On Board Monitoring of 270 Trucks: Data Analysis Case Study

Linda Ng Boyle and Yiyun Peng
Industrial and Systems Engineering
Civil and Environmental Engineering
University of Washington

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Background

- Providing drivers feedback can help
  - enhance drivers' immediate driving performance
  - induce long-term positive changes in driving behavior (Donmez et al, 2008; McGehee et al, 2007)
- Safety/fleet managers have a great influence on the safety attitudes and motivation of drivers (Newman et al, 2008; Arboleda et al., 2003)
- Initial pilot study demonstrated that feedback to commercial drivers hold promise (Hickman et al, 2009)

Study Objective

- To examine whether safe driving habits can be enhanced and risky behavior be reduced among commercial drivers with
    - Real-time feedback
    - Coaching from safety supervisors
- On-Board Monitoring System (OBMS) for Commercial Motor Vehicle safety
    - Research program sponsored by Federal Motor Carrier Safety Administration (FMCSA)
    - In support of their mission to reduce the number and severity of crashes related to large trucks

Real-Time Feedback

- Safety/Performance Event Notification
  - Notify drivers when a safety or performance event has been captured for coaching.
  - Safety event capture: e.g., Large lateral acceleration, Forward collision.
  - Performance event: e.g., hard brake
- Driver State Notification
  - E.g., Aggressive, Inattentive
- Imminent Crash Warning
  - Forward Collision, Lane departure

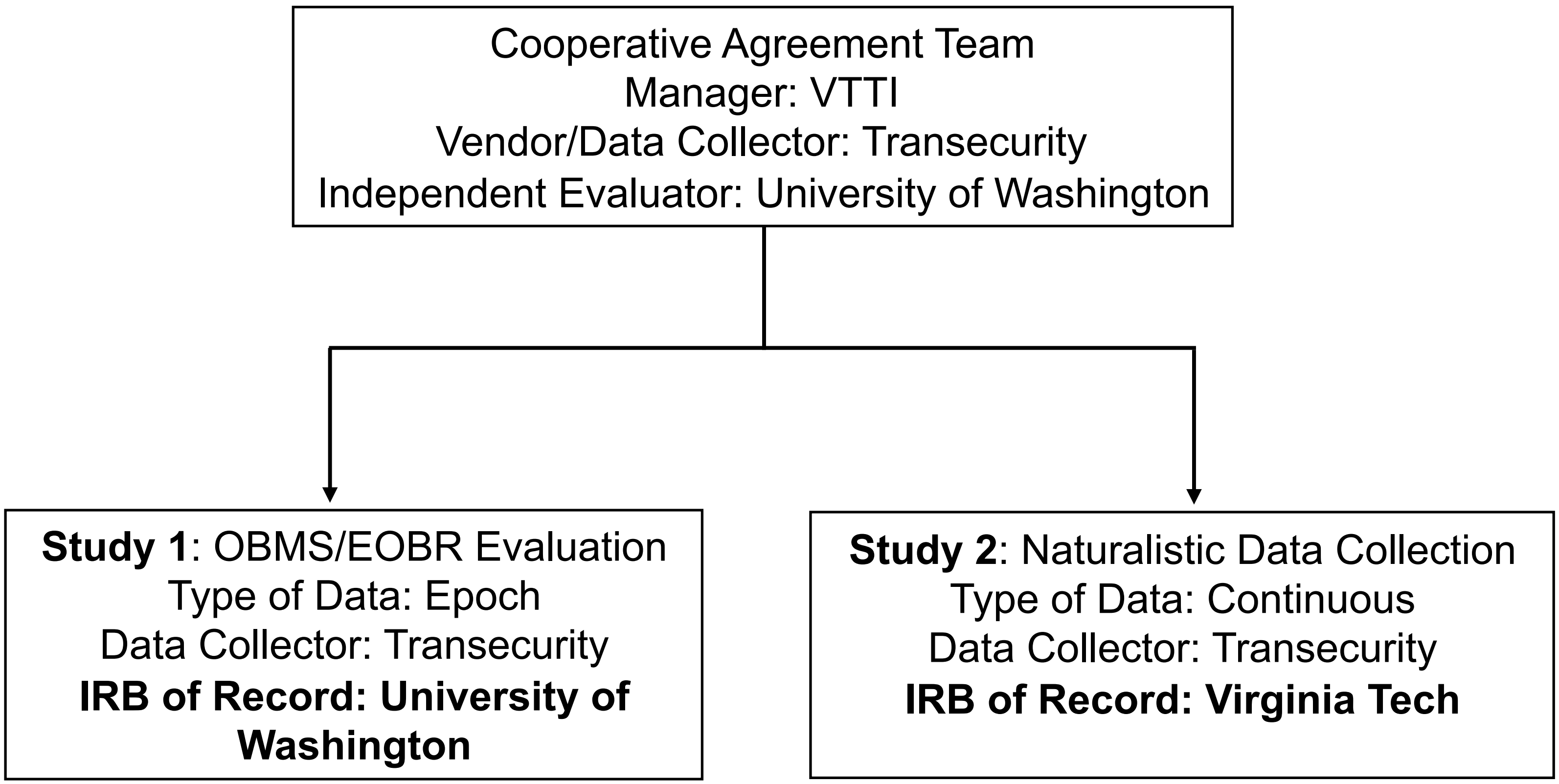
Coaching by safety supervisors

- Record snippets on unsafe driving behaviors (e.g., hard braking)
  - Video data and vehicle kinematic measures
- Reviewed by safety supervisors and used to coach the driver
- Same data will also accessed by research team for an independent evaluation

Data collection

- 270 trucks will have OBMS devices
  - With up to 500 drivers
  - And 18 driver-months of data per driver
- Includes baseline and withdrawal period
  - Identify relative increases/decrease in performance
  - Identify any lasting or residual effects from using the system
- Includes comparison group
  - Drivers who receive no feedback for entire period
- Data will be collected on:
  - Vehicle kinematics
  - Video data
  - Driver Questionnaires

Data Collection Overview



Constraints

- Devices take time to install
  - There is a six-month installation period
  - Total data collection will be conducted over 24 months
- Maximize driver exposure to intervention method (feedback)
  - Also to account for carriers' expectation
- Need to accommodate the likely attrition of participating drivers

Experimental Design

- Three experimental groups
  - Group 1: Baseline group
  - Group 2: Longer-term adaptation group
  - Group 3: Shorter-term adaptation group

	Months																	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
Group 1	Baseline (no feedback)																	
Group 2	Baseline		Feedback (14 months)														WD	
Group 3	Baseline		Feedback (7 months)							Withdrawal (WD)								

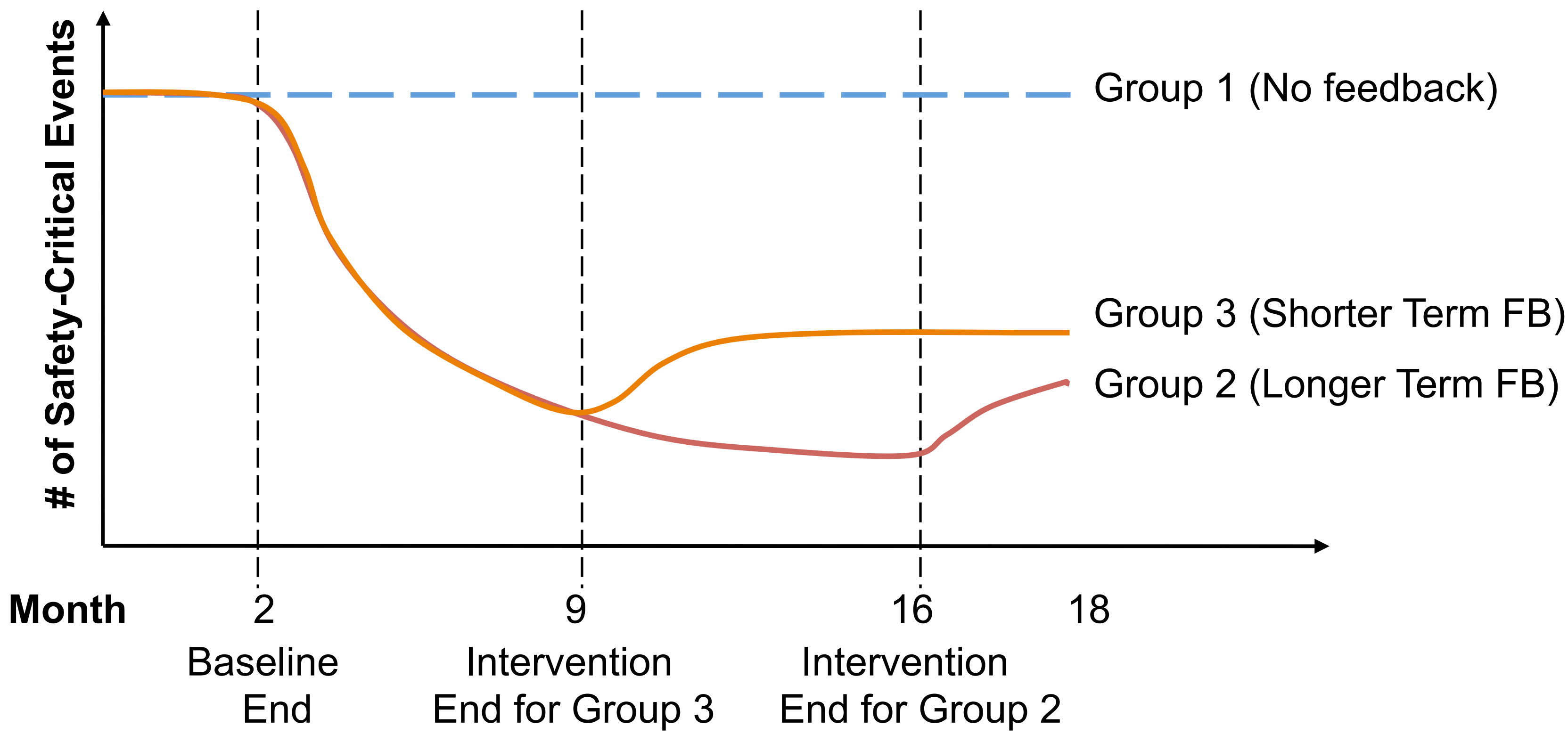
Q1 Q2 Q3 Q4 Q5 Q6

Sample size

Group	Initial Sample Distribution
1: Baseline	30 devices
2: Longer term (14 months)	210 devices
3: Shorter term (7 months)	30 devices

- For longer term feedback (14 months), drivers that attrition out cannot be replaced given the length of feedback
  - Assuming 5 % attrition per month => 88 (of 210 drivers) will complete to month 18
- Drivers that attrition out will be placed into Group 1 (baseline) or Group 3 (shorter term)

Anticipated Outcome



Question: Can driver performance and safety improve over time with OBMS feedback and coaching?

Performance variables

- Performance data (e.g., speed, acceleration, lane deviation)
- Number of safety-critical events per miles traveled (e.g., lane departure events, distraction events, fatigued events)

Accounting for…

- Demographic data (e.g., gender, age)
- Environmental condition (lighting, traffic, roadway, weather, time-of-day)
- Seasonal effects

Random coefficient modeling

- Allows the analysis of multilevel data using a single regression model
- Frequently used in longitudinal study with data clustered across different levels
  - e.g., individual level, between-driver, and group levels
- Can account for non-normally distributed outcomes (e.g, safety critical events)
- Estimate the relationship of individual level predictors with the dependent variable while taking into account clustering

Random coefficient modeling

- **Level 1. individual growth model**, explains the performance change over time (baseline, feedback and withdrawal phase):

$$g(y_{ijt})=\pi_{0ij}+\pi_{1ij}\times C_{ijt}+\pi_{2ij}\times X_{ijt}+\pi_{3ij}\times \mathbf{W}_{ijt}+e_{ijt}$$

  - *g()* represents the link function (e.g., Poisson distribution)
  - *C* is the time variable of study participation (in months)
  - *X* is the study phase (baseline, feedback, withdrawn)
  - **W** represents the matrix of environmental and seasonal factors

Random coefficient modeling

- **Level 2. driver-level mode**l, explains the between-subject difference within study groups (e.g., carriers, age, crash history, Z_{ij}.):

$$\pi_{0ij}=\beta_{00j}+\beta_{01j}\times Z_{ij}+r_{0ij}$$

$$\pi_{1ij}=\beta_{10j}+\beta_{11j}\times Z_{ij}+r_{1ij}$$

$$\pi_{2ij}=\beta_{20j}+\beta_{21j}\times Z_{ij}+r_{2ij}$$

$$\pi_{3ij}=\beta_{30j}+\beta_{31j}\times Z_{ij}+r_{2ij}$$

Random coefficient modeling

- **Level 3. group-level model**, explains the experimental group differences (e.g., baseline, long-term adaptation, short-term adaptation, V_j):

$$\beta_{00j}=\gamma_{000}+\gamma_{001}\times V_j+\mu_{00j}$$

$$\beta_{01j}=\gamma_{010}+\gamma_{011}\times V_j+\mu_{01j}$$

....

Question: If driving performance improves, does it remain improved over time

Autoregressive integrative moving average (ARIMA)

- Time series model
- Accounts for seasonality and influence of change from interventions/withdrawals
- To observe if good driver performance persists even after feedback is removed

Covariate: Baseline group

$$y_t - y_{t-k} = \varphi(y_{t-1} - y_{t-1-k}) + e_t - \theta e_{t-1} - \Theta e_{t-1\text{-}k} + OBMS + CG$$

Safety critical events/miles traveled/month

Seasonal differences

When feedback was turned on/off

Question: How do the driver's opinions and attitudes towards the OBMS system and program change over time?

Questionnaires

- Baseline (before feedback is received)
  - Assessing driver's expectations of the OBMS system
- Feedback
  - Assessing driver's experiences with the OBMS system after they have received feedbacks.
- Withdrawal
  - system when feedbacks are removed.

Questionnaires

Data analysis

- Regression model to predict change (Δ) in response from one phase to the next
- Cluster analysis
  – to observe homogeneous groups of drivers based on their questionnaire responses

Summary

- Study is currently in the pilot phase
- Other areas being evaluated
  - Distinguishing between safe and unsafe drivers
  - Hours of Service: Electronic On Board Monitoring
  - Economics: Cost/benefit analysis of system implementation for carriers
- Other Issues
  - Epoch data only of safety critical events
  - No random events that can provide insights on how drivers may adapt to the system
  - Sampling biases: will need to account for statistically

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For further questions, please contact Linda Ng Boyle

E-mail: linda@uw.edu, tel: (206) 616-0245