



# Evaluation of the VOLVO Truck Demonstrator

VTI/VTEC

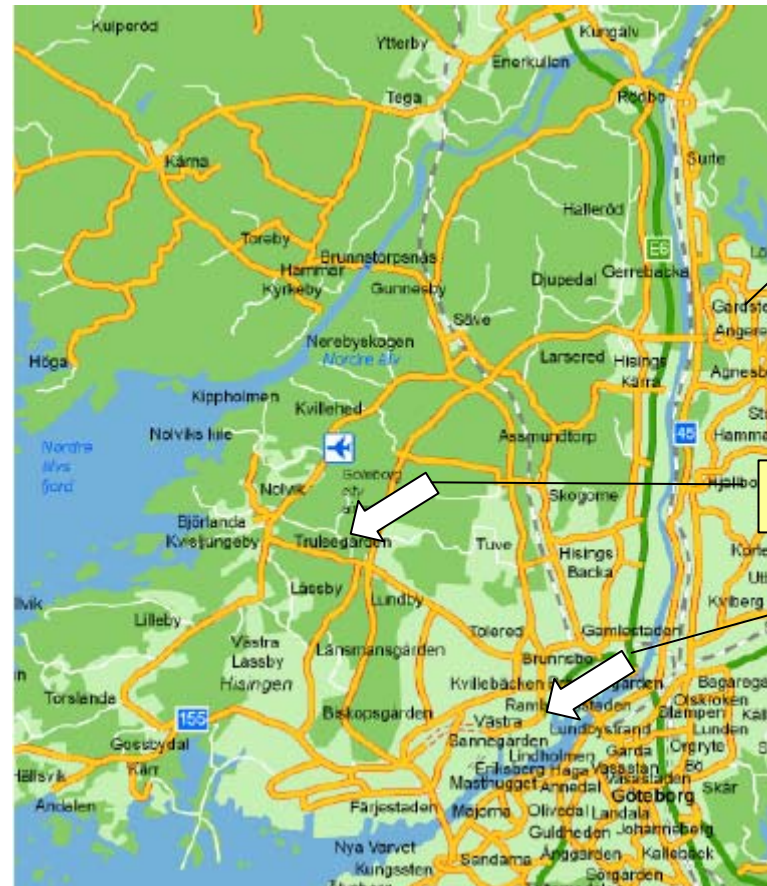
# Experimental design - route



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- Urban (50km/h) and interurban (70/90 km/h) road – approx 40 minutes drive
- Same route all drives, location of UC triggering predetermined – same for all cases
- Rush hours avoided
- Training of in-vehicle systems and tasks preceded the drive
- Start and end at VTEC



Gårdsten

Lundbyleden

Start and finish



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# Experimental design – the vehicle



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Push to talk

Speech microphone



Nomad phone



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# Experimental design – 8 Use Cases



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Demonstrator use case group	Use Case	AIDE	Non-AIDE
Rescheduling to resolve channel conflict	Driver looking for vehicle state information – incoming message (UC5)	Message delayed	Message not delayed
Rescheduling to resolve workload conflict	Intersection with traffic light – incoming phone call (UC7)	Phone call delayed	Phone call not delayed
Output form modification to resolve between channel conflict	Reading SMS – warning message (UC9)	Visual + voice	Visual + sound
Output form modification to resolve workload conflict	Intersection driving demand – warning message (UC8)	Visual + voice	Visual + sound
Output form modification to resolve inattention conflict	High cognitive workload – warning message (UC10)	Visual + voice	Visual + sound
Nomadic device integration	Incoming phone call, outgoing phone call, MP3 song (UC2,3,4)	Integrated HBK + SID	Handheld phone

All UC were repeated 2 times – in total 16 tasks/drive



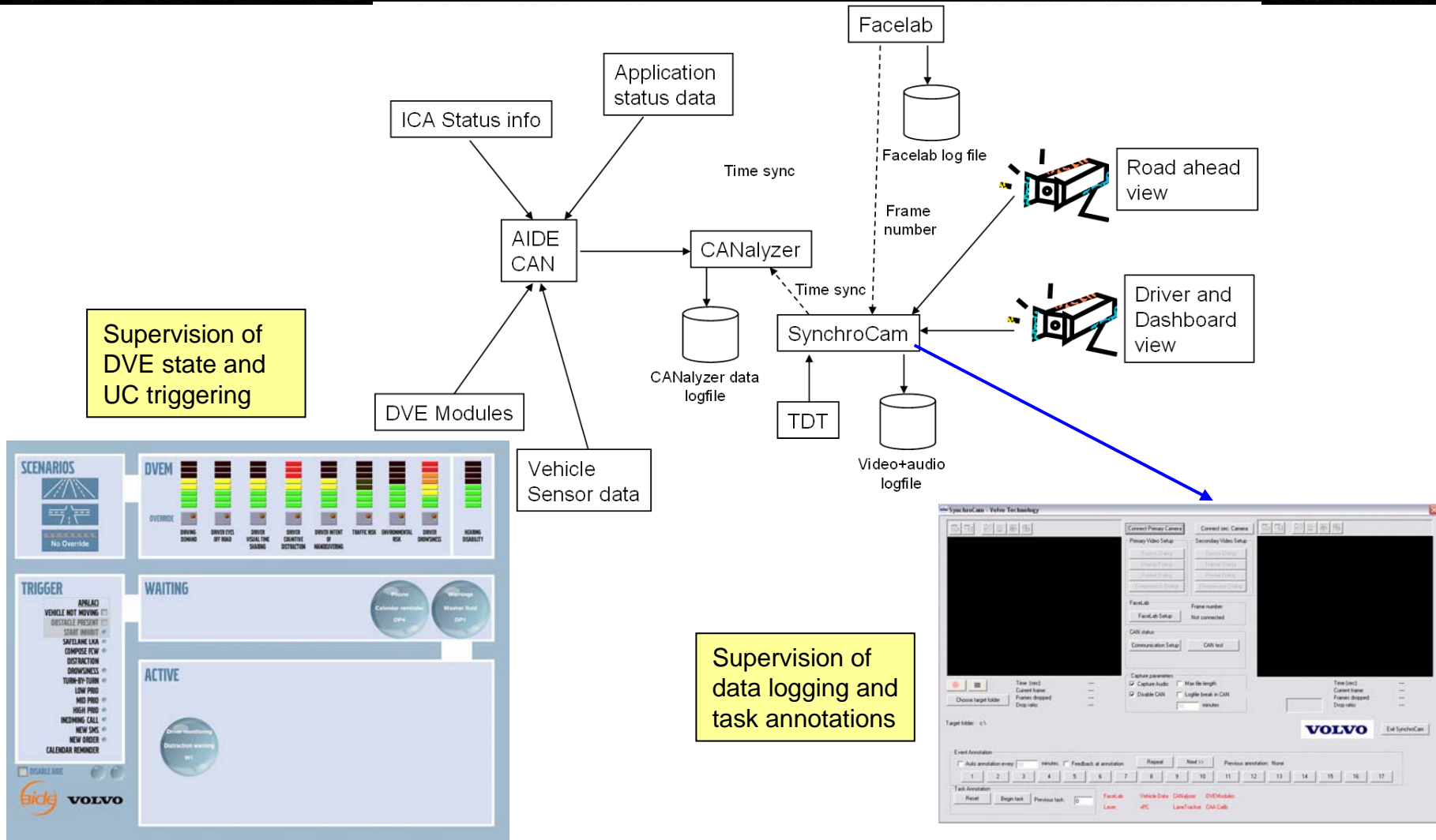
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# Experimental design – triggering and data logging



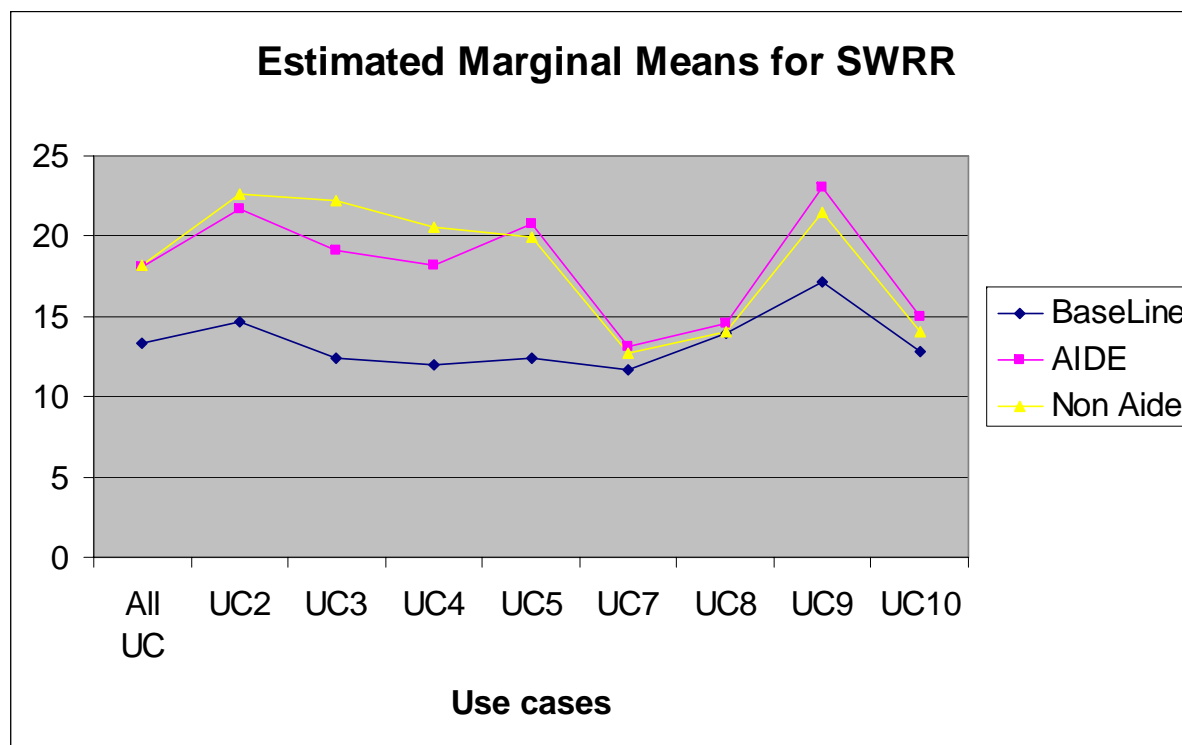
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# Objective data - SWRR



SWRR  
• Gap size = 3  
• LPF = 0.6 Hz

- Higher Visual WL for A and NA in total and for all UC except 7,8 and 10
- Higher for NA v. A for UC3 (phone out)



# Objective data – Speed Control



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- Mean speed lower for NA and A vs. BL – total of all UC
- Mean speed was lower for NA vs. BL for all UC (individually) except UC2, 9
- Mean speed was lower for A vs. BL for UC4
  
- Max speed few significant differences (NA lower vs. BL in UC3,4,5)
  
- Sd speed higher for NA and A vs. BL – total of all UC
- Sd speed higher for NA and A vs. BL in UC4 and 9
- Sd speed higher for NA vs. A in UC2
  
- Conclusion: Lower speed and higher Sd speed in A and NA vs. BL



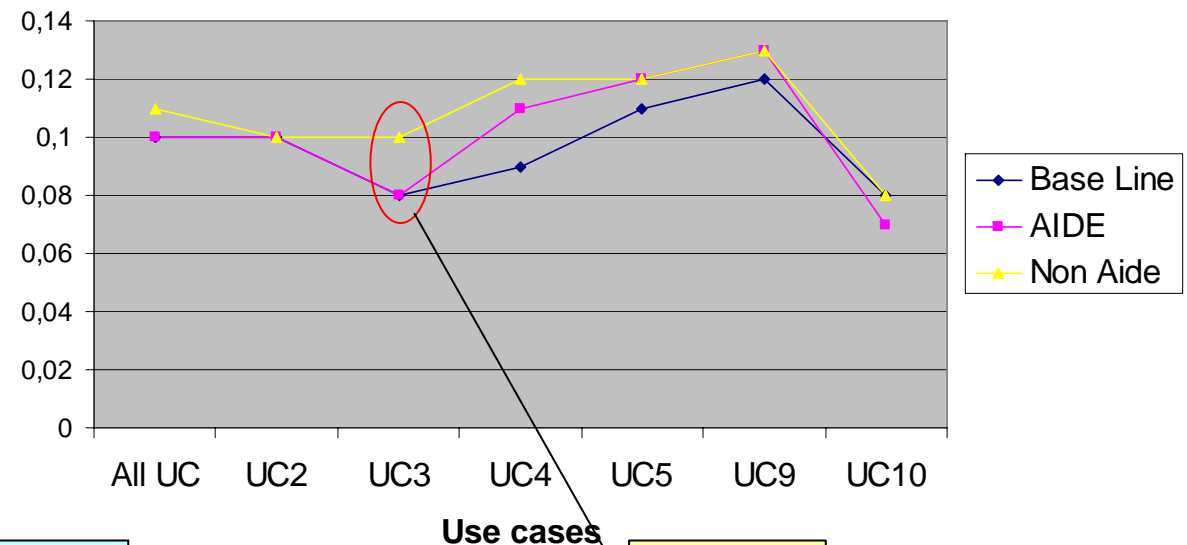
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# Objective data - Lateral Control



- Poor lateral data in many cases
- MSDLP, LC
- Very few differences only MSDLP
- TLC not feasible

Estimated Marginal Means for Mod SDLP



• UC 3 Making a phone call

- A < NA
- BL < NA



# Objective data – Eye Gaze data



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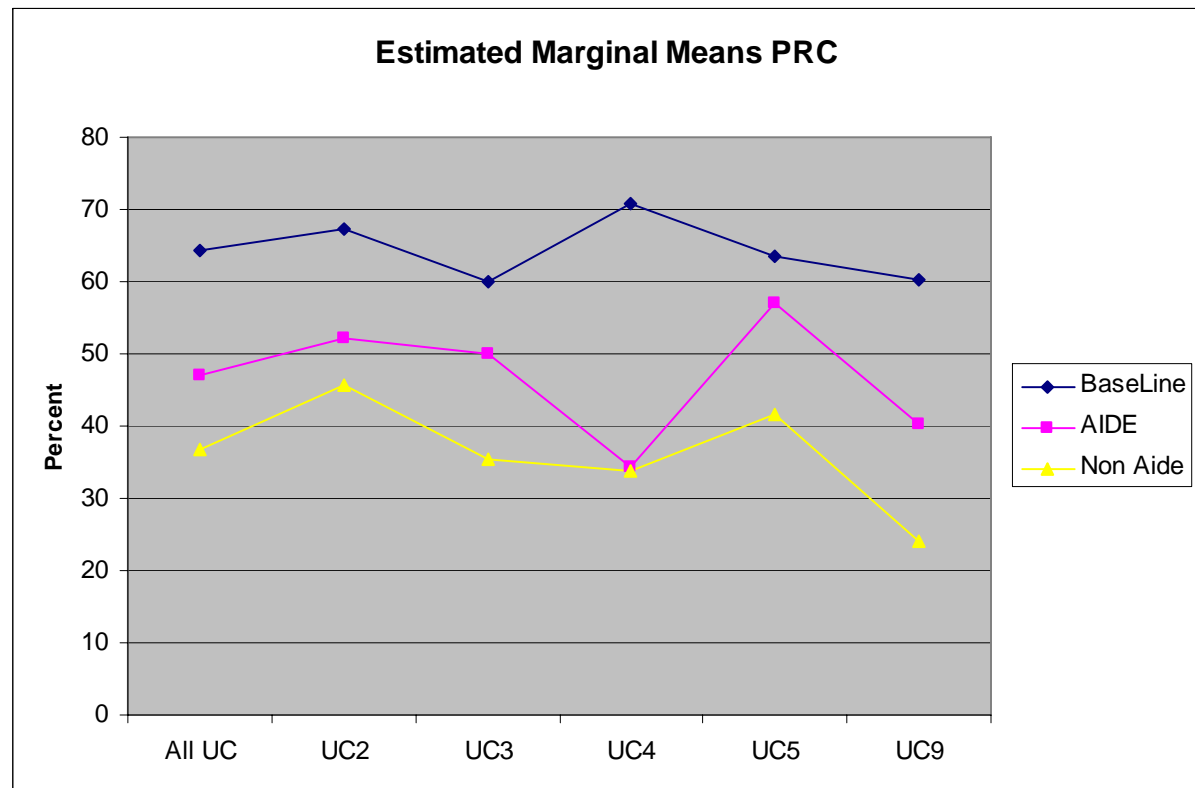
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- FaceLab – 2 camera system
- VDM tool for analysis
- Metrics – PRC, GF, TGT
- Only UC 2, 3, 4, 5 and 9

- NA < BL for All UC (total), all UC (individually)
- A < BL for All UC (total), all UC (individually) except UC5
- NA < A for All UC (Total), all UC (individually) except UC4

Aide helped the drivers to keep their eyes on the road

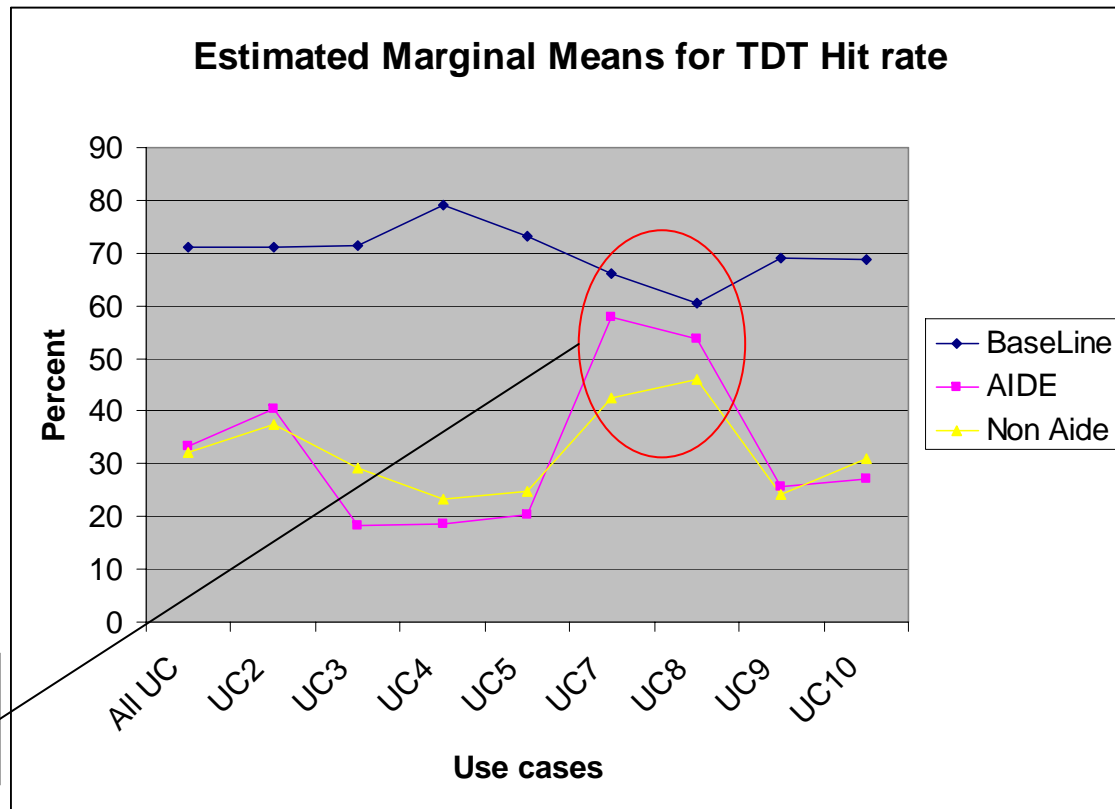
## Percent Road Centre



# Objective data – TDT Hit Rate



- Hit rate lower for NA vs. BL
- Hit rate lower for A vs. BL except UC 7, 8
- Hit rate higher for A vs. NA UC7



- UC7 Delayed phone call
- UC8 Message at intersection

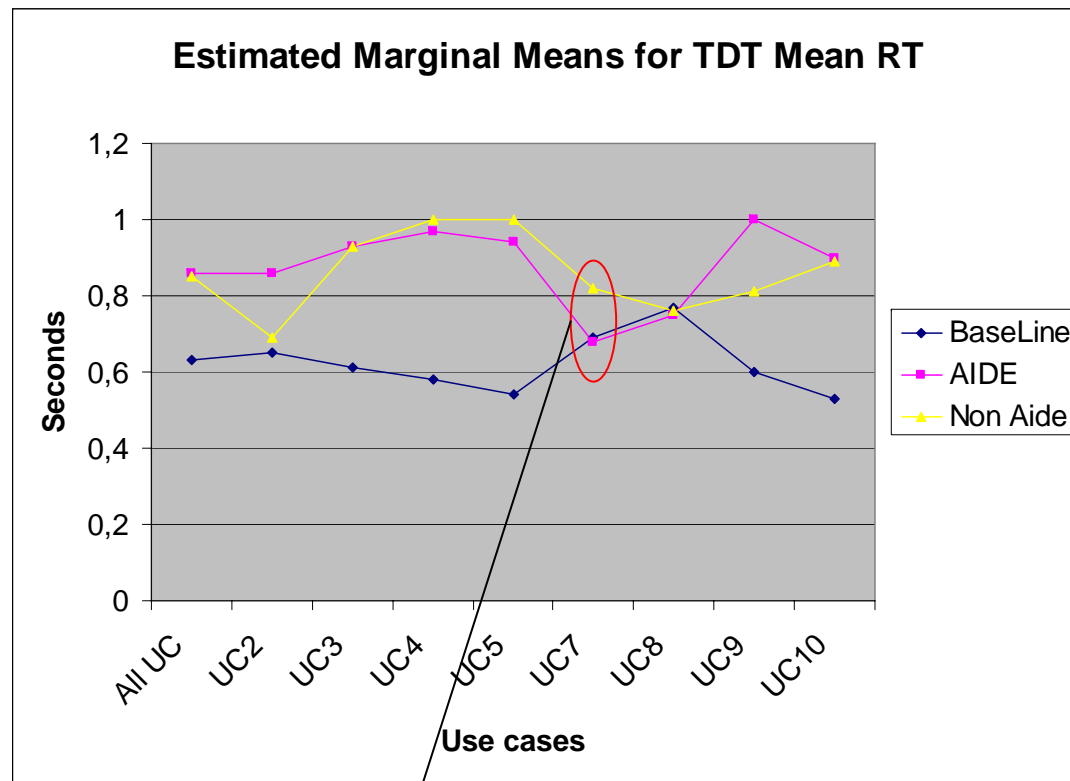


# Objective data – TDT Reaction Time



- RT longer for NA and A vs BL All UC (total)
- RT longer for NA and A in most UC (individually)
- RT longer for NA vs. A in UC2, 7 and 9

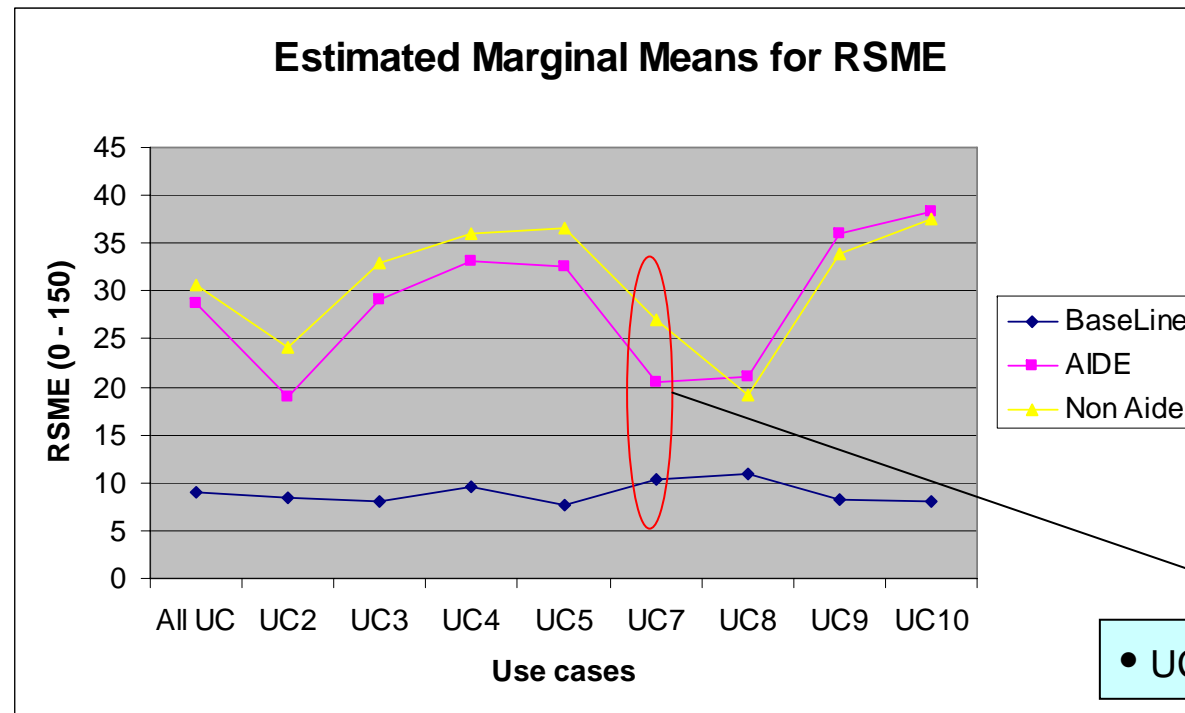
TDT data shows positive effect of Aide in one UC



- UC7 Delayed phone call



# Subjective data - RSME

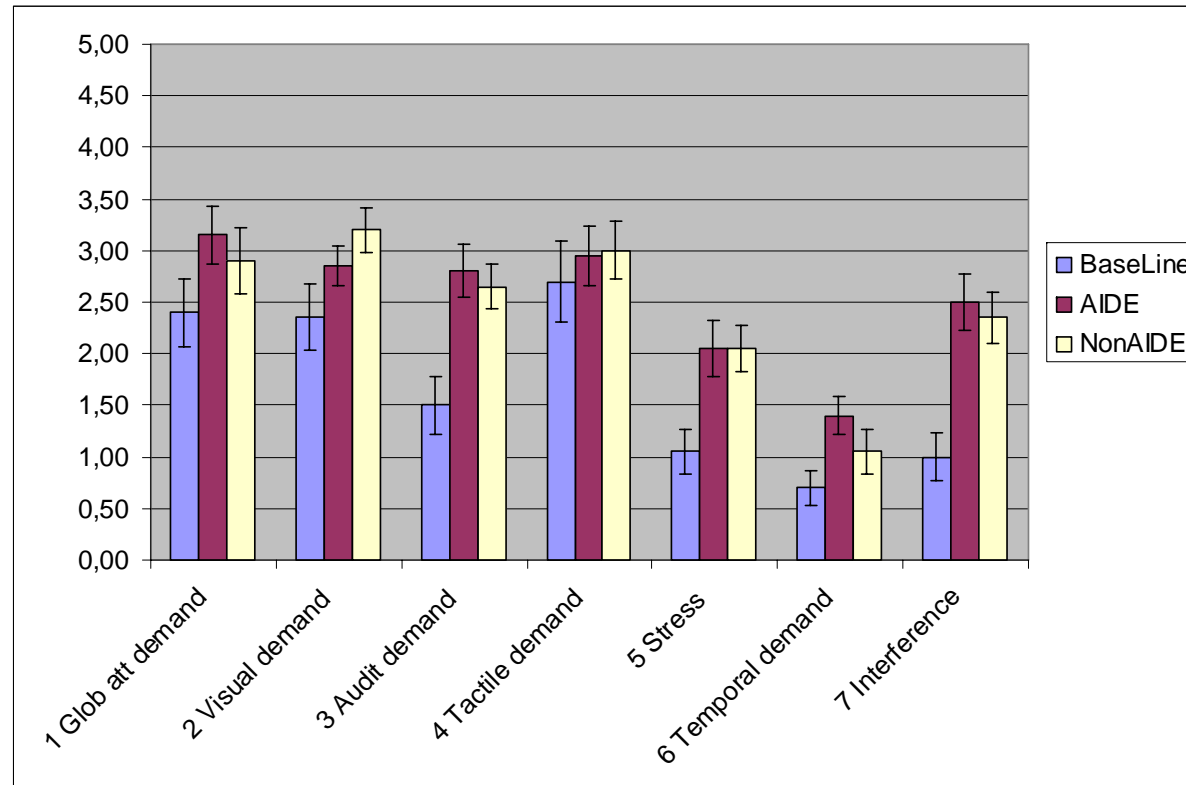


• UC7 Delayed phone call

- RSME was lower for BL compared to A and NA in total and for all UC
- RSME was lower for A compared to NA in total and for UC7 (delayed phone call)
- A trend that RSME is lower in 5 of 8 UC



# Subjective data - DALI



- There were no differences between A and NA
- A ratings were higher vs. BL for global, auditory, temporal and interference
- NA ratings higher vs. BL for visual, auditory, stress, and interference



# Subjective data – CRF questionnaire driving performance



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- Four questions were asked with relation to driving performance
  - General driving performance (Very well – Very bad) - no difference between the three conditions
  - Feeling of safety – (Very safe – Very unsafe) less safe for NA vs. BL
  - Number of errors made (e.g. missed to look in the rear view mirror, missed road signs etc.) most errors in NA and least in BL but no significant differences.
  - Finally, they were asked about the most frequent errors – most frequent, missed to look in the rear view mirrors, missed road signs and misjudging lead vehicle speed.

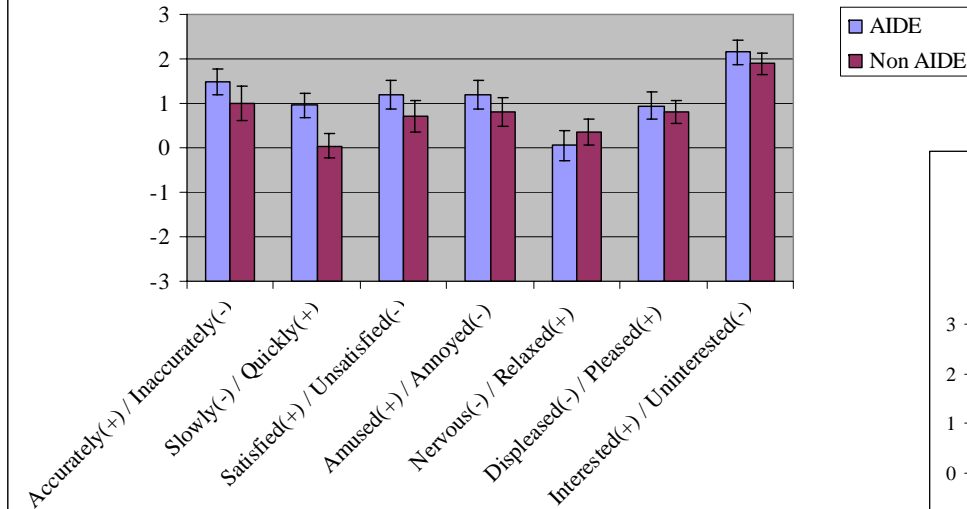


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# Subjective data – CRF Perceived utility

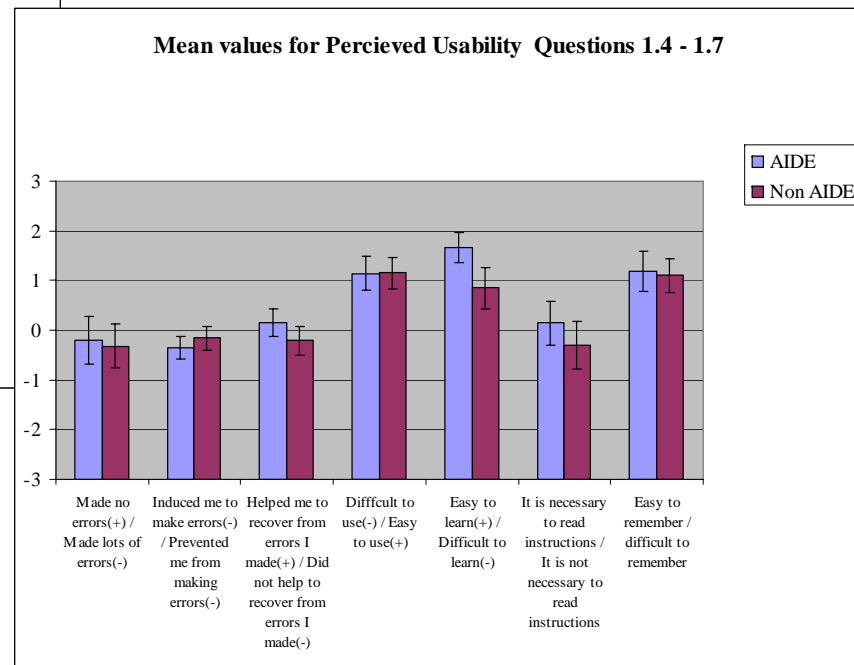


Mean values for Perceived Usability Questions 1.2 and 1.3

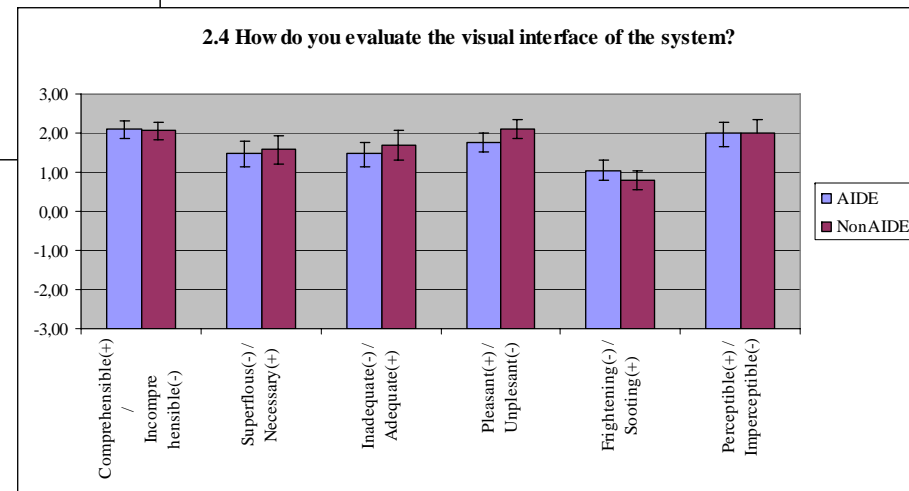
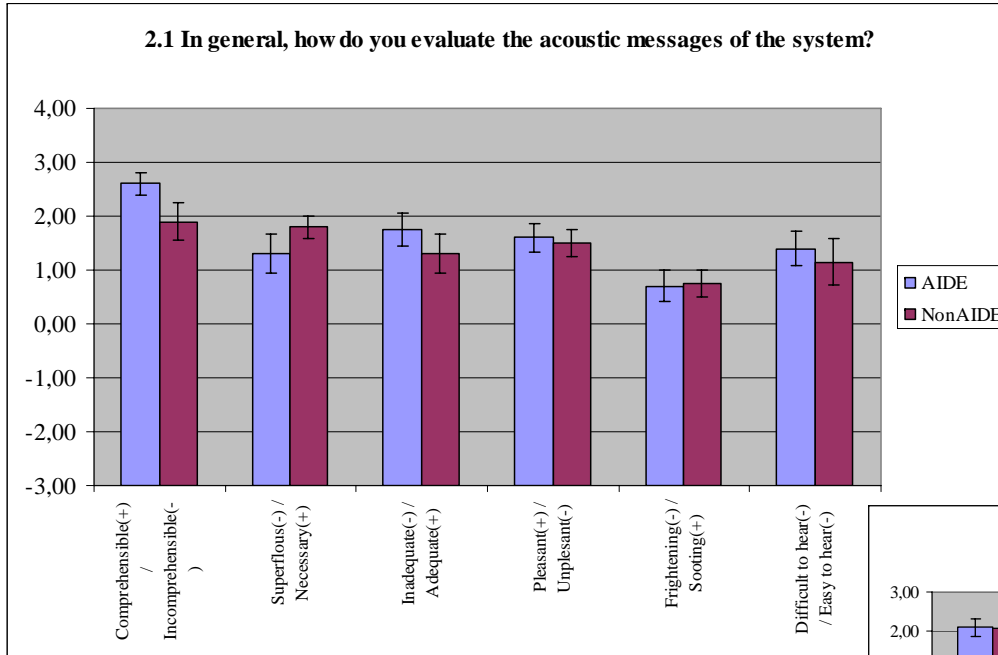


- Most averages on the positive side
- Small differences between Aide and Non Aide

Mean values for Perceived Usability Questions 1.4 - 1.7



# Subjective data – CRF Adequacy of interfaces



- All averages on the positive side
- Small differences between Aide and Non Aide

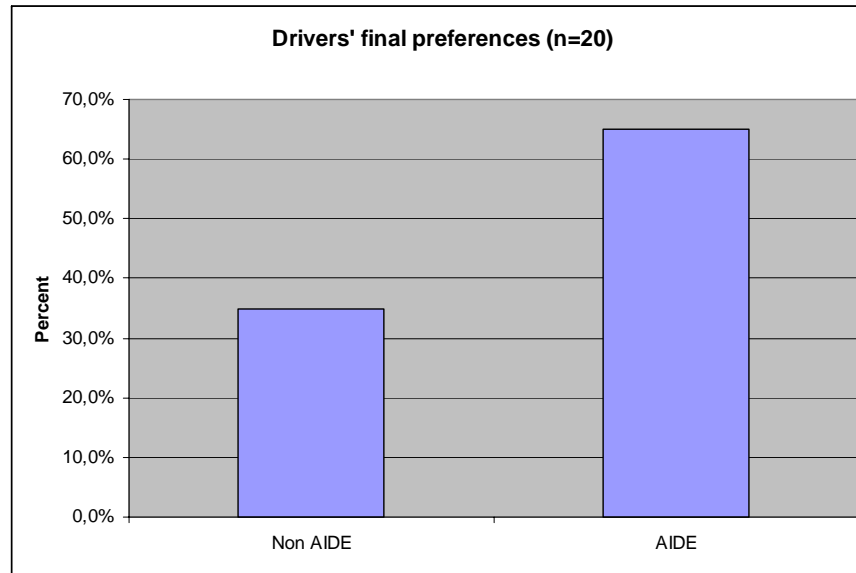


# Subjective data – CRF Final questionnaire



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- The final questionnaire consisted of 11 comparative questions
- One question concerned possible differences (A/NA) with respect to LKA but most did not feel a difference
- However, over 60% preferred the A over the NA condition



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# Summary of results



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- Objective data
  - SWRR – supports hypothesis partly specific UC3 (phone out)
  - Speed – no clear results (but less speed variation for A UC2 (in phone call))
  - Lateral pos – no clear results (but MSDLP lower for A in UC3 (out phone))
  - Eye Gaze – supports hypothesis (driver's eyes on the road)
  - TDT – supports hypothesis for UC7 (delayed phone call)
- Subjective data
  - RSME - supports hypothesis (total and UC7)
  - DALI - indifferent
  - CRF – Driving performance - indifferent
  - CRF – Perceived utility – indifferent
  - CRF – Adequacy of interfaces – indifferent
  - CRF – Final comparison – supports hypothesis



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# Transferring to risk



Risk factor	All Use Cases	Individual Use Cases
Average speed	A & NA ↓ vs. BL	UC2 NA ↑ vs A
Speed variability	A & NA ↑ vs. BL	UC2 NA ↑ vs A
Driver workload		
- SWRR	A & NA ↑ vs. BL	UC3 NA ↑ vs. A
- TDT	A & NA ↓ vs. BL	UC7 NA ↓ vs. A
- RSME	NA ↑ vs. A ↑ vs. BL	UC7 NA ↑ vs. A
- DALI	A & NA ↑ vs. BL	----
Driver distraction		
- PRC	NA ↓ vs. A ↓ vs. BL	UC2,3,5,9 NA ↓ vs. A



# Conclusions



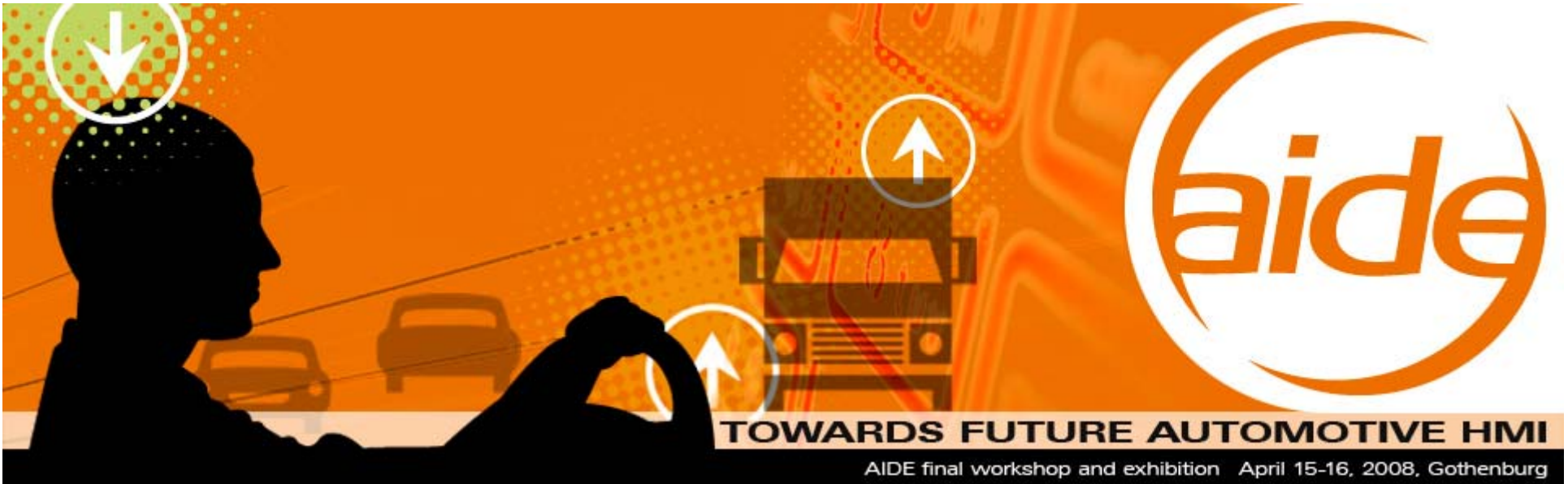
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- Objective data provided useful information for the evaluation
- The UC affected workload, performance, and safety – A/NA
- Aide contributed to improve in some cases e.g. eyes on the road
  
- Subjective data did not contribute much to the evaluation
  - Except subjective workload and general preference
  - Difficult to relate questions to specific phenomena
  
- No difference detected in risk between A and NA
  
- However,
  - Difficult for the drivers to perceive the difference between A and NA
  - The difference between A and NA was not always very distinct e.g. UC8, 9 and 10 – presentation of messages (display/voice vs. display/sound)
  - Too many UC in one drive?
  - Lack of some critical data e.g. headway and improved lateral data



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End