# MPC-582
## October 26, 2018

**Project Title**

Safety Culture, Leadership & Fatigue in Transportation Operations

**University**

University of Denver

**Principal Investigators**

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**Research Needs**

Safety culture continues to be of significant interest to transportation professionals as a key factor influencing the occupational safety health and accident and injury rates of members of their organization and the public. Recently, the National Transportation Safety Board (NTSB) blamed Amtrak for its poor safety culture, for a deadly train crash that killed two workers near Philadelphia (NTSB, 2017). "Amtrak's safety culture is failing, and is primed to fail again, until and unless Amtrak changes the way it practices safety management," said NTSB Chairman Robert L. Sumwalt. Also, "Investigators found a labor-management relationship so adversarial that safety programs became contentious at the bargaining table, with the unions ultimately refusing to participate." (NTSB, 2017)[i] The NTSB noted that "Allowing these unsafe actions to occur were the inconsistent views of safety and safety management throughout Amtrak's corporate structure that led to the company's deficient system safety program that resulted in part from Amtrak's inadequate collaboration with its unions and from its failure to prioritize safety." (NTSBa, 2017).[ii]

The NTSB comments reflect continuous findings from academic researchers such as Petitta, Probst, Barbaranelli & Ghezzi (2017) who asserted that there is a complex relationship between organizational safety culture and safety climate, such that organizations with particular safety cultures may be more likely to develop more (or less) positive safety climates. Moreover, employee safety compliance is a function of supervisor safety leadership, as well as the safety climate and safety culture dimensions prevalent within the organization.

The US Department of Transportation Federal Railroad Administration (FRA) has also commented that "Multiple studies have confirmed what many have intuitively known all along" that safety culture plays a key role in accident prevention. However, visible progress towards established goals is a more effective motivator than money or personal recognition for the average worker in a world-class operation. Moving towards achievement metrics and away from failure metrics becomes increasingly vital. (FRA, August 2011)[iii] In keeping with these positions by the

FRA, NTSB and other academic researchers, the present research is designed to build upon recent advances in the measurement of safety culture as well as examining other factors that contribute to the occurrence of accidents and injuries in the railroad and general transportation industry.

A recent study of the relationship between leadership style and safety management (Frazier, 2018) suggested that organizational leaders might improve safety performance by utilizing transformational leadership practices into their training programs. The study examined the role of leadership, leadership training, and leadership practices which may be related to the development of a positive safety culture. A seminal work on the relationship between culture and organizational performance by Kotter and Heskett (1992) suggests that differences in organizational culture explains why one company success where another fails within an industry. Additionally, one well-known business leader, Jack Welch, offered one more possibility, "If you want to change the culture of an organization change the way it develops its leaders."

Recently, Sherry & Colarossi (2016)[iv] have developed a tool to measure of safety culture. The instrument was normed on a large sample of employees of a large public transportation agency (N=1909) participants were obtained. Various analyses have provided initial evidence of the validity and reliability of the Safety Culture Scale as a measure for the transportation industry in that the scale significantly differentiated ($p<.05$) between persons who had been involved in accidents and safety violations thus demonstrating the relationship between safety culture and accident rates. (See Figure 1.) In addition, a follow-up study with a large regional transportation company demonstrated significant differences in safety culture and attitudes between key departments in the organization. (See Figure 2.)

A normative instrument designed and validated on railroad properties is needed because of the vastly different environment and set of operating practices, corporate culture, historical traditions, and unique set of working conditions. Much of the published material on safety culture has to do with nursing and hospital practices[v] and oil and gas operations

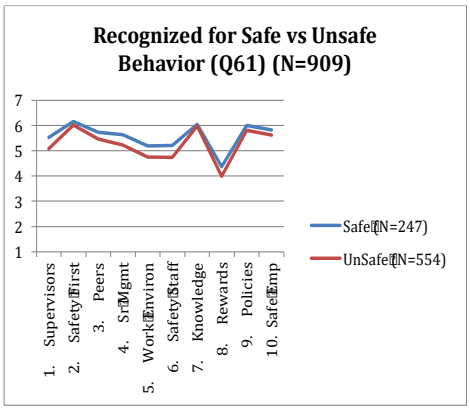


Figure 1.


Figure 2.

Several reports in news media have also questioned the commitment to safety culture for some railroads. (*Rail Workers Raise Doubts About Safety Culture As Oil Trains Roll On*[vi]). One report noted that, "Critics claim the railway has long prioritized speed and profits over safety, with a history of retaliating against workers who report accidents, injuries and safety concerns."[vii] In addition, Canada's Transportation Safety Board identified a number of factors that likely contributed to the Lac-Mégantic derailment[viii] that resulted in a significant loss of life by noting that "In all, we found 18 factors that played a role -- take any one of them out of the equation and this accident may not have happened," according to Canada's Transportation Safety Board Chairwoman Wendy Tadros. Moreover, according to the report the railroad's upper management perpetuated "a weak organizational safety culture, refusing to update operating practices even as shipments of hazardous materials shot upward."[ix] In addition, the TSB noted the Montreal, Main and Atlantic (MMA), that owned the railroad, ""was a company with a weak safety culture that did not have a functioning safety management system to manage risks," the agency said.[x]

Fatigue has also been thought to be a factor contributing to accidents. For example, a fatal bus crash in California's Central Valley in August 2016 was caused by a 'severely sleep-deprived driver' and a bus company with an abysmal safety record, according to federal investigators in a report released November 13. Reports describe a severely sleep-deprived driver and a bus company with a poor safety record were causes of the crash that killed four passengers and injured 20 others, including the driver. The NTSB reported the driver had only slept about five hours over the 40 hours preceding the Aug. 2, 2016 crash.[xi] The bus, traveling from Los Angeles to Modesto, drifted off the right side of Route 99 and struck a highway signpost that nearly sliced the bus from nose to tail.[xii] Fatigue was also cited as a causal factor in a crash that killed 13 people on Interstate 10 near Palm Springs on Oct. 23, 2016 when a charter bus traveling from a casino plowed into the rear of a big-rig whose driver had fallen asleep during a freeway closure. The truck driver was later charged with 13 counts of vehicular manslaughter with gross negligence.[xiii] [xiv] According to FMCSA records Autobuses Coordinados vehicles failed eight of 29 federal inspections in just under two years, pushing its out-of-service rate to 38 percent, almost five times greater than the national average of eight percent. These practices, and the presence of fatigued drivers, suggest a failed safety culture that may have contributed to the high levels of fatigued drivers and safety violations.

The problem of human operator fatigue has also been well documented in various studies and publications. A report by McGeehan, (2018) indicated that driver fatigue led to two commuter train crashes in the New York area in 2016. According to federal investigators Said. Also, a Long Island Rail Road crash at the at the Atlantic Terminal in Brooklyn, which was also attributed in part to fatigue inured over a 100 People and killed an innocent bystander. Fatigue has also been named as a factor related to accidents in other transportation operations. Recently, Hystad, Nielsen, & Eid, (2017) documented the effects of the unpredictable and demanding working conditions faced by seafarers. The relationship between sleep quality, fatigue and safety climate and perceptions of risk among seafarers was studied. Participants were 151 seafarers working in the deck or machine departments on board 11 ships belonging to a Norwegian company. Questionnaires were administered at two different time points, approximately one week apart. Perceptions of risk of personal injuries and ship accidents increase when seafarers are fatigued. Fatigue was found to be associated with poor sleep quality and safety climate that predicted fatigue one week later. The findings point to the importance of maritime organizations being cognizant of

the causes and consequences of fatigue among their employees, and that that policies and prioritizations, ie. policies and attitudes that become part of the culture, are being perceived and interpreted by seafarers that may influence their sleep quality and vigilance when working at sea.

One main impetus for the present study is that, to our knowledge, the relationship between *safety culture and fatigue* in driver operators has not been examined. Research has mostly focused on identifying whether operators might have been affected by por sleep quality, lack of sleep, and sleep apnea. Fatigue is something that drivers and operators develop. However, it seems obvious now, in retrospect, that the norms, attitudes, and behaviors that encourage the loss of sleep, the prioritization of work over sleep, the inability to take time off, etc. might also be a significant result of the culture that is promoted by the leaders of the organization. In fact, it would seem that, the organizational culture that would permit or encourage employees to ignore effective fatigue management or discourage effective fatigue hygiene should also be considered.

If there is a corollary between culture and fatigue, then, to continue to improve safety culture more than just rhetoric is needed. With the development of a standard metric of safety culture, the next step would seem to be the identification of organizational safety leadership practices that can lead to the development of an effective safety culture. These leadership factors affecting culture would either promote or prevent fatigue. Thus, fatigue levels, practices, hours of sleep, and ultimately fatigue related incidents, would be downstream consequences of the leadership practices, that promote a culture that results in either acceptable or unacceptable or unacceptable fatigue levels and ultimately accidents. Thus, the proposed research intends to examine the linkages between Leadership Style, Safety Culture, Fatigue and Accidents.

The present research then, is based a proposed causal relationship existing between the following constructs (see Figure 3):

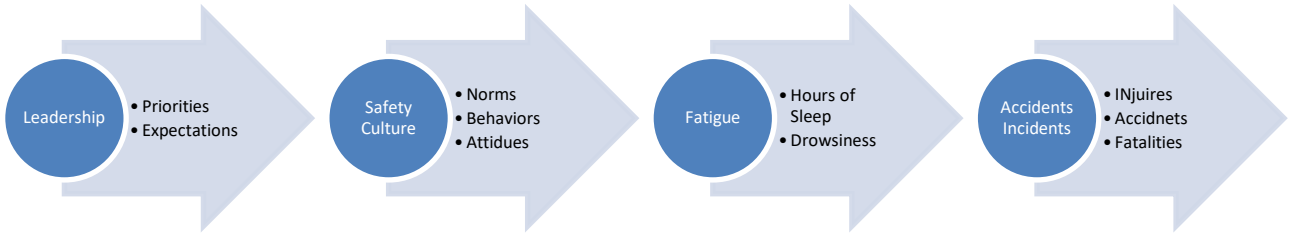


*Figure 3. Leadership process model.*

The proposed research will attempt to identify linkages between leadership practices, safety culture and fatigue management practices that are effective in reducing accidents and injuries in various transportation/transit organizations. (see Figure 3).

Measures now exist that can be used to quantify the constructs included in Figure 3. First, a standard metric of safety culture that enables the normative comparison of organizations to each other has now been validated (Sherry & Colarossi, 2016). In addition, such an instrument will aid

greatly in the identification of areas within an organization, such as departments, relationship between management and labor, training programs and other areas that are in need of improvement relative to establishing a strong safety culture. Second, a measure of fatigue, such as the Denver Fatigue Survey & Sleep Diary has been used in several studies to assess the level of fatigue, amount of sleep, and naps. Third, a Leadership Competency and style measure has been developed that can also been used to assess (Sherry & Durr, 2012). Lastly, historical records can be consulted to assess numbers of accidents and injuries.

Thus, the proposed study will attempt to gather data that will continue to validate and provide normative comparison data on organizational leadership style and competence, safety culture, fatigue levels, and accident and injury data.

## Research Objectives

The objectives of this project are as follows:

1. Identification of suitable organizations engaged in various activities to be able to complete the safety culture, leadership, and fatigue assessment instruments.
2. Conduct a review of current literature on safety culture, fatigue and leadership
3. Brief and educate key stakeholders in the participating organizations on the importance of Safety Culture and its relationship to fatigue and leadership
4. Conduct assessments of employees of participating organizations on Safety Culture through interviews, online, and paper and pencil administration.
5. Analysis of data.
6. Feedback presentations to stakeholders
7. Writing of report & development of recommendations
8. Conduct event/workshop to facilitate technology transfer regarding what has been learned
9. Presentations at key conferences
10. Post final report on web site

## Research Methods

The project will primarily utilize survey and interview methodologies to gather data which will be analyzed using statistical techniques to review and evaluate the conceptual model.

### *Measures & Data Collection*

**Safety Culture Survey.** The data on safety culture will be obtained through the administration of Safety Culture Scale (SCS) (Sherry & Colarossi, 2016). The SCS was developed using a large sample of employees from a large public transportation agency (N=1909). Confirmatory factor analysis (CFA) compared the fit of likely models. One-way between groups analysis of variance, and post hoc tests provided initial evidence of the validity and reliability of the SCS as a measure for the transportation industry in that the scale significantly differentiated ($p<.05$) between persons who had been involved in more accidents and safety violations thus demonstrating the relationship between safety culture and accident rates. Implications of these findings are that the safety culture survey could be used to assess safety awareness and safety culture of trucking or transport companies, small communities, and other organizations involved in transport. By carefully monitoring scores on the SCS efforts could be made in various

communities and organizations to improve attitudes towards safety and ultimately to reduce accidents and improve road safety.

**Observational Data.** A team of investigators will conduct onsite inspections and observations of work behavior and conditions of the sample railroad during a one week period of observation. The inspectors will be looking for examples of safe and unsafe worker behavior. A checklist of typical railroad work behaviors will be prepared prior to the onsite visit.

**Fatigue Survey & Sleep Logs.** A questionnaire and sleep log were used by the FRA in several studies of railroad workers (FRA, 2011). These same instruments will be adapted to the present study. Study participants will be asked to compete the instruments to provide an indication about the amount of sleep they obtain and their subjective level of fatigue and alertness.[xv]

**Leadership Style & Competency.** Leadership style & competency will be measured using a version of the leadership competency assessment instrument developed by Sherry& Durr, 2009).[xvi] This instrument consists of 100 items and other questions designed to collect demographic and other identifying information collectors. The instrument is useful in determining what types of activities and emphases are supported y by the leader. This instrument can be administered on line and is computer scored. Factor analytic studies support the underlying scale structure.

**Historical Data.** Reports on the accident incident rate of the study organization will be examined. Data will be gathered and compared to scores obtained on the survey instrument (SCS). Both analysis of variance and regression analysis will be sued to obtain estimates of the relationship between and the impact of safety culture variables on the occurrence of accidents and incidents. Since this is a correlational field study only associational relationships will be possible to determine.

## Expected Outcomes

The research will identify the relationship between a measure of safety culture, leadership style and competence, and levels of perceived fatigue and alertness in the study participants. and the occurrence of accidents and incidents in the organization. It is expected that a statistically significant degree of association will be found to exist between the main structs demonstrating the hypothesized causal links between the constructs in the model.

## Relevance to Strategic Goals

This project will contribute to the two of the USDOT Strategic Goals, namely safety and economic competitiveness. The safety of the employees and the public is maintained by an organizational culture and policies practices and procedures which ensure the safety of the employees working in the transportation systems while also directly maintaining the safety and security of the public at large. In addition, the economic competitiveness of the transportation system is also influenced by the maintenance of safe work practices and safety culture in that safety is directly tied to the bottom line of a transportation organization. Decreasing accident injuries and fatalities ensures the safe, ethical operation and economically competitive nature of the system. One need only look at lapses in safety culture that have had catastrophic effects on the economy and the environment such as the Exxon Valdez accident and the Deepwater Horizon oil spill which cost Anadarko over

$4 billion in fines and damages not to mention the immeasurable harm to the environment. From a practical perspective the proposed study will contribute to the transportation industry by validating a model that connects leadership, safety culture and fatigue in the transportation industry. In addition, it will enhance and contribute to the safety of the transportation industry and the public at large. Thus, the project will enhance the existing federal effort by **contributing to safety, economic competitiveness and efficiency and developing the work force** in the transportation system in the US. The proposed research is consistent with several areas of the Regional Center's overall program. Specifically, the proposed project is aligned with goal #5 "Transportation Safety, Workers Safety and Workforce Development" The proposed project will look specifically at "safety culture" and its relationship to safety, accidents and fatigue. The proposed project is a direct extension of Goal 5. Paragraph #40. Furthermore, due to the use of sleep assessment technology the proposed project is also related to efforts to decrease worker fatigue in associated with long work hours and poor work schedules as described in Section 5 paragraph # 43.

**Educational Benefits**

Several graduate students will assist with the project thereby contributing to the development and education of graduate students who will later be employed in the industry. These students will gain experience in the data collection techniques commonly used in the rail industry. In addition, they will gain an understanding of the theory and best practices associated with safety and safety culture.

**Technology Transfer**

In order to facilitate the technology transfer obtained in the present investigation three separate events will be undertaken.

1. Educational briefing for stakeholders in the immediate project held on the site or the premises of the research sites.
2. A workshop on the DU Campus with invitees from local DOT and other community agencies to review and discuss key findings.
3. The development of a video and webinar on the findings to be posted on NCIT web page.

**Work Plan**

Achieving the overarching goal of this project requires the completion of several different tasks. Since the project will be built upon the previous work and studies we anticipate that the results will be a significant contribution to the existing literature. Permission from participating organizations will be needed to gather data from participants.

**Task 1 – Literature Review**

Review relevant psychological, operational, and experimental studies and papers To identify work practices relevant to the measurement of safety culture, leadership, fatigue and accidents.

**Task 2 – Data Collection**

Data collection in the various methods and techniques outlined above (survey, observation, and historical).

**Task 3 – Data Analysis**
Data will be analyzed to assess the relationship between the various measures, observed work practices and the accidents and injuries associated with indicators of safety culture.

**Task 4 – Reporting Writing**
Describe the results of the research and identification of hypothesized linkages. Results will be discussed with stakeholders at regional and national meetings and relevant web sites.

**Task 5 – Technology Transfer**
The draft report will be shared with stakeholders. Also, a webinar, stakeholder meetings, a local workshop and presentations at national conferences will be conducted.

| | Months | | | | | | |
|---|---|---|---|---|---|---|---|
| **Task** | **1 – 3** | | **4 – 6** | | **7 - 9** | | **10 – 12** |
| 1 | | | | | | | |
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| 5 | | | | | | | |

**Project Cost**

Total Project Costs: $429,084
MPC Funds Requested: $214,542
Matching Funds: $214,542
Source of Matching Funds: PI time and effort, and Regional Transportation District

| **Categories** | MPC Contribution | University Contribution | **Total** |
|---|---|---|---|
| Center Director Salary | $0 | $0 | $0.00 |
| Faculty Salaries | $91,000 | $91,000 | $182,000.00 |
| Administrative Staff Salaries | | | |
| Staff Fringe Benefits | $23,660 | $23,660 | $47,320.00 |
| Student Salaries | $5,000 | $5,000 | $10,000.00 |
| Student Fringe Benefits | $38 | $38 | $76.00 |
| **Total Personnel Salaries** | $96,000 | $96,000 | $192,000.00 |
| **Total Fringe Benefits** | $23,698 | $23,698 | $47,396.00 |
| **TOTAL Salaries & Fringe Benefits** | **$119,698** | **$119,698** | **$239,396.00** |
| Travel | $25,000 | $25,000 | $50,000.00 |
| Equipment | | | $0.00 |
| Supplies (for Tech Transfer Workshop) | $10,035 | $10,035 | $20,069.20 |

| | | | |
|---|---|---|---|
| Contractual | $15,000 | $15,000 | $30,000.00 |
| Construction | | | |
| Other Direct Costs (Specify)* | | | $0.00 |
| **TOTAL Direct Costs** | **$169,732.60** | **$169,732.60** | |
| F&A (Indirect) Costs | $44,809.41 | | $44,809.41 |
| **TOTAL COSTS** | **$214,542.01** | **$214,542.01** | **$429,084.01** |
| Federal Share | | | |
| Matching Share | | | |

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