Distraction Effects of Manual and Voice Interfaces Used for

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Background

- NHTSA is interested in assessing how in-vehicle technologies impact driver behavior and driving safety
- Recent state initiatives limiting wireless phone use have been based on the assumption that hands-free is safer than hand-held
- Manufacturers hope that voice-based in-vehicle systems will prove to be safer than manual counterparts
- With hands-free interfaces, drivers may keep their eyes on the road, and hands on the wheel

Research Program

- **NHTSA has three ongoing studies addressing issues relating to voice versus manual interfaces**
  - Wireless phone on-road study
  - Voice interface test track study
  - NADS wireless phone research (upcoming)
- **Presentation covers preliminary results of a series of analyses that are underway for the above on-road and test track studies**

Wireless Phone On-Road Study: Objectives

- **Compare phone use patterns for different interface designs**
- **Compare distraction effects for different interface designs**
  - Assess effect of phone use on measures of driving behavior
  - Assess effect of phone use on eye glance behavior

Wireless Phone On-Road Study

- **Naturalistic Study**
  - Instrumented vehicles driven by 10 members of general public for 6 weeks during their normal daily driving
  - Phone interface was changed every 2 weeks
  - Data collected 10/00 – 3/01
- **Drivers selected who used wireless phone regularly while driving**
- **Ages 25 – 55**

INTELLIGENT VEHICLE INITIATIVE

Wireless Phone Study- Interface Conditions

- Commercially available AutoPC systems, purchased in 2000, were present in the vehicle under all phone interface conditions AutoPC instructions were intended to mask study objective

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Wireless Phone Study - Interface Conditions

Interface	*Dialing*	*Conversation*
Hand-held	**Manual**	**Hand-held**
Conventional hands-free	**Manual**	**Hands-free**
Enhanced hands-free	**Voice*** **(digit & tag, *via AutoPC*)**	**Hands-free**

- **** May include some cases of manual input**
- **Order of interface condition presentation was counterbalanced**

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Wireless Phone Study – Data Collected

- **Two data collection phases**
  - Phase 1 (5 subjects)– Event-based sampling
    - – All data obtained for first 2 days in each condition
    - – For remaining days, data obtained during phone use and 2-minute baseline samples
  - Phase 2 (5 subjects)– Continuous sampling
    - – Data obtained during all driving
- **Variety of driver behavior and performance metrics**
- **Phone conversations partially recorded for analysis of conversation content**

Data Analysis Overview

- **Analyses focus on differences between interface conditions**
- **Analyses conducted on 5 topics:**
  - ↘ Exposure analyses (driving undertaken in the study)
  - ↘ Phone usage patterns
  - ↘ Effects of phone use on eye glance behavior
  - ž Effects of phone use on driving behavior
    - – E.g., speed, lane-position variability
  - ž Phone conversation characteristics
    - – Relationship to driving behavior

(↘ *First 3 topics will be briefly discussed here*)

Phone call rates by driving time and mileage (All moving calls)

Interface	Driving hours	Driving miles	Phone calls	Calls per hour	Calls per mile	Total phone hours	% driving hours (on phone)
Hand-held	100.3	2919	180	1.79	.062	9.13	9.1
Hands-free Talking	87.1	2549	163	1.87	.064	5.79	6.7
Enhanced Hands-free (*includes manual interface)	109.2	3343	214*	1.96*	.064*	5.78*	5.3*

Summary of Phone Use Results

- **On average, drivers engaged in**
  - 1.87 calls (moving) per hour (based on all moving calls)
    - 6.3 calls per 100 miles
  - 2.25 calls (overall) per hour (based on Phase 2 data)
    - 7 calls per 100 miles
- **Calls involved 5-9% of driving time**
- **Average call duration was 2.4 minutes (SD = 3.5 min)**
  - Median call duration was 1.2 minutes
  - Longest call was 27 minutes

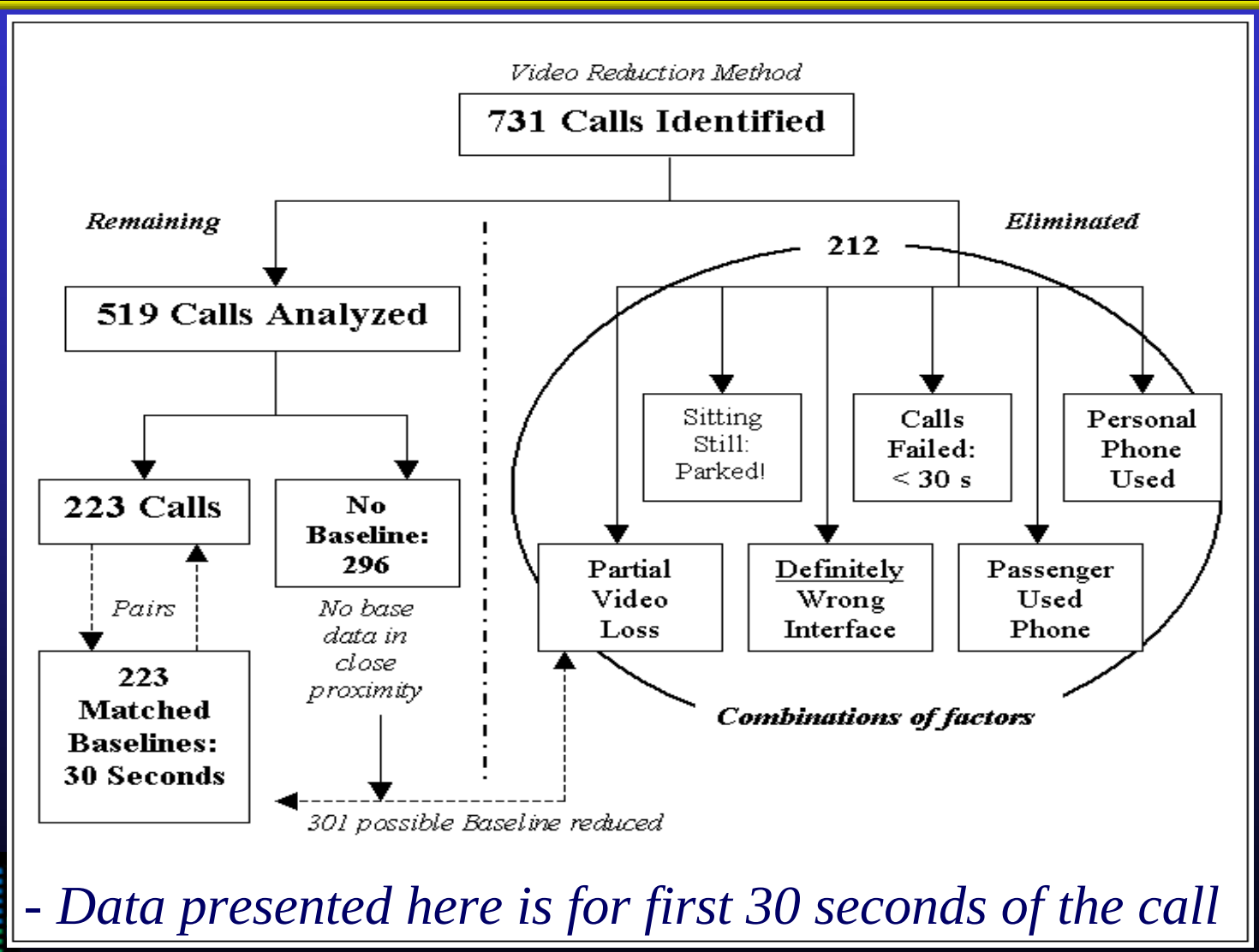
Phone Call Duration (All moving calls)

Interface	Phone calls	Mean duration (sec.)	SD
Hand-held	180	204.8	288.4
Hands-free Talking	163	136.6	198.6
Enhanced Hands-free (* Manual dialing)	93 121*	120.8 107.1*	174.0 138.9*

Summary of Phone Use Results- Effects of interface

- **Drivers used phone with hand-held interface more often and for longer durations**
  - Possible effect of familiarity?
  - Drivers may have felt less comfortable making hands-free calls due to aspects of use
- **More than half of calls made in enhanced hands-free condition were made manually**
  - Drivers often ignored instructions and bypassed voice dialing
  - This implies drivers found voice dialing difficult or inconvenient

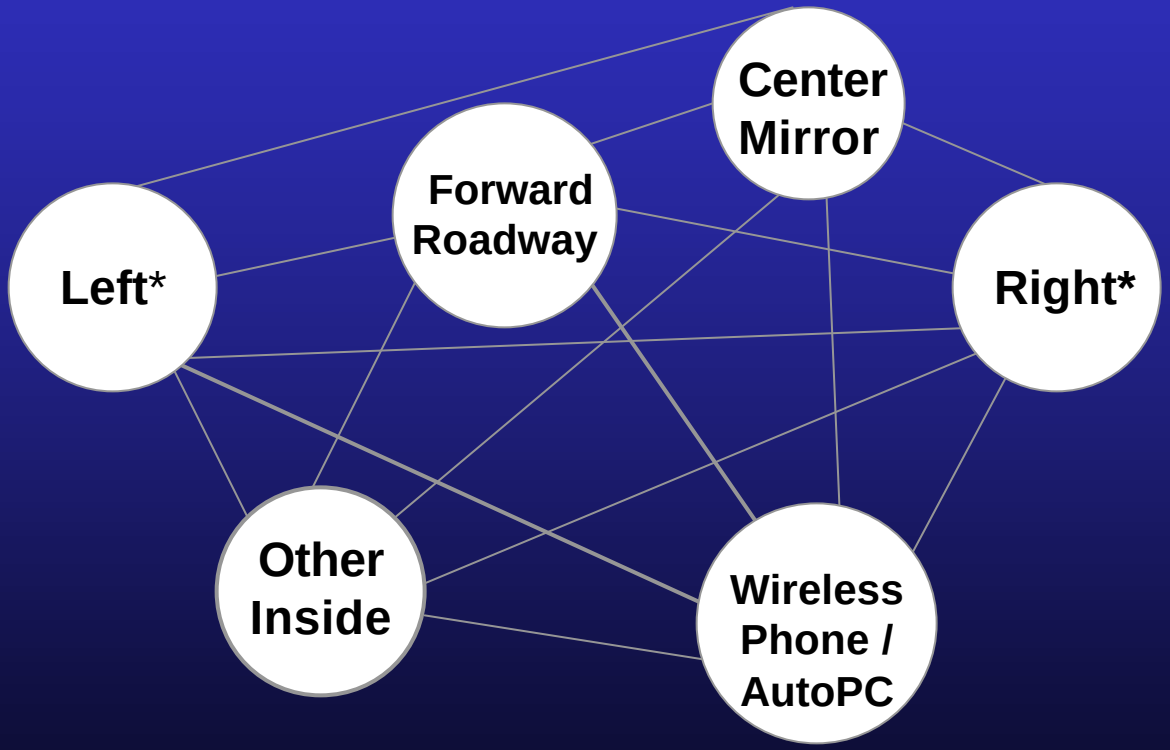
Breakdown of Calls



- *Data presented here is for first 30 seconds of the call*

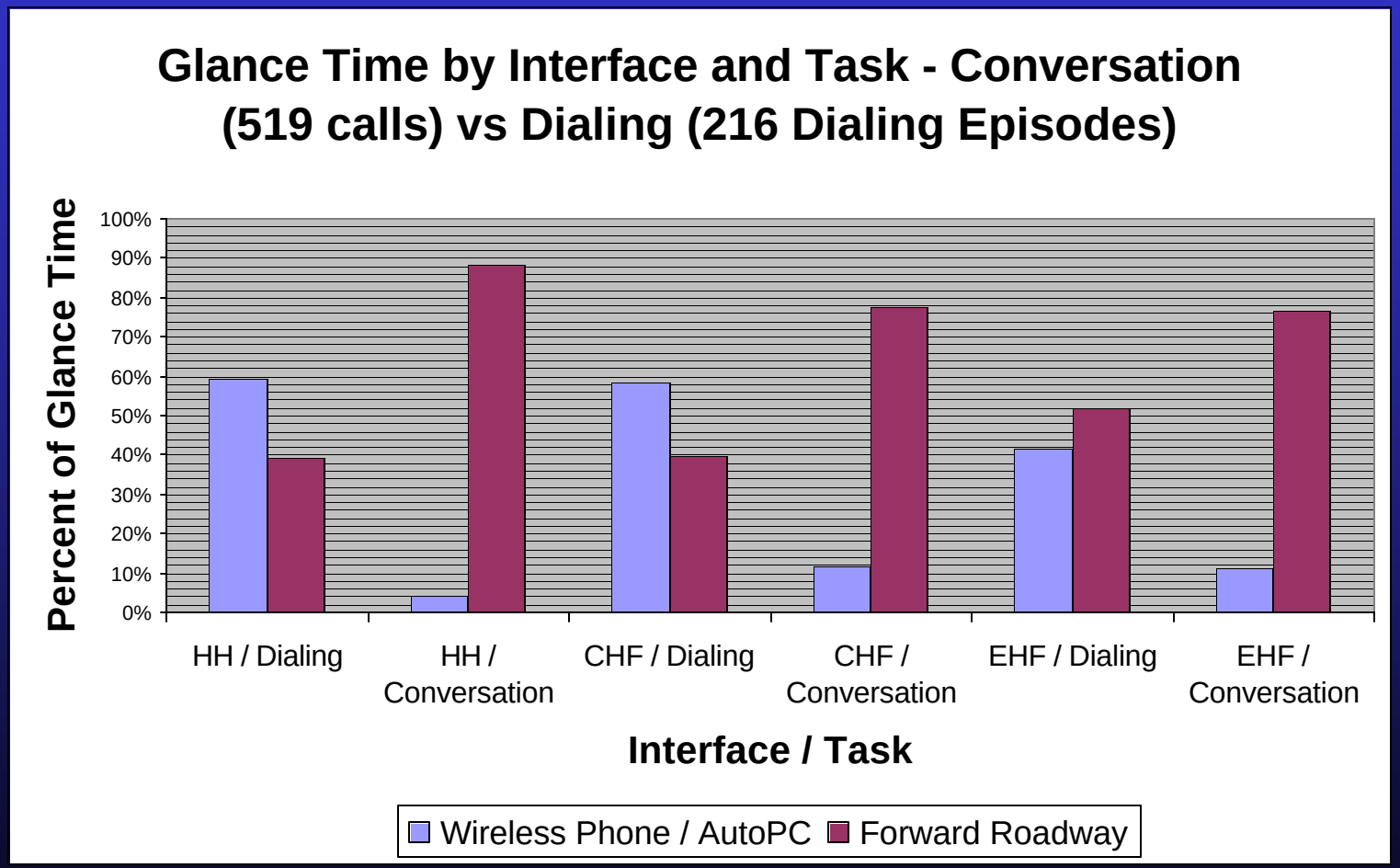
Eye Glance Behavior

- **Glance locations examined**



** 'Left' includes glances to left side mirror, out left window, and over the left shoulder. Likewise for 'Right'*

Glance Time Results by Interface



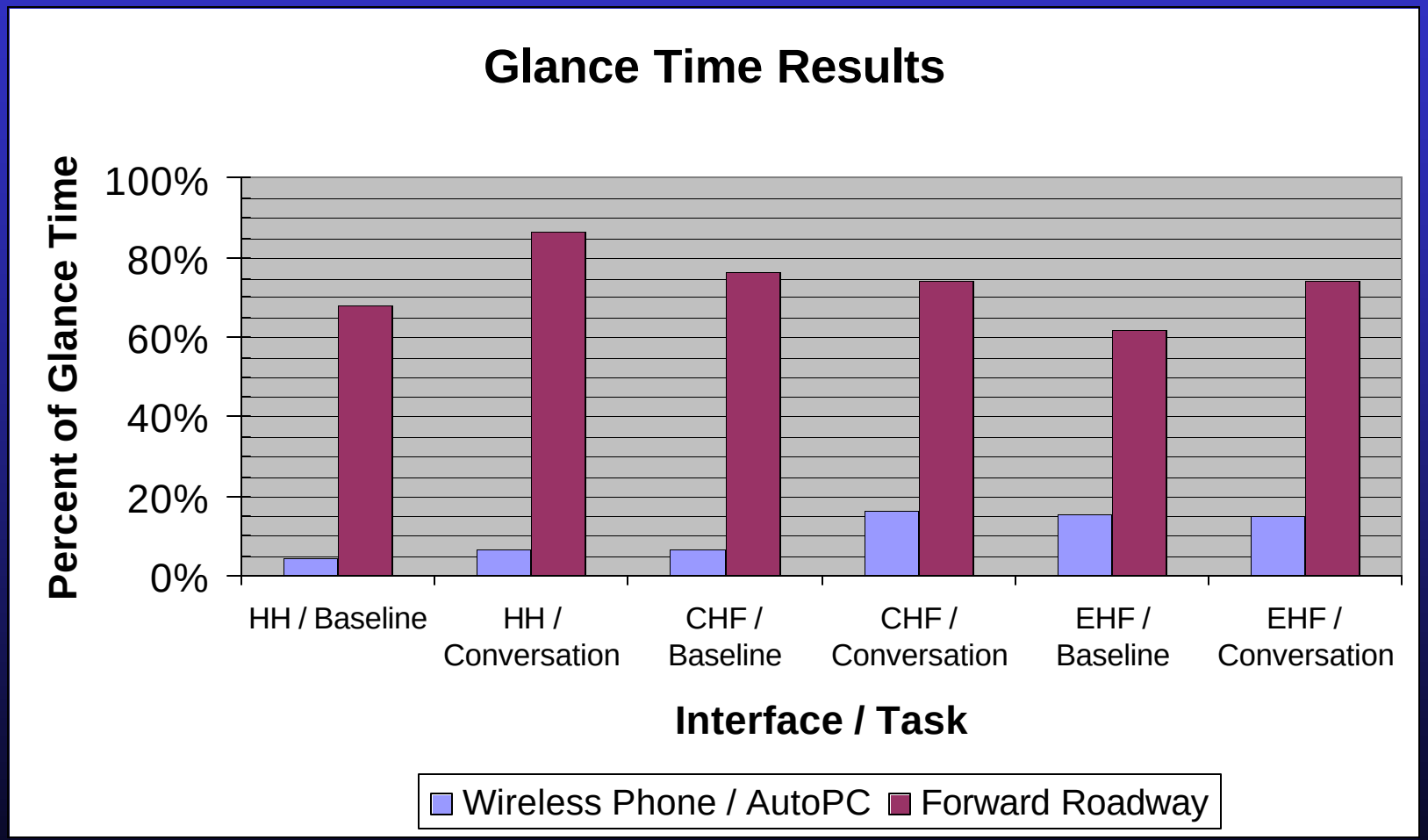
Eyes on the Road

- **Selected glance data results:**
  - Drivers looked away from the forward roadway more during dialing than during conversation
    - Enhanced hands free dialing shows a benefit (more glances to forward roadway, less to wireless phone/AutoPC) but still involves more glance time to wireless phone/AutoPC than during conversation

Eyes on the Road

- **Selected glance data results:**
  - Subjects looked forward more during hand-held conversation than in any other condition.
  - Hands-free conversation is associated with more time spent looking left and right, suggesting better situational awareness

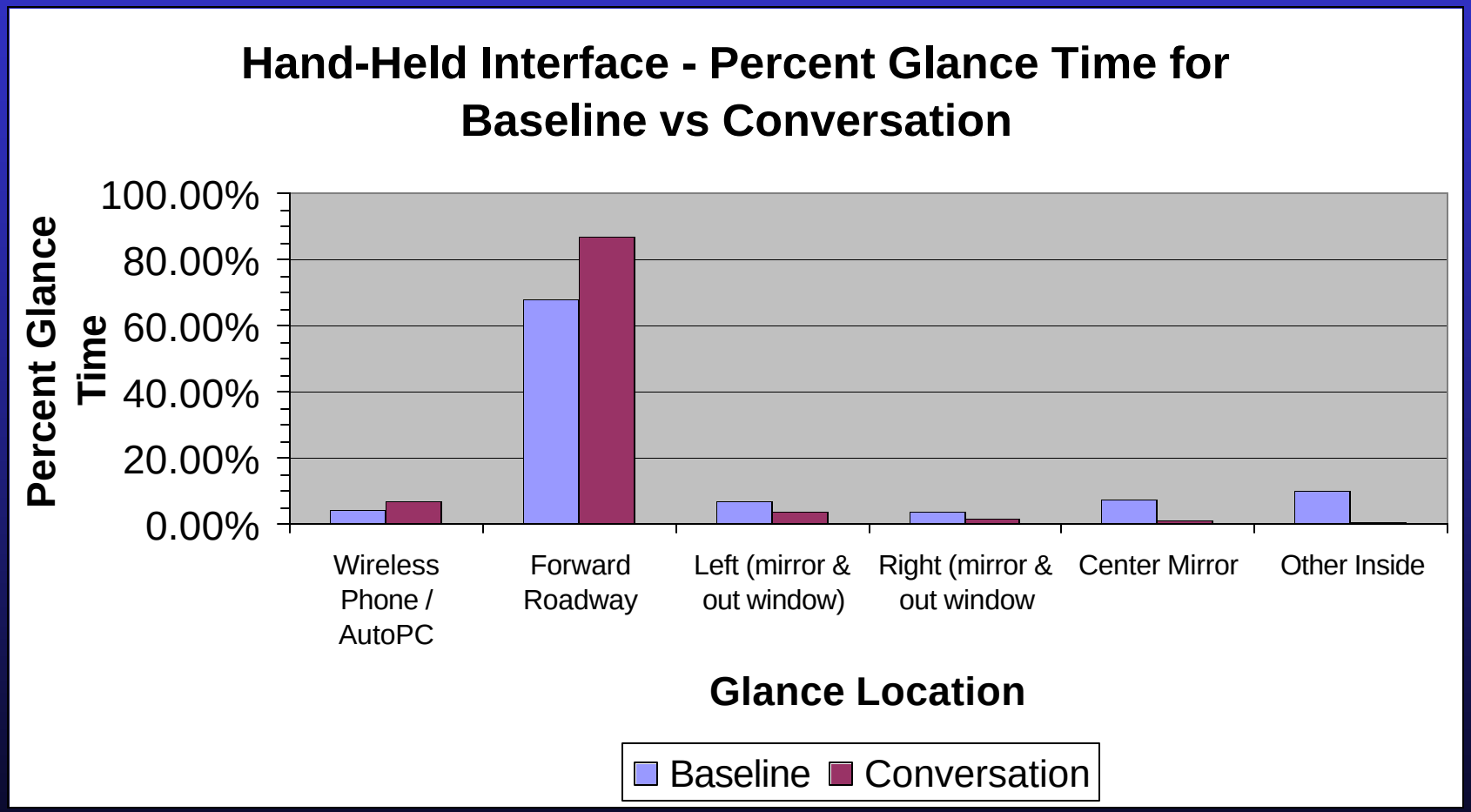
Glance Time Percentage Results by Interface - Baseline vs Conversation



Changes in Baseline Glance Proportions by Interface Condition

- **The proportion of baseline glances to the wireless phone / AutoPC location was higher in the enhanced hands-free condition than in the other 2 interface conditions**
- **This may be due to subjects looking at the AutoPC even when they are not making a call (e.g., glances without manipulation of the system, radio tuning, etc)**

Proportion of Glance Time By Location (59 Matched Pairs)



Additional Analyses Underway

- Hands on the wheel
- Conversation content effects on driving behavior
- Effects of phone use on driving performance

Hands on the Wheel

- **Hypothesis: Drivers will keep their hands on the steering wheel more with hands-free interfaces**
  - We are examining data now to assess whether subjects had 2 hands on the wheel a larger percentage of time (during dialing and conversation) in the hands-free conditions than with hand-held.
  - Qualitative observations suggest that a large number of tasks that were initiated in voice mode, had to be completed manually due to problems with the voice interface.

Effects of Conversation Content on Driving Behavior

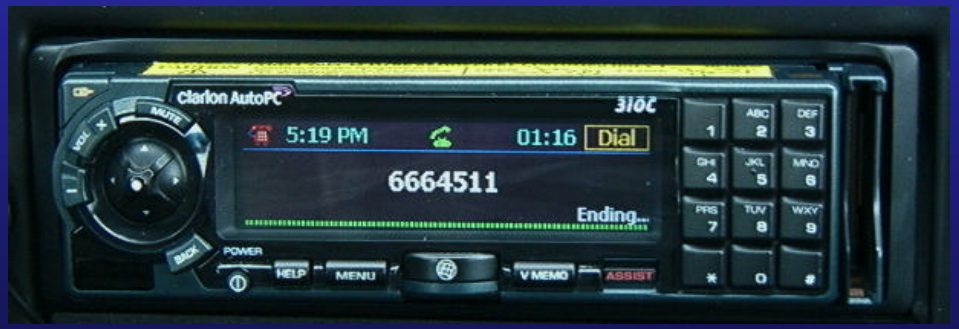
- **Hypothesis: The type of conversation may affect driving behavior**
  - We are examining data now to assess how the complexity or emotional content of a phone conversation may affect driving behavior

What We've Learned So Far

- **Some subjects had considerable difficulty with the voice interface**
- **Glance location analyses show**
  - Reduced situational awareness during hand-held conversation
  - Substantial percentage of glance time looking at phone during hands-free conversation
- **Clinical review of selected phone conversations reveals significant distraction**

Voice Interface Test Track Study

- **Cooperative study between NHTSA and Transport Canada**
- **Compare voice and non-voice technologies for:**
  - Phone dialing
  - Radio tuning
  - E-mail retrieval



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Voice Interface Test Track Study Design

- **21 subjects drove approximately 20 laps on TRC's 7.5 mile oval test track in 2 half-day sessions**
- **Subjects used one interface for each session**
  - Manual interface
  - Voice interface (AutoPC)
- **Subjects comprised two different groups**
  - Group 1: 11 TRC test drivers (Mean age = 47)
  - Group 2: 10 VRTC engineers (Mean age = 32)

Voice Interface Test Track Study Design

- **Subjects performed three concurrent tasks:**
  - Car-following (sinusoidal speed input, 35-55 mph)
  - Secondary tasks
  - Peripheral Detection Task (PDT)
    - Matrix of LEDs reflect off windshield
    - One LED activated every 4-6 seconds
    - Driver responded via button press
- **Tasks significantly loaded the driver**

Voice Interface Test Track Study Design (cont.)

- **Secondary tasks**
  - Simple:
    - Radio tuning (continuous)
    - Phone dialing (continuous)
    - Retrieve email message, record voice memo of shopping list (performed in sequence)
  - Complex:
    - Retrieve email message, find # in address book, place phone call, record voice memo with info from phone call (performed in sequence)

Voice Interface Test Track Study

- Used eye tracker to record glances
- Driving performance, PDT performance, and eye glance behavior are being analyzed

- Results will help determine whether a voice interface reduces interference with driving in a controlled car-following task, relative to a manual interface.

Preliminary Results - Phone Dialing

Performance measure	Manual interface (SD)	Voice interface (SD)
Numbers dialed	5.4 (1.3)	1.0 (1.2)
Equipment problems	1.1 (0.3)	2.5 (0.6)
Subject performance problems	1.1 (0.3)	0.7 (0.4)

Interpretation of Results

- **Subjects dialed more numbers when using the manual interface**
- **Subjects had more difficulty using the voice interface for phone dialing**
  - Difficulty was due primarily to problems with the equipment, rather than the procedure

Preliminary Results: Secondary Task Completion Times – All Tasks

- TRC driver group was slower in task completion than VRTC engineer group
- Interaction of ‘Group’ and ‘Interface’ approached significance (p = .08)

Preliminary Results: Secondary Task Completion Times – All Tasks

- **Difference by driver type**

	TRC Drivers Mean (SD)	VRTC Engineers Mean (SD)
Manual	143.0 (48.0)	114.8 (43.7)
Voice	136.9 (47.7)	118.3 (45.6)

Additional Analyses Underway

- Effects of interface on car following performance
- Effects of interface on PDT performance
- Effect of interface on eye glance behavior

Preliminary Overall Conclusions

- **Both studies reveal problems with the particular voice interface used**
- **No clear benefit of this voice interface on secondary task performance**

Example of Subject Difficulty with Voice Interface

(video from on-road wireless phone study)

NADS Distraction Studies

- **Wireless phone studies**
  - Study 1: Effects of different interfaces on dialing, talking and answering phone in driving situations that vary in driving task demand
    - Experiment to be run in mid-2002
    - Results will complement on-road study findings
  - Study 2: Conversation Content
  - Study 3: Willingness to Engage in Wireless Calls While Driving

The End

Thank you for your attention!

Questions?