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From Video to Driver Cockpit Layout:
Using Naturalistic Data to Guide Human/Vehicle Interface Design

First VTTI Human Factors Symposium:

Naturalistic Driving Methods and Analyses

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Overview

- Application of naturalistic video data
    - Case Study 1 – Decreasing bus driver workload during passenger loading/unloading
    - Case Study 2 – Steering wheel controls for a Line Haul tractor
- Conclusions and observations

Case Study 1:

Decreasing bus driver workload during passenger loading/unloading

Background

- New conventional school bus program initiated in 1999/2000
  - Opportunity to create new driver package and update cockpit
- Needed to understand bus drivers' tasks
- Collected naturalistic video data and conducted task analysis

Legacy Bus Cockpit

Collected video of bus drivers

- **Eight separate drives, 4 drivers, at 3 school systems**
  - New Haven, Indiana
  - Elizabethtown, Kentucky
  - San Diego, California
- **Captured over 10 hours of video data**
  - Analyzed second-by-second (>36,500 frames)
  - Quantified:
    - Driver Location
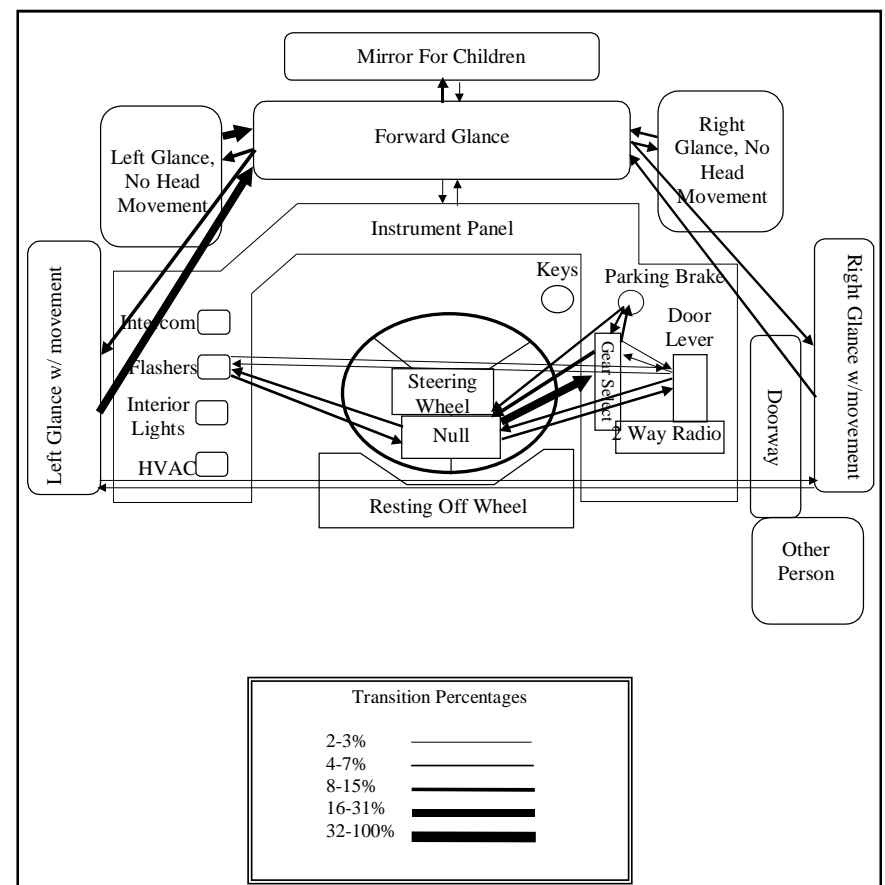   - Eye glance
    - Instrument Panel
    - Road State
    - Left Foot
    - Right Foot
    - Left Hand
    - Right Hand

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Link Analysis

Right and left hand transitions
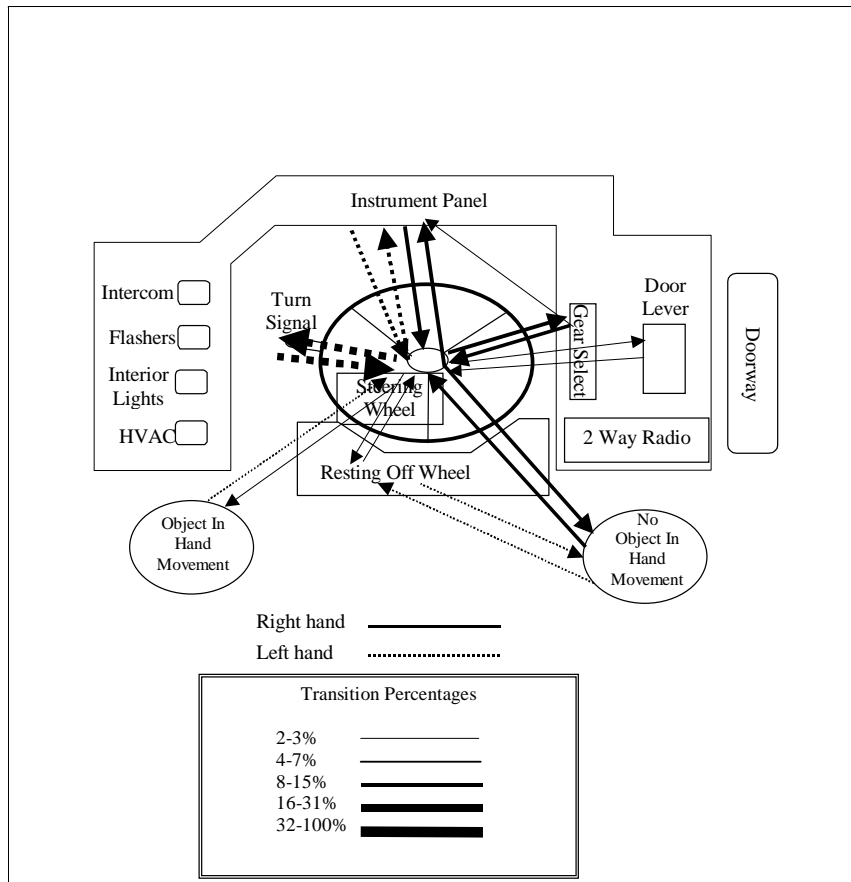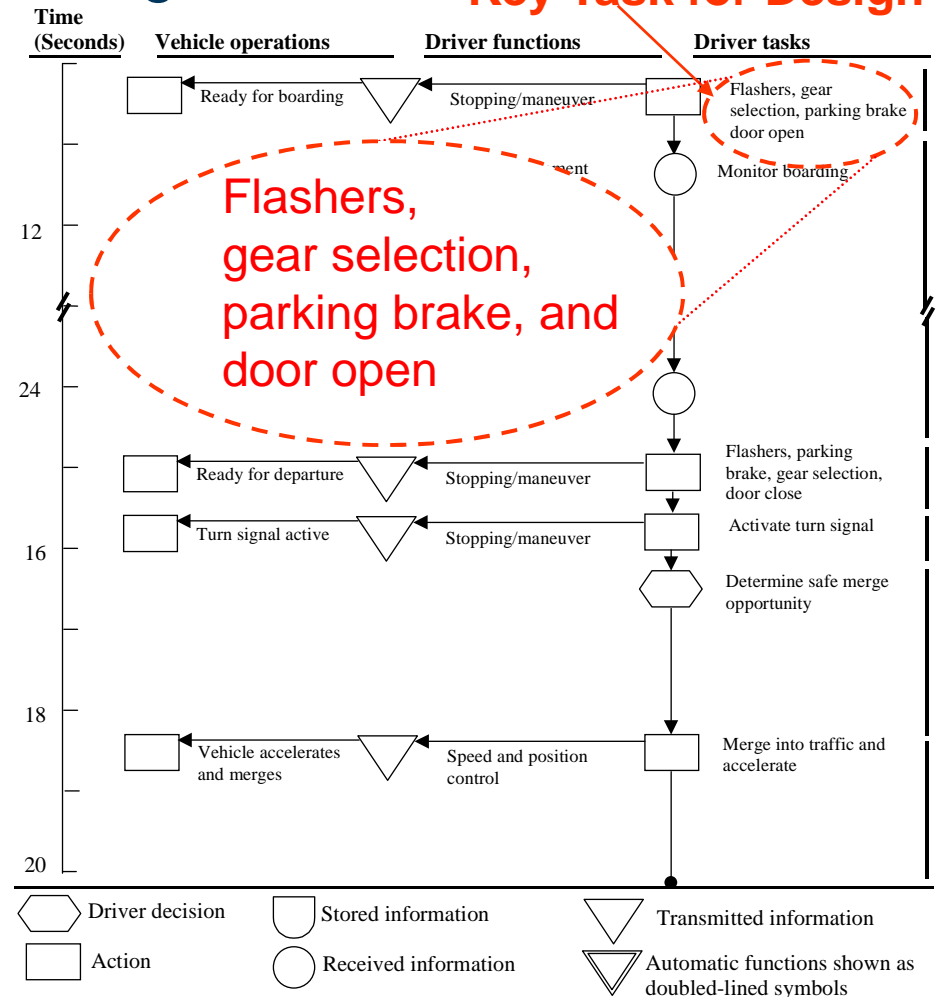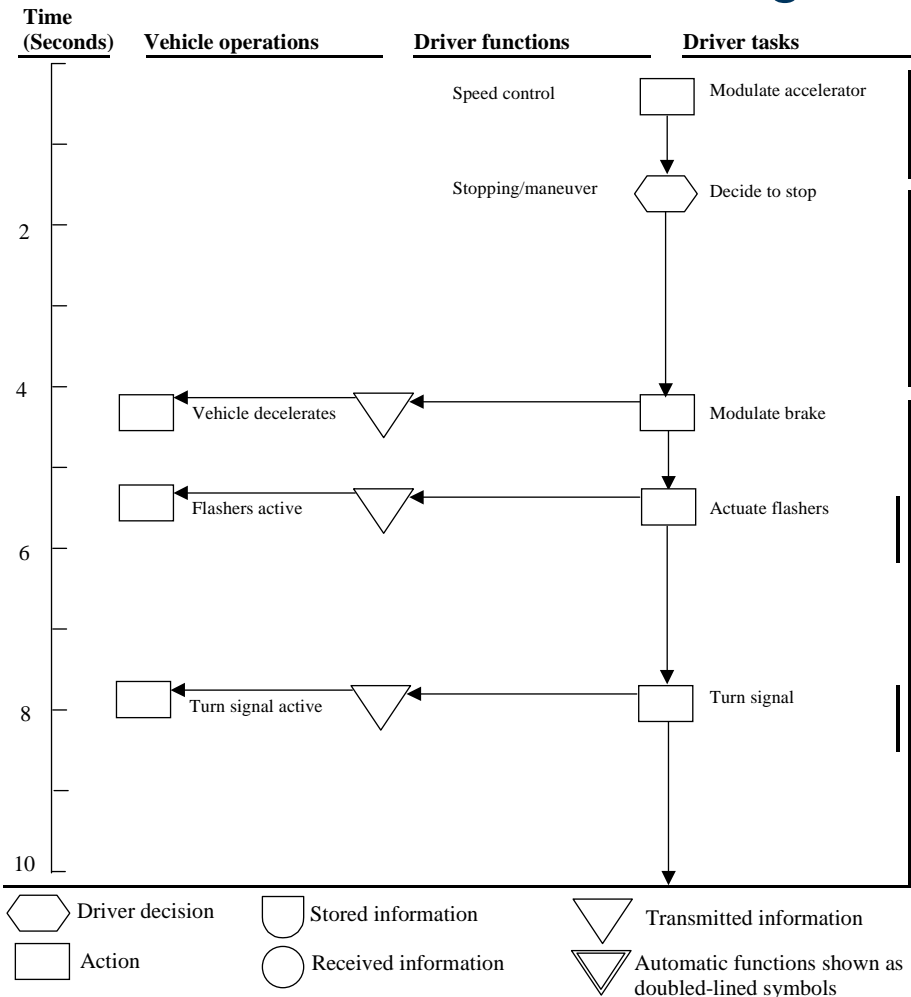

IP states and eye glances

Key Driving Tasks Identified

Task Number	Task Name	Frequency	Median Duration	Mean Duration	Standard Deviation	Percent of Total Drive
101	Stopping at intersection	0.29	15.0	21.0	18.0	10.0
102	Loading, unloading children	0.20	21.0	30.0	42.0	10.0
103	Rejoining roadway	0.01	10.0	12.0	8.0	0.0
104	Railroad, bus stop encounter	0.02	16.0	33.0	49.0	1.0
105	Radio communication	0.02	18.0	23.0	14.0	1.0
106	Turning, merging with traffic	0.20	10.0	16.0	15.0	5.0
107	Pedestrian encounter	0.00	4.0	4.0		0.0
108	Instrument panel interaction	0.60	3.0	4.0	6.0	4.0
109	Driver exiting bus	0.01	27.0	21.0	17.0	0.0
110	Child management	0.16	3.0	6.0	15.0	2.0

Loading and Unloading Children

Operational Sequence Diagram

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Loading/Unloading Children

Key Task for Design
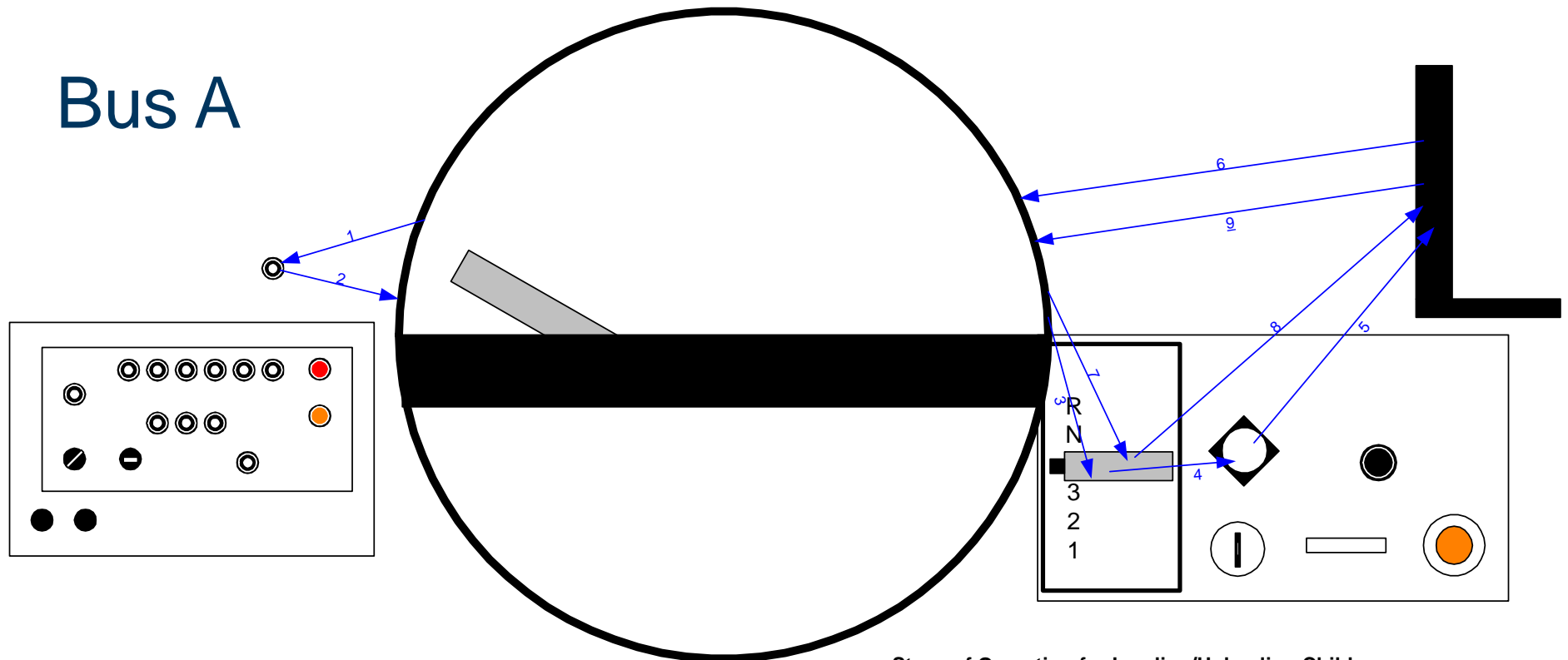
Flashers, gear selection, parking brake, and door open

From Video to Driver Cockpit Layout

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Bus A

R
N
3
2
1

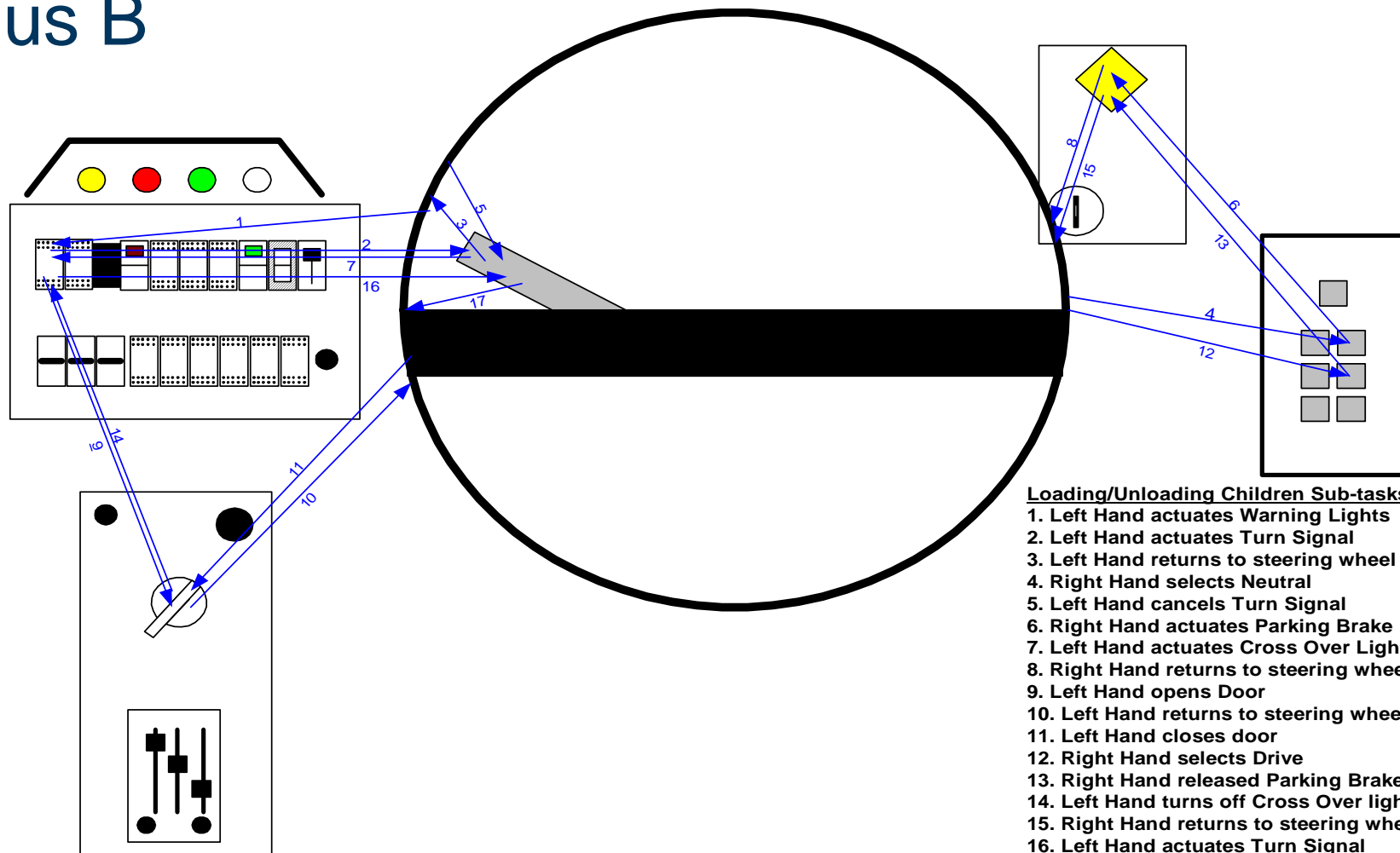**Steps of Operation for Loading/Unloading Children:**
1. Left Hand actuates Warning Lights
2. Left Hand returns to steering wheel
3. Right Hand selects Neutral
4. Right Hand actuates Parking Brake
5. Right Hand actuates Door Openner
6. Right Hand returns to steering wheel
7. Right Hand selects Drive
9. Right Hand releases Parking Brake
10. Right Hand closed Door
11. Right Hand returns to steering wheel

Bus B

Loading/Unloading Children Sub-tasks:
1. Left Hand actuates Warning Lights
2. Left Hand actuates Turn Signal
3. Left Hand returns to steering wheel
4. Right Hand selects Neutral
5. Left Hand cancels Turn Signal
6. Right Hand actuates Parking Brake
7. Left Hand actuates Cross Over Lights
8. Right Hand returns to steering wheel
9. Left Hand opens Door
10. Left Hand returns to steering wheel
11. Left Hand closes door
12. Right Hand selects Drive
13. Right Hand released Parking Brake
14. Left Hand turns off Cross Over lights
15. Right Hand returns to steering wheel
16. Left Hand actuates Turn Signal
17. Left Hand returns to Steering Wheel

Design Recommendation

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Steps of Operation for Loading/Unloading Children:
1. Left Hand actuates turn signal
2. Right thumb actuates warning lights
3. Right Hand selects Neutral
4. Right Hand pulls parking brake
5. Right Hand returns to steering wheel
6. Right Thumb actuates red cross-over lights
7. Left Thumb opens door

Children Load/unload
8. Right Hand selects DRIVE
9. Right Hand releases parking brake
10. Left Thumb closes door
11. Right Hand resumes steering position
12. Left Hand actuates turn signal
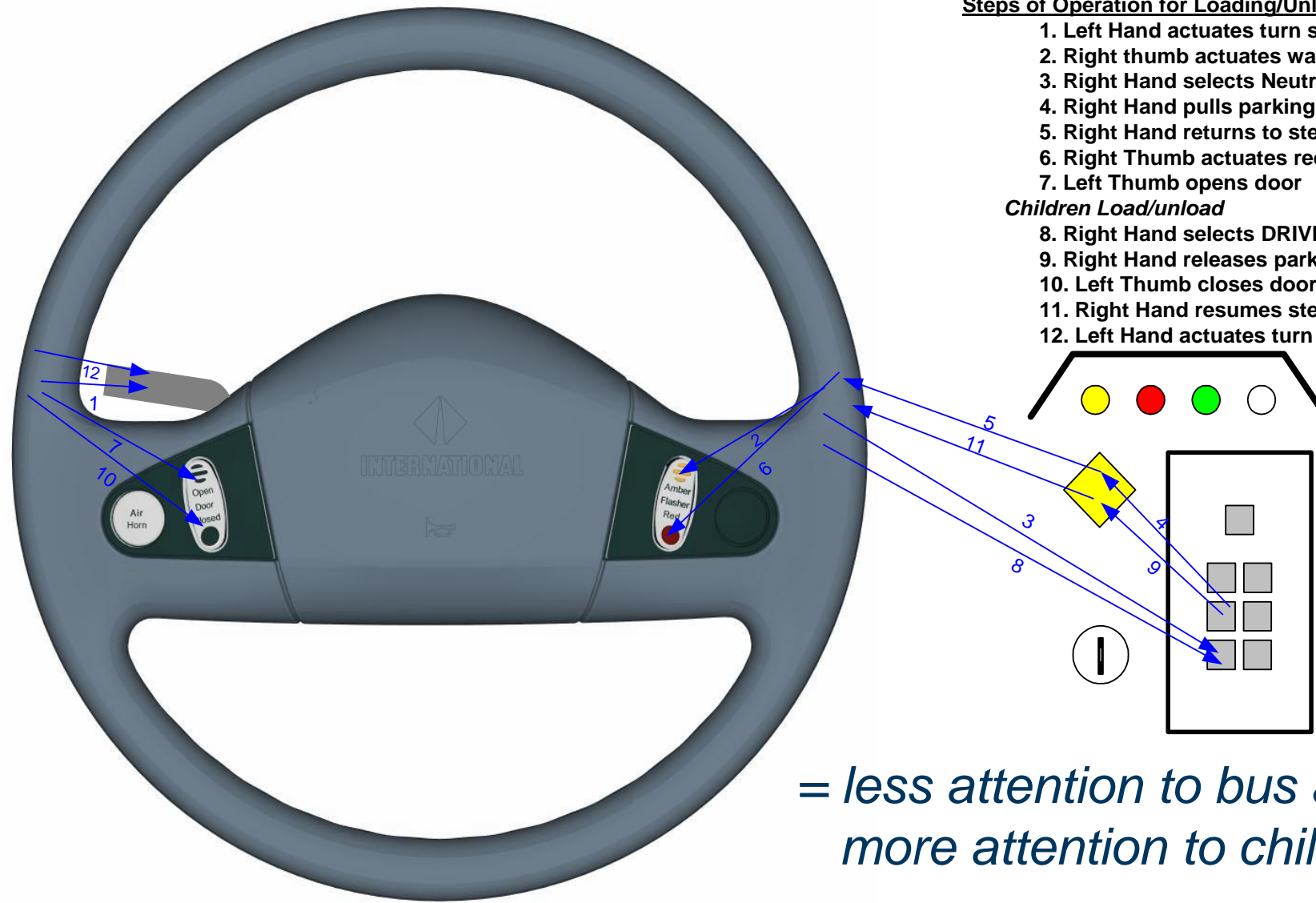
= *less attention to bus and more attention to children*

Old Design

New Design

- Functions moved to steering wheel
- Parking brake located closer to driver

Case Study 2: Steering wheel controls for a new Line Haul tractor

Background

- New line haul tractor program (re)initiated
  - Opportunity to create new driver package and update cockpit
  - Needed to understand line haul drivers' tasks
- Collected naturalistic video data and conducted task analysis
  - Focus on incorporating more switches on the steering wheel to free up instrument panel space

Collected video of line haul drivers

- Three evaluation rides, 3 drivers
  - California (Round-trip: Corona – Bakersfield)
  - Wisconsin (Round-Trip Twice: Marshfield – Sheboygan)
  - Georgia (Round Trip: La Grange – Atlanta)
- Reduced 30 hours of video during 1400 miles of driving
  - Seven specific driving tasks identified
    - Left turns
    - Right turns
    - Lane change left
    - Lane change right
    - Start from a stop
    - Backing
    - Parking

These tasks comprised only 9% of total driving time

Camera Setup

Multiplexed Video Image

Driver face view

Driver feet view

03-07 10:29:56:21

Forward roadway scene view

Steering wheel, gear selector, instrument panel and button panel view

Backing to Dock

Hand Movement Link Associations across all tasks
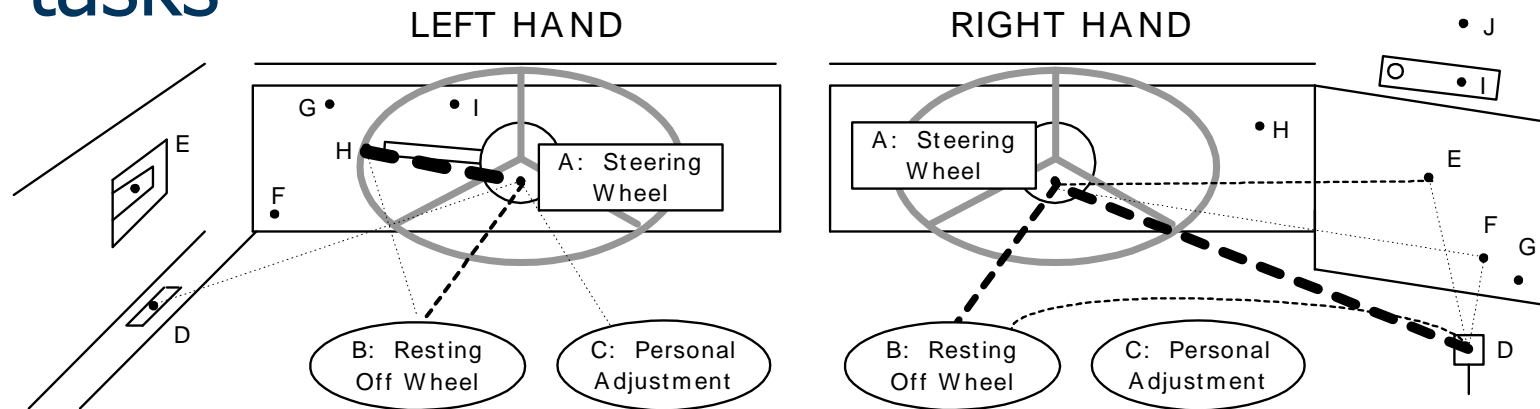
Left Hand	
A:	Steering Wheel
B:	Resting Off Wheel
C:	Personal Adjustment
D:	Driver window
E:	Driver door
F:	Ignition
G:	Turn signal
H:	Hazard lights
I:	Steering tilt

Transition Percentages

2-3%	....
4-7%	---------------
8-15%	- - - - - - - -
16-31%	– – – – – – –
32-63%	— — — — — —
64-100%	▬ ▬ ▬ ▬ ▬ ▬

Right Hand	
A:	Steering Wheel
B:	Resting Off Wheel
C:	Personal Adjustment
D:	Shifter
E:	Button panel
F:	Parking brake
G:	Trailer air supply
H:	Phone
I:	Radio
J:	CB

Summary of Button Usage

Button	Driver 1 (CA) (8.5 hrs)		Driver 2 (WI) (9.9 hrs)		Driver 3 (GA) (8.9 hrs)		Total (27.3 hrs)	
	Total	# / hr	Total	# / hr	Total	# / hr	Total	# / hr
Engine Brake	11	1.3	54	5.5	2	0.2	67	2.5
Headlights	38	4.5	5	0.5	2	0.2	45	1.6
Cruise on/off	14	1.6	18	1.8	0	0.0	32	1.2
Fan Override	9	1.1					9	1.1
Cruise set	6	0.7	11	1.1	11	1.1	28	1.0
Marker Flash	8	0.9	1	0.1	4	0.4	13	0.5
Wipers	12	1.4	0	0.0	0	0.0	12	0.4
Mirror Adjust	2	0.2	0	0.0	1	0.1	3	0.1
Total	100	11.8	89	9.0	20	2.2	209	7.7

HEAVY	None	City Horn	Air Horn	Cruise	Radio	Marker Interrupt	Headlight Flash	Engine Brake	HVAC	Shift Control	Head Lights	Phone	Traction Control	Driver Information Center
International		X	X	X	X	X	X	X		X				
Freightliner	X													
Volvo		X	X	X	X	X	X							
Kenworth		X	X	X		X	X	X						
Peterbilt	X													
Sterling	X			X										
Western Star	X													
Mack	X				X									

AUTO	None	City Horn	Air Horn	Cruise	Radio	Marker Interrupt	Headlight Flash	Engine Brake	HVAC	Shift Control	Head Lights	Phone	Traction Control	Driver Information Center
Honda		X		X	X									
Cadilac *		X		X	X				X			X		X
Buick		X		X	X				X					X
Lexus		X		X	X									
Land Rover		X		X	X									
Mercedes		X		X	X							X		X
Pontiac		X		X	X									
Chrysler		X		X	X									

Supplementing the Task Analysis Data

Driver Preferences

Importance of Having the Control Located in the Steering Wheel, n=20

Control	City Horn	Air Horn	Cruise	Radio Channel	Radio Volume	Engine Brake	Marker Interrupt	Headlight Flash	Auto/Manual	shift up/down
Series1	76.6	62.1	74.5	35.9	36.4	51.1	51.3	52.7	61.9	65.8
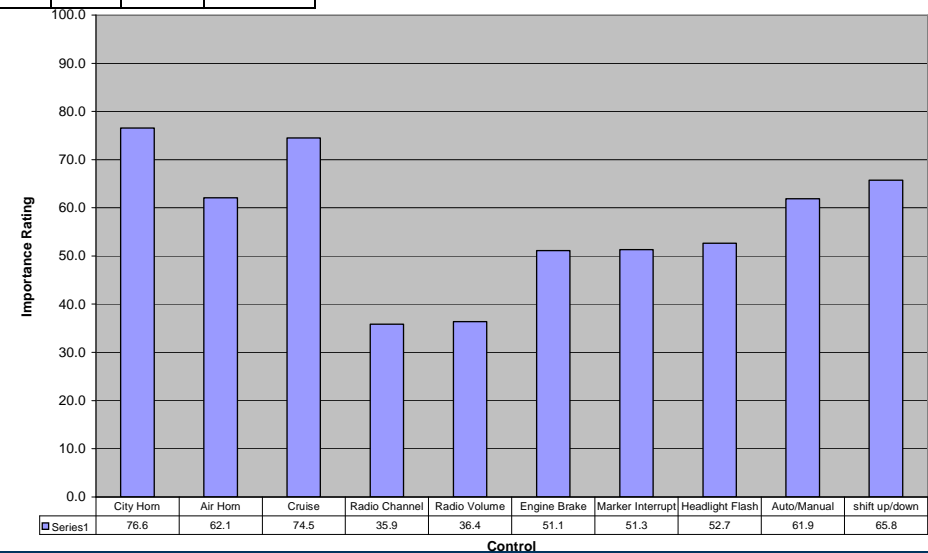
Proposed Steering Wheel Controls:

- City and Air Horns
- Cruise
- AMTC shift up/down
- Radio Volume/Seek
- Engine Brake
- Marker Interrupt
- Headlight Flash

Conclusions and Observations

- Naturalistic video provides useful data to improve product design
  - Use in conjunction with other data (benchmarking, customer surveys, etc.)
- Product program development timelines and resource availability limit opportunity to collect video data
- Need master data base that could be mined for specific product design applications

Questions