides guidance on how to prepare and secure loads for shipment. Topics include loading and restraining hazardous materials; rules for loading, blocking and bracing of freight in closed trailers or containers; tested and approved securement methods for a wide variety of freight types; use of dunnage material for cargo protection; etc.

Chemical Manufacturers Association publishes a safety manual for shipment of hazardous materials. The manual is entitled: Interindustry Bulk Chemical Highway Safety Task Force: Manual of Recommendations. It contains guidance on how to meet and exceed the DOT safety regulations and requirements for shippers and carriers of hazardous chemicals. For personnel safety the guidelines state that all personnel (especially those involved in loading and unloading of hazardous chemicals) should be equipped with protection equipment appropriate for the hazards of the commodity in transportation. Chemical protective clothing and equipment includes: gloves, face masks, goggles, shoes, respirators and supplemental breathing devices. The guidelines provide suggestions for enhancing communication between shipper and carrier; marking and labeling; availability of safety equipment; training of personnel; pressurization procedures for tank trucks; safety procedures in transit, etc.

American Trucking Associations publishes manuals for shippers and carriers on working with hazardous materials, including one entitled Handling Hazardous Materials (American Trucking Associations, 1997), intended to help carriers operate safely and comply with HazMat regulations, and a Hazardous Materials Shipper's Guide. Many other hazardous materials manuals were identified, but were not examined in detail.

Studies of loading and unloading performed in the trucking industry

Loading and unloading effects on driver performance (Mackie & Miller, 1978). Mackie and Miller's work (1978) is the only published work directly aimed at the current driver loading and unloading issues. Their study must serve as baseline information both in terms of methodological approaches and its rich findings for subsequent work on this topic. This study was discussed extensively in Section I, the Task 1 report for this project, and is only briefly summarized here.

Mackie and Miller (1978) subjected long haul drivers to combinations of irregular work schedules and varying amounts of loading and unloading of cargo into their trucks, over a four-day driving schedule. They found that engaging in moderately heavy cargo loading had mixed effects on the subjective feelings, physiological status, and performance of sleeper drivers. Performing the loading task appeared to have some beneficial activating effects that persisted for much of the driving periods, especially during late night and early morning trips. It appeared that periodic interruptions of the driving task to participate in cargo loading could have a beneficial though not lasting effect on the subsequent alertness of the driver as he resumed the driving task. However, when combined with subsequent long periods of driving, physical work can have adverse effects on driver fatigue and performance. They concluded that *participation in moderately heavy cargo loading to the extent engaged in by many relay truck drivers increases the severity of fatigue associated with irregular working schedules.*

Midwest Transportation Center study of loading and unloading practices related to lumping. Looking to improve freight transportation industry business methods, a study team at the Midwest Transportation Center at Iowa State University examined trucking industry practices associated with ***lumping***: the loading and unloading of motor carrier freight by individuals other than the employees of motor carriers, shippers, or receivers. The study (Allen, Poist, Blanshan, & Thompson, 1994) was an examination of the impact of lumping at all levels of the transport supply chain. The study focused on three industry segments or business areas, selected on the basis of preliminary survey work indicating that they were the segments most likely to employ lumpers. The segments were: general freight, refrigerated products, and agricultural commodities, and the study looked at truckload shipments only. Using six survey instruments the study team surveyed carriers, shippers, receivers, drivers, and third-party lumpers in the American trucking industry, and held various focus group meetings and discussions on the topic.

Lumping practices are pervasive, occurring throughout the U.S., with 2/3 of motor carriers in the selected business segments indicating that lumping occurs in most or virtually all of their

markets. Several findings from this study of loading and unloading practices are pertinent to truck driver workload and driver fatigue issues and therefore are summarized here.

When the various survey groups were queried about the *benefits* of using lumpers:

1. the two benefits most often identified by *carriers* were reduced driver fatigue, and reduced risk of driver injury from loading and unloading (Allen et al., p. xvi);

2. *shipper* benefits included reduced loading time during periods of normal demand;

3. *drivers* identified the most important benefits as getting needed rest and faster unloading (these were listed by 81% and 71% of the respondents respectively and no other reason was cited by as many as 50% of the driver respondents);

On the contrary, some of the problems cited with regard to using lumpers also seem to involve driver fatigue. Drivers pointed out the changed nature of the "involuntary requirements to use lumpers" from the former techniques of "physical coercion" (now outlawed through the Motor Carrier Act of 1980) to the current ones of forcing longer waiting times upon drivers if they do not employ available lumpers, which results in forced delays in the unloading process. The most common methods reportedly being used to force drivers to use lumpers include:

- delays in unloading if a driver does not use a lumper,

- drivers not being allowed to unload without hiring a lumper,

- restricting the time permitted to unload,

- requiring the load to be broken down or repalletized, and

- permitting lumpers to use materials handling equipment, but requiring the driver to load/unload manually.

Drivers indicated the most important reasons for involuntary lumping were:

- a general attitude of shippers, receivers, and carriers that exploits truck drivers, and

- a lack of Interstate Commerce Commission (ICC) enforcement of existing laws (both listed by 72% of drivers).

Over 50% of the drivers report their most common response to dealing with situations involving coercion is to simply "hire the lumper." No other response was mentioned by more than 10 percent of the drivers. Each of the five driver concerns listed above has implications either for

the amount of waiting time encountered by drivers, or for the amount of physical labor the driver must engage in to have his/her truck loaded or unloaded.

The Midwest Transportation Center study team points out that lumping services, if properly utilized, can help carriers meet time-sensitive schedules and reduce driver exposure to injury and fatigue (Allen et al., 1994). They determined that drivers use lumpers extensively for floor loads and almost as much for unitized loads requiring breakdown and re-palletization. The commodity groups (among those carried by the selected respondents) most likely to be handled by third party lumpers are refrigerated or frozen foodstuffs and tires.

When drivers choose not to employ lumpers to assist them in loading or unloading, the most frequent reasons seemed to revolve around different concerns inherent in direct personal contact with lumpers. Drivers identified the major reasons for not using lumpers as:

- the costs of lumpers exceed carrier reimbursements (64% of respondents),
- risks in carrying and handling cash to pay lumpers (37%), or
- drivers want additional income from the loading/unloading allowance (31%).

No other problem was cited by as many as 25% of the respondents.

This Midwest Transportation Center report is rich with survey data and conveys a very comprehensive picture of many other facets of truck transport shipping practices, although it does represent only a portion of the trucking industry. Other important data, seemingly less pertinent to the topics in this literature review, are at least tangentially relevant to the issues of how truck drivers spend large portions of their time concerning issues of loading and unloading (Allen et al., 1994). This study found that motor carriers, shippers, receivers, drivers, and other parties view lumpers and lumping services as producing both important benefits and problems. On the positive side, the authors conclude that lumping services provide an alternative for hand loading or unloading by drivers so that they can meet time-sensitive schedules and reduce their exposure to injury as well as *fatigue*.

Among the several initiatives the study recommends, the authors suggest governmental action could be taken to eliminate motor carrier and driver involvement in loading and unloading processes. They say this initiative, applied to truckload shipments only, involves what may be referred to as driver "no touch" loads (Allen et al., 1994, pg. xxiv).

Obviously such suggestions, and other ideas embedded within this important study, have the potential for changing some driver loading and unloading circumstances, especially those commonly associated with use of self-employed or independent lumpers. Some such changes might lessen the amount of physical labor drivers perform in actual loading or unloading; proposed changes could restructure and decrease the inherent "waiting time" drivers presently

face at many receiver docks; changes might permit drivers to have better control of their own schedules to allow more time for rest and sleep. Such changes could therefore be of help in alleviating some amount of truck driver fatigue.

Interstate Truckload Carriers Conference (ITCC) refrigerated carrier driver survey. This report, commissioned by the Executive Committee of the ITCC presents a study of the attitudes and satisfaction of refrigerated carrier ("reefer") drivers. The goal was to highlight driver-unfriendly companies that contribute to poor driver relations, and to develop ways to remedy conditions at shippers and receivers (Martin Labbe Associates, 1996).

This questionnaire survey inquired of many drivers (1,500 responses) concerning their views on many work-related issues, including some issues regarding on-duty but non-driving activities which undoubtedly impact driver fatigue and alertness. Some of the survey results are selected for highlighting here because they are pertinent to driver fatigue issues.

Job factors important to drivers. When asked about the most important factors determining how they feel about the work they do, drivers listed three factors most: a) getting good directions to find the shipper or receiver, b) the attitude of the carrier's dispatcher and the freight receiver, and c) the *amount of time spent waiting to load or unload.*

Longer trips mean less loading and unloading. Over half of the respondents in Labbe's study of reefer drivers described average length of hauls greater than 1,000 miles, with correspondingly fewer occurrences of loading and unloading. This survey also indicates that young truck drivers (21 to 25 years of age) get home more often than drivers who are over 26 years old; but as driver age increases beyond age 40, the tendency to be home more often increases. Reasons given by the authors for the "at home frequency" differences ranged from companies not assigning young inexperienced drivers to long haul trips, to owner-operators and independent contractors seeking out longer trips for revenue making reasons (Martin Labbe Associates, 1996, p.12).

This finding leads to two important points concerning our work here:

- on longer trips, there is less loading and unloading because the freight is kept on the truck for a longer delivery run;

- it seems reasonable to presume that the drivers who are at home more often may actually do loading and unloading more frequently, but this is subject to verification.

If the second conclusion is so, then can we say that the older drivers and the youngest drivers are loading and unloading more frequently? Are there any age effects to be explored here?

Type of commodities. When asked about the commodities these reefer truckers haul, the respondents stated they carried a very wide range of commodities that require refrigeration. In

addition to the obvious frozen and refrigerated foods, other items hauled included candy, wax, beer, produce, flowers, and plants (Martin Labbe Associates, 1994, p. 14).

Many of the responses to "preferred commodities" and "worst commodities" hauled focused on the packaging of the goods. Not having to touch the freight, but instead having it contained on a pallet or shrink-wrapped was an important issue (Martin Labbe Associates, 1994, p. 14).

Drivers do not like "high maintenance freight," freight which requires extra effort or might be damaged easily. For example, strawberries appeared on the "worst commodity" list due to special packaging and hauling requirements. Another notable commodity disliked was plants, because of the dirt they leave behind (Martin Labbe Associates, 1996, pg. 14).

Size and dimensions of freight/cargo. Equally important was the size of pallets. Drivers do not like to break down pallets more than is necessary, as this increases the time they spend unloading the truck (Martin Labbe Associates, 1996, pg. 14).

Frequency of driver loading and unloading trucks. The refrigerator drivers in the Labbe study stop to load, on average, 3.1 times per week, while unloading an average of 4.1 times per week. Labbe Associates state: "The difference in the number of loadings and unloadings is to be expected because the figures reflect both linehaul carriage and more localized pickup and delivery between warehouse and retail outlets. Thus drivers that pick up once and have multiple drops increase the average number of unloadings." (Martin Labbe Associates, 1996, p. 15)

Waiting and loading/unloading time. The Labbe study identified as fundamental issues the time that drivers spend at either end of trips, and a need for better communications between the dispatcher and shipper/receiver, and better organized docks. Refrigerator drivers were asked "On average, how much time do you spend for each load: waiting to load; waiting to unload; actual loading time, and actual unloading time." Table 4 shows their responses, averaged for each of the three driver groups.

Table 4. Time for Loading and Unloading

Time in minutes	Company Drivers	Owner Operators	Drivers - Leased Fleet
Waiting to load	191min.	200	219
Actual loading time	104	97	84
Waiting to unload	170	186	122
Actual unloading time	143	139	114

(From Labbe Associates, 1994, p. 16)

The surveyed drivers spend, on average, close to ten hours total at loading and unloading sites for each freight shipment that they pick up and deliver. If a driver has several shipments per trailer load he/she could spend ten to fifteen hours total time at loading and unloading sites. (Martin Labbe Associates, 1996, pg. 16)

For drivers paid by the mile or by percentage of revenue, the time spent waiting comes straight out of their pocket, because they are constrained by HOS regulations. Labbe's data indicates drivers of leased fleets are able to make up some time by being more efficient in loading and unloading freight. However, they are frequently made to wait longer than company drivers and owners, thereby spending the same amount of time at each stop. The study authors state that their results support the need to improve logistics and communications by highlighting the average time spent waiting and loading or unloading.

Shipper/receiver assistance in loading/unloading. When asked what share of the time is loading or unloading assisted by shipper/receiver personnel or lumpers, the refrigerator drivers indicated that on average they estimate shippers assist the driver with loading about 2/3 of the time. At the receiving end, the driver has a 47% chance of being assisted by the consignee (receiver) and the rest of the time the driver must hire a lumper or do the unloading himself or herself. Thus, shippers are more likely than receivers to help with loading and unloading.

Criticality of loading/unloading. Reefer drivers were asked to rate sixteen work related factors (ranging from parking and security to attitudes of dock personnel) in terms of their importance on the job. Having clear loading and unloading areas was rated critical by 41.3%, rated as important but not critical by 54.8%, and least important of the 16 items by 8.0% of the reefer respondents (Martin Labbe Assoc., 1996 pg. 23).

Miscellaneous time drains on drivers. Many specific driver responses to open ended items on the ITCC survey tend to highlight additional issues which may contribute to driver fatigue. Some of them address loading and unloading directly, others speak of other demands on the driver's non-driving time. We present several reefer (refrigerator truck) driver quotes from the Labbe report which seem relevant here:

- Eliminate waiting - loading - unloading and the illegal operations of trucks.
- Often a driver is physically unable to unload the truck, lumpers have to be hired.
- We should be compensated for time lost either by loading, unloading or waiting for dispatch. This amount has exceeded 3 hours per week. How do we account for this time in the HOS considerations?
- Waiting is not always first come first serve and different loads are given preference loading or unloading.

- Receivers need to start unloading their loads themselves, or provide the necessary equipment for us if we are to unload it ourselves.

- The driver who unloads his own truck may have driven all night to get there, unload (for $60) then have to drive again to get his next load underway. That is a dangerous situation.

- People on the dock being paid by the hour can't see time as a problem, as owner/operators can. Efficiency levels are sometimes sub-par.

- Equipment is substandard. They give you a broken jack to unload.

- Getting directions to receiver and correct times of deliveries really helps.

- Be aware and inform drivers of where they can park overnight.

- Contrary to popular belief, we are not married to that truck.

There was a general complaint from produce drivers who see themselves frequently serving as the middlemen running between the telephone and the dock when there is freight damage to be reported, missing or rotten products. Their carriers have the drivers interact directly with the shipper or receiver. This imposes a time demand, and is a very stressful exercise: relaying messages between dispatcher and shipper.

Other sources on loading and unloading practices

We found few information sources on loading and unloading practices, but here some quotes and summaries we were able to find. *Trucking: A truck driver's training handbook* (Gilliland & Millard, 1989) has pertinent comments on loading and unloading: a)"It is customary for city drivers or local drivers to handle the breakout and loading of freight in the dock area;" and b)"a line driver very rarely gets involved in the actual handling of the freight at a terminal. Instead, all freight to and from a line-haul unit is handled by the dock workers." Beilock and Mahan (1987) noted drivers are usually alone, fatigued, and under a time constraint to unload. Lumpers might be organized, and have tacit or overt support of personnel at the loading or unloading facility. Equipment available to the lumpers might be denied to drivers. These factors combine to create market situations that favor the seller over the buyer, leading to inefficient results.

When asked to list contributors to fatigue (Williamson et al., 1992), 47.2% of 947 responding Australian truck drivers reported "loading and unloading" as a factor contributing to fatigue (it was the 5th highest item on the 22 item list, exceeded only by poor roads, bad weather, long driving hours, and dawn driving); 42.6% of these drivers reported loading and unloading as an important contributor (the highest of all factors listed) to driver fatigue (pg. 67). The drivers (77%) reported doing at least some of their own loading or unloading, with the mean time spent in this activity being 3.5 hr per trip. Drivers (74%) considered that more efficient loading-unloading practices would be a useful fatigue-reduction strategy.

National truck driving championships

Several interesting findings came out of the surveys completed at the National Truck Driving Championships (NTDC) at Columbus, Ohio, August, 1996. Presented first is information characterizing the type of equipment driven by the respondents and the cargo they transport. Then their responses on loading and unloading questions are summarized.

Characterization of drivers' work

Table 5 displays responses of 308 drivers to the question: "What type of vehicles do you normally drive?" (check all multiple-choice categories that apply). Many drivers drive more than one type of truck, resulting in a total of 395 responses. Dry vans were by far the most commonly driven truck, with refrigerated vans second, and fewer of other types.

Table 5. Driver Responses on Vehicles Driven

Type of Truck driven	N responding
Dry van	196
Refrigerated van	78
Liquid Tankers	40
Other	21
Flatbed	21
Household goods van	14
Auto carrier	8
Package truck	6
Dry bulk tankers	6
Dump truck	5
Total responses	**395**

Table 6 depicts responses of the 308 drivers to the question: "What are the most frequent types of freight/cargo you haul? Twelve categories plus "other" were provided. The drivers gave an average of more than two responses each, for a total of 634 responses. The most common cargo was general freight, followed by several categories of food and food-related products. In total, there were 334 responses to the four food/grocery-related categories. Bulk cargoes and industrially-related goods were carried by many fewer of these drivers.

The above "demographic" data are provided as background to the responses of the Columbus drivers (in 1996) on questions related to loading and unloading of their trucks. It is interesting that the drivers represented here seem to be clustered in those industry segments that the Midwest Transportation Center (Allen, et al., 1994) lumping study found likely to employ lumpers and to have loading/unloading issues in their work.

Table 6. Driver Responses on Cargo Carried	
Cargo Carried	**N Responding**
General freight	143
Other grocery related	102
Non-refrigerated foodstuffs	93
Refrigerated foodstuffs	81
Fresh produce	58
Dry chemicals/materials	40
Liquid tank cargo	39
Other	25
Building materials	16
Metal products	15
Forestry products	13
Household goods	7
Mining products	2
Total responses	**634**

Responses to loading and unloading questions

Figure 1 shows the reported frequency with which the responding drivers reported loading their trucks. The exact wording of the item was, "How often do you participate in the actual physical activity of "loading" your truck? (by whatever means of loading, including using mechanical assists like those listed in Question 10)." Almost equal numbers (about 1/3 of drivers each) reported that they almost never loaded and almost always loaded, with the remaining third loading some or most of the time.

Figure 2 shows the frequency with which these drivers reported unloading their trucks. The question was worded just like the one on loading, with the word "unloading" substituted for "loading." It is clear that more drivers unload than load in this group. 52% "always" (defined in the item as "about every time out") unload, and only 19% almost never unload.

Figure 3 depicts the percent of the Columbus drivers responding to each alternative on questions about the time usually taken to load their trucks. Figure 4 shows reported time to unload.

These responses indicate fewer drivers spend time loading than unloading, and when they do perform the work, it takes less time to load than to unload. For two reasons we advise caution in interpreting these and the preceding graphs on frequency of loading and unloading. We are uncertain whether the drivers interpreted these questions exactly as they were intended, and the "time to unload" question was inadvertently omitted from some survey forms, contributing to the 16% "missing" responses on that question.

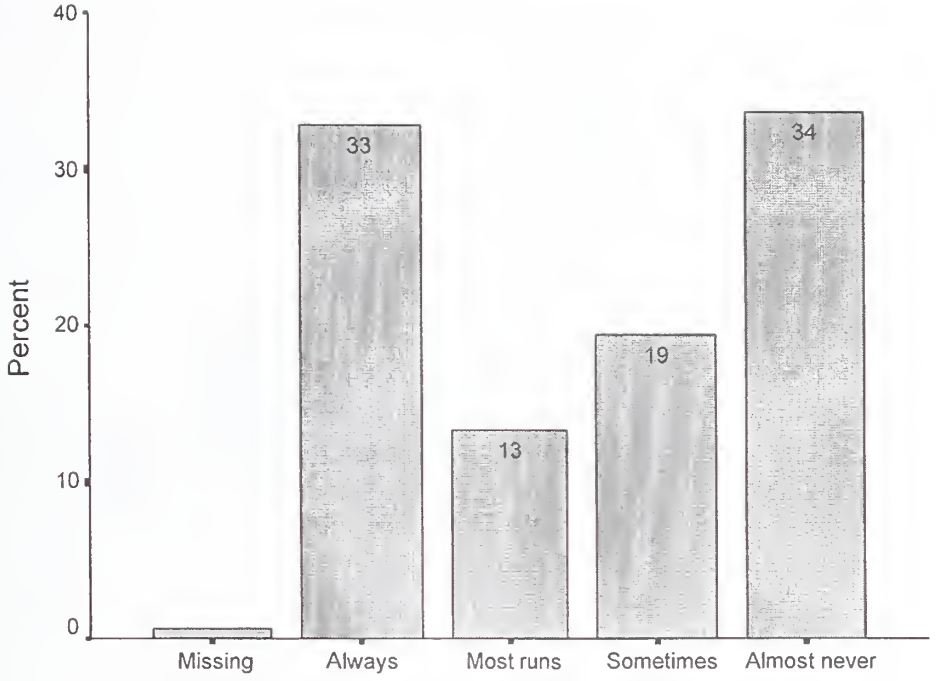

Figure 1. Frequency of loading (% of respondents)

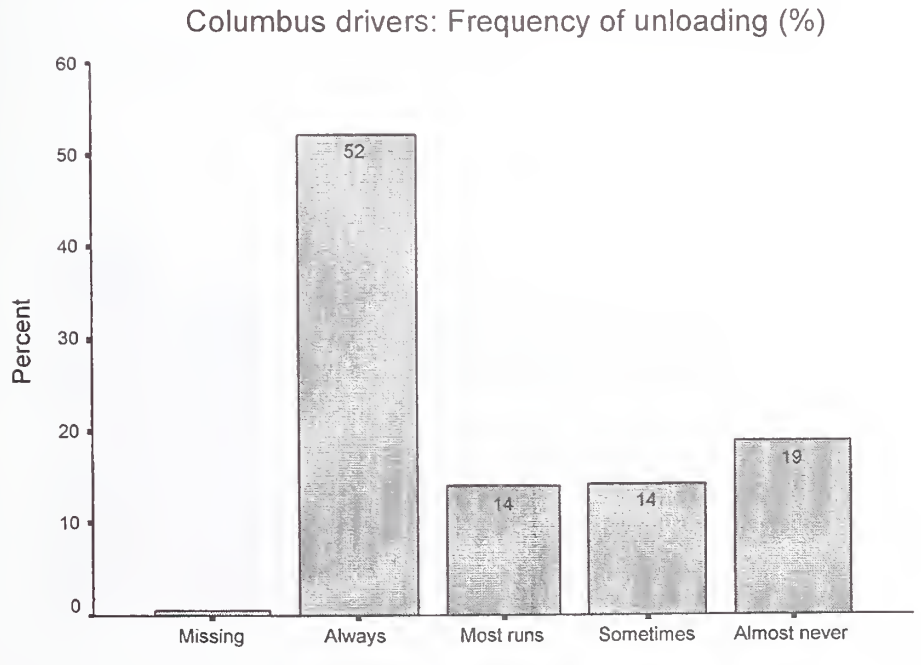

Figure 2. Frequency of unloading (% of respondents)

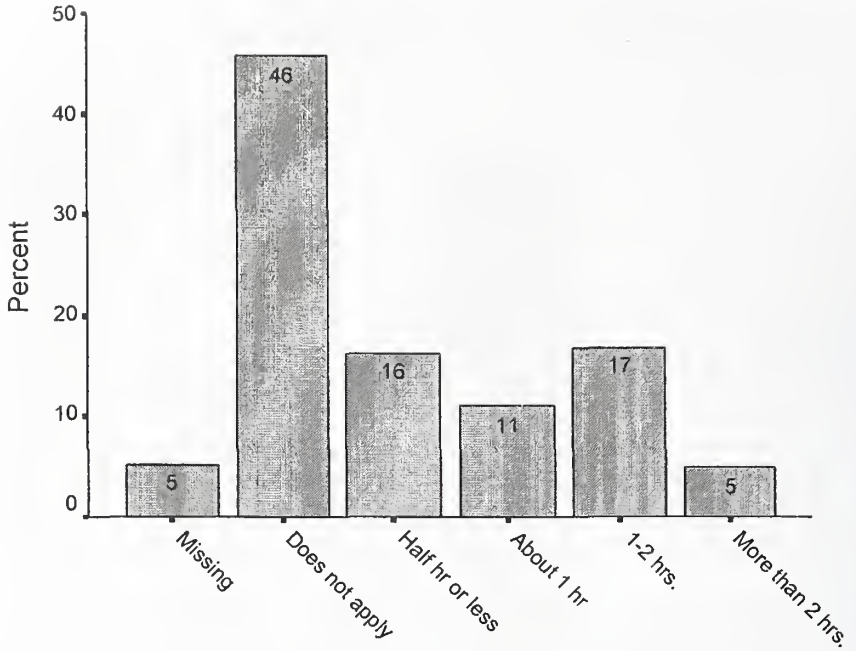

Figure 3. Time to Load (% of respondents)

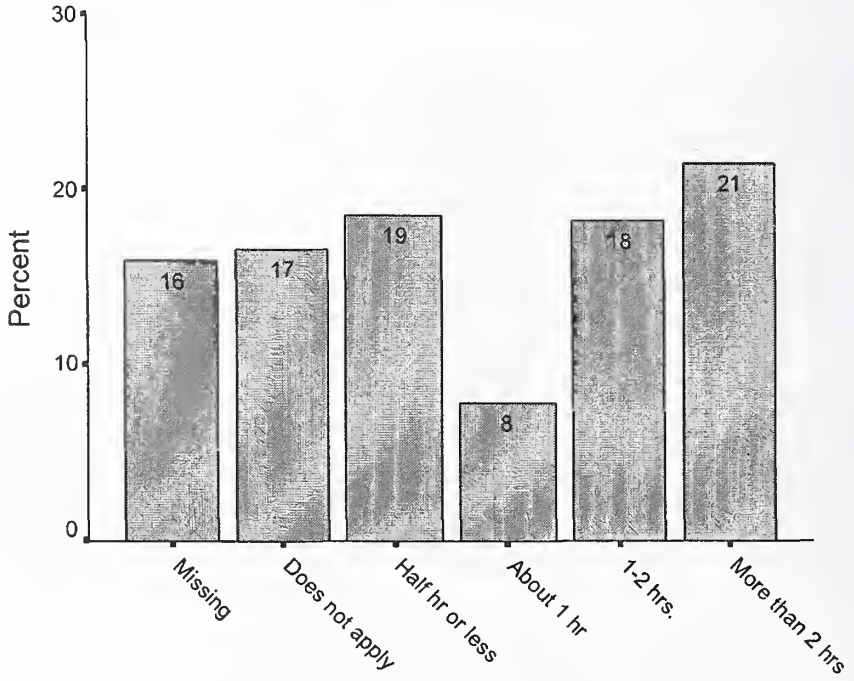

Figure 4. Time to Unload (% of respondents)

Our uncertainty about how the questions were interpreted stems from cross-tabulations that showed inconsistencies between the questions on frequency of loading and unloading and those on time to load and unload. Thus, 15 drivers who responded that they "always" load their trucks, 10 who said they loaded "on most runs," and 28 who said they loaded "sometimes" also responded that the item on how long it takes to load "does not apply, I do not generally load my truck." We are not certain what these inconsistencies mean. It is possible that some drivers who normally supervise loading/unloading by others responded positively to the questions on whether they "physically participate" in loading/unloading, but then gave the "does not apply" response when asked how long they spent loading/unloading.

Open-end item responses. The qualitative, open-ed item responses from the Columbus competition drivers were interesting, because they alerted the study team to issues and problems associated with loading and unloading. Thus they helped us to design the questions for the interview and focus group sessions that followed. Below, we present a small sampling of comments chosen to represent the issues most frequently mentioned, or described as of highest priority or importance. A more extensive sample of these responses is found in Appendix D. The comments here are organized by the specific open-ended questions they were responding to.

Question 17: What are some of the most difficult loads you have loaded/unloaded?

- Grocery loads that are on the floor and have to be sorted and palletized. Because it seems that every receiver has their own way of wanting this done and they are all different.
- Heavy pipe; you can't hardly handle the pipe with fork lifts or hands.
- High gravity petroleum product, because of vapor pressure and cavitation of pump.
- Log cabin kits.
- Any load with multiple products on each pallet that have to be sorted.
- Ammonia which is very hazardous.
- Loose grain in a van trailer because it has to be shoveled out.
- Any loads to a grocery warehouse because they are extremely slow at making appointments & checking in freight.
- Sulfuric acid, must wear full safety gear; chemical protective clothing is problematic.
- Tires, you have to handle each one. Sometimes it takes 2 hr or more.
- Flour products in 100 lb. bags; dog food in 100 lb. bags.

– Heavy products – appliances, customers without fork lifts, inside delivery building and up stairs.

– Beef quarters; you have to carry over 200 lbs. and hook and rail.

– Loads of milk; milk crates are very slippery and tend to make trailer floor very slick.

Q. 18. Does the type or the amount of loading and unloading you do affect your ability to follow the hours of service (HOS) regulations? If yes, please describe the situation here.

– Yes, because if you show line 4 on the log book it counts against you on the total hours for that log! You add driving time to loading or unloading time you will use up your hours very fast!!

– Yes, if I take too much time to load and unload, after several loads, it greatly reduces my available driving time.

– Yes; sometimes it does but if we are running close on hours we just lay over in a motel. 7 or 8 hr off duty.

– Yes; the time involved for loading/unloading has to be logged legally. Also, who wants to drive late at night after already doing a day's work? (This is where fatigue happens!)

– Yes; sometimes it takes 2-3-4 hr to get it done and when you get paid by the mile, you have to cheat a little to get it all done in time.

Q. 19. Does your physical activity in loading and unloading make you more alert or less alert (more fatigued), or it doesn't make a difference for driving?

– Less alert: when unloading, especially in the summer, the trailers are extremely hot so naturally along with the physical work is the exhaustion from being in the extreme heat.

– If it is hand unloaded, it takes quite a bit from your system.

– Lumping a load of freight can be very physical work, and especially tiring if you have just driven a ways to get to your destination.

– When you help unload you got your blood going a little faster. It helps you get more motivated.

– Wakes me up, gets the blood flowing after a 2-hr drive to the first stop (usually at 1-2 AM).

- If driving and unloading is within the correct HOS it doesn't affect my driving ability but the time of day does.

- Tarping and untarping loads takes a good portion of my energy, especially on hot days.

- I usually unload 12-15 stops a day. After about 10, you are getting worn down.

- Multiple drops of 50 or more cases take two drivers and if you do this all night and half the day, one of you will be driving tired. If you unload by yourself it takes longer and you have to stay on ETA.

- In many cases we are required to be suited in full chemical protective gear. It takes a lot out of one's body on hot summer days due to dehydration.

- Lots of loading tires me early [in the workday]. Loading and unloading later helps me wake up (physical activity is good break mentally as well as physically).

Q. 22. What other driver loading and unloading topics or concerns do you think we ought to be exploring in our focus group discussions?

- More consistency of shipper load and receiver unload.

- More uniform warehousing techniques.

- Training of new help in loading and unloading the right way.

- Requirements by some receivers to place cargo on their pallets in accordance with their specs; driver becomes their warehouseman.

- Shippers & receivers making unreasonable pickup/delivery intervals.

- Waiting in line to load or unload.

- More parking at major warehouses such as [grocery retailer names] and at cold storage places all over the country. Many places won't let you park or the city has "No Parking" signs all over. As a result, many trucks must go into the city at rush hour and contribute to congestion. Most over-the-road drivers prefer to get to where they are delivering or loading when they get near a town. It might be 10PM or 3AM, but you have to park 30 to 75 miles from town.

- Communication between drivers and dock management.

- Receivers who won't let drivers sleep when they are waiting in line to unload. If drivers fall asleep other trucks will pass them up in the line.

- Driver on pedal runs who have to unload their entire truck by hand and have to stop very frequently. By the time they are at the end of the run, they are exhausted and out of hours, but some company policies make them finish or return to terminal even if they are out of hours or shouldn't be driving because of alertness.

- Inside deliveries. Sorting freight per item for customers on less than truckload (LTL) shipments.

- Team 10-hr rule.

Driver focus groups and interviews

The findings from the formal interviews and focus groups with drivers are presented in the next sections, organized by the nine cargo/passenger types identified in the Methodology section. For each of these cargo types, the findings are given first in tabular summaries of the interviews and focus groups, and then are discussed in more detail as needed.

Each table gives the same categories of information, defining the drivers' typical trip length and type, the extent to which the drivers do overnight trips, the availability and use of sleeper berths, and the extent of team driving. Then the truck type and cargo characteristics are described, followed by descriptions of the loading and unloading performed by the particular driver group, and of other physical labor they perform. Finally, the drivers responses to questions about fatigue are summarized, along with special considerations that may apply to the particular group, and notes on other information the study team found pertinent or interesting.

Dry groceries and related items

Table 7 lists summary findings for dry (non-perishable) groceries and related products (cleaning supplies, paper goods, cosmetics, pet supplies, other food store items). These findings are based on the focus group with 15+ drivers at a large southeastern grocery chain (company A)and from interviews with individual drivers (some of them included in other groups, such as agricultural commodities) who carried groceries as well as other cargo. Company A drivers carry both dry and refrigerated loads of cargo, but their responses are included in this table, since each driver may haul both types of load.

Particular concerns of grocery drivers concentrate on the loading and unloading process, the practices of grocery warehouses concerning waiting time to unload, requirements for drivers to break out and re-palletize already palletized loads, and issues of using lumpers. These remarks corroborate the Columbus NTC survey responses, which centered on the same issues. When Interviews made it clear the situation of drivers hauling from a retailer's warehouse to that retailer's stores is quite different from for-hire grocery carriers. The private (e.g., Company A) drivers' employer is the shipper, carrier, and receiver, and thus has no reason to shift responsibility (i.e. for unloading) from one of these functions to another, as separate shippers and receivers may. They also are able to coordinate operations, using uniform pallet sizes and

company-wide procedures. Because of this, the private drivers perceive fewer problems, and find it easier to work as a team with warehouse and store personnel. Company A drivers did report problems with insufficient or poorly maintained unloading equipment at some stores, and also with the store employees assigned to help them unload. They reported that store stock persons sometimes were physically unable to do the work, and sometimes were not trained in what they needed to do. This sometimes left the drivers feeling they had to do more than their fair share of the physically tiring unloading work.

Table 7. Responses of Grocery Drivers

Characteristics	Predominately loads of Groceries
Where interviewed	Atlanta, GA; Los Angeles, CA; So. Florida, other locations
Typical trip origin and destination	From manufacturers to wholesale warehouses; from wholesale warehouses to retailer warehouses and stores
Typical trip length	Short to long haul.
Overnight trips (away from home)	Sometimes (not for Company A and other local or regional private carrier distribution situations).
Sleeper berth available? used?	Sometimes; sometimes.
Team driving?	Occasionally.
Truck type	Dry van, sometimes reefer (refrigerated truck).
Typical loads	Company A (includes produce, etc.): Dry boxed goods; produce, baked goods, dairy goods from warehouse to stores. Other drivers: dry boxed goods.
Typical load "format"	Nearly all palletized.
Time sensitive?	Somewhat for dry goods; yes for bakery, dairy, etc.
Driver loading frequency	None by drivers interviewed.
Driver unloading frequency	Company A: Frequently. Driver and store help unload using pallet jacks. Other drivers: Sometimes. May be required to break down palletized cargo.
Load handling equipment used	Pallet jacks for drivers; others may have fork lifts, motorized pallet lifts. May be required to use lumpers.
Other physical work required	Breaking down pallets if not acceptable as loaded.
Waiting time a factor?	Often for unloading. Receivers may be "picky" about missed appointments.
Special considerations	Many comments on dislike of practices at grocery warehouses: problems with lumpers, breaking down pallets, waiting to unload.
Major sources of fatigue	Waiting time; occasional need to hand-unload, break down pallets.
Notes	Common carriers (e.g. producer to wholesaler, wholesaler to retailer) have a different environment than private carriers (e.g. Company A warehouse to Company A stores). For private, few conflicting interests, the shipper, carrier, receiver are all one company; little incentive to shift costs to other parties.

Agricultural products

Table 8 lists responses of the agricultural commodity drivers interviewed. These drivers haul a wide variety of products, moving with the seasons to wherever the next crop is ready for harvest. Drivers interviewed were intra-state haulers in California, so they operated under California hours of service rules, permitting 12 hours driving per day, and more during harvest "rush."

Table 8. Responses of Agricultural Drivers

Characteristics	Agricultural (bulk) Cargo
Where interviewed	Stockton, CA.
Typical trip origin and destination	Fields to packing sheds, processing plants, grain elevators.
Typical trip length	Less than 4 hr
Overnight trips (away from home)	No, but may work night shift.
Sleeper berth available? used?	No; no.
Team driving?	Seldom
Truck type	Flatbed, hopper.
Typical loads	Bulk fruit, vegetables, nuts, grain.
Typical load "format"	Bins on flatbed, bulk (hoppers).
Time sensitive?	Yes, especially fruits and vegetables.
Driver loading frequency	Very seldom load. Often hook up loaded trailer and go.
Driver unloading frequency	Seldom unload fruits, vegetables; may unload grain.
Load handling equipment used	Vacuum or gravity feed for grain.
Other physical work required	Tying down or tarping of bins, hoppers.
Waiting time a factor?	Often in fields, at elevator or port facilities; may have long waits to pick up fruit/vegetables or unload grain in season.
Special considerations	Seasonal work; heavy workload and long hours at peak times. Weather can influence loading, waiting times.
Major sources of fatigue	Waiting to unload (grain) or load; long days in peak season.
Notes	Drivers unhappy about lack of space for trucks queued up to unload. Often must park illegally by side of road in industrial areas.

Drivers did not perform much loading or unloading; they occasionally worked at unloading grain hoppers, but only in positioning trucks and hooking up to unloading equipment. More often they picked up loaded trailers at the harvest point, and either dropped loaded ones, or waited while others unloaded them at a processing or packing site or the port. Sometimes they were required to tarp or tie down bins or hoppers of produce, a job they estimated takes up to 15 min per load.

Waiting time was an issue, both in the farming fields for fruit, vegetable, and nut crops (especially in bad weather, when harvesting was slowed), and at elevator or port facilities for grain crops. Interviews at the Port of Stockton and at Continental Grain corroborated drivers' claims that at peak seasons, up to one hundred trucks can be found lined up waiting to unload wheat or rice. Drivers concerns include lack of suitable queuing systems for the unloading process, the shortage of safe legal parking places, the absence of suitable places to sleep or nap at or near these unloading facilities. Facility managers seemed unconcerned about these issues.

Most agricultural hauling is short to regional haul, since processors, packers, and storage facilities are usually located in the producing area. The agricultural drivers interviewed in Stockton drove grocery products from packing houses to wholesalers/distributors in the winter, and their responses on that cargo have been incorporated in Table 7.

Produce, dairy, other refrigerated cargo

Table 9 lists responses of drivers of produce, dairy products, and other refrigerated (reefer) cargo.

Table 9. Responses of Produce, Other Reefer Drivers	
Characteristics	**Produce, other Refrigerated Cargo**
Where interviewed	Los Angeles, CA area; other locations.
Typical trip origin and destination	Packing sheds (farms) to produce warehouses; dairies, frozen food plants, wholesale warehouses to retailer warehouses, stores.
Typical trip length	Long hauls, often cross-country or south to north for produce, frozen foods; shorter for dairy.
Overnight trips (away from home)	Yes.
Sleeper berth available? Used?	Yes. Sometimes.
Team driving?	Occasionally. Frequently for cross-country hauling of fresh produce.
Truck type	Refrigerated van, refrigerated tanker (bulk dairy).
Typical loads	Boxed produce ready for sale; dairy products, frozen foods; plants.
Typical load "format"	Nearly always palletized. Seldom floor loads. Bulk milk, etc. in tankers.
Time sensitive?	Yes.
Driver loading frequency	Very seldom load. May hook up loaded trailer and go.
Driver unloading frequency	May unload or have lumper unload; or receiver may unload. May drop trailer.
Load handling equipment used	Pallet jacks for drivers; others may have fork lifts, motorized pallet lifts.
Other physical work required	Breaking down pallets if not acceptable as loaded.
Waiting time a factor?	Often for loading; sometimes for unloading.
Special considerations	Many comments on dislike of practices at grocery warehouses: problems with lumpers, breaking down pallets, waiting to unload.
Major sources of fatigue	Waiting time; occasional need to hand-unload, break down pallets.

The drivers interviewed included several in the Los Angeles, California area, and others encountered at various locations (e.g. a dairy driver working for Ryder in Atlanta, Georgia, and drivers from farm to the dairy in Virginia).

Reefer drivers reported the same problems at warehouses as the dry grocery drivers: long waiting times; appointment requirements seem unreasonable; pressure to use lumpers; delays if lumpers were not used; and receivers requiring that loads be re-palletized or broken down. Drivers

especially disliked requirements to break down and re-palletize unitized (palletized or shrink-wrapped) loads; this must be done by hand, one carton or crate at a time.

Heavy construction materials, pipe, large equipment, etc. (flatbed)

Table 10 presents responses of drivers hauling pipe, steel, construction materials and equipment, and other large flatbed cargo such as railroad locomotive repair parts (e.g., for Amtrak).

Table 10. Responses of Flatbed Truck Drivers

Characteristics	Pipe, Tubing, Metal Products, Other Flatbed Loads
Where interviewed	Harvey, IL (Cresco).
Typical trip origin and destination	Long haul; other drivers do local deliveries.
Typical trip length	Long haul (drivers in this group).
Overnight trips (away from home)	Yes.
Sleeper berth available? used?	Yes.
Team driving?	Occasionally.
Truck type	Flatbed.
Typical loads	Pipe, tubing, 3 to 25 ft. long, thin to very thick, heavy.
Typical load "format"	"Bundles" of pipe, may mix sizes in one load. Telephone poles mentioned.
Time sensitive?	Sometimes.
Driver loading frequency	Usually loaded when they pick up.
Driver unloading frequency	Often.
Load handling equipment used	Kangaroo lift does the heavy work, but it can be tedious if there are multiple drop-offs requiring re-tarping after each.
Other physical work required	Drivers have to strap down, secure, and tarp the load when they pick it up, and after partially unloading. Standard tarp weighs 75-80 lb. Climbing over uneven loads.
Waiting time a factor?	At busy time, can be a 4-6 hr delay getting truck loaded. At good times, about an hour to get load, secure and tarp it, get on the road. May have to wait to unload.
Special considerations	Unloading cargo can be time-consuming and treacherous. Injury-prone situation, with "slips, trips, and falls" accidents.
Major sources of fatigue	Waiting time; tarping, securing loads in bad weather; pre-dawn driving hours.
Notes	Strong feelings on rest stop shortage; misuse of some truck stop spaces for dropped trailers; police harassing drivers trying to sleep.

A group of these drivers, interviewed at Cresco Lines, Harvey, Illinois mostly haul pipe and tubing products for a contract shipper; others also haul other flatbed loads for other shippers. Flat bed truck drivers found some loads difficult to handle, since the products are not easily loaded or unloaded by hand, and can be awkward to move and secure even with power equipment. Most pipe hauling trucks had cranes or "Kangaroo lifts" on them, used to lift loads on and off the trucks. Drivers secure and tarp loads by hand, which can be taxing work. Climbing on top of loads, stepping on wet, slippery tarps on uneven stacks of pipe, fencing and other materials, especially at night, leads to slips, trips, and falls. Drivers especially disliked

multiple-delivery runs, where the load had to be uncovered and part of it removed, and then had to re-tarp and re-secure the remainder before continuing the delivery run. This group, mostly long-haul drivers, also expressed concern about the perceived shortage of rest stop spaces, and the practices of police who would not permit drivers to rest with their trucks parked in places other than truck rest areas.

Tank cargoes (gasoline, petroleum products, chemicals, foodstuffs, etc.)

Table 11 shows responses of tank truck drivers interviewed primarily at the Houston, Texas bulk carriers conference and exposition.

Table 11. Responses of Tank Truck Drivers

Characteristics	Tanker Loads
Where interviewed	Houston, TX; Atlanta, GA.
Typical trip origin and destination	From chemical and petroleum products plants, refineries, terminals to customers. From oil fields to refineries, pipeline heads, terminals. May be local or cross-country.
Typical trip length	Mostly long haul; regional, short-haul also common for tankers (e.g., gasoline from terminals to service stations; home heating oil from terminal to residences).
Overnight trips (away from home)	Yes.
Sleeper berth available? used?	Yes; yes.
Team driving?	Frequently
Truck type	Tankers of several varieties.
Typical loads	Petroleum, oils, lubricants, chemicals (often HazMat), dry or wet bulk products.
Typical load "format"	Bulk tanks, wet or dry loads, some light loads (e.g., plastic pellets), but mostly heavy liquids.
Time sensitive?	Sometimes.
Driver loading frequency	Often hook up and disconnect hoses.
Driver unloading frequency	Often hook up and disconnect hoses.
Load handling equipment used	Cargo feed or unloading connector pipes and hoses; load sample testing materials.
Other physical work required	Climbing ladders over tank covers for opening and closing; hauling heavy hoses, making hose connections.
Waiting time a factor?	Generally not. Loading/unloading schedules adhered to, with occasional queue at plants to load. Often await chemical testing of cargo.
Special considerations	Safety consciousness about cargo; HazMat training and strict rules to follow. Chemical tests of cargo at load, again at unload can be problematic.
Major sources of fatigue	Long hours cross-country; waiting for chemical tests on loads. Some loading wearing chemical protective clothing approx. 1-hr in heat and humidity.
Notes	Very safety-conscious drivers; pride in their profession. Requirement for attention to detail for safe delivery may impose some stress.

Tank truck drivers are often involved in loading and unloading their trucks and use equipment and procedures unique to their type of truck and cargo. In these processes they connect and disconnect hoses and pipes some of which are heavy and difficult to handle. Loading and unloading HazMat cargoes the drivers sometimes must wear chemical protective clothing and unloading, and may climb on the tank to open top hatches to allow air to enter during unloading.

Waiting time for these drivers is chiefly associated with the need to have chemical analyses of cargo performed at the point of pickup or delivery. Drivers may participate in taking samples of the cargo, (this may involve climbing on the tank to sample through the top hatch) and then must wait while the tests are completed before proceeding to load or unload.

Large bulky goods, equipment (dry van)

Information on these cargoes came from high value items drivers at North American Van Lines, from informal interviews with drivers at truck stops, and from survey responses and interviews at the National Truck Driving Championships. Table 12 shows the responses of these drivers.

Table 12. Responses of Drivers of Bulky Cargo in Vans

Characteristics	Large, Bulky Cargo in Vans
Where interviewed	North American Van Lines, Ft. Wayne, IN.
Typical trip origin and destination	Anywhere; manufacturer's warehouses to stores, office buildings; convention centers for trade shows, expositions.
Typical trip length	Long haul, cross-country; local.
Overnight trips (away from home)	Yes.
Sleeper berth available? Used?	Sometimes; sometimes.
Team driving?	Sometimes.
Truck type	Moving van, often with lifting equipment installed.
Typical loads	Large electronic equipment: copy machines, computers, medical equipment, X-ray machines, office equipment.
Typical load "format"	"High value products": Large, bulky, expensive equipment requiring special handling.
Time sensitive?	Often.
Driver loading frequency	Driver guides loading process; use of truck-mounted hydraulic lift on many loads.
Driver unloading frequency	Always supervising others.
Load handling equipment used	Specially designed trailers. Hydraulic lift, mounted on tracks on interior of trailer roof, lifts, moves, & places cargo in trailer.
Other physical work required	No.
Waiting time a factor?	Frequently downtown in cities: wait for parking, wait in queues at conventions.
Special considerations	Highly responsible drivers.
Major sources of fatigue	Waiting in city traffic; waiting in convention center parking lots; delivering equipment to tall office buildings.
Notes	Frustrations with large truck sizes and no dock accessibility or parking in city centers. Loading and unloading is difficult in big cities; frequent moving of truck for lack of parking spaces.

General cargo (dry van)

Table 13 shows the responses of the general freight drivers interviewed formally in Atlanta. Other general freight drivers were interviewed informally at truckstops. Also, many grocery and produce drivers also carry general freight on backhauls, and provided information on their experience with those loads when interviewed. Although the Custom Carriers (Coca Cola) drivers do not haul general freight for hire, their mixed cargo of tanks, drums, boxes, and other load formats led us to include them in this group.

The two companies whose general freight drivers we interviewed in Atlanta are quite different from each other. Custom Carriers (a Coca-Cola-owned company) is a private carrier delivering bulk goods for Coca-Cola, and its drivers run regular days and hours on regional runs of under 500 miles one-way, working five days per week. These drivers return to the home terminal each afternoon or evening and typically have a couple of hours off before picking up their next load.

Table 13. Responses of General Freight (Dry Van) Drivers

Characteristics	General Freight in Dry Van
Where interviewed	Atlanta: Custom Carriers, a Coca Cola company; Ryder Integrated Logistics.
Typical trip origin and destination	Custom Carriers: Manufacturers warehouse to bottling plants and commercial customers, and return. Ryder: Representative driver works when and where needed for 2 or 3 different contract clients. May do longer hauls.
Typical trip length	Custom Carriers: Up to 450 mi each way on daily round trips. Ryder: Unpredictable, mostly under 500 mi.
Overnight trips (away from home)	Custom Carriers: Yes. Ryder: Yes. Likes to pick up in late evening, drive to destination, sleep there before unloading in AM.
Sleeper berth available? used?	Custom Carriers: Yes. Yes. Ryder: Yes, sometimes used.
Team driving?	Custom Carriers: Nearly all regional drivers. Ryder: no.
Truck type	Custom Carriers: Dry van. Ryder: Dry van.
Typical loads	Custom Carriers: Tanks or drums and boxes ("bag-in-a-box") of ingredients and Coke syrup. Ryder: Varies. All dry van.
Typical load "format"	Custom Carriers: Full tanks and boxes out; empties back. Ryder: Varies.
Time sensitive?	Custom Carriers: Somewhat, but mostly regular, routine runs. Ryder: sometimes.
Driver loading frequency	Custom Carriers: Never load outbound. Trucks are loaded, ready to pick up at warehouse for outbound trips. May load or assist in loading empty containers to be returned to plant. Ryder: Seldom or never load.
Driver unloading frequency	Custom Carriers: Often. Sometimes customer unloads, sometimes driver. May use customer equipment. Ryder: Often.

Table 13. Responses of General Freight (Dry Van) Drivers	
Characteristics	**General Freight in Dry Van**
Load handling equipment used	Custom Carriers: Customer fork lifts, pallet jacks, etc. Ryder: none mentioned.
Other physical work required	Custom Carriers: No. Ryder: In former jobs, had to tie-down loads.
Waiting time a factor?	Custom Carriers: Not a major one Ryder: May have to wait to load (1 account) or unload.
Special considerations	Custom Carriers: These are Teamster drivers.
Major sources of fatigue	Custom Carriers: Believe they get enough rest. Some drivers not using time effectively. Given extra couple of hours to get to delivery point, some drivers use that time for activities at home; leave at last minute, cannot stop for rest or nap. Ryder: Driving. Physical work more tiring now than when younger.
Notes	Custom Carriers: Drivers interviewed drive in teams. Most work 8 hr shifts. One drives out, other back, while other sleeps in berth. Most switch day/night each week. A few teams prefer 4/4hr shifts. Work a five day week. Complaints about roughness of ride, difficulty sleeping, because of how Coke positions the fifth wheel (to avoid axle weight violations). Some have suspended berths to reduce motion. Also have 10 or 12 local drivers, and a few who drive single for longer distances. Some take 15-min to 1 hr naps if tired. Ryder: Uses naps sometimes, finds them helpful.

Most of them run in teams using sleeper berths, and their major sleep periods during the workweek are taken in the berth. These drivers are also Teamster union members. The Ryder general freight driver is an "on-call" driver, filling in as needed on regional and long-haul runs for several clients.

Other drivers we interviewed as grocery or produce haulers, for example, often carry general freight as well. Thus we met a driver at a produce distribution warehouse who hauls bathtubs and shower enclosures outbound for a contract carrier, and picks up other cargo as available (in this case, potatoes) on backhaul trips.

Because of the diversity of the general freight category, and the various working arrangements of the drivers who haul it, it is difficult to generalize about this cargo type. We can discuss the responses of those we interviewed.

The Coca-Cola drivers do not load their trucks on the outbound trip. They pick up loaded trailers at the plant. The cargo includes drums, cylinders, and "bag-in-a-box" cartons of product or product ingredients. Some of this cargo is characterized as corrosive and is categorized as HazMat. Drivers sometimes unload this cargo, with receivers often unloading as well. When they unload, the receiver provides the equipment. The drivers often load empty containers (drums and

cylinders for reuse; cartons and plastic for recycling) into their trucks for the return trip to the plant. These drivers had few complaints about loading or unloading, and reported short waiting times, mostly.

Household goods (dry van)

Table 14 shows the responses of the household goods movers interviewed at North American Van Lines and the drivers who participated in the focus group at the American Movers Conference meeting in Alexandria, Virginia.

Table 14. Responses of Household Goods Drivers

Characteristics	Household Movers
Where interviewed	Ft. Wayne, IN; Alexandria, VA.
Typical trip origin and destination	Anywhere on long-haul.
Typical trip length	Any long haul.
Overnight trips (away from home)	Yes.
Sleeper berth available? used?	Yes; Yes.
Team driving?	Sometimes; few of those interviewed drove in teams.
Truck type	Moving van.
Typical loads	Household furniture, appliances, boxed household goods.
Typical load "format"	Floor load, individual items must be secured.
Time sensitive?	Somewhat.
Driver loading frequency	Always; with helpers.
Driver unloading frequency	Always; with helpers.
Load handling equipment used	Loading ramps, 4-wheel dollies, appliance hand-trucks, ladders; straps, padding, cartons, tape.
Other physical work required	Much. Climbing inside van; bending, reaching, stacking to strap and secure items in van.
Waiting time a factor?	Sometimes; usually restricted to daytime loading and unloading. If they arrive in evening, must wait till next morning to unload at customer's home.
Special considerations	Emotional involvement of shippers requires PR skills, care of customers' treasured possessions. Loading in hot weather: inside trailer has no ventilation, gets very hot/humid. Good helpers are hard to find; bad ones add considerably to stress, difficulty of loading task. Securing load is paramount.
Major sources of fatigue	Work hours; Loading (physical effort); Stress of responsibility to and interaction with homeowners/ shippers; supervision of bad helpers.
Notes	Rest stop shortage is critical to these drivers. Drivers appreciate new higher speed limits in western states.

Of all the long-haul drivers interviewed for this study, the household goods movers probably are the most involved in loading and unloading. The driver is the team leader on a moving van, and is responsible for the safe and efficient loading, packing, and unloading of the cargo. He or she supervises the helpers and the co-driver (if there is one), and deals with the consequences of their mistakes. Household goods movers also often have to deal with cargo that is irregular in shape and size, and that may not be properly packed. Finally, the driver, as the carrier's representative,

must inventory the load as it is packed, note any pre-existing damage, and deal directly with the shipper/customer, in most cases a head of household who has a strong attachment to his or her possessions and may be under considerable stress. Additionally, the driver must represent the carrier when dealing with inspectors (e.g. government inspections on contract moves; state agricultural inspectors at some state borders).

Household goods movers perform their loading, packing, and unloading under unpredictable conditions in all weather, often with the truck parked some distance from the residence. Without a loading dock in most cases, they must carry goods up or down a ramp at the back or side of the trailer during loading and unloading. They may have to deal with multiple flights of stairs, small elevators, narrow hallways, or other obstacles to efficient loading. The contents of a large house may take a full workday to load and secure in the truck.

The drivers interviewed stressed how physically tiring the loading process can be, especially in summer (peak moving season) heat and humidity. They were concerned about the difficulty of finding good helpers and the difficulty of doing the job with unskilled, unreliable, or otherwise deficient help. They identified this as a factor that can increase stress and fatigue for the driver. They also raised the issue of insufficient rest areas for truckers, a problem they felt was severe. Several drivers indicated that they close up the trailer, the helpers go home, and the driver then drives to a weigh station, then eats a meal, and then searches for a rest stop to sleep, only to find they are all full. Household movers, whose peak work season (summer) coincides with most people's family vacation season, were especially disturbed with recreational vehicles that park for the night in rest area spaces designated for trucks.

Passenger buses

Table 15 shows the responses of the inter-city bus drivers and other bus company employees interviewed at the Washington, DC terminals of Greyhound Lines and Peter Pan Trailways.

The bus drivers do not do a great deal of loading or unloading work on most runs. Major terminals employ baggage handlers to do that work. However, on charter runs and at small town stations (often an agency at a convenience store or other small business), especially late at night, drivers often have to handle baggage. They mostly reported that it was "fairly hard" or "not very hard" work.

Waiting time is a problem for some "extra" drivers. Greyhound has recently switched from local dispatchers to a centralized dispatching system. The drivers reported that since dispatching has been centralized they often are called in to work and then have to wait several hours for a trip. They believed that they had more control of their schedules when they worked with local dispatchers. Under that arrangement they knew the dispatcher and could bargain with him or her, and could "trade off" trips with other drivers they knew, and they knew their position (priority to be called in to work) on the "extra board."

Charter trips often involve considerable waiting while passengers tour or engage in other activities. Drivers sometimes are able to rest during these times, but often are not, especially in

cities where they cannot easily park their buses with the motors running to provide climate control.

Table 15. Responses of Inter-city Bus Drivers	
Characteristics	**Buses**
Where interviewed	Washington, DC: Greyhound, Peter Pan Trailways.
Typical trip origin & destination	City terminal to city terminal.
Typical trip length	Varies; Seldom more than two days away from home base at a time. Many return to base each day.
Overnight trips away from home	Yes.
Sleeper berth available? used?	No.
Vehicle Type	Inter-city bus.
Typical loads	Passengers, passenger baggage; occasional freight.
Typical load "format"	Passengers; luggage (suitcases, packages); packages.
Time sensitive?	Yes; published schedules to meet.
Driver loading frequency	Seldom at major terminals. May load at small town stations if no helpers are available; often load on charters.
Driver unloading frequency	Seldom at major terminals. May unload at small town stations if no helpers are available; often unload on charters.
Load handling equipment used	None.
Other physical work required	Little or none.
Waiting time a factor?	On charters and for "extra" drivers when called in and required to wait for trip. Some find long layovers tiring (increased length of workday).
Special considerations	Greyhound: Union drivers. Paid by the hour. Not paid for layover time over 30 min.
Major sources of fatigue	Irregular work/rest hours for "extra" drivers. Layovers, waiting time.

The Greyhound drivers can be classified into two types, based mostly on seniority. The "extra" drivers do not have regularly scheduled runs, but are on call to drive when and where needed. Drivers may remain "extras" for 10-15 years. They generally drive relief runs for regular drivers (when regulars are off-duty or sick), charters, and extra buses put on to accommodate high demand. These drivers complained of difficulty planning and obtaining adequate rest. They frequently are called back to work after a minimum nine hours off, and seldom feel comfortable refusing such calls. (Occasionally these drivers are able to arrange to drive regular relief runs on senior drivers' days off.) The more senior drivers "bid" for and drive regular runs, and are able to organize their time for rest and personal activities much more easily. (A similar arrangement, with "part-time" and "regular" drivers was described at Peter Pan Trailways.)

There were wide individual differences in reported difficulty driving late night/early morning runs. Some drivers reported difficulty overcoming fatigue during these hours, while others had no such problems. Some drivers take naps, especially on layovers; some do not.

Safety manager questionnaires, focus groups, and interviews

The information received in our many contacts with safety managers and other company personnel responsible for safety functions generally agreed with what we heard from drivers. Safety managers more often raised issues directly related to safety, or related other issues to health and safety. Thus, safety managers, when discussing loading and unloading, often mentioned the need to train employees in sound lifting and carrying methods, and to avoid injuries from improper practices; drivers (with the exception of household movers) seldom mentioned this aspect of loading work. Similarly, the safety managers consistently related fatigue to safety; not all drivers explicitly made this connection. Several safety officials had previously worked as drivers, and some held other positions in their companies (including at least one dispatcher) along with their responsibility for safety. These respondents were especially aware of the competing priorities and economic factors affecting operational practices such as driver scheduling, use of lumpers, and expectations for drivers to load or unload.

Safety managers showed the same disagreement as drivers when simply asked whether loading and unloading activity makes a driver more alert or tires him. Like the drivers, when they discussed the question in more detail most seemed to believe that light or moderate loading or unloading work might more likely be beneficial, but that excessive physical labor would be more likely to tire a driver than to help his alertness.

The survey responses from safety managers at the National Truck Driving Championships in Columbus were very similar to those of the drivers in corresponding industry segments, with similar distributions of cargoes, truck types, and responses to questions on loading and unloading. No separate tabulations are given here for these respondents, because the differences from the driver tabulations were trivial. The ATA Safety Management Council and NPTC Safety Committee meeting attendees also gave similar responses.

The American Trucking Associations Safety Management Council focus group members were especially interested in the complex issues of fatigue involving shippers, receivers, and carriers, and the economic factors that affect the industry. They spent considerable time discussing the need to educate customers to the drivers' needs for reasonable rest.

Integration of findings across groups

In the following sections, we integrate the findings of the various interviews and focus groups, pointing out where generalizations can be drawn across the industry segments, and where particular segments are unique. The major topics addressed are the frequency of loading and unloading activity, driver and safety manager perceptions of the effects of such activity on driver fatigue and other issues related to driver fatigue that emerged from the information-gathering activities. Table 16 provides a summary of the findings related to loading and unloading across industry segments, based on all sources of information discussed above.

Frequency of loading, unloading

It is clear that the frequency of loading and unloading activity varies greatly across industry segments (defined by cargo type) and even within segments. Some drivers pick up and drop off loaded trailers without ever touching the contents. Others personally load or direct loading and unloading of every item in the truck. Between these extremes are large numbers of drivers who do varying amounts of loading and unloading work, with more or less physical labor required.

Table 16. Summary of Loading and Unloading Across Industry Segments

Industry Segment	Frequency of Loading	Frequency of Unloading	Contribution of Loading/Unloading to Fatigue	Other Fatigue Issues
Grocery-related cargo	Very infrequent	Occasional to frequent	Hand unloading, breakout, repalletizing are fatiguing.	Waiting time at loading/unloading sites
Agricultural cargo	Very infrequent; may secure, tarp loads	Infrequent to occasional	Minimal physical labor involved	Waiting time at loading/unloading sites; Long work-days in peak season
Produce, reefer cargo	Very infrequent	Variable	Hand unloading, breakout, repalletizing is fatiguing. Not a major factor	Waiting time at loading/unloading sites
Flatbed: pipe, metal products, large items	Infrequent; frequently tarp and secure loads	Frequent	Fatiguing when multiple drop-offs are required	Waiting time at loading/unloading sites; tarping, securing loads; rest area shortage
Tank cargo	Frequently assist	Frequently assist	Hauling hoses and pipe fatiguing, esp. in hot weather and/or protective gear	Waiting for chemical tests; long hours cross-country
Bulky cargo in Vans	Nearly always supervise	Nearly always supervise	Minimal	Waiting time; difficulty of loading/unloading in cities
General freight in dry vans	Very infrequent	Variable	A factor for some drivers	Waiting time at loading/unloading sites
Household goods	Always	Always	A major factor	Stress of dealing with customers; rest area shortage
Buses	Infrequent	Infrequent	Minimal	Irregular, unpredictable working hours; Layovers and waiting time

In general, we found that it is more common for a driver to be involved in unloading than in loading the truck. It appears that shippers take responsibility for loading more often than receivers take responsibility for unloading. There is a real tension in the industry between those (many drivers, some carriers) who believe that the receiver should unload the cargo and those (receivers, some carriers) who expect that unloading is part of the service to be provided or paid for by the carrier.

Drivers in the industry segments associated with the retail grocery industry are most likely to report that they are expected to unload freight, break out loads, re-palletize, and perform other services at the point of delivery (or to hire lumpers to do these things). This includes dry van haulers of non-perishables and such goods as paper and cleaning products, and haulers of produce and other reefer cargo. Although the movement of these cargoes on and off the truck is usually accomplished using motorized or at least hydraulic equipment, breaking out and re-palletizing is hand work, with each carton or other item often needing to be handled individually.

In the household goods moving business as well, every item must be hand loaded, stacked, secured, and later unpacked and unloaded. The driver is responsible for performing and/or supervising all of this work, which is done with very little mechanical assistance, often at sites not designed for loading or unloading. Increasing his or her workload and stress, the household goods driver also bears responsibility for customer relations, must deal sensitively with homeowners concerned about moving their prized possessions, with moving inspectors, and with day-hire helpers of varying experience levels.

Short-haul or regional drivers who make several deliveries and/or pickups in a day are likely to spend a larger proportion of their working hours loading and unloading than most other driver groups. This group includes some of the grocery store distribution route drivers. Long-haul drivers are more likely to drive long distances between pickup and delivery, and often deliver a load only once every several days. These drivers are also more likely to be hauling truckload shipments to be dropped off at a terminal for breakout. Thus they have fewer opportunities or requirements to perform loading or unloading.

Perceptions of loading/unloading effects on fatigue

The drivers and safety managers we interviewed and surveyed did not agree when asked simply whether the physical work of loading and unloading was fatiguing. They showed more agreement when we probed farther. Many stated that a moderate amount of loading or unloading keeps them alert, "helps get the blood flowing," or is adrenaline producing, and invigorating, and that loading or unloading can provide a break from the monotony of driving, and thus reduce fatigue. Most agreed, however, that intense or extended physical work is fatiguing.

Respondents agreed that drivers who are in good physical condition are less likely to be fatigued by physical work than those who are out of shape. They also mentioned other variables that contribute to the fatiguing effects of loading and unloading labor, especially working in hot or

humid conditions, the use of cumbersome protective clothing, outdoor work such as securing and tarping loads in cold, wet or slippery conditions.

Overall, we found that when drivers and others expressed the idea that "loading" or "unloading" was a source of fatigue, they were referring in a "gestalt" way to the entire loading or unloading process. In addition to the physical work of moving cargo on and off the truck, this includes securing and covering loads, breaking out and repalletizing cargo, waiting time and queuing practices, access to docks and equipment, paperwork and other administrative procedures, and interactions with shipper and receiver personnel and lumpers. Some of the issues that our respondents associated with fatigue, but that go beyond the physical work of loading or unloading, are discussed below.

Issues associated with fatigue

Waiting time and conditions. The requirement to "hurry up and wait" at loading and unloading sites was mentioned by a very large number of respondents as a contributor to fatigue. Examples include the need to queue up behind other trucks to load or unload. Most drivers believe that it is necessary to remain on duty during this waiting time, both for logbook purposes and practical reasons; other trucks will "jump the line" if the driver in front is caught napping when his turn comes up. Only team drivers can get rest in this situation, with one sleeping while the other is responsible for the truck. Some shippers told us that they assign numbers to truckers as they arrive, and will call a driver on the CB to wake him when his turn comes up. We observed such queuing systems seemingly working quite well in the Southern California produce shipping segment. However, most drivers say that it is not commonly observed throughout the industry. Drivers also mentioned long waits to unload if they missed an appointment by only a few minutes, and lack of adequate truck parking spaces around warehouses and yards.

Drivers expressed particular displeasure with shippers who require them to arrive for loading at an appointed time, but do not have the load ready to go, sometimes for several hours. Shippers still expect the load to be delivered at the originally promised time. Drivers told us this often means they use up several hours of their duty day waiting, and then are expected to drive many hours more. Drivers say that often they cannot satisfy the shipper's requirement without violating hours of service regulations and driving fatigued.

Loading and unloading environments. Some drivers were dissatisfied with the way they are treated at loading docks. They described many of the same situations documented in the Midwest Transportation Center (Allen, et al.,1994) lumping study, including pressure to use lumpers, lack of access to unloading equipment, and delayed dock access if they choose not to use lumpers. Drivers characterized all of these problems as adding to the stress and fatigue of loading and unloading operations.

Hours of service regulations. Many drivers expressed frustration with the hours of service regulations as they now stand, and were interested to hear that changes to these regulations are under consideration by OMCHS. They suggested a wide variety of possible modifications to the regulations. Many voiced the belief that there should be some regulation of shippers as well as

carriers and drivers, to reduce what they consider to be unreasonable pressure on carriers and drivers to deliver loads more quickly than is compatible with safety.

Shortage of truck rest areas. Another problem mentioned by our respondents has also been documented previously. Many drivers noted that there are not enough places where a trucker can safely park his truck and sleep, and that drivers are often "harassed" by police if they stop at places other than truck rest areas, or once in a designated truck rest area, are only permitted a few hours stay, leading to fragmented or insufficient sleep. This is corroborated by the FHWA's (1996) report on commercial driver rest and parking requirements.

Summary of findings

The overall objectives of Task 2 were: a) to characterize the trucking industry practices, procedures and methods by which long haul truck drivers carry out loading and unloading of their trucks, b) to determine the extent to which long haul truck drivers engage in the physical labor of loading and unloading of their trucks, and c) to assess whether truck drivers perceive loading/unloading activities to be a determinant of (or contributor to) driver fatigue.

Literature. We located very little literature that describes trucking industry procedures, methods and practices of driver involvement in loading and unloading. Available truck training manuals, handbooks, and workbooks present general training information and guidance for anyone who handles, loads, secures, covers, or unloads freight or cargo, and provides safety procedures for dealing with hazardous cargo. This guidance includes instruction on how to properly lift items without injury, to stack and distribute load weight in a van, and to secure specialized rigging for large bulky items on flatbeds.

That documentation is helpful for describing how *anyone* should load cargo onto or into trucks; but it does not by itself convey whether or not truck *drivers* become involved in the actual loading and unloading process. Therefore the scant literature we obtained was of little help in achieving the three objectives listed above.

Surveys, Interviews, Focus Groups. The distribution of a driver survey (questionnaire) at the National Truck Driving Championships, and the conduct of about a dozen focus group interviews with drivers and trucking industry safety managers were far more helpful for determining the extent to which drivers participate in the loading/unloading process. This report documents the methodology and process of conducting that survey and those focus group interviews in nine freight/cargo categories, ranging from produce and refrigerated cargo to household furniture, steel pipe, and hazardous chemicals in tank trucks, and including interviews of bus drivers.

The frequency and amount of driver loading and unloading varies across trucking industry segments (defined by cargo type) and even within segments. In general, for bus drivers, whose cargo is mostly handled by others, loading and unloading is not a significant factor. For most truck cargo categories, many truck drivers also do not do substantial amounts of loading and unloading of their own trucks. In many settings people other than drivers (e.g. shipper and

receiver personnel, dock workers, hired lumpers, helpers, and others) do most of the loading and unloading of trucks. Much of the loading is done with mechanical assistance in the form of fork lifts, electric pallet jacks, hydraulic cranes, gravity and air pneumatic suction feed mechanisms (e.g. at grain elevators, petroleum refineries), and is accomplished by personnel trained to operate that specific equipment to load or unload trucks. Truck drivers then, very often supervise the cargo handling for their trucks, and in some cases merely pick up or drop off trailers of cargo and are not even present for the cargo handling process.

When truck drivers are involved in handling the cargo, they are more likely to be involved in the unloading than the loading process. In several industry segments, drivers pick up trucks or trailers pre-loaded and prepared by others, and simply proceed to drive the truck and trailer to the delivery destination. Upon reaching the delivery point, some drivers become involved in the unloading process; in some cases they accomplish all the unloading themselves.

For commercial bus drivers loading and unloading are not a contributing factor to fatigue. Truck drivers most involved in handling freight and actually performing loading and unloading of their trucks were identified in two commodity groups: 1) household goods moving van drivers who do both loading and unloading, and 2) grocery haulers who tend to do more unloading than loading. In the movement of household goods and other furniture, large numbers of van drivers are involved in actual loading and unloading of substantial amounts of cargo almost daily. Many, but not all grocery drivers occasionally unload, breaking out items from pallets and re-palletizing to fit store or warehouse requirements, or even completely unloading pallets one carton at a time, at grocery stores without delivery docks.

To estimate the size and importance of the segment of carriers serving the retail food store industry, we consulted the 1992 Census of Transportation (U. S. Department of Commerce, 1995). This publication estimates 723,000 trucks of all types, traveling 21,434,500 miles, were used for carrying processed foods. Additionally, some of the 295,500 trucks carrying paper products and some of the 491,800 carrying "miscellaneous products of manufacturing," as well as some from each of several other cargo categories, also served the retail food store industry.

It would be instructive to know how many moving van drivers are active in the country, but the exact number is difficult to obtain. The 1992 Census of Transportation shows 102,600 trucks of all types, including 30,000 combination trucks to carry household goods, but moving companies carry other cargoes as well. In April 1997, the largest of the industry trade organizations, the American Movers Conference (AMC) in Alexandria, Virginia, estimated the $7 billion a year moving industry employs 450,000 workers. AMC's members report operating about 66,000 trailers, 32,000 tractors, and 18,000 straight trucks. The AMC has 25 van lines, 980 independents, and 1,000 independently owned companies possessing interstate operating authority. AMC estimates 30,000 active independent owner-operators own and drive their own tractors and are responsible for transporting, loading and unloading the trailers they pull.

From the focus group interviews it appears when drivers discuss "loading and unloading," they often refer to it in a general sense, not only to their own physical labors associated with moving

freight onto or off of a truck. They are really thinking of the whole process, a "gestalt" of loading and unloading, including meeting dock appointments, waiting and moving the truck in queues, counting loaded items, processing cargo shipping or receiving paperwork (e.g. bills of lading, or chemical cargo analysis results etc.). By far, we encountered many more complaints from drivers regarding the fatigue effects of frequent lengthy "waiting periods" for loading/unloading than we did complaints of getting tired from actually physically performing the loading and loading of cargo. Many drivers suggested the amount of time expended in doing loading and unloading noticeably cuts into their time for rest and sleep between drives.

Physical fatigue. When asked about the extent to which the physical labor of loading/unloading impacts driver alertness, or if it contributes to development of driver fatigue, drivers give mixed responses. Clearly, some drivers whose loading/unloading work necessitates much physical labor (e.g. household goods movers; and some grocery haulers) assess that work as contributing to both physical fatigue and the general mental fatigue of concern to driving safety. Many of these drivers openly described how their long bouts (2-6 hr commonly reported) of physical work makes them acutely tired, and how they must be careful not to over-extend themselves when they drive over-the-road after such physical work. Sometimes their schedules do not permit much choice but to begin their long drives shortly after expending large amounts of physical energy in the loading/unloading process. These are the drivers most at risk that physical fatigue contributes to their general mental fatigue behind the wheel of the truck.

However, most drivers we interviewed or surveyed did not portray the physical aspects of loading and unloading to be a significant problem, and stated it was not a large contributor to driver fatigue. Rather, many drivers indicated the modest amounts of physical activity associated with their own loading and unloading helps keep them physically fit, and even stimulates their general alertness for short periods of time thereafter.

Thus, the effects of large amounts of physical labor preceding long haul driving are reported to vary, depending upon the cargo commodity being delivered, and upon other factors (e.g. delivery procedures, time of day of driving etc.).

Implications for further research.

The results of this industry characterization study suggest:

a) *It would not be fruitful* for FHWA-OMCHS to expend large funding resources for field experimentation to examine long haul driver fatigue effects as a function of the physical labors of drivers loading and unloading trucks across most of the long haul trucking industry, because they simply do not engage in that activity very much; and

b) If FHWA-OMCHS decides to explore further the relationship between the physical labor of loading and unloading and driver fatigue, the grocery and household goods moving industry segments could offer a clear test case for exploring the extent to which loading and unloading contribute to driver fatigue.

Section III. Behavioral task analysis of CMV driver loading/unloading activities (Phase I, Task 3)

Introduction to Task 3

The initial Task 3 proposal was to conduct a set of thorough task analyses, to include collecting physiological measures of energy expended by drivers during performance of loading and unloading tasks in various trucking industry settings. However, in Phase I, Task 2, it became apparent the amount of loading and unloading of trucks by drivers varied immensely across trucking industry segments. Significantly, it was determined that in a very large variety of trucking industry-wide sets of cargo/freight loading and unloading task situations, the physical labor of loading and unloading of trucks usually is performed by persons other than the drivers themselves. In many long haul cargo operations, loading personnel called lumpers, warehouse equipment operators, other dock workers, other shipper and receiver staff do much, if not most of the loading and unloading of trucks. Many long haul drivers merely pick up a truck and/or trailer and drive it from point A to point B; or they may supervise and observe others in the loading/unloading of a trailer, but the drivers often do not actually touch the freight themselves.

It became apparent that because of the wide diversity of cargo movement options, it would be cost prohibitive to collect extensive physiological measurements for the numerous trucking situations in which drivers actually do handle freight. Instead it was determined that for conduct of Phase I, Task 3, a simple behavioral task analysis would be conducted on several driver loading-unloading tasks in trucking settings where drivers commonly perform such physical activities. The settings selected for study were to be representative of the types exhibited across the shipping industry.

Methods and Procedures for Task 3

Task 3 entailed observation and video recording (but no physiological measures) of drivers loading and unloading their trucks in normal work settings. Based upon findings in Task 2, workers in several trucking industry segments (household goods moving industry; grocery delivery; beverage delivery; fast food supply delivery; and tank truck carrier operations) were chosen for study to represent industry segments where loading and unloading are significant parts of drivers' jobs. The tasks and types of physical activities necessitated in their accomplishment are representative of industry practices, and are thought to account for the vast majority of driver loading/unloading and similar intense physical activities.

A sample of such operations was studied in detail. Videotaping, still photo and interview sessions were accomplished with several drivers and their crews in the household goods moving, grocery, beverage and fast food supply delivery sectors, and tank truck liquid product delivery operations. The video recordings were analyzed to develop a taxonomy of loading and unloading tasks. Estimates of frequency and duration of the most prevalent tasks and activities were developed to characterize and permit comparison of a variety of loading/unloading situations across trucking industries.

Explanation of job task analyses

Observation and description of people engaged in work is central to the work of ergonomists, who observe others at work in the process of attempting to optimize the work of humans in systems, to design equipment and interfaces, to devise optimum operational procedures for accomplishing job tasks, and to produce operator training programs (Stammers & Shepherd, 1995). Job task analysis, one of the principal techniques of ergonomic study, employs quantitative and qualitative methods to describe and analyze human work, with particular emphasis on measurement and quantification of job-related activities.

There are in fact many task analysis techniques in ergonomics, but there is not a consensus on what is actually called a task analysis technique, nor what the component stages of task analysis processes are. Also, there is no clear agreement on a definition of what constitutes a "task" (Stammers & Shepherd, 1995). These somewhat theoretical issues are not of direct pertinence here. For more detail see Stammers & Shepherd, 1995; Luczak, 1997; McCormick, 1982.

> Common assumptions about what constitutes a task are that:
>
> - The term "task" generally applies to a unit of activity within work situations
> - A task may be given to or imposed upon an individual or alternatively carried out on the individual's own initiative and volition
> - It is a unit of activity, requiring more than one simple physical or mental operation for its completion
> - It is often used with the connotation of an activity which is non-trivial, or even in some cases onerous in nature
> - It has a defined objective.
>
> (Stammers & Shepherd, 1995; pg. 148)

In a number of task analysis approaches, the activities of a worker or equipment operator are defined in terms of overall tasks that are broken down into a number of component tasks. Lower level tasks may in turn be divided into subtasks. Ergonomists normally consider three interacting components of tasks:

1. task requirements, referring to the objectives or goals for the task performer
2. task environment, referring to factors in the work situation that limit and determine how an individual can perform (e.g. by restricting actions that can be taken and their sequencing, or by providing aids or assistance that channel operator actions in a particular way)
3. task behavior, referring to the actual actions carried out by an operator within constraints of the task environment to fulfill task requirements.

The first two aspects of tasks (requirements and environment) are generally determined by the context; whereas task behavior, given identical requirements and conditions, can vary greatly between individuals and especially with experience or skill level.

It is important to maintain a clear distinction (differentiate) between what the worker does and what is accomplished as the consequence of his or her work activities. Job task analysis focuses on rigorous description of *what the worker does*. The main practical concerns here are those of description of the type and amount of physical labor performed by truck drivers during the process of loading/unloading their trucks.

Methodology for behavioral task analysis data collection

Star Mountain researchers arranged to accompany or "follow along behind" several household goods and furniture moving van drivers, beverage haulers/delivery men, grocery drivers, pizza supply delivery drivers, and tank truck carrier drivers on their runs, and to videotape and photograph their loading or unloading activities. We interviewed these drivers, and we observed, took notes, recorded and videotaped, and took still photos of drivers performing their jobs. We especially concentrated on those activities the drivers engaged in which were actual loading or unloading of their trucks.

We also collected several measures of the heights and distances that various objects were moved into or out of trucks and various delivery locations. Where practical, estimates were made of the weight of some cargo items and objects moved.

Often job task analysis processes are iterative, particularly if they are done for new equipment system and procedural design purposes. That is, the analytical data collection portions are done repeatedly until the required levels of detail for all important tasks and sub tasks have been identified. Although we viewed some video films repeatedly, we did not return a second time to the actual workplaces to collect more observations beyond the initial data collected.

The overall objective of Task 3 was to produce a "task description document" for each of the cargo commodity groups analyzed. Therefore, based on our observations, we determined an appropriate level of detail to include in the description for the task analysis write-up. The next section presents our findings.

Results

The findings of the behavioral task analysis are described in this section. The information is organized by cargo commodity segment, and within each segment is divided into four sections:

1) A general description of the drivers' jobs;

2) A description of the specific task activities observed;

3) Time measurements for tasks and activities; and

4) Physical performance expectations for the drivers.

Household goods moving van drivers:

General description of household goods moving van drivers

In the most basic terms, the job of the household goods moving van driver is to transport people's household goods and furniture from one residence to another, or to a warehouse for temporary storage. The driver has several responsibilities to fulfill at the loading end of an assigned job and repeats most of these in the reverse sequence at the delivery end of the job. The precise sequence of the activities listed below may vary somewhat depending upon circumstances. For example, the driver might obtain an empty trailer weight before picking up helpers.

Driving between pickup locations and delivery locations may be interstate, and even across the country, and therefore may take from 1 to 3 days between stops.

Task activities of the typical household goods moving van driver

1. Driver reports in to a central dispatch office, a local agent, or to a shipment broker to obtain his/her assignment for shipment of household goods. This report/contact will either be reporting to the office in person with his/her truck and trailer, or it will be via a telephone call to receive instructions, directions etc. to the next job.

2. Driver obtains an empty or "pre-loading" truck weight before beginning the job of loading household goods. Driver may be able to have the truck and trailer weighed at the pickup location (e.g. local agent) or he/she will have to drive several miles to a nearby weigh-in station to accomplish this task.

3. Driver picks up from 1 to 3 helper personnel and escorts them to the job site (usually a pickup of furniture and household goods at a residence, or at a warehouse where household goods are stored awaiting delivery to a residence). The helpers are to assist the driver in loading/unloading tasks at the job site - residence or warehouse.

4. Driver arrives at loading site, assesses site, parks truck in best possible location.

5. Driver reports to or greets the client (resident or homeowner) at the front door of the house to discuss/plan out the actual loading process. (Helpers may or may not be introduced to client at this time; helpers normally begin preparing the truck, loading ramps at curbside and other equipment for the job).

6. Driver does a walk-through visual inspection of the household to survey the job; assesses how much and what kinds of furniture and prepacked boxes of household goods are to be loaded; determines an estimate of how much additional packing and assembly-disassembly of furniture (e.g. beds, appliances) items he/she and crew will need to accomplish. Driver also checks for stairways, tight corners, narrow passages or doorways, difficult pieces to move, and plans how to deal with these.

7. Driver addresses helpers to assign them their initial loading (or unloading) tasks.

8. Driver often must place one or two loading ramp platforms into place at the side or rear doors of the van (driver may do this alone, or with assistance of helpers; or driver may instruct and supervise helpers in doing this; or if they are experienced helpers, they install ramps themselves). This involves extracting heavy, large portable loading ramp(s) from their storage location on the underside of the truck trailer, and then setting them side-by-side stretched from the van bed either to the ground, or over the roadside curb to reach a flat surface driveway or sidewalk. Thus an incline ramp is constructed upon which to carry or roll household goods into or out of the trailer (see photos, Appendix F).

9. Driver conducts inventory listing of resident's furniture and boxes of household goods by writing entries on bill of lading inventory, while placing corresponding inventory number stickers on shipping items for identification, and while noting furniture condition (e.g. scratches, dents etc.) on inventory sheet entries. This task may continue while goods are being loaded by helpers.

10. Driver may spend some time moving items around various rooms within the house, in conjunction with doing the inventory list; that is, in crowded rooms, driver moves items of furniture or packed boxes just far enough to get at them in the process of listing items on the inventory and placing a number sticker on the items.

11. Driver interacts with client/customer and the helpers from time to time during the loading process, which may take from 2 to 6 hours or even longer depending on how large and varied is the particular shipment. Drivers may also interact with household goods shipment inspectors (e.g. for federal government sponsored moves) who show up unannounced and want to inspect and discuss the progress of the move with the driver and/or the shipper.

12. Driver plans the packing of the load and instructs helpers in how it should be done. Drivers frequently secure loads of furniture, boxes etc. inside the trailer, or they will supervise a senior helper in this activity (see photos, Appendix F).

13. Driver himself may physically move some items from the house to the truck trailer. More likely, the driver supervises the helpers as they do most of the movement of goods into or out of the truck trailer.

14. Driver disassembles (either themselves or supervise helpers in this) larger furniture items (e.g. tables, cabinets, beds) and prepares appliances (refrigerators, clothes washers and dryers) for moving, if this was not done by the pre-move packing team the day before. Driver also either supervises, or does himself, preparation of large boxes and packing of mattresses etc.

15. Driver may assist his/her helpers in moving large, fragile or bulky items (normally furniture and large appliances) from the house to the curbside, or into the truck trailer. As a minimum, driver almost always supervises this activity.

16. Driver often moves some boxes, lifting of numerous items above shoulder height, etc. in the process of packing the trailer for shipment. This activity usually involves overlaying numerous heavy cloth pads to protect furniture from scratches, affixing and tugging at securing straps to tie the load inside the trailer; standing in awkward postures on step ladders in the trailer to place items at the top of stacks and to secure them in place, etc. (see photos, Appendix F).

17. When outbound household goods are almost all loaded into the trailer, driver meets with the client to review the itemized property inventory list and the bill of lading. Together they complete and sign all paperwork associated with the move.

18. Driver supervises and assists in the final loading of the truck; secures the loading equipment, ramps and doors; says good-bye to the client; and drives away (with or without a helper or two in the truck cab).

19. Driver proceeds to a weigh station to have the loaded truck weighed; obtains load weight receipts for the paperwork; inspects the loaded truck for shifting of load.

20. Driver pursues one of several activities: drive to a resting place where driver will first re-inspect the load for balance and packing security; then likely telephone a broker or dispatcher to receive instructions for the next pick-up assignment; find a place to clean up, have a meal, and/or sleep in the sleeper berth, or perhaps a motel.

21. Sometimes driver might take all or part of the load of household goods to a local warehouse for storage.

22. Driver may drive some miles toward the delivery or next pickup destination, and then stop for a rest/sleep along the way.

23. Driver proceeds (with or without a helper or two as passengers in the cab) to another city where he/she may take on other loads en route to a final destination; or may drive toward the long haul destination city, where he/she will either have the truck unloaded at a storage warehouse, or proceed according to schedule to the delivery residence and begin the unloading process, or sleep until an agreed upon appointment time for unloading.

Time measurements, household goods drivers

Time measurement data for the above tasks by household goods drivers are presented here only conceptually and not precisely because there is significant variability in these time measures according to the size and complexity of various household pickups or deliveries. In particular, the size of the load (e.g. 8,000 vs. 18,000 lbs. of household goods) makes for significant differences in total time on-site for each job described. Generally, the time measures for the drivers' activities include:

Time to prepare equipment: moving van, doors, loading ramps, pads, straps, hand carts, dollies, etc. These time estimates vary significantly depending upon how much is accomplished by helpers, versus the driver. Estimated range is from 15 - 45 minutes per job.

Time to deal with client/shipper: Initial contact and review of papers usually takes about 15 minutes. Intermittently during the course of the job, short conversations with the client normally last about 2-3 minutes at a time. Depending upon the length of the inventory and whether or not there is discussion about discrepancies, the final paperwork phase usually takes 10-15 minutes,

Time to apply inventory item stickers, write the items one-by-one on the inventory list: usually occupies from 90 - 180 minutes depending on how large the inventory is, and how much writing the driver must do to describe furniture condition. Some inventory lists can include from 200 to 400 items. The writing and labeling process is frequently intermittent because other tasks (e.g. supervision and discussion with others) are interspersed.

Time spent in actual moving of goods: from house to truck (outbound shipment) or from truck to house (inbound) varies significantly depending on the availability of helpers; the amount of useful work accomplished by the helpers; the amount of supervision required for the helpers; the tendency of driver to get involved in the labor simply because that is the personal work style of the driver. A reasonable estimate is a range of from 30 - 90 minutes per job.

Time spent in trailer packing and securing the load of household goods: This time too varies depending upon how experienced and effective the helpers are at accomplishing the set of packing and securing load tasks themselves. Many drivers are very compulsive about ensuring

the load is secured to their satisfaction because they are liable for furniture damages due to load shifts in the trailer during transit and/or delivery. Thus drivers may spend large amounts of time (estimated range of 30 - 180 minutes) either supervising or accomplishing the securing of the load inside the trailer.

Physical performance expectations of household goods drivers

Because of the many differences in the household goods pick up and/or delivery settings, and due to the differences among drivers in work style, it is difficult to make a general statement regarding the amount of physical work (physical energy expended) put forth by household goods drivers. The amount of physical work accomplished by the driver varies significantly among drivers as a function of: 1) personal work style and habits; 2) the size and complexity of the load of household goods to be shipped; 3) the amount and caliber of work performed by any helpers who do the tasks versus the driver; and 4) the time element the crew must meet to conduct the move for a particular client.

After observing several drivers during this study, having interviewed many of them in Task 2, and having watched various drivers over numerous personal moves of our own (about 15 for these two authors), we feel comfortable stating that generally a household goods shipment driver puts forth physical activity (energy in work output) at a *moderate* work pace (i.e. 325-500 watts energy expenditure) for about two hours per move; and for another 2 - 3 hours per move is likely to work at a *light* pace (i.e. 170-325 watts). Krueger and Van Hemel, 1997 (Task 1 report) provides technical descriptions of the work pace categories.

Photographs of household goods moving tasks are presented in Appendix F.

Grocery delivery drivers

General description grocery drivers

In our survey work in Task 2 we determined almost all grocery delivery drivers pick up a truck trailer that is preloaded by others and therefore does not normally perform *loading* activities. Drivers are more likely to engage in *unloading* of their grocery trucks, but the amount of physical labor they perform is highly situation dependent. Grocery drivers may work either for a large grocery company and therefore deliver goods to their company's own stores or franchises, or they may work for a carrier who delivers from wholesale warehouses to individual stores or to other warehouses. In the former instance there are likely to be more company employees available to accomplish unloading of the truck at a company-owned store. If the driver is visiting other stores, he/she may deliver a full load to a single location, or more likely will make from 4 - 6 stops per day in which he/she is likely to accomplish much of the actual unloading with assistance from the stores' employees.

The driving between delivery stops may vary from a long haul of several hundred miles per trip, to short drives of between 10 and 50 miles each to reach delivery stops; or the work day may include combinations thereof.

Task activities of the typical grocery delivery driver

1. Generally, a driver reports in to a regional food distribution warehouse and shipping center (which may be his/her daily place of reporting to work) at a scheduled time (frequently sometime between 2 and 6 AM). After short discussion with the dispatcher or trucking assignment manager, and picking up various sets of delivery paperwork, he/she drives away with a pre-loaded truck of groceries to make the day's deliveries. The truck will usually have pre-packed pallets of groceries which have already been inventoried and prepared for delivery to particular customers. Frequently, but not in all cases, the pallets of groceries are wrapped with a plastic wrap to maintain the integrity of the stack of small boxes on the pallet for shipment and delivery.

2. Upon arrival at a delivery destination, a grocery driver occasionally must wait for access to loading docks or other unloading areas in order to unload the truck.

3. Drivers who deliver to chain stores large enough to have a cargo loading dock will back the trailer up to the dock.

4. After consulting about the delivery load with the grocery store or warehouse receiver personnel the driver opens the truck doors, and then may engage in a range of delivery activities:

    - Watch while others unload; check actual goods being delivered against appropriate paperwork; obtain receipts etc.,

    - Supervise the unloading done by others,

    - "Tail gate" the load. Use a pallet jack or lift to bring loaded pallets to the back of the trailer for others to do the actual unloading.

    - Unload by himself/herself, or with help (e.g. lumpers)

    - Re-palletize some of the groceries after unloading from the truck.

5. Drivers frequently retrieve loaded pallets from deep in the trailer (actually the front of the trailer) and using a pallet jack, drag the loaded pallets (weighing from 600 - 1000 lbs. each, depending on what is stacked on them) to the tailgate and deck of the trailer so the pallets are accessible to loading dock personnel. In the case of making deliveries by himself, the driver might be required to move all the groceries the entire length of the trailer during the course of his delivery day (see photos, Appendix F).

6. In some situations, grocery delivery drivers are expected to unstack one or more pallets of groceries, and to re-palletize them onto different pallets for more convenient storage in the receiving grocery store or warehouse. In other instances, the driver may be expected to extract only portions of a pre-packed pallet to make proper distribution for delivery of a small quantity of the items to each stop along his/her route.

7. In making deliveries to stores that do not have loading docks, if the truck has a hydraulic lift, the tasks are similar to those described below for pizza supply delivery tasks. The driver uses the lift to move goods from the truck to the ground, and proceeds from there using whatever moving equipment aids are available and appropriate to the situation.

8. At stores without loading docks, if the truck does not have a lift, the driver positions the truck as close to the rear door of the grocery store as is practical, and proceeds to construct a roller-conveyor system (see photos) to facilitate delivering boxes of groceries from the truck into the store by sliding items down the roller belt. The construction of the roller system may be done by the driver himself, or commonly, with the assistance of one or more store employees assigned to help with the delivery process.

9. Once the roller system is constructed and checked for stability, the driver begins to unload groceries, one carton at a time, onto the roller belts, and slide them down the rollers into the store to the waiting store employee(s) who grasp the boxes, count and mark them off on the shipping order inventory list, and move them in to stack them in the storage area (see photos, Appendix F).

10. Drivers engage in this activity with varying degrees of efficiency and speed, in part depending on the competency of the driver and the store employees engaged in the activity, the specific design and efficiency of the roller system (old ones stick, ,and do not always roll easily); the speed with which the packages can be inventoried on the listing; sorting out any discrepancies on the order; the size, number, and specific type of packages to be delivered (e.g. boxes of small breakable bottles must be handled more carefully than large boxes of tissue paper); and the need to move pallets from the front of the trailer to the rear before unwrapping them and proceeding to unload the boxes.

11. Rest breaks for the several people involved are a consideration. Sometimes the driver needs to rest his back from all the bending and reaching (photo), and sometimes the store employees require or just take a break - or are called away to do something in another part of the store.

12. Driver secures his loading equipment and the doors to the truck and trailer after delivery of all items to a particular stop is complete.

13. Driver meets with receiving personnel, and transacts necessary paperwork for the load.

14. Driver departs on his way to the next delivery stop.

Time measurements, grocery drivers

The pictures in Appendix F depict a typical driver delivering groceries in Florida to a small "mom and pop" style grocery store. The particular delivery depicted in the photos involved 137 grocery boxes, many of them small to medium in size. The entire process from the time the driver drove up to the parking lot, until he finished his delivery and drove away was about two hours. The driver spent approximately 90 - 100 minutes of that time in moving groceries around in the truck and onto the roller conveyor. This particular driver indicated he generally had six stops to make each day, driving as far as 180 miles one way to some of the stops, and his work day generally lasted from 11 - 14 hours.

Physical performance expectations of grocery drivers

Our estimate is that the amount of work (energy expended) put forth by the grocery driver in dragging loaded pallets on a pallet jack in the trailer, breaking down the pallets, moving the cartons onto the roller conveyor ranged intermittently from *light* (170-325 watts of energy) to *moderate* (325-500 watts). Grocery drivers surveyed at the August 1996 National Truck Driving Championships at Columbus, Ohio estimated that they spend from 1 ½ to 6 hours a day performing loading/unloading tasks.

Beverage delivery drivers

General description of beverage delivery drivers

Although some beverage delivery drivers are long haul, most of them are more likely to carry out short haul deliveries (generally within a 100 mile radius of the shipping warehouse. The drivers participating in the Truck Driving Championships in Columbus, Ohio (August, 1996) indicated that the role of beverage delivery driver often involves a significant amount of physical activity, as it includes hefting cases of beverages from trucks and delivering them into commercial establishments of many physical configurations. Members of the ATAF and the NPTC encouraged us to examine the tasks of local beverage delivery drivers.

Star Mountain analysts studied six local short haul beverage drivers in the Washington, DC suburbs by following them on their routes, interviewing them, videotaping their work, and shooting still photos of their delivery activities. There is considerable diversity but also much commonality of activity in the beverage delivery business.

Task activities of the typical beverage delivery driver

1. Driver reports in to a dispatcher, or trucking manager at a regional beverage warehouse and distribution point (his usual daily place of work). The driver normally reports in person (rather than by phone) and at the same location picks up his assigned truck which already has been loaded by others; picks up paperwork orders for deliveries; does an inventory of the shipments packed on his truck; acquires some cash from the company dispersing agent for making change if needed; and then sets out on his run to make the day's deliveries.

2. Driver will normally make from 5 to 10 delivery stops in a full work day which may last from 8 to 12 hrs. The stops may be in close proximity to one another (e.g. several blocks or miles apart) or they may be longer distances apart (as much as 30 to 60 driving miles) for some routes, particularly in larger suburban or rural areas. The quantity of beverages (usually cans or bottles in cases, but perhaps liquid in kegs as well) will vary according to the size of the customer order.

3. Drivers normally work by themselves, and thus accomplish all the work themselves as well.

4. Drivers usually find a truck parking spot as close to the customer's delivery access door as the client, and the particulars of the parking situation, allow. Sometimes this means very close to the front door, or a back delivery door of beverage stores, grocery or convenience stores, restaurants, hotels, liquor stores, bars, night clubs, bowling alleys, etc. The parking arrangements therefore are quite varied, and accordingly the distances the driver must "haul" the beverages from the truck to the customer's door vary widely from as short as 20-50 feet from the door, to sometimes 100 or more yards across a crowded parking lot (see photos, Appendix F).

5. Driver unloads a hand-truck from the delivery truck onto the parking lot surface. Driver uses a set of door access keys to unlock slide-up doors (see photo) to gain access to shelf-mounted stacks of beverage cases. Normally, each of a variety of products (different brands, different products) is stacked behind a different door.

6. Driver removes the deliverable cases of beverages one at a time from the side-mounted shelves on his truck, and proceeds to stack them on the hand-truck on the pavement (see photos, Appendix F).

7. Driver can unload some cases from the truck shelves while he is standing on the parking lot surface. For others, he may have to climb up onto the truck and shelves to reach the highest stacked cases (see photos), and through a short sequence of moving the cases around, negotiate them down to the ground level where he can add them to the growing stack of beverage cases on the hand-truck. Thus, depending upon where

the driver is in fulfilling the customer's specific order, he may load the hand-truck entirely from one panel door compartment, or he may move to several compartments in succession to acquire one of this and two of that for the stack.

8. Driver completes his stack of beverage cases on the hand-truck and prepares to move them inside the commercial establishment for delivery to the customer. We witnessed hand-truck loads of as few as 2-3 cases at a time, to as large (tall) a stack as six or eight cases at a time (see photos). If the driver is large and strong enough, he can and may handle tall heavy stacks of beverage cases, and this can speed up his delivery process. If the driver is smaller and feels more comfortable moving a smaller stack, he can do so, but it will take more time to make the deliveries.

9. Note, we observed a beer delivery driver unloading very heavy (160 lb.) 15-gallon metal kegs of beer, and delivering them either one at a time on a hand-cart, or carrying them over the shoulder, even up flights of stairs (see photos). Returning from the business establishment to the truck usually involved return of two empty beer kegs at a time to the truck storage cabinets (see photos, Appendix F).

10. Ease of access into commercial establishments varies significantly. Some places it is a simple matter of pulling or pushing a hand-truck loaded with beverage cases across a door threshold right into the place, and then wheeling the load down a grocery aisle to the location the customer wants the beverages stacked (see photos), or stored (in rows on the aisle floor, or into a walk-in cooler etc.). In other places, there may be a long and winding ramp upon which to wheel the loaded hand-truck to permit winding one's way up 10-15 or more feet to get the load to the doorway entrance level. In other significantly different arrangements, we witnessed a delivery access to be a rather worn set of deep wooden steps (about 16 of them) to gain access to a private club on the second floor of a building (see photos, Appendix F).

11. Once inside the customer's establishment, the driver may be expected to re-stack some of the beverage cases into walk-in coolers, and may have to move other items around to make space for his delivery items (see photo). Or he may have to cut off the cardboard tops of beverage cases, affix sales price stickers or tags on the items and stack them into a display ready for customer selection (see photos, Appendix F).

12. After the physical work of loading the beverage cases into the establishment is complete, the driver usually must meet with the client's representative, usually the manager on duty, and assure him/her that the appropriate goods have been delivered; then together perform necessary paperwork transactions such as signing of bills or invoices for the delivery. In many cases, drivers actually collect payment in the form of a check or cash (in several instances we witnessed counting of numerous one dollar bills as payment).

13. After transacting the business, the driver then re-loads his hand-truck into the delivery truck, returns any empties such as reusable beer kegs to the truck cabinets; ensures all cabinet doors are properly secured and locked; then returns to the truck cab, completes any bookkeeping requirements, and drives off toward his next delivery.

Time measurements, beverage delivery drivers

A representative delivery of a stack of beverage cases (e.g. a range of from 20 - 80 cases) may take a driver from 20 - 90 minutes depending upon the accessibility and complexity of the order and the delivery setting (e.g. parking, door access to the business establishment etc.). The driver can determine his own pace of delivery at a particular stop, but must be efficient in order to accomplish his day's list of deliveries.

Drivers indicated their delivery times usually are extended in bad weather (rain, snow, wind etc.) both for the driving time and the actual unloading time.

Physical performance expectations of beverage delivery drivers

Beverage drivers heft numerous cartons and cases of bottles and cans from truck side-mounted storage shelves down to the pavement level and then stack them on a handtruck. Sometimes the driver's body posture, stretched (see photos) over the storage shelf support brackets makes the slinging of these cases strenuous. The amount of such hefting of the beverage cases varies according to the particular order being filled, the way that the cases are stacked on the truck shelves, and upon the driver's personal work style.

A case of soft drinks, beer, and other beverages, in either bottles or cans, weighs between 12 and 30 lbs. Filled beer kegs (10 to 15 or more gallons of beer each) weigh from 120 lbs. to 160 lbs. each.

A beverage driver is likely to expend from *moderate* (325 - 500 watts) to *heavy* (> 500 watts) amounts of physical energy during any delivery stop depending upon how many cases of beverages are to be delivered. This work effort increases in hot, humid weather and especially if the driver must deliver his load of beverages up significant numbers of stairs (see photos).

Photographs of beverage delivery tasks are presented in Appendix F

Fast food supply delivery drivers

General description fast food supply drivers

Delivery drivers for fast food and other mass-market restaurant chains may engage in long haul delivery (100-400 miles per trip) or short haul local deliveries (e.g. from 5 to 100 miles between delivery stops). They typically deliver loads of food service supplies to franchise and chain dealerships. The trucks are usually refrigerated trucks. Many of the trucks are equipped with hydraulic lift platforms, handtrucks, and other tools to facilitate unloading the supplies.

Drivers pick up a pre-loaded truck at a regional warehouse. Drivers pull trucks into each subsequent stop along a delivery route (as many as 8-10 deliveries per day) and do the unloading themselves or with a helper who may accompany them on the day's trip. The particular operation we were able to document in detail was the delivery of supplies to stores in a pizza chain.

Task activities of the typical pizza supply delivery driver

1. Driver parks delivery truck in a convenient place near the pizza store access door.

2. Driver converses with pizza store proprietor for confirmation of delivery agreement.

3. Driver opens side and rear panels of refrigerated truck; engages hydraulic lift mechanism in either location (side or rear).

4. Driver lifts individual boxes of pizza supplies out of truck storage shelves and sets them onto a stack on a hand operated two-wheel truck positioned on the hydraulic lift platform.

5. Driver operates hydraulic lift platform to lower the cargo to parking lot/street level; wheels the handtruck off platform and into the pizza establishment.

6. Driver positions perishable goods (vegetables etc.) inside walk-in cooler and/or places other goods in storage room.

7. Driver closes/locks truck doors; restores hand truck to storage shelf under truck bed; folds and returns hydraulic lift(s) to stowed position for transit.

8. Driver completes transaction with pizza store employee.

9. Driver drives away to head to next delivery stop.

Time measurements fast food delivery drivers

A representative pizza supply delivery may take from 20 to 60 minutes depending upon how large the delivery is and the particular circumstances at the pizza store. Individual handtruck loads of supplies probably take the driver about 5 - 10 minutes each to extract from the delivery truck and another five minutes to take it into the pizza store.

Physical performance expectations of fast food delivery drivers

Pizza supply delivery drivers probably expend a *light* amount of energy (175-325 watts) during their short visit(s) to pizza stores. The work is not particularly strenuous, and the hydraulic lifts on the side of the delivery truck lessen the requirement for any heavy lifting, hefting, or climbing while carrying loads.

Tank truck drivers

General description tank truck drivers

A petroleum or oil tank truck driver reports in to a regional oil and petroleum storage depot and distribution point; signs in at manager's office, punches a time clock, draws safety clothing and equipment, completes paperwork, picks up order sheets, and reports to an assigned tank truck on the parking lot where he/she will load the petroleum products himself. Depending upon how many miles must be driven, and upon traffic and other conditions, a representative delivery day may include making 5 or 6 delivery stops, with intervening drives back and forth to and from the storage site, per day. This might be a 9 to 11 hour representative work day.

The gasoline delivery drivers we observed make about 5-6 full tank delivery loads (9,000 gallons of fuel each load) for a work day of from 9 to 11 hours, depending largely upon road traffic flow in suburban driving situations (e.g., Washington, DC suburbs).

Task activities of the typical petroleum tank truck driver:

1. Driver inspects and prepares truck for delivery runs; pulls truck up to covered tank loading stanchions.

2. Driver hooks up electrical grounding cables, hooks up gas vapor capturing hose; unfastens caps on several (usually 2 or 3) loading port connectors on side-mounted truck hookup piping.

3. Driver attaches flexible overhanging hose hookups to connecting ports on side of truck.

4. Driver places account ID card into automated dispensing machine, then keys in data for the precise delivery order(s) to be filled, e.g. number of gallons and grade of fuel to be loaded, before loading.

5. Driver turns on valves to begin loading product into truck; makes last of four connections when one bay is filled and repeats the fill procedure for remaining truck storage compartment(s).

6. Driver disconnects all hoses and cables; completes transaction at pumps; pulls truck out from under the overhang and stops in parking lot; driver may or may not go inside to discuss directions to receiver locations or additional instructions for delivering the load.

7. Driver enters highway with loaded truck and proceeds to first delivery stop.

8. Driver pulls truck into a delivery stop (e.g. gasoline service station) and locates suitable parking place for truck near the ground level fill ports for underground storage tanks. (Driver may have to await movement of several other vehicles to gain access to usable good parking spot).

9. Driver connects grounding cable from truck to grounding point(s) on parking lot surface above underground storage tanks; opens ground port caps; may insert measuring pole to ascertain level of fuel already in storage tank.

10. Driver unfastens truck side panel storage bin (with a key) and extracts two large pipe connector fittings (about 7 lbs each); carries them to the ground port and emplaces them (see photo, Appendix F).

11. Driver removes long, flexible 3.5 inch plastic hoses from trough on side of truck and carries them (hefting about 1/2 the length of hose at a time) to fit onto the truck exit ports and connect to the ground port fittings (see photos). These are two per underground tank (one for fuel going into ground tank and one for rising fuel vapors and fumes to be returned into the truck's tank).

12. Driver notes meter readings on valves, then turns on valves; then driver stands near underground entry ports to visually monitor the gravity feed of fuel from truck to underground tanks.

13. Driver notes complete drainage of fuel from truck; turns off valve at side of truck; inserts measuring stick into underground tank and confirms fuel level in underground tank.

14. Driver hefts the long plastic hose (again 1/2 the length of the hose at a time) back into the truck side-mounted trough; this action usually involves holding hose above his head to permit any residual liquid to drain from the hose into the underground tank (see photo, Appendix F).

15. Driver disconnects the two connector fittings from ground tank port, and secures the metal fittings back in the side of truck storage bin; locks cabinet door with key.

16. Driver secures all equipment on truck; ensures underground storage tank ports are secure.

17. Driver reports inside establishment; transacts paperwork with fuel station proprietor.

18. Driver pulls tank truck away from station and then he usually returns to the regional fuel depot; or if he has a small delivery (delivered less than a full truck load of petrol), he may proceed to the second delivery stop on his run.

Time measurements, tank truck drivers

Tank truck carrier operations may vary considerably with the type of commodity being shipped, and therefore also the type of truck and other equipment being used. Our observations were made only on gasoline tank truck carrier operations. For the handling of the various hoses, connectors, measuring sticks, turning valves etc., each activity independently takes only two or three minutes. In the aggregate to make a gas station delivery, drivers spend approximately 30 - 50 minutes at a gasoline station stop.

Physical performance expectations of tank truck drivers

The tank truck carrier operations we observed (gasoline delivery operations) require only a modest amount of physical activity on the part of the driver. The equipment items used (hoses, connectors, measuring stick etc.) are all quite light in weight. The amount of energy expended by these drivers is undoubtedly in the *light* category (170-325 watts of energy per hour).

Photographs of tank truck driver tasks are presented in Appendix F.

Assessment of Findings

Commonalities among truck driver loading/unloading activities

At first glance, the jobs of these several types of drivers and industry segments appear very different, but if analyzed carefully, commonalities among them may be identified. This analysis categorized the job tasks by the sequence in which they normally are performed, and broke the work down into major phases. The tasks have been generalized to some extent, to facilitate the identification of commonalities among the cargo commodity types, but the authors believe the common tasks and subtasks represent meaningful units of the drivers' work. Table 17 lists a synthesis of tasks and activities observed in some form in delivery of all or nearly all of the cargo commodity types studied in this project task.

Table 17. Commonalities observed in loading/unloading tasks	
Preparation	
	Obtain assignment, check with dispatcher or equivalent
	Pick up cargo for delivery, if applicable; complete record-keeping
	Drive to first stop
	Position truck for loading/unloading
	Set up transport aids or tools (ramps rollers, lifts, hoses, handtrucks, pallet jacks, lifts, etc.)
	Determine with delivery consignee or shipper (pickup) exactly what is to be loaded/unloaded.
Load/unload:	
	Take cargo from its current place
	Load cargo on transport aid or "vehicle" (lift, jack, handtruck, etc.)
	Move cargo to desired location
	Position cargo
	Secure cargo in truck if picking up
	Place cargo wherever required if delivering
	May require unpacking, breaking out, prepping cargo for use
Complete transaction	
	Confirm that proper cargo has been loaded/unloaded (inventory)
	Communicate with shipper/consignee rep., obtain sign-off, or payment
	Record transaction as required
	Secure truck for transit; stow transport aids
	If necessary, communicate with dispatcher
	Leave for next destination

Task taxonomy of loading/unloading tasks developed from task analysis data

In a second analysis, the authors looked at the common tasks that were identified for all or nearly all drivers, and analyzed them by the general functions or objectives of the tasks and subtasks. Thus we identified functions such as communications, preparation for loading, loading, etc., and analyzed them into smaller task and subtask units. This functional taxonomy is depicted in Table 18. The tasks are listed with the most general, high-level units at the left; increasing indentation signifies more detailed, "micro" levels of analysis and specificity.

Table 18. Functional taxonomy of driver tasks

Communications

- Telecommunication
    - Receiving assignments from dispatch
    - Reporting location to dispatch
    - Reporting transactions, problems to dispatch or supervisor
- Personal communication
    - Greeting shipper/consignee
    - Reviewing inventory, order, bill of lading, etc.
    - Obtaining signature, confirmation of receipt/delivery
    - Performing cash transactions(also listed under record-keeping)
    - Problem-solving, negotiating with shipper/consignee

Record-keeping, paperwork

- Dispatch/work assignment
- Inventory, meter reading, other measurements
- Confirmation of receipt/delivery

Preparation for/completion of loading/unloading

- Positioning, parking truck
- Unlocking, opening truck or compartments
- Re-locking truck or compartments

Use of transport aids

- Setting up ramps, rollers, lifts, etc.
- Unstowing, positioning "vehicles"

- Moving, placing, securing cargo onto "vehicles"
- Hooking up connectors, hoses, etc.
- Unhooking, stowing connectors, hoses, etc.
- Stowing vehicles, lifts, roller ramps, etc.

Movement of cargo

- Lifting cargo
- Carrying cargo
- Negotiating stairs, ramps, passageways
- Pulling "vehicle"
- Pushing "vehicle"
- Manipulating valves, etc.

Positioning, securing cargo

- Delivery, unloading:
  - Unloading cargo from "vehicle"
  - Placing cargo as required
  - Breaking out pallets
  - Re-packing pallets
  - Stacking cartons, other objects
  - Prepping merchandise for sale
- Pickup (household goods, empties, etc.):
  - Wrapping, padding goods
  - Positioning goods in truck
  - Securing load

Section III Summary and Recommendations

The amount of physical work (energy) expended by drivers in loading/unloading of trucks varies substantially across commodity types. It also varies as a function of the amount of assistance (helpers, mechanical equipment available etc.) assigned to work with drivers on pickups or deliveries. The driver's personal work habits and style of performing loading/unloading tasks also contribute to the variance in amount of energy expended. However, it appears from this task analysis, that drivers who are involved in household goods, grocery and beverage delivery sectors of trucking delivery frequently expend significant amounts of physical energy in performance of loading/unloading tasks.

It appears that from time to time some household goods drivers, and some grocery delivery drivers engage in *moderate* to *heavy* work energy expenditure in the performance of their loading/unloading activities associated with on-duty non-driving chores in the workplace. The influence the expenditure of *moderate* to *heavy* work has on these drivers' subsequent driving alertness, performance, development of drowsiness, fatigue at the wheel, or highway safety is really not known. This was in part a topic for study in the research proposed in this program as outlined in the Phase I, Task 4 report (O'Neill, Krueger, & Van Hemel, June, 1997).

On the basis of the behavioral task analysis data collected, further field study of the relationship between the physical labor of loading/unloading and subsequent driver alertness or fatigue could be best accomplished in the household goods and grocery delivery sectors of the trucking industry.

The actual resultant research project, including an assessment of driver loading and unloading activities as they affect CMV driver performance in a truck simulator, are described in detail in O'Neill, Krueger, Van Hemel, and McGowan (1999) and in O'Neill, Krueger, Van Hemel, McGowan, and Rogers (1999).

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Mobil Oil Co., Inc.
Manassas, Virginia

North American Van Lines
Fort Wayne, Indiana

Publix Groceries, Inc.
Lawrenceville, Georgia

Smith's Moving and Storage Co., Inc.
Alexandria, Virginia

Von Paris Moving and Storage
Alexandria, Virginia

Glossary of Terms

American Trucking Associations (ATA): an organization comprising 50+ state trucking associations and several conferences representing subdivisions of the trucking industry.

Auto Transport: a long metal truck trailer designed for carrying usually 6 to 10 automobiles and light trucks.

Breakout (sometimes "breakdown") or re-palletization of freight loads: for unitized loads (see below), the breaking up of the units in order to reorganize the contents or place them in a new configuration to meet the requirements of the receiver. For example, goods may need to be re-palletized to fit the receiver's warehouse pallet racks.

Cargo: goods or commodity carried; freight.

Carrier: a company that moves cargo by truck. The carrier may own the trucks and employ drivers, or may contract with owner-operators.

Consignee: the recipient of (he who signs for) a load at the receiver end of the cargo delivery chain.

Flatbed truck: a truck with a flat-surface, uncovered platform trailer without sides or stakes, on which cargo (usually large-size) is placed, often covered with a tarp or cargo cover, and secured with tie-downs, straps, chains or other devices.

For-hire carrier: a company whose primary business is trucking, and that is paid to haul cargo for clients.

Freight: any goods or commodity being transported; cargo.

Freight forwarder: an individual or company that accepts less-than-truckload (LTL) shipments from shippers and combines them into truckload lots.

General freight carrier: a carrier which handles a wide variety of cargoes.

Hand loading and unloading of freight: loading and unloading without the use of motorized or electric unloading equipment. Hand loading includes use of handtrucks, dollies, and prybars.

HazMat: hazardous material which by law requires a placard on the truck and special handling practices.

High value products: valuable cargo, such as electronic equipment, requiring special handling because of its value and susceptibility to damage.

Hours of service (HOS): the work hours that must by government regulation be recorded in the driver's log book. The U S Department of Transportation Office of Motor Carriers regulates HOS for interstate drivers.

Intercity trucking: trucking operations which carry freight beyond the local areas and commercial zones.

Interstate Truckload Carriers Conference (ITCC): a unit of the American Trucking Associations representing carriers specializing in full truckload, long distance carriage.

Involuntary lumping: freight pickup or delivery in which motor carriers did not want to use available lumpers, but were required/coerced to do so by shippers or receivers. Most lumping takes place at unloading sites.

Less than Truckload (LTL): a quantity of freight less than that required for the application of a truckload rate. Usually less than 10,000 pounds and generally involves the use of terminal facilities to break and consolidate shipments.

Long-haul drivers: drivers who make delivery runs over 100 air miles from home base

Lumpers: persons who are paid to load or unload trucks at shippers' or receivers' docks. Lumpers may be self-employed or may work for businesses specializing in providing loading and unloading services. Lumpers may sometimes be called swampers.

Lumping: the loading and unloading of motor carrier freight by paid individuals other than the employees of motor carriers, shippers, or receivers.

Motor Carrier Safety Assistance Program (MCSAP): a program by which the US Department of Transportation Office of Motor Carriers assists states in the regulation of trucking and the promotion of truck safety.

National Private Truck Council (NPTC): an organization representing businesses whose primary business area is not trucking, but who maintain their own truck fleets.

Over-the-road drivers: see long-haul drivers.

Reefer: refrigerated truck trailer unit.

Re-palletize: see Breakout

Shipper: The organization from which a shipment originates, and that arranges for it to be hauled. In private carriage, the shipper may also be the carrier.

Straight truck: a truck with the traction (motor) and cargo carrying area in a single unit, not separable or articulated.

Swamper: see Lumper (term used in produce industry).

Tank truck: a truck with an enclosed tank for cargo.

Third party loading/unloading firm: an independent business firm that specializes in contracting to provide loading and/or unloading services to shippers, carriers or receivers.

Tractor-trailer: a truck with separate tractor and cargo units.

Truckload (TL): quantity of freight required to fill a truck.

Twins: trucks hauling two trailer units.

Unitized freight shipments: shipments with the contents contained on pallets, shrink-wrapped, or otherwise packed in units larger than individual cartons, crates, bags, etc. These shipments can usually be handled by pallet jack or lift, fork lift, or similar equipment.

USARIEM: United States Army Research Institute of Environmental Medicine, at Natick, Massachusetts.

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Appendix A: National Truck Driving Championships Drivers' survey form

The **ATA Foundation,** Inc.
2200 Mill Road ALEXANDRIA, VIRGINIA 22314-4677
Phone: (703) 838-1966

August, 1996

Truck Driver Loading and Unloading Survey

Dear Professional Driver:

The American Trucking Associations (ATA) Foundation and the Federal Highway Administration are conducting a study of the practices truck drivers use in loading or unloading their trucks. We are particularly interested in describing the many differences in methods truck drivers use to load or unload trucks in different segments of the trucking industry. We plan to conduct in-depth focus group discussions on the topic with drivers and trucking industry managers in several regions of the country.

With that idea in mind, we ask that you please complete this short questionnaire on your loading and unloading experiences. Your responses will help us to select and configure the focus groups, to organize those focus group meetings, and to decide what questions to ask in our discussions.

Please note that your questionnaire responses will only be used by our research staff for purposes of organizing our focus group discussions. We have asked for your name on the questionnaire only so that we may contact you for more discussion about your ideas. Your written responses here will be treated in confidence and will not be seen by others outside our research staff except in group summary format in a report.

If you turn your completed questionnaire in at the ATA Foundation booth in the convention center exhibit area, we will offer you a choice of a nice ATA gift as a token of our appreciation for your assistance. Stop by the ATA Foundation booth on Thursday August 22nd or Friday August 23rd to turn in your questionnaire, to talk about the survey, or to volunteer to participate in the focus groups. Thank you.

Sincerely,

Clyde E. Woodle
Trucking Research Institute

Gerald P. Krueger, Ph.D.,
Star Mountain, Inc.

Please answer the following questions thoughtfully. It should take you only a few minutes. Mark or check-off only the answers that most nearly describe you or your experiences with loading and unloading trucks during your driving career. Several items permit you to write about your own loading and unloading experiences, and the procedures and methods you follow. Your answers to these questions will help us determine how to set up industry focus groups to discuss these topics in greater depth.

When you have completed the survey, just drop it off at our ATA Foundation booth in the exhibit area, to receive your ATA gift as a token of our appreciation for participating.

Please print or write legibly

Your name _____

Your employer or company: _____

1. Please check the class of driving championship competition you will drive.

_____ Straight Truck	_____ Flatbed
_____ Three-axle	_____ Auto Transports
_____ Four-axle	_____ Twins
_____ Five-axle	_____ Tank Truck
_____ Other, please specify:	_____

2. What is your age?
   - _____ 30 years old or younger
   - _____ 31-50 years old
   - _____ 51-65 years old
   - _____ 66 years old or older

3. How many years have you been a professional truck driver?

   - ____ 3 years or less
   - ____ 4-10 years
   - ____ 11-20 years
   - ____ 21 years or more.

4. Which type of employer do you presently work for?
   - _____ Truckload
   - _____ Less than truckload (LTL)
   - _____ Company whose primary business is not trucking (private carrier)
   - _____ Self-employed (owner-operator)
   - _____ Other please specify: _____

5. What types of vehicle(s) do you normally drive? (check all that apply)

_____ dry bulk tankers
_____ liquid tankers
_____ normal dry van
_____ household goods dry van
_____ refrigerated van
_____ package truck
_____ auto carrier
_____ flat bed truck
_____ dump truck
_____ other; please specify

6. In terms of distances driven, what presently describes most of your driving?

_____ long haul
_____ regional
_____ short haul (less than 100 miles)
_____ frequent pickups & delivery (close to home base)

7. What are the most frequent types of freight/cargo you haul?

____ fresh produce (e.g. lettuce, fruit, potatoes, etc.)
____ refrigerated foodstuffs (e.g. meat, frozen foods, ice cream etc.)
____ non-refrigerated foodstuffs (e.g. cereal, canned foods, beverages, etc.)
____ other grocery related products (e.g. paper, soap, pet food, dry boxed goods, etc.)
____ dry chemicals/materials
____ liquid tank cargo
____ general freight (mixed cargoes)
____ building materials
____ forestry products
____ metal products
____ mining products
____ household goods
____ other, please specify: _____

8. How often do you participate in the actual physical activity of "**loading**" your truck? (by whatever means of loading, including using mechanical assists like those in Question 10).

_____ always (about every time out)

_____ for most of my runs (very often)

_____ sometimes (occasionally)

_____ almost never

9. How often do you participate in the actual physical activity of "**unloading**" your truck? (by whatever means of unloading, including using mechanical assists like those listed in Question 10).

_____ always (about every time out)

_____ for most of my runs (very often)

_____ sometimes (occasionally)

_____ almost never

10. What type of **devices, boosts, or assistance** do you generally use in loading or unloading your truck? Please check all that apply:

____ fork lift
____ loading crane
____ front end loader
____ conveyor belts
____ hand carts (2-wheel push truck)
____ pressure hoses for dry or wet tank loads
____ gravity feed pipe or funnel systems to dump cargo from above
____ hydraulic lift systems
____ winch
____ others, please specify: _____
____ Generally, I do not use the above devices to load or unload my truck.

Pertinent details: _____
_____
_____
_____

11. How frequently do you yourself load or unload cargo **by hand** (e.g. lift, carry, push boxes, handle floorloads etc.)?

_____ always (about every time out) If so, please briefly describe the circumstances:

_____ for most of my runs (very often) _____

_____ sometimes (occasionally) _____

_____ almost never _____

12. When you are **assisted by others** to load or unload your truck, generally who are these others? Please check all that apply.

_____ lumpers hired for the purpose Pertinent details? _____
_____ other company personnel assigned the task _____
_____ my driving partner _____
_____ receiver or shipper personnel _____
_____ other please specify: _____

13. What types of devices do you generally use to secure your cargo loads?

_____ cables, chains
_____ tie down straps, ropes
_____ tarps
_____ load covers
_____ others, please specify: _____

14. On typical loads, **how long** dies it usually take you to load the truck prior to a run?

_____ this question does not apply, I do not generally load my truck
_____ half-hour or less Pertinent details? _____
_____ about one hour _____
_____ 1 to 2 hours _____
_____ more than two hours _____

15. On typical runs, **how long** does it usually take you to **unload** the truck?

____ this question does not apply, I do not generally unload my truck
____ half hour or less check here: ____ if it's because you make multiple deliveries
____ about one hour
____ 1 to 2 hours
____ more than two hours

Pertinent details?: _____
_____

16. Which of the following best describes your attitude toward **hand loading/unloading** of freight?

____ really like it
____ like it
____ neutral (no feeling either way)
____ dislike it
____ really dislike it

17. What are some of the **most difficult freight/cargo loads** you have loaded or unloaded? Why? Please describe briefly.

_____

_____

18. Does the type or the amount of loading and unloading you do **affect your ability to follow the hours of service** (HOS) regulations? ____ Yes ____ No If yes, please describe the situation here:

_____
_____
_____

19. Does your physical activity in loading or unloading make you (check one)
_____ more alert, or ____ less alert (more fatigued) or ____ it doesn't make a difference for driving?

Please explain briefly here: _____
_____
_____
_____

20. Which regions of the country did you serve during the past year? (Check all that apply).

____ Region 1 (Washington State, Oregon, California, Nevada, Arizona)
____ Region 2 (Idaho, Montana, Wyoming, Colorado, Utah, New Mexico)
____ Region 3 (Texas, Oklahoma, Louisiana, Arkansas)
____ Region 4 (North & South Dakota, Nebraska, Kansas, Minnesota, Missouri, Iowa)
____ Region 5 (Wisconsin, Illinois, Michigan, Indiana, Ohio, Kentucky, W. Virginia)
____ Region 6 (Tennessee, Mississippi, Alabama, Georgia, Florida, North & South Carolina)
____ Region 7 (Virginia, Maryland, D.C., Delaware, Pennsylvania)
____ Region 8 (Maine, Vermont, New Hampshire, Massachusetts, New York, Connecticut, Rhode Island)

21. In which region(s) of the country did you experience the greatest frequency of driver loading and unloading problems during the past year?

____ Region 1 ____ Region 2 ____ Region 3 ____ Region 4
____ Region 5 ____ Region 6 ____ Region 7 ____ Region 8

22. What other driver loading and unloading topics or concerns do you think we ought to be exploring in our focus group discussions? Briefly describe here.

_____
_____
_____
_____
_____

23. Would you like to be considered as a participant in our focus group sessions to discuss these issues at greater length? ____ Yes ____ not really

If yes, how can we contact you?
Phone number where you can be reached: ( ) --

Mailing address: _____
_____
_____

Thank you very much for your participation in completing this questionnaire. Your answers will help us formulate useful topics for our focus group discussions on loading and unloading methods. We repeat that your responses here will be treated with confidence and will not be seen by people outside our immediate research staff, except in group format in a report later. Be sure to drop your completed questionnaire off at our ATA Foundation booth for your gift.

Appendix B: National Truck Driving Championships Officials' (safety directors and others) survey forms

The **ATA Foundation,** Inc.
2200 Mill Road ALEXANDRIA, VIRGINIA 22314-4677
Phone: (703) 838-1966

August, 1996

Truck Driver Loading and Unloading Survey

Dear Trucking Safety Supervisor, Manager, or Company Official:

The American Trucking Associations (ATA) Foundation and the Federal Highway Administration are conducting a study of the practices truck drivers use in loading or unloading their trucks. We are particularly interested in describing the many differences in methods truck drivers use to load or unload trucks in different segments of the trucking industry. We plan to conduct in-depth focus group discussions on the topic with drivers and trucking industry managers in several regions of the country.

With that idea in mind, we ask that you please complete this short questionnaire on your loading and unloading experiences. Your responses will help us to select and configure the focus groups, to organize those focus group meetings, and to decide what questions to ask in our discussions.

Please note that your questionnaire responses will only be used by our research staff for purposes of organizing our focus group discussions. We have asked for your name on the questionnaire only so that we may contact you for more discussion about your ideas. Your written responses here will be treated in confidence and will not be seen by others outside our research staff except in group summary format in a report.

If you turn your completed questionnaire in at the ATA Foundation booth in the convention center exhibit area, we will offer you a choice of a nice ATA gift as a token of our appreciation for your assistance. Stop by the ATA Foundation booth on Thursday August 22nd or Friday August 23rd to turn in your questionnaire, to talk about the survey, or to volunteer to participate in the focus groups. Thank you.

Sincerely,

Clyde E. Woodle
Trucking Research Institute

Gerald P. Krueger, Ph.D.,
Star Mountain, Inc.

Please answer the following questions thoughtfully. It should take you only a few minutes. Mark or check-off only the answers that most nearly describe your own experiences, or the experiences your drivers have with loading and unloading trucks. Several items permit you to write about loading and unloading experiences, and the procedures and methods you follow. Your answers to these questions will help us determine how to set up industry focus groups to discuss these topics in greater depth.

When you have completed the survey, just drop it off at our ATA Foundation booth in the exhibit area, to receive your ATA gift as a token of our appreciation for participating.

Please print or write legibly

Your name _____

Your employer or company: _____

You are a: _____ safety supervisor
_____ company official or manager
_____ competition judge

1. Please check the class(es) of driving championship competition you will inspect, judge, or officiate this week.

_____ Straight Truck
_____ Three-axle
_____ Four-axle
_____ Five-axle
_____ Other, please specify: _____

_____ Flatbed
_____ Auto Transports
_____ Twins
_____ Tank Truck

2. What is your age?
_____ 30 years old or younger
_____ 31-50 years old
_____ 51-65 years old
_____ 66 years old or older

3. How many years did **you** work as a professional truck driver?

_____ I never was a truck driver
_____ 3 years or less
_____ 4-10 years
_____ 11-20 years
_____ 21 years or more.

4. Which **type of employer** do you presently work for?

_____ Truckload
_____ Less than truckload (LTL)
_____ Company whose primary business is not trucking (private carrier)
_____ Self-employed (owner-operator)
_____ Other please specify: _____

5. What types of vehicle(s) do your drivers normally drive? (check all that apply)

_____ dry bulk tankers
_____ liquid tankers
_____ normal dry van
_____ household goods dry van
_____ refrigerated van
_____ package truck
_____ auto carrier
_____ flat bed truck
_____ dump truck
_____ other; please specify: _____

6. For company officials, in terms of distances driven, what presently describes **the driving done by your drivers**? (please check all that apply).

_____ long haul
_____ regional
_____ short haul (less than 100 miles)
_____ frequent pickups & delivery (close to home base)

7. What are the most frequent types of freight/cargo your drivers haul? (check all that apply).

____ fresh produce (e.g. lettuce, fruit, potatoes, etc.)
____ refrigerated foodstuffs (e.g. meat, frozen foods, ice cream etc.)
____ non-refrigerated foodstuffs (e.g. cereal, canned foods, beverages, etc.)
____ other grocery related products (e.g. paper, soap, pet food, dry boxed goods, etc.)
____ dry chemicals/materials
____ liquid tank cargo
____ general freight (mixed cargoes)
____ building materials
____ forestry products
____ metal products
____ mining products
____ household goods
____ other, please specify: _____

8. How often do your drivers participate in the actual physical activity of "**loading**" their trucks? (by whatever means of loading, including using mechanical assists like those in Question 10).

_____ always (about every time out)

_____ for most of their runs (very often)

_____ sometimes (occasionally)

_____ almost never

9. How often do your drivers participate in the actual physical activity of "**unloading**" their trucks? (by whatever means of unloading, including using mechanical assists like those listed in Question 10).

_____ always (about every time out)

_____ for most of their runs (very often)

_____ sometimes (occasionally)

_____ almost never

10. What type of **devices, boosts, or assistance** do your drivers generally use in loading or unloading their truck? Please check all that apply:

____ fork lift Pertinent details: _____
____ loading crane _____
____ front end loader _____
____ conveyor belts _____
____ hand carts (2-wheel push truck)
____ pressure hoses for dry or wet tank loads
____ gravity feed pipe or funnel systems to dump cargo from above
____ hydraulic lift systems
____ winch
____ others, please specify: _____
____ Generally, I do not use the above devices to load or unload my truck.

11. How frequently do your drivers themselves load or unload cargo **by hand** (e.g. lift, carry, push boxes, handle floor loads etc.)?

_____ always (about every time out) If so, please briefly describe the circumstances:

_____ for most of our drivers' runs (very often) _____

_____ sometimes (occasionally) _____

_____ almost never _____

12. When your drivers are **assisted by others** to load or unload your truck, generally who are these others? Please check all that apply.

_____ lumpers hired for the purpose Pertinent details? _____
_____ other company personnel assigned the task _____
_____ their driving partner _____
_____ receiver or shipper personnel _____
_____ other please specify: _____

13. What types of devices do your drivers generally use to secure their cargo loads?

_____ cables, chains
_____ tie down straps, ropes
_____ tarps
_____ load covers
_____ others, please specify: _____

14. On typical loads, **how long** dies it usually take your drivers to load the truck prior to a run?

_____ half-hour or less Pertinent details? _____
_____ about one hour _____
_____ 1 to 2 hours _____
_____ more than two hours _____
_____ does not apply, my drivers generally do not load their trucks.

15. On typical runs, **how long** does it usually take your drivers to **unload** their trucks?

____ half hour or less check here: ____ if it's because they make multiple deliveries
____ about one hour
____ 1 to 2 hours
____ more than two hours
____ does not apply, my drivers do not generally unload their trucks

Pertinent details?: _____
_____

16. Which of the following best describes your truck drivers' attitudes toward **hand loading/unloading** of freight?

____ really like it
____ like it
____ neutral (no feeling either way)
____ dislike it
____ really dislike it

17. What are some of the **most difficult freight/cargo loads** your drivers have loaded or unloaded? Why? Please describe briefly.

_____
_____
_____

18. Does the type or the amount of loading and unloading your drivers do **affect their ability to follow the hours of service** (HOS) regulations? ____ Yes ____ No If yes, please describe the situation here:

_____
_____
_____

19. Does the physical activity your drivers expend in loading or unloading make them (check one) _____ more alert, or ____ less alert (more fatigued) or ____ it doesn't make a difference for driving?

Please explain briefly here:

_____
_____
_____
_____

20. Which regions of the country did your drivers serve during the past year? (Check all that apply).

____ Region 1 (Washington State, Oregon, California, Nevada, Arizona)
____ Region 2 (Idaho, Montana, Wyoming, Colorado, Utah, New Mexico)
____ Region 3 (Texas, Oklahoma, Louisiana, Arkansas)
____ Region 4 (North & South Dakota, Nebraska, Kansas, Minnesota, Missouri, Iowa)
____ Region 5 (Wisconsin, Illinois, Michigan, Indiana, Ohio, Kentucky, W. Virginia)
____ Region 6 (Tennessee, Mississippi, Alabama, Georgia, Florida, North & South Carolina)
____ Region 7 (Virginia, Maryland, D.C., Delaware, Pennsylvania)
____ Region 8 (Maine, Vermont, New Hampshire, Massachusetts, New York, Connecticut, Rhode Island)

21. In which region(s) of the country did your drivers experience the greatest frequency of driver loading and unloading problems during the past year?

____ Region 1 ____ Region 2 ____ Region 3 ____ Region 4
____ Region 5 ____ Region 6 ____ Region 7 ____ Region 8

22. What other driver loading and unloading topics or concerns do you think we ought to be exploring in our focus group discussions? Briefly describe here.

_____
_____
_____
_____
_____

23. Would you like to be considered as a participant in our focus group sessions to discuss these issues at greater length? ____ Yes ____ not really

If yes, how can we contact you?
Phone number where you can be reached: ( ) --

Mailing address: _____
_____
_____

Thank you very much for your participation in completing this questionnaire. Your answers will help us formulate useful topics for our focus group discussions on loading and unloading methods. We repeat that your responses here will be treated with confidence and will not be seen by people outside our immediate research staff, except in group format in a report later. Be sure to drop your completed questionnaire off at our ATA Foundation booth for your gift.

Appendix C: Letter for Survey form NPTC Safety Committee meeting

Note: The questions asked of the attendees at the National Private Truck Council Safety Committee Meeting on 10 October 1966 were identical (see Appendix D) to those asked of the Safety Supervisors and Company officials at the ATA Truck Driving Championships in August 1966, with the exception that the particular questions pertaining to what Championship events they might be judging were deleted.

PFMI
Private Fleet Management Institute

NPTC
National Private Truck Council
66 Canal Center Plaza, Suite 600, Alexandria, VA 22314

Private Carrier

Date: October 2, 1996

To: Attendees at the 10 October 1966 NPTC Safety Committee Meeting

From: Dave Barry, Director, ITS and Research Programs

pages to follow: 5

As part of our federally funded research programs, NPTC is teamed with the American Trucking Association (ATA) to conduct a series of truck driver fatigue and driving safety studies. One study addresses the work related activities that LONG HAUL drivers perform when they are on duty, but not actually driving. We are particularly interested in describing methods, practices, and issues related to drivers loading and unloading their trucks. We know that there are differences in various segments of our diverse trucking industry, and we suspect that there may be some distinct differences within private fleets, and that you can be of help in characterizing those differences.

With that in mind, I have enclosed a survey we are using to "test the waters" and I am requesting you complete it and bring it with you (or fax it back) to the Safety Committee meeting next week. Your participation will assist us to identify and describe issues related to driver loading/unloading and other non-driving activities and fatigue, as we develop research strategies.

Star Mountain, Inc. (an industry leader in fatigue research) is the firm leading our research efforts. Dr. Gerald P. Krueger and Dr. Susan B. Van Hemel from Star Mountain will be attending our Safety Committee on 10 October 1996. The Safety Committee agenda does not permit a presentation by Star Mountain. However, Dr. Krueger and Dr. Van Hemel will attend the late Thursday afternoon session of the meeting and remain for the reception. I would appreciate your giving them a few minutes of your time during the reception to informally discuss the topics mentioned above and in the survey.

Your views as Private Fleet managers is key to the success of our research efforts. I thank you for your previous support of our programs and thank you in advance for your support of this program.

Appendix D: Columbus, Ohio truck driver questionnaires: Responses to open-ended questions

The comments included here represent somewhat less than half of the comments received. We have tried to maintain approximately the proportions of comments on particular issues, positive and negative, etc. found in the full set. We have removed company names and corrected spelling and grammar only enough to ensure readability.

Q. 17. What are some of the most difficult freight/cargo loads you have loaded or unloaded? Why? Please describe briefly.

- grocery loads that are on the floor and have to be sorted and palletized. Because it seems that every receiver has their own way of wanting this done and they are all different.
- heavy pipe; you can't hardly handle the pipe with fork lifts or hands.
- high gravity petroleum product, because of vapor pressure and cavitation of pump.
- log cabin kits.
- any load with multiple products on each pallet that have to be sorted.
- dry freight groceries.
- load of fiberboard roof insulation: load 13'6" high, hard to climb up and down the ladder to strap down and tarp.
- ammonia which is very hazardous.
- loading of jet fuel requires samples and testing; also for unloading.
- 720 bags of bark by hand.
- any bulk load on my trailer: trying to keep legal weight.
- railroad spikes, they are hand loaded/unloaded in 50lb bags.
- honey bees, some of them always get out of the netting.
- helicopters – multi $million value; oversize loads involve more work.
- empty totes, very unstable when stacked high.

- foodstuffs; it's difficult because the food warehouse can be hard to deal with.
- frozen imported seafood load that was floor loaded and had 20 different types. The load weighed 47,500 lbs.
- goods that have to be re-palletized at consignec because their pallets are different sizes.
- skids of small boxes that may not be shrink-wrapped tight enough and fall over.
- condensate or high gravity oil, because the gas properties of the product make it hard to pump.
- loosc grain in a van trailer because it has to be shoveled out.
- any loads to a grocery warehouse because they are extremely slow at making appointments & checking in freight.
- sulfuric acid, must wear full safety gear; chemical protective clothing is problematical.
- fabric bolts, heavy and wears you out. Don't like driving tired, hot and sweaty.
- bundles of pipe, metal pieces, because of the length, and so easily damaged.
- cargo requiring 100ft plus of 3" hoses to reach customers' unloading lines. These hoses full of cargo are extremely heavy.
- tires, you have to handle each one. Sometimes it takes 2 hr or more.
- roof coating because of extremely high temperatures (in excess of 400 degrees F).
- big boxes like swing sets, heavy boxes.
- grocery warehouse: if cargo is on pallets they always want it on a different sized one.
- pump out a tank in the ground.
- gasoline; every load is difficult when hauling hazardous materials.
- high center of gravity loads.
- livestock.
- flour products in 100 lb. bags; dog food in 100 lb. bags.

- heavy products – appliances, customers without fork lifts, inside delivery building and up stairs.

- frozen internal valve switch during winter months (fuel tanks).

- beef quarters you have to carry over 200 lbs. and hook and rail.

- produce because of need for temperature control and pack in non-uniform crates.

- loads of milk; milk crates are very slippery and tend to make floor on trailer very slick.

- 80 to 100 lb. boxes of boxed meat loaded on the floor of the trailer

- farm machinery; it is heavy and bulky and does not load or unload well.

- it is never the load; the difficulty is in the facility of the customer (e.g. malls and office buildings are hard to deliver to).

- watermelons, citrus fruit, these items are consistently heavy, and wear you down by the time you finish.

- cases of bleach, antifreeze, windshield washer fluid, detergent, due to weight of boxes.

- double stack washer & dryer combos; 48 cubic ft. refrigerator.

- unstable heavy freight; hard to secure.

- boxed meat in summer, because they load it on spacers for air circulation and they are unstable because they break when stepped on.

- watermelons carried in racks; you must bend over to pick each one out by hand.

- rolls of fabric; heavy and very tiresome.

- grocery & cigarettes; lots of separation and bending over.

- inside deliveries because you have to put them at the rear of the trailer, then unload them to the ground, and then wheel the shipment into the customer's store. You move the same freight 3 times before you get it into the store.

- metal, heavy & long.

- wire trailers. They are long and can't stack on top; and can't stand up.

– kegs of beer because they are so heavy and awkward.

– taking loads upstairs.

– heavy cartons; inside deliveries.

– milk, it won't stay on the pallet.

– large rolls of carpeting shipped to residence, no equipment to use and no manpower, no unloading facilities.

– particle board or gypsum board or sheet rock. If you get it too tight you damage it, if not tight enough it will slide on you!!

– steel, usually because it is unloaded from the tail-gate with a crane.

– steel pipe loads in a van.

– steel belted tires (big trucks) they are heavy and stick to each other.

– unloading at food warehouse: sort and separate freight to put items on small or larger pallets.

– some places still do not have a dock. If we have a large shipment to one of these places and they cannot or will not provide help this sometimes causes a lot of climbing in and out of the trailer.

– improper loading, it tips to one side.

– cylinders because they are hard to handle.

– roller stops which are receiving heavy product; conveyor type rollers, lot of lifting and moving grocery boxes into a 48 ft trailer.

– big rolls of carpet. Customer doesn't have equipment to handle the order.

– used cars or wrecks.

– loading and unloading large 4 x 4 pickups with dual wheels.

– large trucks and vans.

– anything larger or wider than a pallet.

– garage doors, they were heavy and bulky to handle.

- large steel bars; long heavy plastic sheeting, anything larger than receiver's equipment capabilities.

- wide sheet metal on a closed box; wire screening.

- a lot of small boxes; large very heavy boxes or machines.

- munitions because it is more paperwork and you have to make more safety checks.

- heavy furniture by yourself.

- high gravity condensate; highly explosive; contains high concentrations of propane, makes hard to load or unload.

- usually re-bar or machinery is hard because in a dry van you're limited to access once its inside the rear door.

- explosives, a lot of waiting time.

- iron, farm machinery, fencing.

- large mainframe systems (computers) because of size and weight.

- mixed stops with same type labels on packages.

- 55 gallon drums.

- long steel or sheets of steel in a van.

- construction, because usually it is hard to unload their freight.

- I deliver mixed loads of dry groceries, produce and frozen goods with a hand cart and ramp off back of trailer is very difficult.

- milk; our milk is stacked on pallets 6 layers high. Load must be secured very well or the crates will slide on the pallet during the trip.

- when grocery warehouse crams trailers with 26 pallets worth of product on 22 pallet trailer.

- produce, because we send all products down on rollers and produce boxes do not roll good.

- watermelons when loose are difficult.

– loose loaded misc. sized boxes – each labeled for different receiver – requires too much sorting.

– loads that are loaded out of sequence causing me to move several stores' groceries first in order to get the right order for that store.

– agricultural products; implement parts; sharp corners, pinch points.

– front end loader for farm tractors; never crated, shipped in one piece, very awkward.

– produce loads & meat loads hard for warehouse to get a good "stack" on a pallet.

– cylinders, because cylinders are hard to secure being round.

– when the warehouse tries to stuff the trailer to make the load fit.

– long steel pipe on a van-trailer, because usually broken bands make it difficult.

– construction sites always uneven ground and hard to muscle out of the trailer.

– any type of load that bags are a fact of, such as flour, potatoes, carrots, they are awkward to handle.

Q. 18. Does the type or the amount of loading and unloading you do affect your ability to follow the hours of service (HOS) regulations? If yes, please describe the situation here.

– yes, because if you show line 4 on the Log book it counts against you on the total hours for that log! You add driving time to loading or unloading time you will use up your hours very fast!!

– puts a driver behind in his or her pickup and delivery run.

– no, but if I was on over-the-road grocery warehouses it sure would.

– yes, if I take too much time to load and unload after several loads, it greatly reduces my available driving time.

– yes, it is all part of HOS and I will spend about 15 to 20 hr a week loading/unloading.

– yes; many times we are maxed out on our HOS by the time we return to our domicile terminal.

– no, because we basically work off an oil field log, 10 hr driving 5 hr of on duty not driving, total of 15 hr on time.

- yes; sometimes it does but if we are running close on hours we just lay over in a motel. 7 or 8 hr off duty.

- yes; the time involved for loading/unloading has to be logged legally. Also, who wants to drive late at night after already doing a day's work? (this is where fatigue happens!).

- yes; sometimes it takes 2-3-4 hr to get it done and when you get paid by the mile, you have to cheat a little to get it all done in time.

- **Q. 19. Does your physical activity in loading and unloading make you more alert or less alert (more fatigued), or it doesn't make a difference for driving?**

  - less alert: when unloading, especially in the summer, the trailers are extremely hot so naturally along with the physical work is the exhaustion from being in the extreme heat.

  - if it is hand unloaded, it takes quite a bit from your system.

  - lumping a load of freight can be very physical work, and especially tiring if you have just driven a ways to get to your destination.

  - when you help unload you got your blood going a little faster. It helps you get more motivated.

  - wakes me up, gets the blood flowing after a 2-hr drive to the first stop (usually at 1-2 AM).

  - it usually gets my adrenaline going.

  - if driving and unloading is within the correct HOS it doesn't affect my driving ability but the time of day does.

  - when unloading and loading 4 to 6 thousand pounds you get fatigued.

  - tarping and untarping loads takes a good portion of my energy, especially on hot days.

  - my physical activity is limited because cranes or forklifts do most of the work.

  - I usually unload 12-15 stops a day. After about 10, you are getting worn down.

  - it is usually cold where I unload (Maine); it keeps me alert.

  - handling products like we haul (hazardous chemicals), you have to stay alert.

  - some light exercise helps me stay in shape.

  - my product is gasoline and I have to be very alert.

- multiple drops of 50 or more cases take two drivers and if you do this all night and half the day, one of you will be driving tired. If you unload by yourself it takes longer and you have to stay on ETA.

- in many cases we are required to be suited in full chemical protective gear. It takes a lot out of one's body on hot summer days due to dehydration.

- we are unable to rest due to the need to move the truck in lines constantly as trucks await their turn to be loaded.

- breaks highway fatigue/routine. It also provides some extra safety and operational inspection time.

- after driving all night, unloading the truck and getting to the motel 12 or 14 hr after I left home is really rough.

- we can rest when we are waiting.

- doesn't matter because we almost always use a lift to unload.

- once I get out to unload in sunshine or cold it's more refreshing to go back driving and with a clear head not thinking about unloading while driving.

- if you unload a truck at multiple stops and you physically unload the load it takes away from you mentally and physically after working 12 hr or more.

- it doesn't matter: I am always alert because my job depends on it. If I do become tired or fatigued I will stop my vehicle and rest.

- I believe that it would only affect your driving if the person lets that happen.

- it breaks up boredom and keeps you in shape more physically.

- we usually have to unload two 48-foot trailers per week along with driving 2,000 miles.

- you are usually ready to go when you get to where your loading, but if you have to set around waiting it just wears me out.

- more alert for a short period, afterwards and then while driving you feel more fatigued.

- the more you use your muscles the better you feel and the stronger one becomes. A weak person is less alert, because he is fatigued from straining his muscles.

- 10 hr of sorting & segregating is a lot of exercise for one person and will cause fatigue or exhaustion.

- after loading my runs for each day, my general physical condition is not the same as I had when I reported for work.

- when you make as many as 30 stops per day, you don't get fatigued as you would if you had a lot of idle time. We are constantly on the move.

- more alert, doing lots of stops on a 150 to 250 mile run is much better for me then just driving 10 hr a day doing nothing.

- doesn't matter; if I have enough rest as I usually do my unloading multiple stops and driving from stop to stop and back home does not affect me much.

- more alert, gives me some exercise which doesn't hurt anyone !!!

- lots of loading tires me early [in the workday]. Loading and unloading later helps me wake up (physical activity is good break mentally as well as physically).

- more alert; because I have to get in and out of the truck to load and unload and it is better than sitting in the truck for extended periods of time looking at the road.

- less alert; manually load and unload makes it very hard to drive 10 hr without fatigue – it cannot be done.

- more alert; you are more alert because you get to talk to 20-30 different people all day along and the friendships with them add interest to my day.

- more alert; short periods of loading/unloading serve to make me more alert, while whole trailer loading/unloading would contribute to fatigue.

- more alert, if just a couple of hours of loading, it does not fatigue you; if several hours of loading it may affect your driving later.

- less alert; I average 13 hr a day and handle about 800 cases of soda by hand so by days end I'm really fatigued.

- more alert; because when you are loading gas with 3 hoses you have to be alert at all times loading and unloading.

- more alert; my shift begins at midnight and I get on the road between midnight and 2:30 a.m. Any physical activity is welcome to break up the monotony and prevent highway hypnosis. After sunrise it doesn't make a difference for driving.

– more alert; the frequent stopping and starting visiting with customers and time demands make me more alert.

– less alert; can cause some physical exhaustion.

– less alert; it makes me less alert at times because of not enough rest and unloading four thousand pounds and I am getting older (51-65 yr old).

– more alert; just driving all the time does not give me exercise. As the sometimes monotony of the interstate sometimes makes a person drowsy. Unloading and loading sometimes relieves this.

Q. 22. What other driver loading and unloading topics or concerns do you think we ought to be exploring in our focus group discussions?

– more consistency of shipper load and receiver unload.

– more uniform warehousing techniques.

– training of new help in loading and unloading the right way.

– flatbed securing of loads.

– requirements by some receivers to place cargo on their pallets in accordance with their specs; driver becomes their warehouseman.

– shippers & receivers making unreasonable pickup/delivery intervals.

– waiting in line to load or unload.

– there should be some way to limit waiting times at factories. We have no choice but to wait hours past our appointment times.

– the problem of hiring lumpers.

– when picking up back haul sometime it gets to be a long wait.

– I don't mind pulling the pallets off the trailer, but the receiver should take care of the breakdown.

– long haul drivers being forced to unload by warehouses even after having been on duty driving for 10 hr to get to the destination.

- waiting time and sorting and palletizing of product at cold storage warehouse.

- more parking at major warehouses such as [grocery retailer names] and at cold storage places all over the country. Many places won't let you park or this city has "No Parking" signs all over. As a result, many trucks must go into the city at rush hour and contribute to congestion. Most over the road drivers prefer to get to where they are delivering or loading when they get near a town. It might be 10PM or 3AM, but you have to park 30 to 75 miles from town.

- communication between drivers and dock management.

- a driver should not be a lumper.

- I think it is important to discuss the problems that arise when the driver has to unload his truck after driving 10 hr.

- road drivers should not have to load or unload.

- why should a driver have to break down freight or move it to a smaller pallet because that warehouse can't put regular pallets in their racks? That is not the driver's fault. Driver is not a slave, he is a professional driver, not a dock worker.

- some gasoline loading docks may not be as safe as others.

- mainly the time a driver has to wait at a shipper while waiting for his load to be released for loading or unloading.

- I think the shipper and receiver should load and unload their freight so the driver will be physically fit and ready to go on his or her next run.

- receivers who won't let drivers sleep when they are waiting in line to unload. If drivers fall asleep other trucks will pass them up in the line.

- driver on pedal runs who have to unload their entire truck by hand and have to stop very frequently. By the time they are at the end of the run, they are exhausted and out of hours, but some company policies make them finish or return to terminal even if they are out of hours or shouldn't be driving because of alertness.

- I have worked for private carriers who delivered to grocery warehouses. They make you wait to unload sometimes over 8 hr. Even when you have an appointment, the driver has to re-palletize their products, and wait for pallets, and then sometimes wait for the checker. If you are late for an appointment, they make you reschedule.

- when driving over the road, drivers having to load or unload their trailers after having to run 500 miles or more and not being able to get enough rest.

- when delivering a load on pallets and the customer wants it broken down onto smaller wood. I think if these people want it on small wood they should switch it over themselves. It not only takes a lot of time, but I think its a lot of wasted manpower on both ends.

- fatigue.

- proper use of equipment and tools; stacking of freight with proper material, securing the loads.

- grocery warehouse vs carrier sorting and palletizing policies.

- the manual labor lifting techniques to save your back.

- long haul driving/unloading/loading; LTL line haul drivers working the docks.

- shippers or receivers not honoring appointment times. Driver facilities: e.g. restrooms, broken facilities, access to telephones, and very importantly: parking areas.

- I think after drivers drive all night to grocery warehouses they should not be required to unload truck or hire lumpers. I think these grocery chains are taking advantage of drivers for free labor.

- I would like to see some changes in loading and unloading! Because a lot of drivers get paid on percentage or by the mile. The shipper or receiver gets paid by the hour or salary, and could care less on how many trucks are loaded or unloaded!! They go home after 8 to 10 hr and the drivers are stuck making nothing.

- On some home deliveries we expected to unload 200 to 400 lbs of freight in one place by our selves. We need to set some form of limit to stop personal injuries of backs and knees.

- Log books – long haul personnel have 2 or 3 log books. These drivers give good service, and rates, but are always in breaking the law.

- hazmat material knowledge.

- let driver use forklifts; most receivers do not operate well.

- having the necessary tools for unloading available to drivers. Customers delaying drivers unnecessarily long. Weather conditions adding to drive time after loading.

- companies are getting bad about needing appointments for small shipments.

- unloading at grocery warehouse and having a big delay and having to sort items and put them on pallets.

- lifting heavy /bulky freight.

- adopt building codes to require a smooth surface from the parking area to the location where freight is deposited. This would eliminate lifting and, (also) turning around and pulling a hand cart backwards.

- inside deliveries. Sorting freight per item for customers on LTL shipments.

- team 10-hr rule.

- loading and unloading versus hours of service. Productive use of highly trained CDL drivers versus use of non-skilled labor for loading/unloading.

- handling hazardous materials.

- safety in the use of power jack or manual jacks on liftgates.

- I would like to see the trucking industry go to shipper load and receiver unload.

- drivers loading their own truck, driving all night then having to unload.

- when you have an appointment it would be nice to have the product you are to pick up staged and ready to load so there wouldn't be any delay time.

- more options at companies who do not have proper unloading tools for heavy objects.

- HOS; driver training.

- slip sheets.

- access ladders or steps to add safety to getting in and out of vans.

- I think freight designed for flat bed loading should go on a flat bed. Loading this kind of freight on a van trailer will raise the chance of a freight claim if damage trying to unload off the back door instead of the side like it should be.

- the attitude of the driver. We are paid to do a job, and as part of it, a driver's attitude plays a large part. We must go into our job with a good attitude and a smile, no matter what problems we encounter at our point of unloading (or loading).

Appendix E: Photographs of truck loading equipment

The photos on the following pages were taken at the sites visited for interviews and focus groups. The photos were chosen to provide examples of a variety of equipment(s) used in loading or unloading trucks.

Fork lifts at wholesale produce market

Fork lifts and hand trucks used in loading/unloading trucks

Non-Motorized (hand pulled) pallet jack

Motorized (electric) hand-pulled pallet jack

Motorized platform truck used for "picking" grocery orders

Multi-pallet fork lift truck

Flatbed with "kangaroo" lift for loads of pipe tubing

Pipe tubing being tarped and secured on flatbed

Appendix F: Task analysis photographs of loading & unloading 4 types of cargo and trucks

The photos on the following pages were taken as part of the behavioral task analysis (Task 3) of truck drivers loading, or unloading their trucks. The photos were chosen to provide examples of a variety of loading and unloading equipment and procedures, and of a range of truck and cargo types. The driver tasks depicted are representative of those observed in driver duties associated with:

1) **household goods moving**
2) **grocery delivery**
3) **beverage delivery, and**
4) **tank truck carrier operations & petroleum products delivery.**

Positioning moving van at curbside

Loading ramp at curb into moving van

Unloading equipment: ramps, packing materials, furniture pads, etc.

Driver inventorying boxes and furniture, yard items

Household Goods Moving

Helpers carrying cartons and furniture from house to curbside and into trailer

Household Goods Moving

Helpers carrying cartons and furniture from house to curbside and into trailer

Helpers wrapping furniture with protective pads, plastic, etc.

Grocery Delivery

Trailers loaded with groceries at warehouse await driver pickup with tractor

Driver positions truck and trailer near store's access door

Roller conveyor set into place from truck to store receiving area

Driver unwrapping groceries to break apart pallet

Driver moves cartons onto rollers for delivery into store

Driver extracting cases of beverages from truck shelves to load on handtruck

Beverage Delivery

Driver unloading beer kegs from delivery truck

Driver extracting empty kegs from business and recycling them back to the truck

Tank Truck Operations

Liquid and chemical products tank trucks

Dual Mode: Truck and Rail Tanker

Petroleum Products Tank Truck Delivery

Driver hooks up connectors from gasoline storage tank pumps to tank truck compartments

At gas station, driver unloads & emplaces connector fittings & hoses to underground tanks

Driver lifts hoses to empty remaining liquid into underground tanks