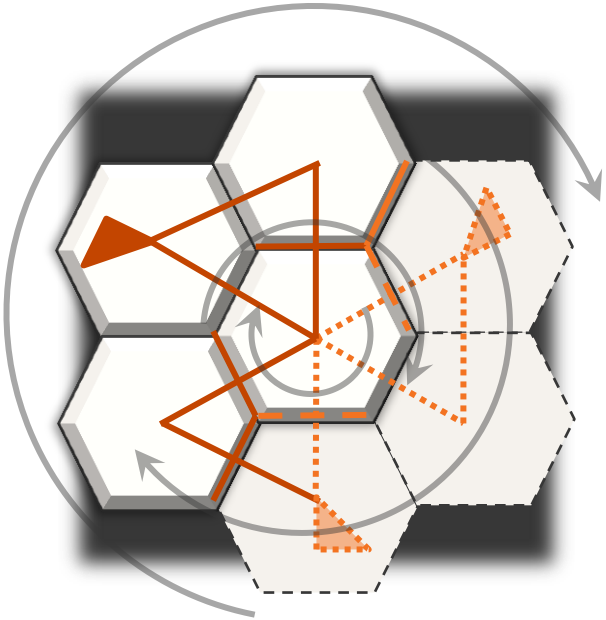
School of Mechanical, Industrial and Manufacturing Engineering

OSU Oregon State University

Cab Analysis and Scoring Tool (CAST)



CaRSEM

Change and Reliable Systems Engineering and Management

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Agenda

- CAST Introduction
- Project Implementation
- Application

CaRSEM

Change and Reliable Systems Engineering and Management

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CaRSEM
Change and Reliable Systems Engineering and Management

Initial Scope

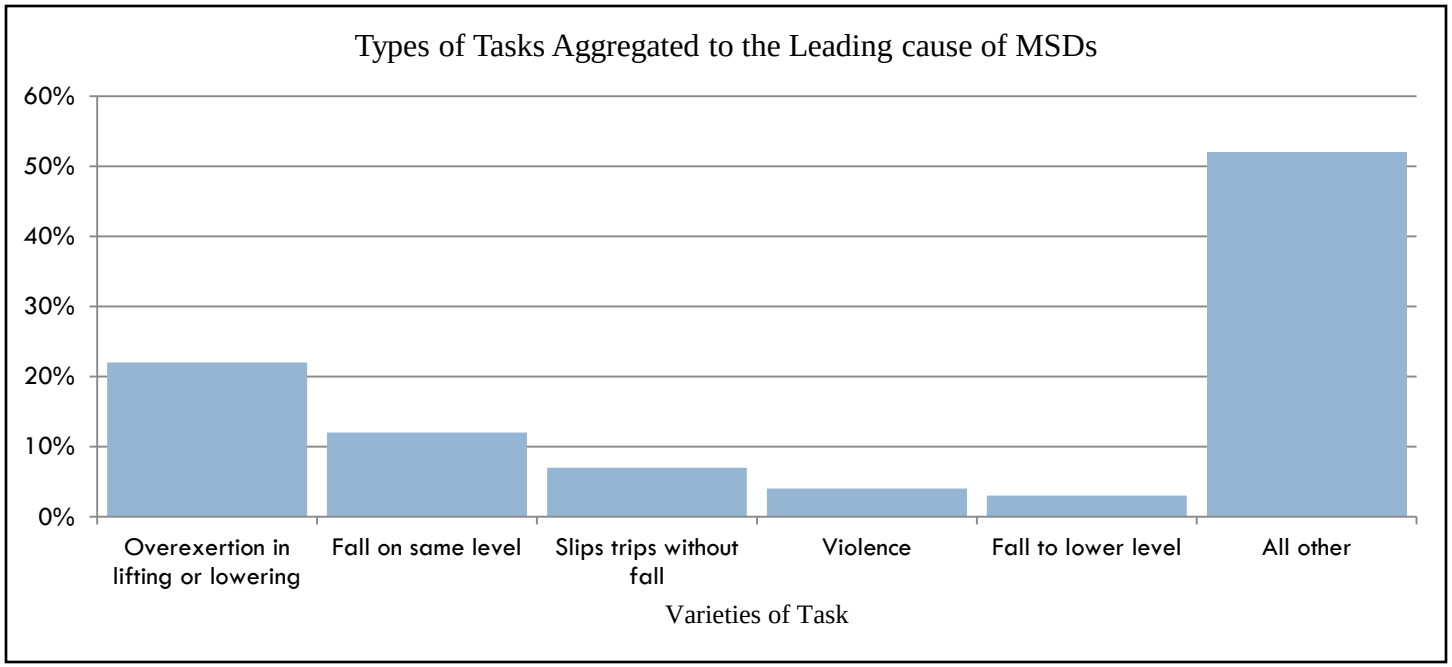
- ODOT is moving to a more flexible truck fleet
- General purpose 10 ton dump truck that can be configured for one of several functions (sanding, deicing, roadside vegetation control, etc.)
- ODOT was in the process of developing a "Concept Truck" that required the integration of:
  - Console/controller unit
  - Manual equipment
  - Controls
  - Auxiliary controls and displays
- Requested 3 cab layout designs that optimized safety, performance and comfort of the operator into the existing baseline truck cab

Analysis of Initial Scope

- The initial RFP only had metrics for steering wheel diameter, line of sight, and heel point to back of cab wall
- More effective to create a process that identifies the best baseline cab layouts
  - Based on safety, performance and comfort of the operator
- ODOT requested a methodology that
  - Guides a user through a baseline cab selection process.
  - Accounts for human factors and ergonomics

Cab Analysis and Scoring Tool (CAST)

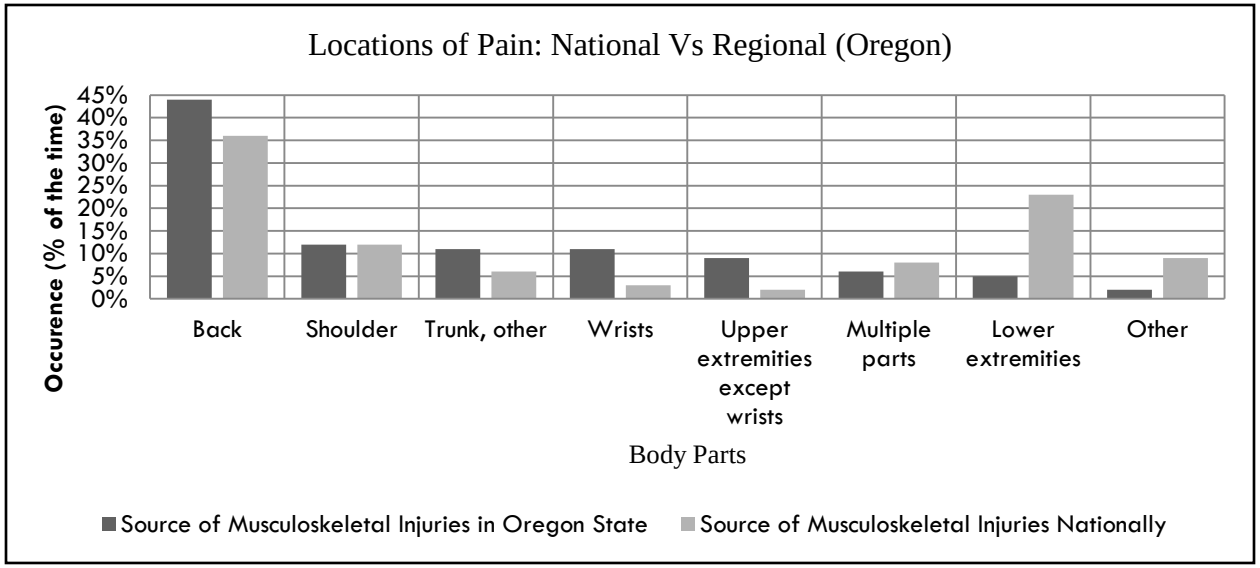
- Types of tasks that Present the Highest Musculoskeletal Disorders (MSD) Incidence Rate



- 4BLS, B. L. of S. Nonfatal Occupational Injuries and Illnesses Requiring Days Away from Work. Publication USDL - 12 - 2204. Bureau of Labor Statistics, 2012.

Cab Analysis and Scoring Tool (CAST)

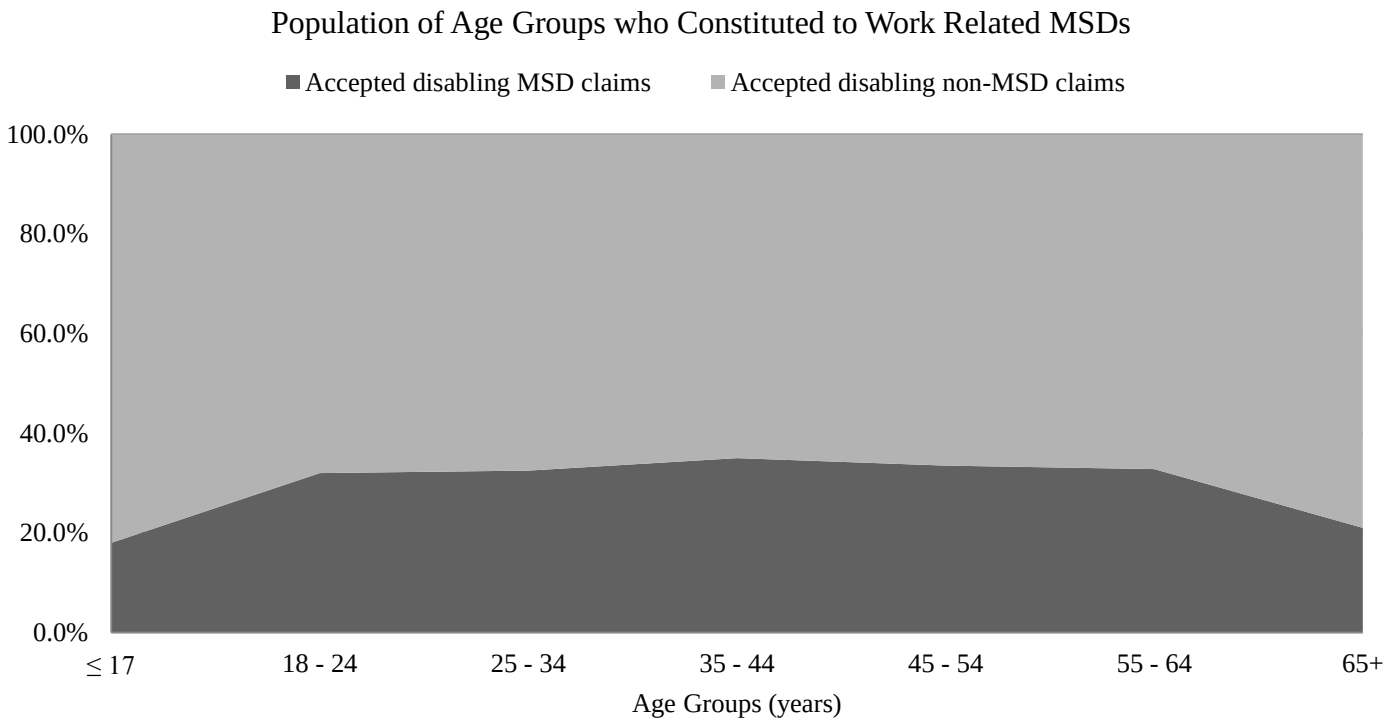
- Locations of Pain Related to Truck Driving Activity



- Christensen, K., J. Douglas, M. Green, L. Karam, J. Walters, and J. Wray. Work-related Musculoskeletal Disorders (MSDs). 2009.
- 4BLS, B. L. of S. Nonfatal Occupational Injuries and Illnesses Requiring Days Away from Work. Publication USDL - 12 - 2204. Bureau of Labor Statistics, 2012.

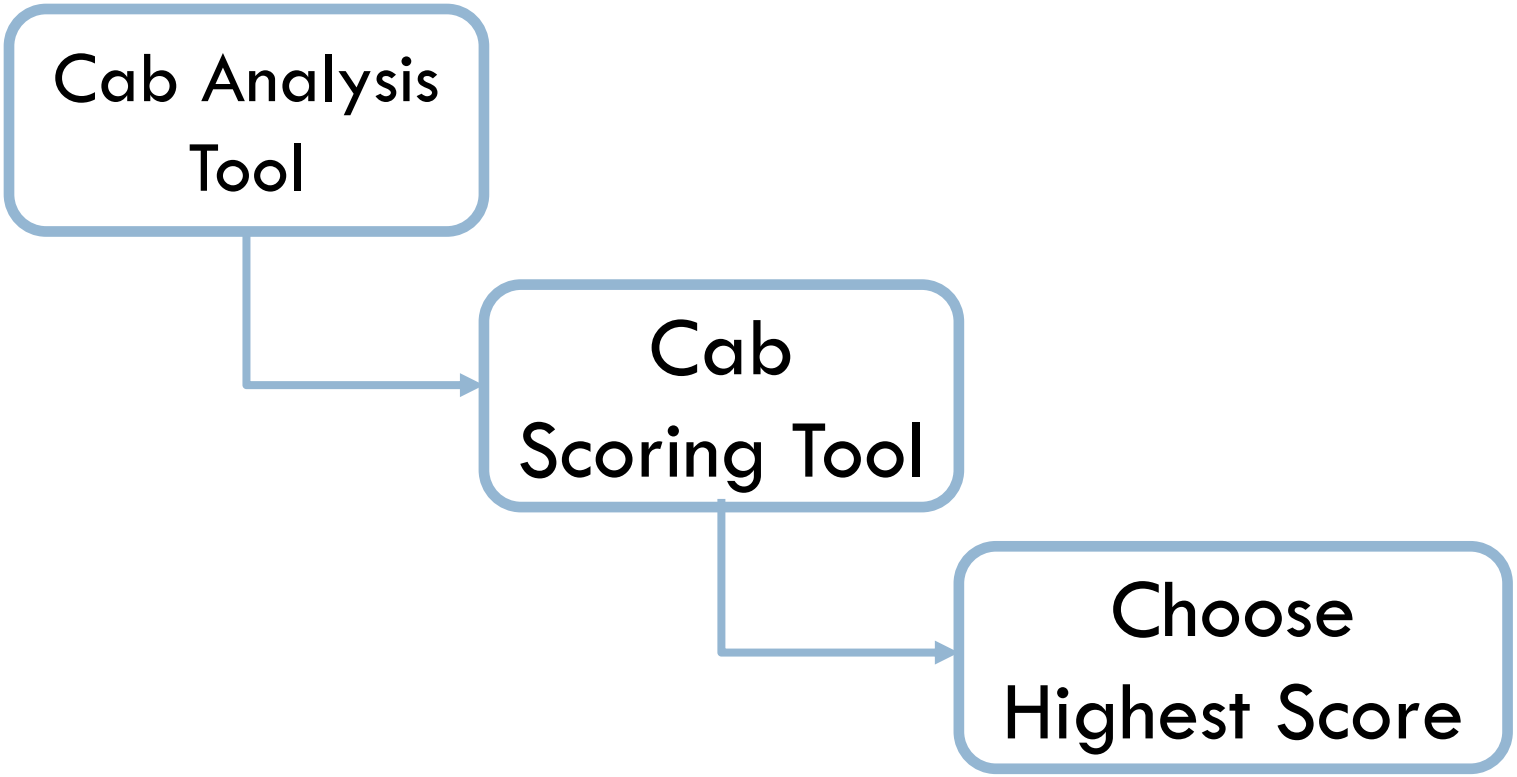
Cab Analysis and Scoring Tool (CAST)

Age Distribution of Groups Who Develop MSDs



- Christensen, K., J. Douglas, M. Green, L. Karam, J. Walters, and J. Wray. Work-related Musculoskeletal Disorders (MSDs). 2009.

Cab Analysis and Scoring Tool Structure



Agenda

- CAST Introduction
- **Project Implementation**
- Application

Implementation: dimensions

- Why should a particular dimension be included?
- Which dimensions should be included?
- What impact does a particular dimension have on cab ergonomics and human factors?
- How should each dimension be represented?

Implementation: dimensions

- Why should a particular dimension be included?
  - Ergonomic significance
  - Human factors significance
    - Human error and risk of injury
  - ODOT

Implementation: dimensions

- Which dimensions should be included?
  - Group brainstorm
  - ODOT
    - Brainstorm
    - Past requirements
    - Driver input
  - Research
  - Eliminating redundancy
  - Accounting for significant features

Implementation: dimensions

- What impact does a particular dimension have on cab ergonomics and human factors?
  - Relates to factors previously covered
  - Weighting system

Implementation: dimensions

- How should each dimension be represented?
  - Dynamic
  - Static
  - Features

Implementation: dimensions

Dynamic	Static	Features
Seat height	Heel to back of cab	Overhead space
Seat back to steering wheel	Back of seat mount to back of cab	Heated windshield
Steering wheel tilt	Driver door to passenger door	Heated side view mirrors
Steering wheel telescope	Distance from break pedal to gas pedal	Heated door windows
Seat cushion to cab ceiling	Knee impact zone (seat up)	Dash light dimmer
	Knee impact zone (seat down)	Night setting for cab lights
	Distance to accessory cluster	Telescopic side view mirrors
		Motor control mirror adjustment
		Steering wheel <19”
		Driver seat arm rests
		Foot operated steering wheel adjustment

Implementation: measuring and scoring

- How do we assess each dimension?
- How do we score a dimension based on its measurement?

Implementation: measuring and scoring

- How do we assess each dimension?
  - Standardized measuring process
    - Reference points
    - Dynamic dimensions
    - Static dimensions
    - Features

Implementation: measuring and scoring

- How do we score a dimension based on its measurement?
  - Benchmarking other truck cabs in ODOT fleet
    - 2013 SD114 Freightliner, 2009 Peterbilt, 2013 VHD Volvo 13
  - Ergonomic research
  - Anthropomorphic study
    - *U.S. Truck Driver Anthropometric Study and Multivariate Anthropometric Models for Cab Designs* in journal "Human Factors: The Journal of the Human Factors and Ergonomics Society."
  - Weighting system
    - Ergonomic impact, human factors, ODOT requirements

Agenda

- CAST Introduction
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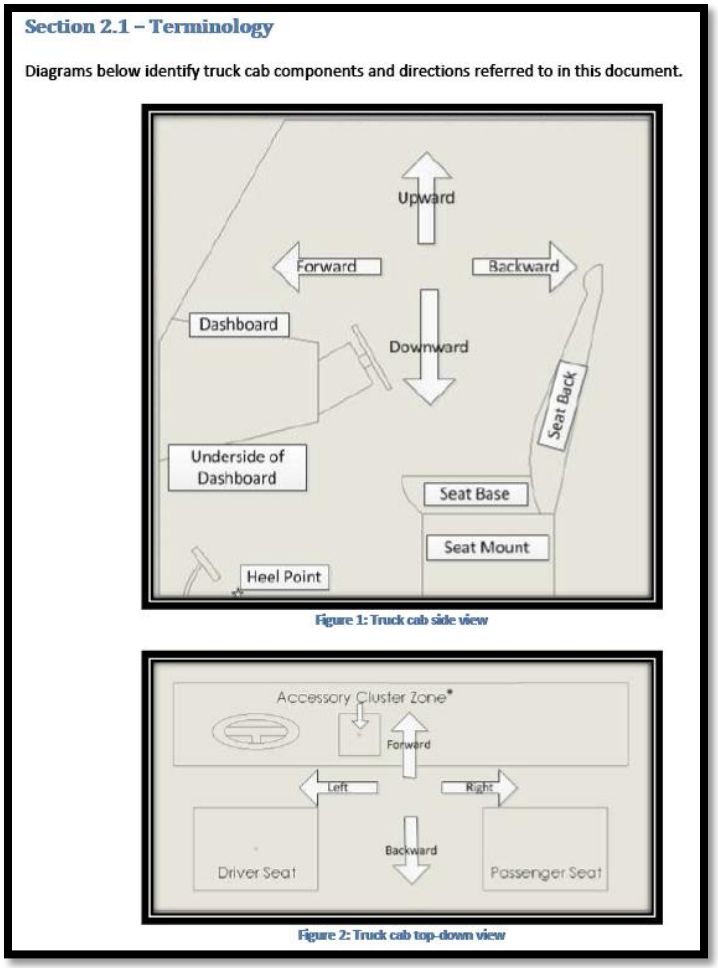
Change and Reliable Systems Engineering and Management

Cab Analysis Tool

- Standardized instructions for data gathering
- All dimensions and features included
- Includes-
  - Terminology
  - Tools
  - Reference points
  - Measurement pages

Cab Analysis Tool- Terminology



Section 2.1 – Terminology

Diagrams below identify truck cab components and directions referred to in this document.

Figure 1: Truck cab side view

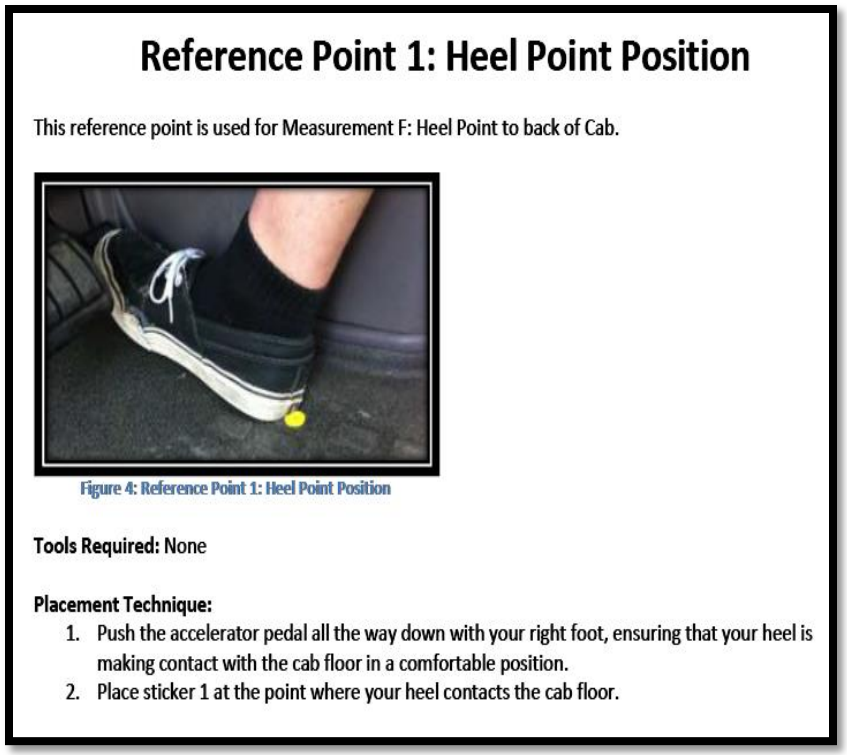
Figure 2: Truck cab top-down view

- Identify truck cab components and directions referred to in the Cab Analysis Tool

Cab Analysis Tool- Required Tools

- Identifies tools required for data gathering
  - Tape Measure
  - Straight Edge
  - Angle Finder

Cab Analysis Tool- Reference Points



Reference Point 1: Heel Point Position

This reference point is used for Measurement F: Heel Point to back of Cab.

Figure 4: Reference Point 1: Heel Point Position

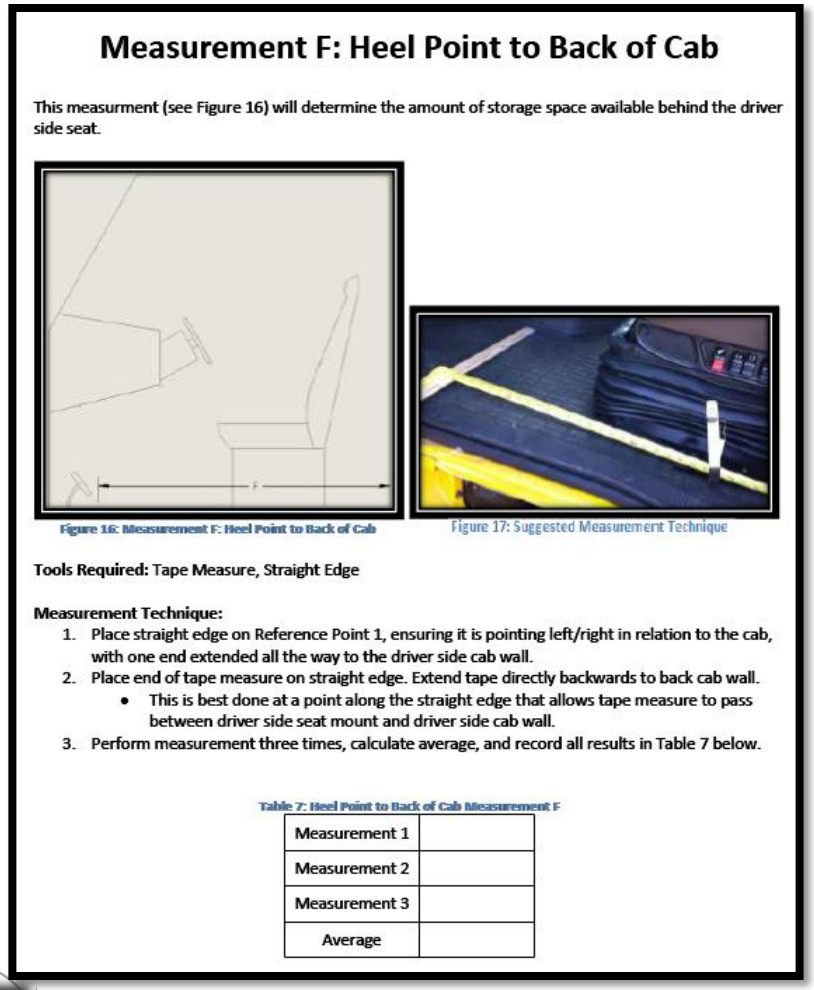
Tools Required: None

Placement Technique:

1. Push the accelerator pedal all the way down with your right foot, ensuring that your heel is making contact with the cab floor in a comfortable position.
2. Place sticker 1 at the point where your heel contacts the cab floor.

- Instructions for marking reference points in a cab for the purpose of gathering measurement data
- 7 Reference points

Cab Analysis Tool- Measurement Pages



Measurement F: Heel Point to Back of Cab

This measurment (see Figure 16) will determine the amount of storage space available behind the driver side seat.

Figure 16: Measurement F: Heel Point to Back of Cab

Figure 17: Suggested Measurement Technique

Tools Required: Tape Measure, Straight Edge

Measurement Technique:

1. Place straight edge on Reference Point 1, ensuring it is pointing left/right in relation to the cab, with one end extended all the way to the driver side cab wall.
2. Place end of tape measure on straight edge. Extend tape directly backwards to back cab wall.
   - This is best done at a point along the straight edge that allows tape measure to pass between driver side seat mount and driver side cab wall.
3. Perform measurement three times, calculate average, and record all results in Table 7 below.

Table 7: Heel Point to Back of Cab Measurement F

Measurement 1	
Measurement 2	
Measurement 3	
Average	

- Explains measuring process for key ergonomic areas
  - Picture of measurement
  - List of tools
  - Measurement Technique
  - Table for recording data
- Repeat measurement three times

Cab Scoring Tool

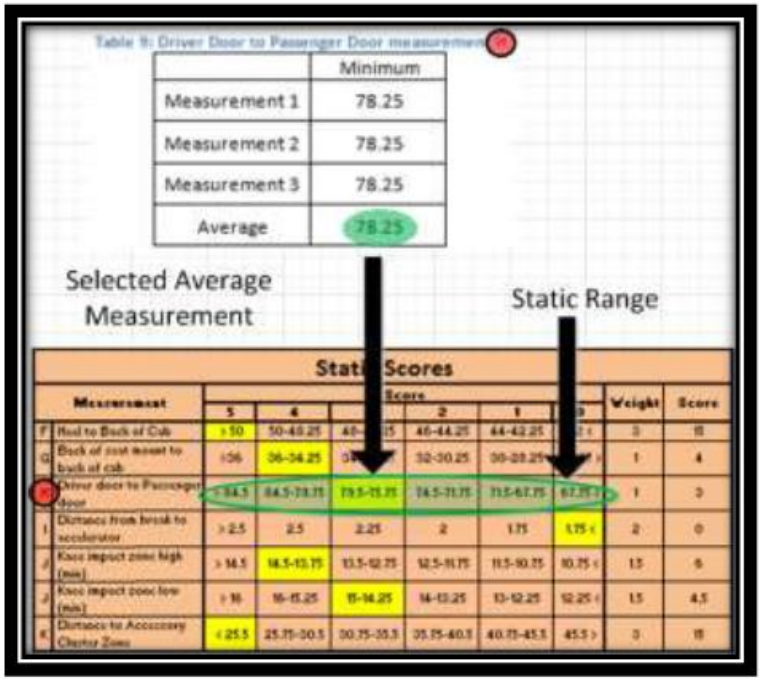
- The Cab Scoring Tool (CST) is an Excel program that will generate a cab score based on the measurements gathered by the user
- Three different tables of measurements
  - Dynamic measurements
  - Static measurements
  - Additional features
- Calculations are performed automatically by program

Cab Scoring Tool- Scoring

- Each measurement receives a base score
  - Ranges for base scores are based on industry averages, critical points, or ergonomic risk zones
- Each measurement was assigned a weight (1-3)
  - 3 – High ergonomic injury risk
  - 2 – Human error and ergonomic environment
  - 1 – Driver comfort
- Final score for measurement (Base Score X Weight)
- Final cab score is normalized $\frac{\sum Scores}{156} \times 100$

Cab Scoring Tool- How to Use

- Locate corresponding row via the measurement letter (red circle)
- Click once on the range which corresponds to the average from the measurement page (green circle)



Cab Scoring Tool- How to Use

- The final score of the measurement is automatically calculated when a new range is highlighted

Static Scores

	Measurement	Score 5	4	3	2	1	0	Weight	Score
F	Heel to Back of Cab	> 50	50-48.25	48-46.25	46-44.25	44-42.25	[illegible] <	3	9
G	Back of seat mount to back of cab	> 10.25	10-8.25	8-6.25	6-4.25	4-2.25	< 2	1	3
H	Driver door to Passenger door	> 84.5	84.5-79.75	79.5-75.75	74.5-71.75	71.5-67.75	67.75 >	1	0
I	Distance from break to accelerator	> 2.5	2.5	2.25	2	1.75	1.75 <	2	10
J	Knee impact zone (Seat Up)	> 14.5	14.5-13.75	13.5-12.75	12.5-11.75	11.5-10.75	10.75 <	1.5	0
J	Knee impact zone (Seat Down)	> 16	16-15.25	15-14.25	14-13.25	13-12.25	12.25 <	1.5	0
K	Distance to Accessory Cluster Zone	< 25.5	25.75-30.5	30.75-35.5	35.75-40.5	40.75-45.5	45.5 >	3	0

- Final score for measurement (Base Score X Weight)

Cab Scoring Tool- How to Use

- The final score of a cab is automatically calculated when a new range is highlighted

$$\frac{\sum Scores}{156} \times 100$$

- 100 possible points

Summary	
Truck Model	
Final Score	68.59