Fatigue in Winter Maintenance Operations

Michigan Winter Operations Conference
October 20, 2015

Matt Camden
Research Associate
mcamden@vtti.vt.edu

VirginiaTech
Transportation Institute

Acknowledgements

- This project was funded by the Clear Roads pooled fund TPF-5(218) http://clearroads.org/wp-content/uploads/dlm_uploads/11-05-Factors-Causing-Fatigue-Final-Report_MnDot.pdf

- VDOT
- Allen Williams

Project Overview

- Goal:
  - Cost-effective, realistic recommendations for reducing or eliminating fatigue
- Focus areas:
  - Work and rest schedules
  - Contributing factors of fatigue-related incidents
  - Countermeasures to reduce fatigue and potential incidents

How did we do this?

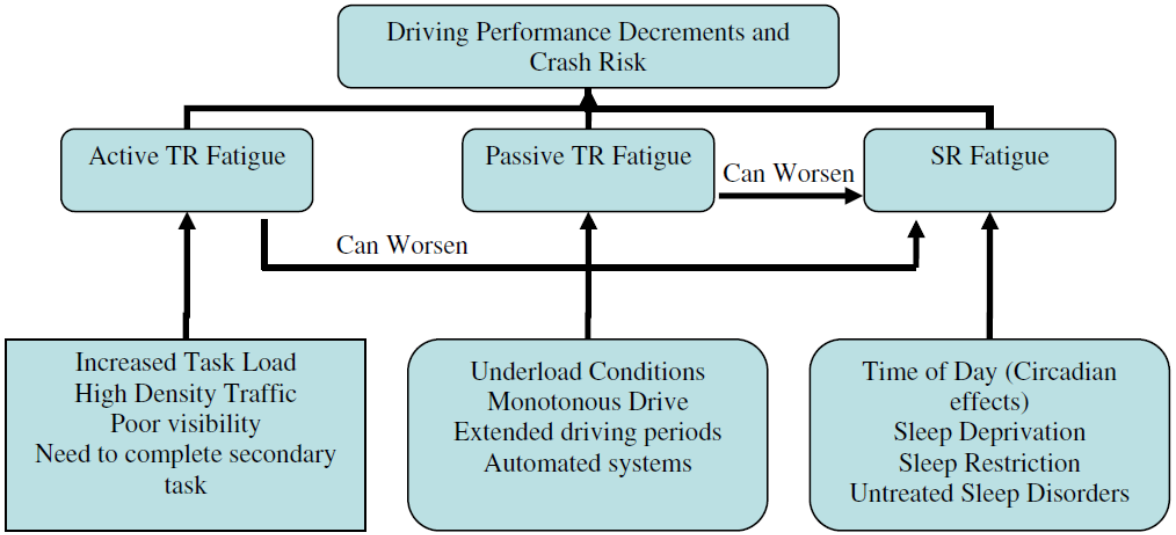
- Three data collection approaches
  - Literature review
  - Questionnaires
  - Naturalistic data
    - Driving
    - Sleep

Literature Review Summary (1 of 3)

- Lack of research with winter maintenance operators
- Focused on fatigue/drowsiness in trucks
  - Heavy vehicle
  - Inconsistent, varying schedules
  - Long shifts
- Fatigue in 15% to 30% of crashes

Literature Review Summary (2 of 3)

- Two types of fatigue
  - Task-related
  - Sleep-related



Literature Review Summary (3 of 3)

- Ways to reduce fatigue
  - Reduce stress
  - Schedules with opportunities for rest/sleep
  - Increase knowledge of fatigue
  - Cab/equipment design
  - Increase off-duty rest
  - Fatigue management technologies

Naturalistic Driving Methods

- 4 VDOT operators
- 2 instrumented trucks
- Drove for 3 consecutive months
- 2 drove night shift, 2 drove day shift
  - 7p to 7a
  - 7a to 7p

Why Use Naturalistic Data?

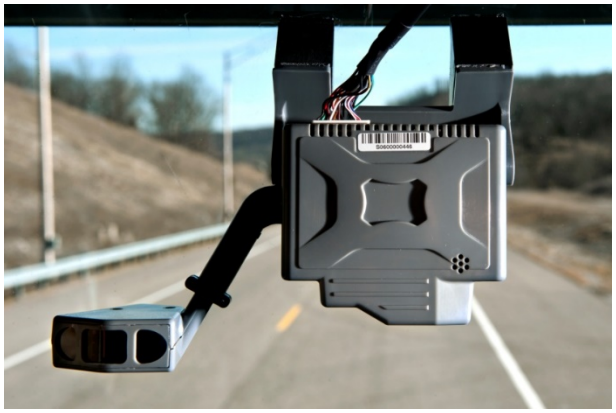
- No experimenter present; no specific instructions
- Highly capable data acquisition systems
  - 5 cameras and various sensors
- Data collected continuously
- Able to get detailed pre-crash/crash data

What are we looking for?

- What do winter maintenance operators encounter on a daily basis?
- What happens during winter emergencies?
- How does sleep affect safety during winter emergencies?

Test Vehicles

Cameras



Video


Video: Whole
00:59:28.611 of 03:05:05.360
0
2,000,000
4,000,000
6,000,000
8,000,000
10,000,000

Video Disclaimer

The research participants you are about to see have agreed for VTTI to show clips of their study data at meetings and conferences. However, the audience is not permitted to video tape or otherwise record these clips, so please put away your phone

Example – Crash Relevant Conflict

Example – Near Crash

Example - Crash

Sensors

- Jbus
- GPS
- Yaw Sensor
- X/Y accelerometer
- Vehicle network

Event Triggers

Trigger Type	Definition	Description
Longitudinal Acceleration	Hard braking or sudden acceleration	Acceleration or deceleration greater than or equal to |0.20 *g*|. Speed greater than or equal to 1 mph (1.6 km/h).
Swerve	A sudden “jerk” of the steering wheel to return the truck to its original position in the lane.	Swerve value greater than or equal to 2 degrees. Speed greater than or equal to 15 mph (24.14 km/h)

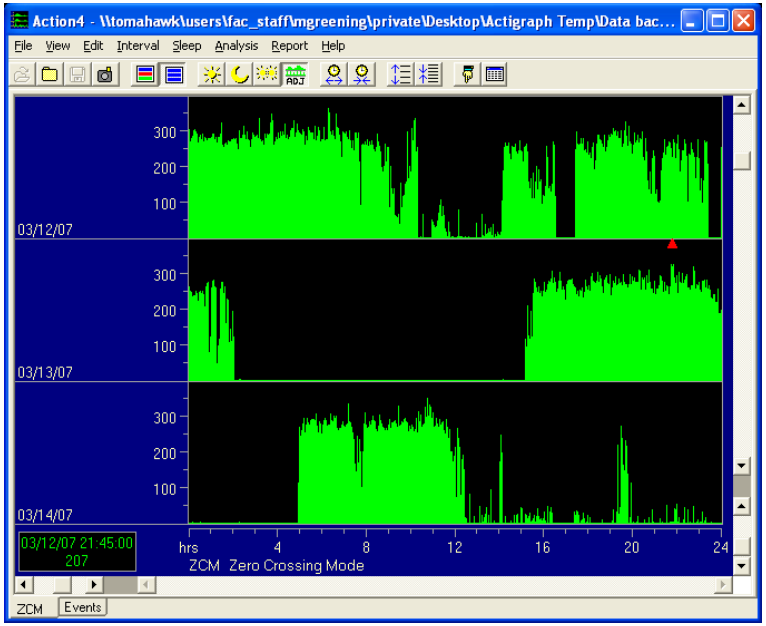
Apply Data Directory

- Identified a number of variables describing the situation
  - Pre-event movement
  - Critical reason for the conflict
  - Distractions
  - Road condition
  - Weather condition
  - Winter emergency
  - Observer rating of drowsiness

Classify Incident Type

Event Type	Description
Crash	Any contact with an object, either moving or fixed, at any speed
Crash: Low-hanging Branch	Any contact with a low-hanging tree branch at any speed.
Curb Strike: Avoidable	Any contact with a curb or median where it is apparent that the driver could have performed a maneuver to avoid the contact.
Curb Strike: Unavoidable	Any contact with a curb or median where it is apparent that the driver could not have performed a maneuver to avoid the contact.
Near-crash	Any circumstance that requires a rapid, evasive maneuver (e.g., hard braking, steering) by the subject vehicle (SV) or any other vehicle, pedestrian, cyclist, or animal to avoid a crash.
Crash-relevant Conflict	Any circumstance that requires a crash-avoidance response on the part of the SV or any other vehicle, pedestrian, cyclist, or animal that was less severe than a rapid evasive maneuver (as defined above) but greater in severity than a normal maneuver.

How did we measure sleep?



Summary of Naturalistic Data

Participant #	Winter Emergency Video (hr:min:sec)	Non-winter Emergency Video (hr:min:sec)	Total Video (hr:min:sec)	Acceleration Triggers	Deceleration Triggers	Swerve Triggers
1	102:07:35	2:00:44	104:08:19	820	1,449	2,822
2	106:52:25	5:00:13	111:52:38	1,626	890	6,505
3	65:44:34	12:49:02	78:33:36	1,349	1,238	4,796
4	64:13:13	10:05:21	74:18:34	646	1,167	2,717
Total	**338:57:47**	**29:55:20**	**368:53:07**	**4,441**	**4,744**	**16,840**

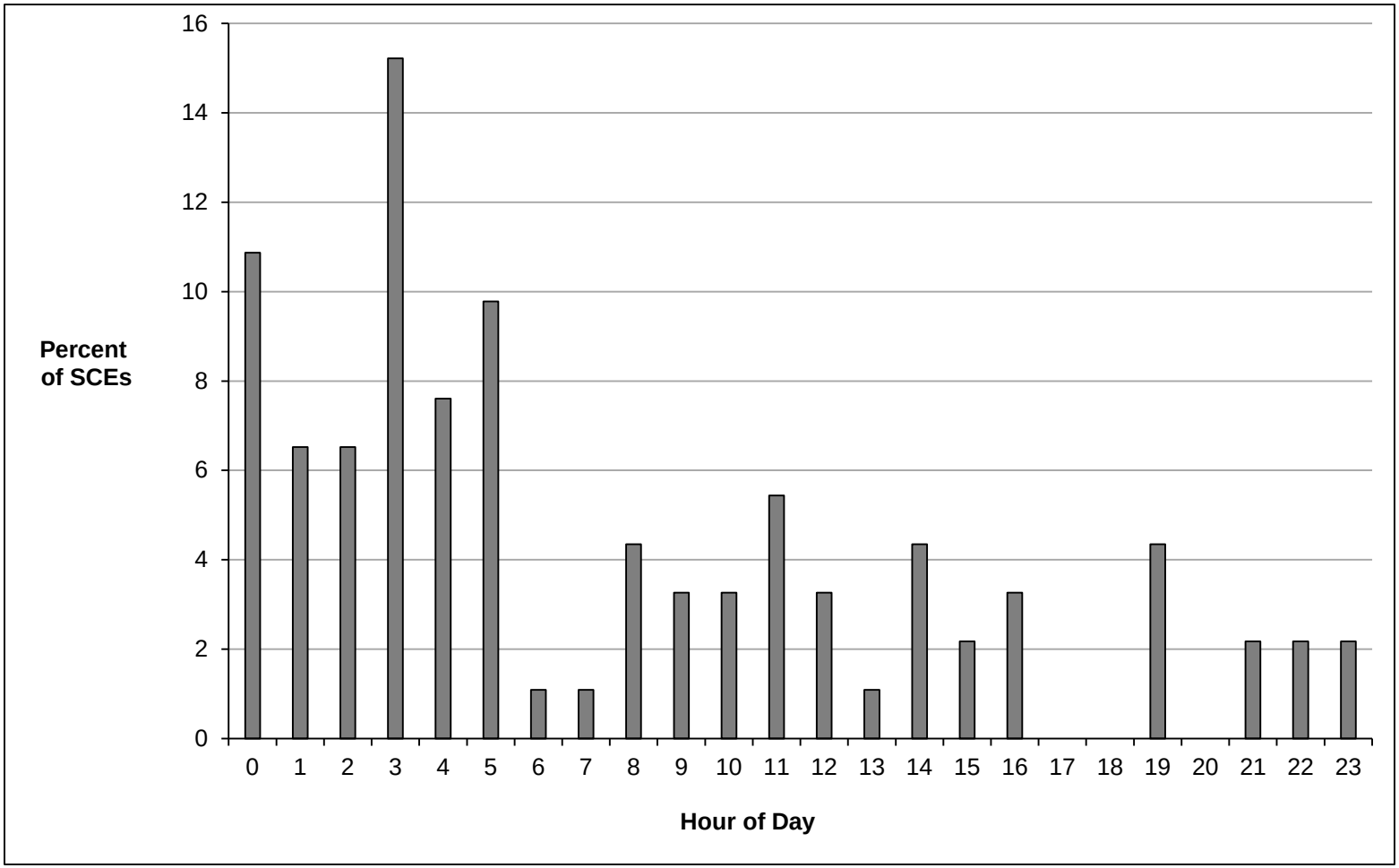
Crash Severity	Number (%)
Crash	3 (3.26%)
Crash: Low-hanging Branch	16 (17.39%)
Curb Strike: Avoidable	3 (3.26%)
Near-crash	21 (22.83%)
Crash-relevant Conflict	49 (53.26%)
Total	**92 (100%)**

Driver Fatigue Example 1

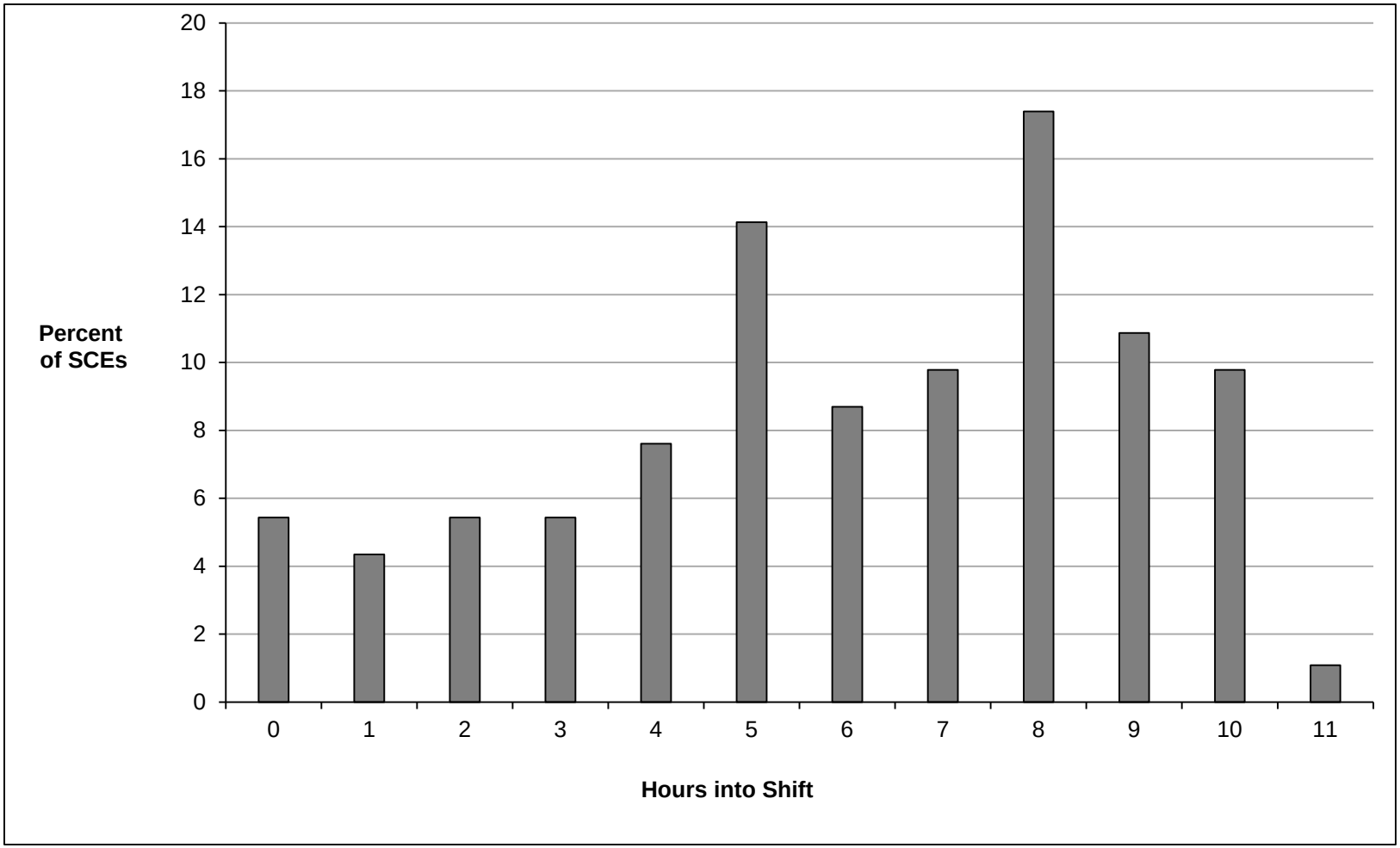
Driver Fatigue Example 2

Driver Fatigue Example 3

Results – Time of Day



Results – Time on Task



Fatigue

Participant #	Total Number of SCEs	Total Number of Fatigue-related SCEs	Percent of SCEs Where Driver was Drowsy
1	52	33	63.5%
2	12	N/A	N/A
3	16	0	0%
4	12	0	0%
Total	**92**	**33**	**35.9%**

Actigraph Data

Participant #	Total Minutes Worn	Total Bad Minutes	Percent Bad Minutes
1	128,729	19,123	14.86 %
2	129,065	15,244	11.81 %
3	129,029	12,289	9.52 %
4	130,044	6,956	5.35 %
Total	**516,867**	**53,612**	**10.37 %**

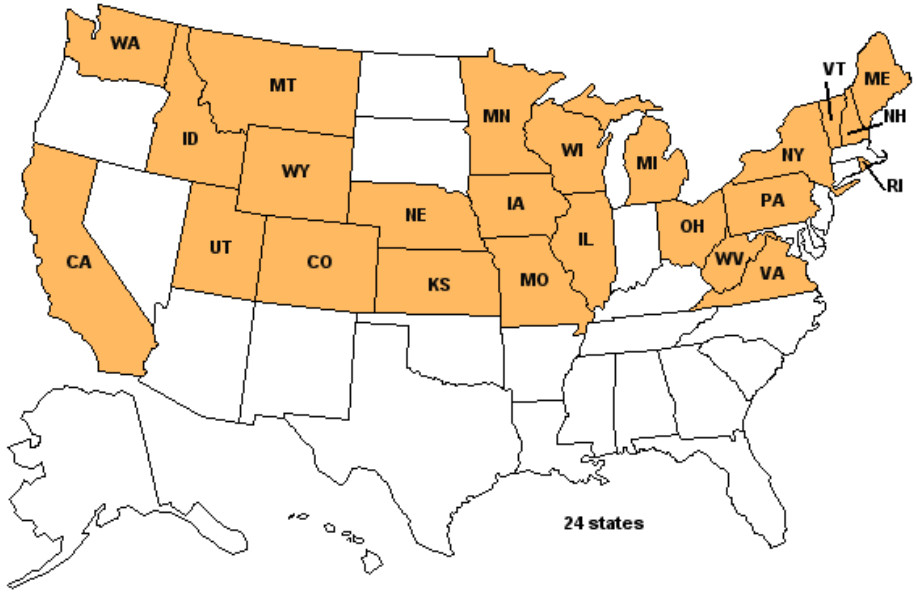
Participant #	Daily Sleep	Daily Sleep during Non-winter Emergency	Sleep 24 Hours Prior to a Winter Emergency	Sleep during Consecutive Winter Emergency Shifts	Sleep 24 Hours Prior to SCE
1	8.05	8.63	6.31	7.48	4.55
2	10.04	10.66	8.58	8.71	8.83
3	8.12	8.10	8.26	8.32	8.02
4	8.64	8.53	8.31	8.73	7.81
Average	**8.71**	**8.98**	**7.87**	**8.31**	**7.30**

Questionnaire Overview

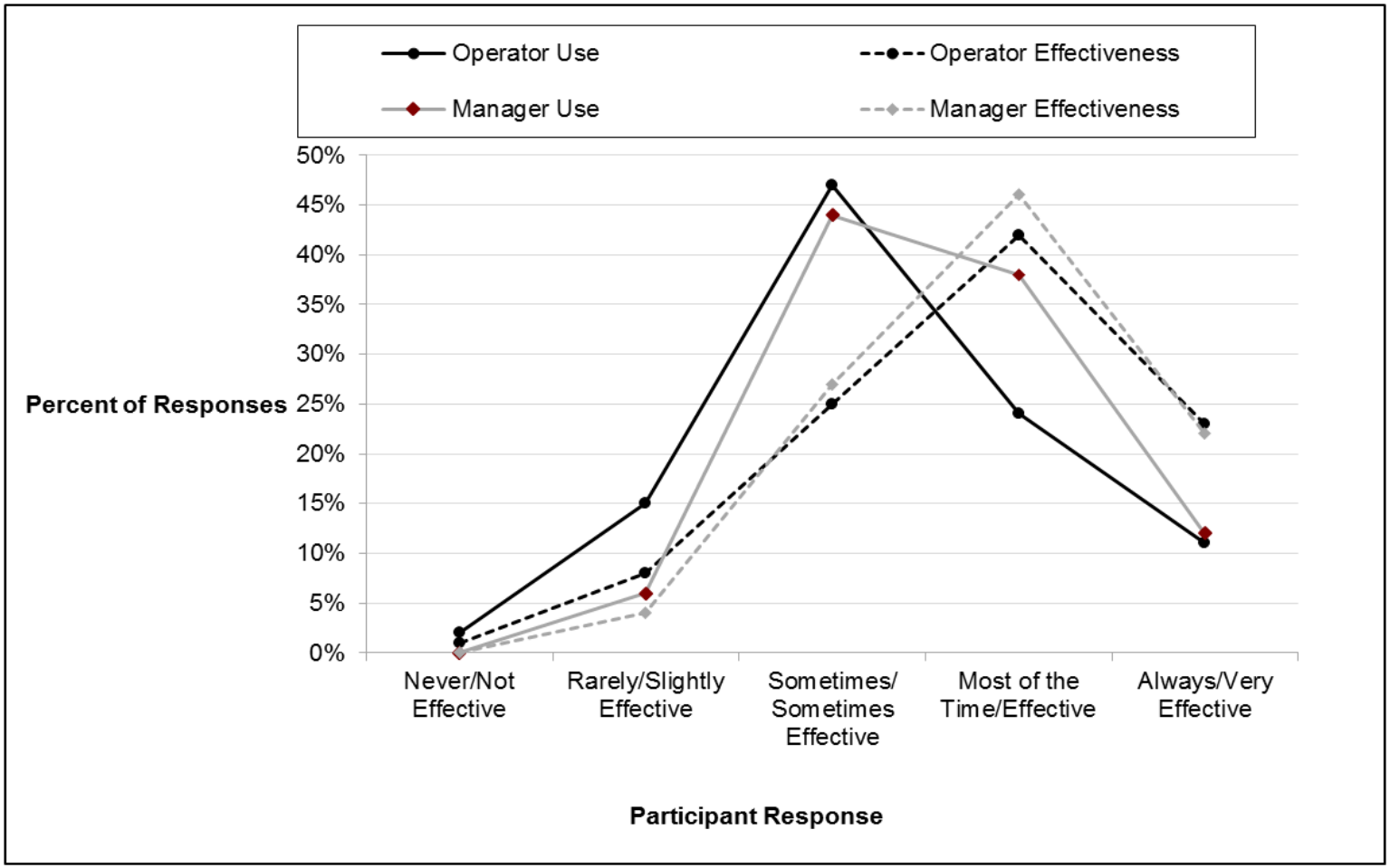
- Two parallel questionnaires
  - Maintenance managers
  - Winter maintenance operators
- Assessed
  - Work hours, type of equipment used, freedom to refuse work due to fatigue, rest periods, fatigue awareness, overtime, medical issues, and fatigue management strategies

Summary of Questionnaire Results

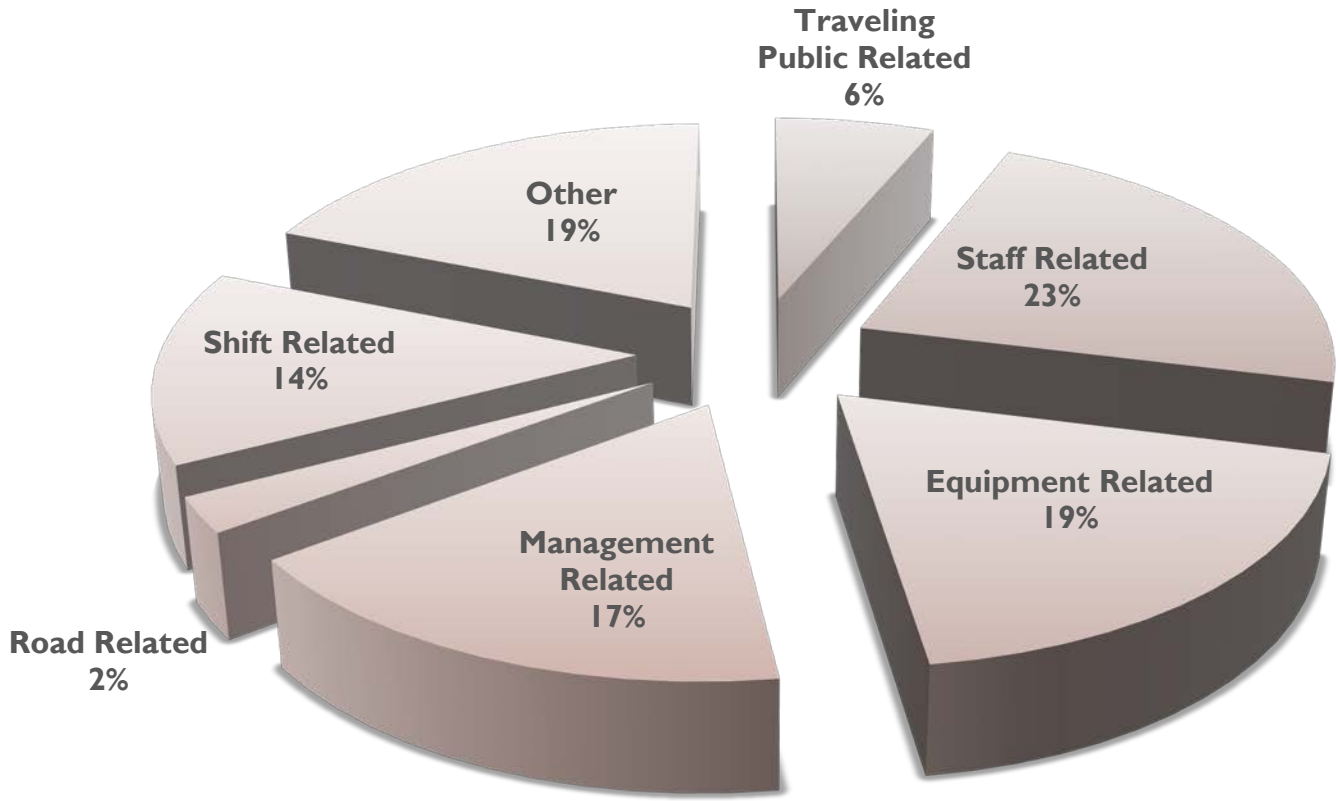
- 1,043 winter maintenance operators
- 453 maintenance managers
- 24 participating states



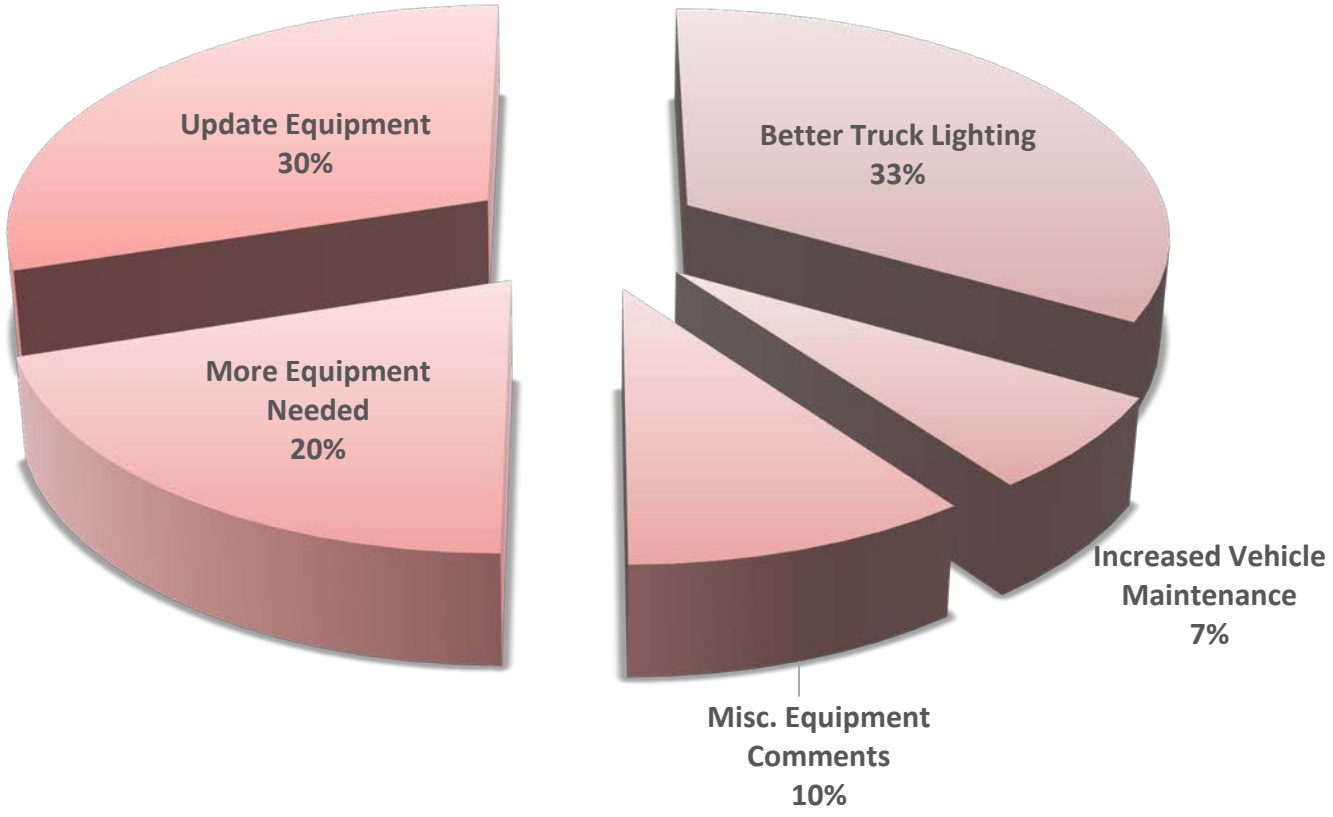
Use and Effectiveness of Breaks in Reducing Fatigue



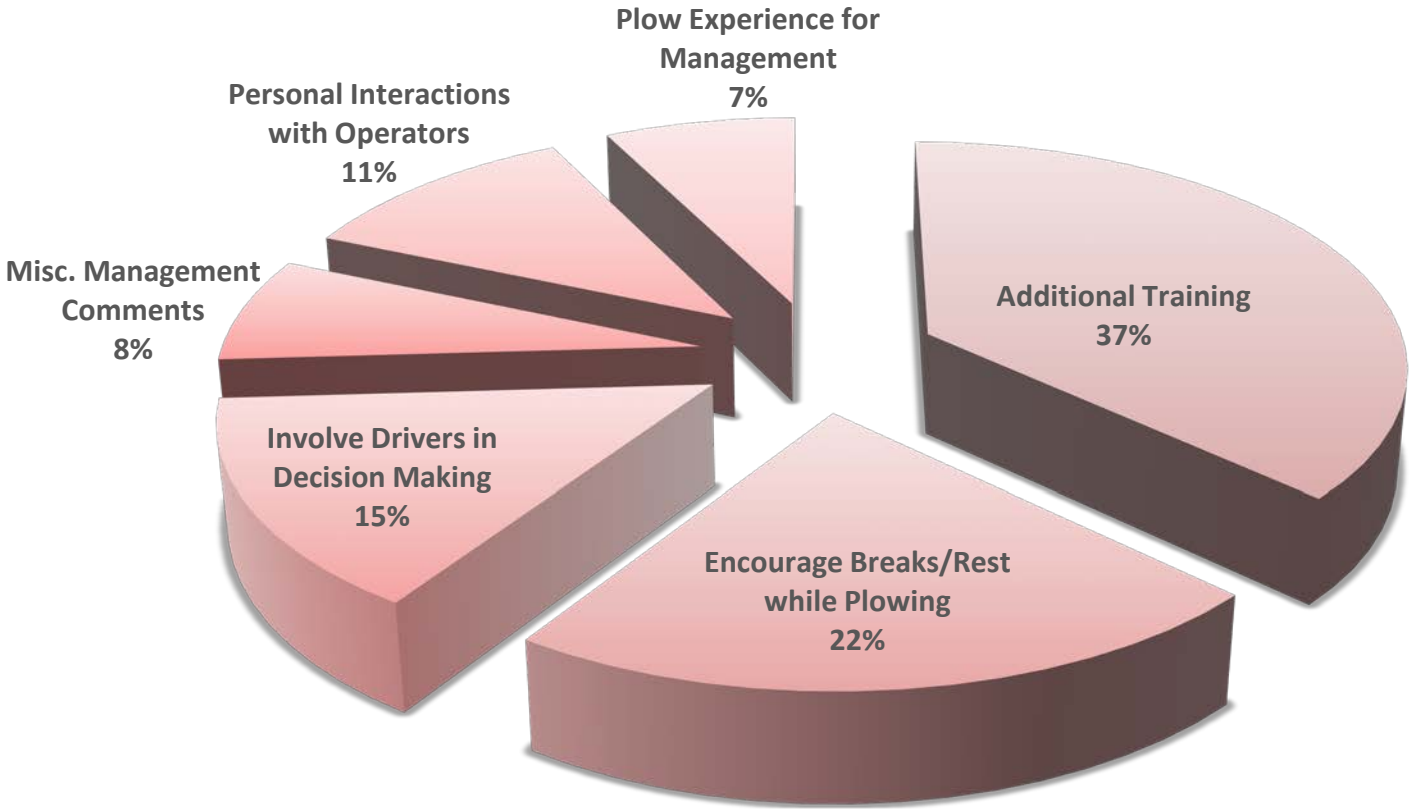
Managers' Suggestions to Improve Safety



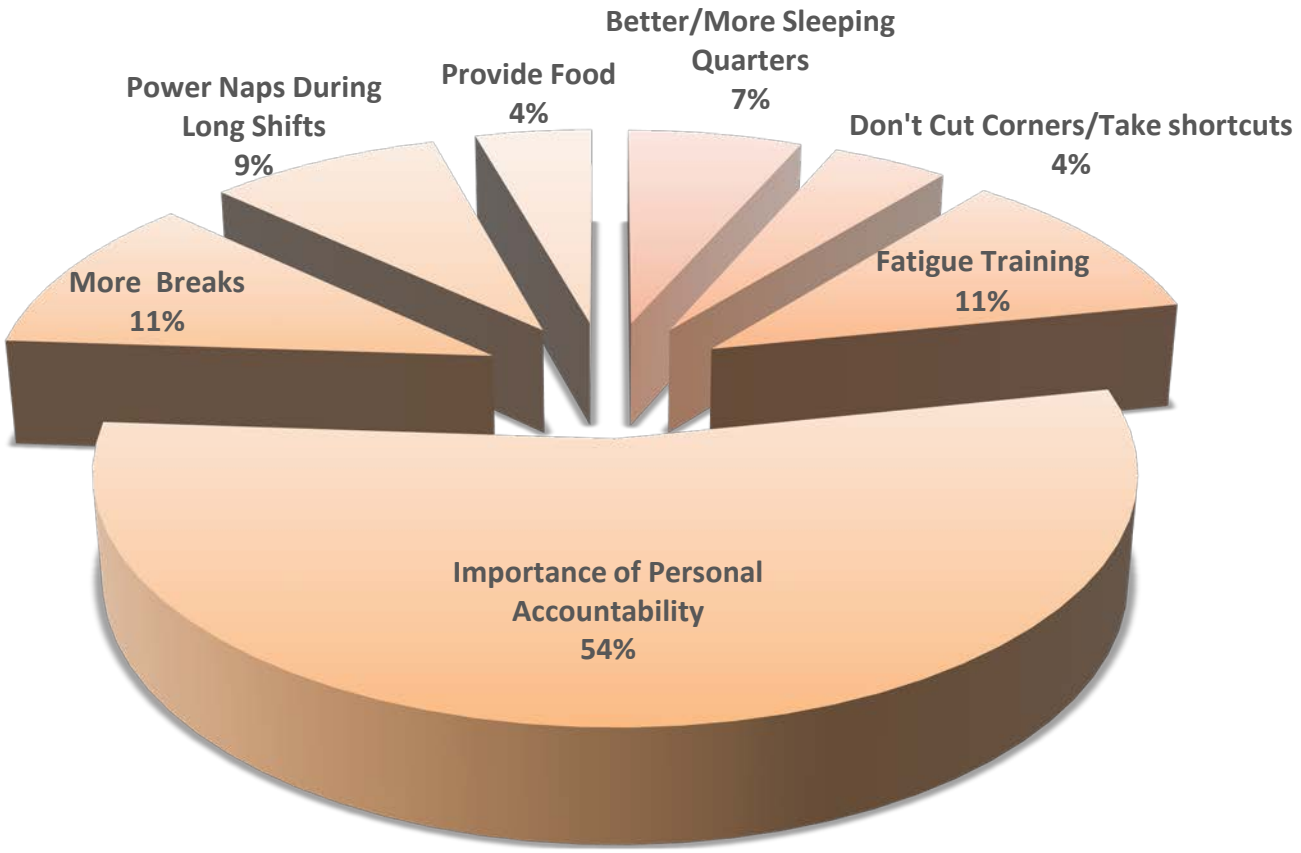
Equipment-Related Suggestions



Management-Related Suggestions



Drivers' Suggestions



Discussion (1 of 2)

- The majority of SCEs (97.8%) occurred during a winter emergency
- The majority of SCEs (56.5%) occurred between 12:00 a.m. and 6:00 a.m.
- Almost all the drowsy driving SCEs (97.0%) occurred between 12:00 a.m. and 6:00 a.m.
- Fatigue was the critical reason in 28.3% of the SCEs
- Driver inattention/distraction was a contributing factor in 59.8% of the SCEs

Discussion (2 of 2)

- Operators averaged less sleep during winter emergencies
- Operators averaged less sleep prior to a SCE
- Appeared there was knowledge, but less use

Final Recommendations (1 of 2)

- Encourage use of breaks/naps
- Encourage winter maintenance operator fatigue reporting
- Increased vehicle maintenance
- Investigate winter emergency shift start/end times (including shift length)
- Offer shift options

Final Recommendations (2 of 2)

- Involve winter maintenance operators in the decision-making process
- Increase personal interactions with winter maintenance operators
- Maximize off-duty rest

Future Research

- Data showed some interesting trends
- Need more research
  - Large scale naturalistic study with more trucks and operators
  - Log books to investigate naps
  - Design an FMP for winter maintenance operators
    - www.nafmp.com
  - Investigate equipment-related fatigue

Questions?

Matt Camden
mcamden@vtti.vt.edu
540-231-1503