DSC 2019 EUROPE VR

Driving Simulation & Virtual Reality Conference & Exhibition

Round-Table Discussion

Operational Standards for Driving Simulator Experiments

Dr. Catherine Pons-Himbert (BIOPAC)

Mr. Omar Ahmad (NADS)

Dr. Florent Colombet (Renault)

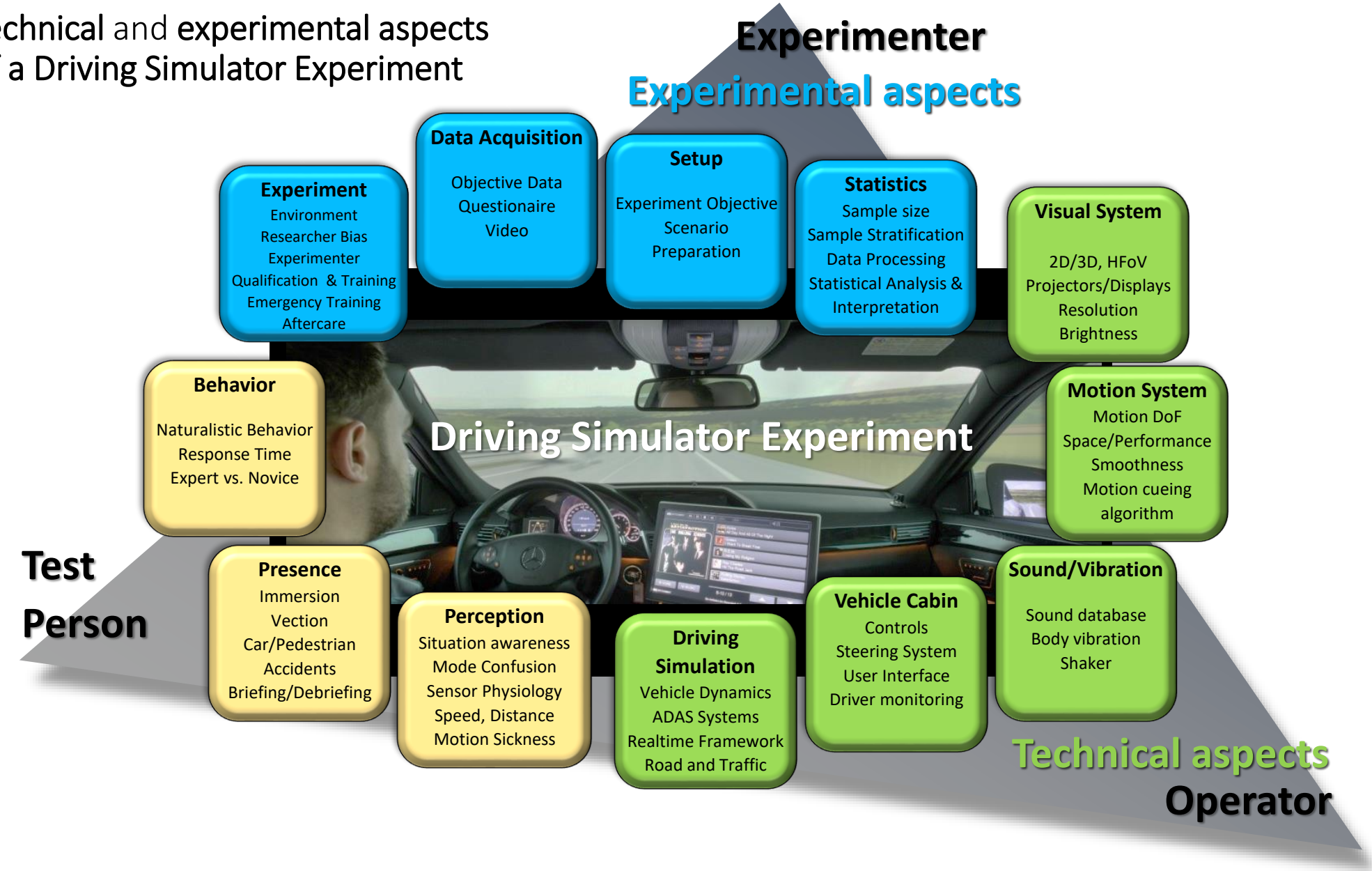
Mr. Marcus Hewat (AV Simulation)

Dr. Paolo Pretto (Virtual Vehicle)

Moderated by Dr. Jens Haecker (Daimler)

Palais des Congrès - Strasbourg September 4, 2019

Technical and experimental aspects of a Driving Simulator Experiment



Motivation

Technical as well as **experimental aspects** are fundamental for **collecting valuable results from simulator experiments** with human drivers in the loop

Increase **validity**, **comparability** and **transferability** of experiment results collected in different simulators

Standards or **operational guidelines for driving simulator experiments**

Round-Table Discussion on DSC 2018

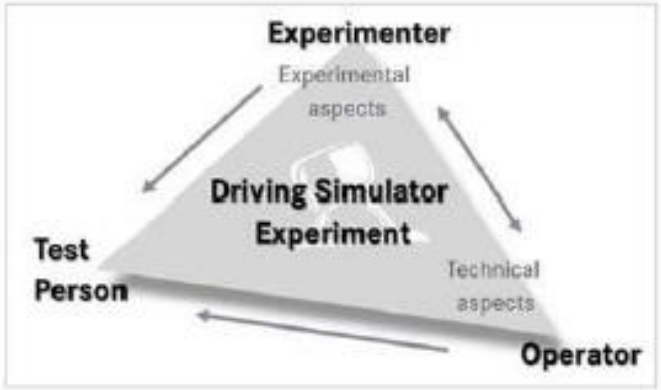
Operational Standards for driving simulators
DSC 2018 - Round Table Discussion

Wednesday, September 5th, 2:00 p.m. – 3:00 p.m., Davis Room

Participants:

- Mr. Stéphane Masfrand (PSA)
- Dr. Stéphane Espié (IFSTTAR)
- Dr. Gerd Baumann (FKFS)
- Mr. Arne Nåbo (VTI)
- Dr. Joost Venrooij (BMW)
- Mr. Omar Ahmad (NADS)

Moderated by Dr. Jens Haecker (Daimler)



What are topics considered most important?

(… let‘s look at some examples…)

Certification Standard

Performance is about to check the rendering level of each perceptual cues with appropriate configuration management (software and hardware) for an efficient use of the simulator equipments. **(RENAULT, Andras Kemeny)**

Motion Sickness

Defining standard parameters for measuring motion sickness. (FKFS, Cristian Holzapfel)

Simulator Design/Categorisation

Driving simulator operation standards (DSOS) **should always be task-oriented if not task-based.** You need to know what you want to use driving simulation for, before you start looking for the suitability of a driving simulator. **(WIVW, Marcus Schmitz)**

Simulator Fidelity

Relevant Cues (Immersion) for Presence and Perceptual Realism, Engagement **(DAIMLER, Katja Nagel)**

Collection of Topics

Sample Distribution

Simulator Training

Motion Sickness

Simulator Experiment Comparison

Certification Standard

Standards/Guidelines Scope

Safety/Ethical Approval

Statistical Methods

Distributed Simulation

Simulator Fidelity

Experiment Design

Standardization Software/Data

Motion Cueing

Simulator Design/Categorisation

Driving Simulator Operational Guidelines

Motion Cueing

- **On the relevance of motion cues for driving simulator experiments (DAIMLER, Hannsjoerg Schmieder)**
  Today, both fixed base as well as motion base driving simulators are used in the car development context. Several car manufacturers – like Mercedes, for example - even operate both types of simulators within their simulator centers, and thus run specific experiments on their fixe base simulators, while other experiments are done on the motion base.
  Topics for further discussions:
  Are there any known or validated criteria to decide, whether an experiment can only be done on a motion base?
  Which criteria have to be fulfilled to allow the use of a simulator without any motion?
  A common phrase says: no motion is better than bad motion. Is this true?
  What is good or bad motion?
- **Motion cueing (VTI, Arne Nabo)**
  What should be the appropriate motion cueing depending on the capability of the simulator? There are simulators ranging from multiple degrees of freedom all the way to just those indicating onset of events. Scaling of accelerations, durations, wash-out procedures etc. should be considered.

Motion Sickness

- **Simulator sickness in AV passenger experiments (LEEDS, Richard Romano)**
- **Best Practice Motion Sickness (DAIMLER, Katja Nagel)** (standard procedures for prevention and for critical situations, staff training)
- **Simulatoreingewöhnung**. **(TU DARMSTADT, Chris Zoeller)** auf Basis von bisherigen Erkenntnissen gut möglich, ein Standardszenario (Dauer, gefahrene Strecke, Hinweise an Probanden…) zur Eingewöhnung in den Simulator vorzugeben, um bspw. Motion Sickness zu minimieren.
- **Defining standard parameters for measuring motion sickness. (FKFS, Cristian Holzapfel)**

Driving Simulator Operational Guidelines

Standards/Guidelines Scope

- For maximum acceptance, **the development of DSOS should include all relevant interest groups and research domains** in the automotive sector (i.e. identify and define a) different interest groups and b) different scopes of application for driving simulation). **(WIVW, Marcus Schmitz)**
- Potential outcome of DSOS should be **guidelines/recommendations/best-practices, not quality seals for driving simulators**. **(WIVW, Marcus Schmitz)**
- **experimental good practices (MPI, Heinrich H. Bülthoff),** most important item is a shared understanding of 'experimental good practices'. To do so, the group should attempt to involve researcher from universities and research institutes who are more working on the fundamental problems of perception and action.

Safety/Ethical Approval

- **Ethical approval of study design (DAIMLER, Katja Nagel)**
  (discussion of reasonable situations: experience of accidents, shocking situations)
- **Ethische- und Sicherheits-Standards. (TU DARMSTADT, Chris Zoeller)**
  Für diese Themen lässt sich meist noch am ehesten ein Konsens finden, auch untersuchungs- und fahrsimulatorübergreifend (wobei evtl. Klassifikationen erforderlich sind, z.B. mit oder ohne Bewegungssystem).

Driving Simulator Operational Guidelines

Sample Distribution

- **Managing test participants (VTI, Arne Nabo)**
  This should be about how to manage the human being as a test participant. It could include recruitment, selection criteria, scanning for simulator sickness syndrome, information/instructions given before test, de-briefing, incentives to boost performance, refreshments, compensation, how to balance order effects, within- or between subject study design, ethical approval etc
- **Test participants (DAIMLER, Katja Nagel)**
  (recruitment, stratified sample, permutation method, level of information (novice vs. Expert), preconditioning procedure)
- **Stichprobenumfang und -verteilung. (TU DARMSTADT, Chris Zoeller)**
  Hier wäre es zumindest möglich, Empfehlungen zu geben. Dadurch könnte man zumindest vermeiden, dass bei Studien mit 5 Personen das Fehlen einer Signifikanz zu der Schlussfolgerung führt, dass kein Effekt existiert. Evtl. ließe sich auch für verschiedene zu untersuchende Effektklassen eine Empfehlung geben. Zudem wäre es sicher hilfreich, Empfehlungen zu geben, wie eine „Allrounder“-Verteilung aussehen könnte (Alter, Geschlecht), die für möglichst viele Untersuchungen geeignet ist. Dazu gehören Empfehlungen, bei welchen Untersuchungsklassen davon abzuweichen ist.
- Undertaking studies with test subjects: **minimum requirements for a collective of test subjects**, **(FKFS, Christian Holzapfelristian Holzapfel)**
  e.g. age groups, gender (more precise requirements again depending on the research question).
- **Representative sample** of the intended driver population **(Fraunhofer ITWM, Rene Reinhardt)**

Driving Simulator Operational Guidelines

Statistical Methods

- **Identifying the most effective experimental designs and analysis methods (LEEDS, Richard Romano)**
- **Statistische Auswertemethoden. (TU DARMSTADT, CZ)**
  Hier gibt es ja teilweise schon gute Entscheidungsbäume, welche Signifikanztests bei welcher Verteilung angewandt werden usw.. Dies nochmal für die Community zusammenzufassen und erforderliche Werte vorzugeben, die für die Bewertung einer Studie essentiell sind, ist denke ich noch am besten umsetzbar.
- **Agreeing on standard metrics (LEEDS, Richard Romano)**
- **DSOS need to be data driven, i.e. approved by means of validation studies (WIVW, Marcus Schmitz)**
- **Experimenter (DAIMLER, Katja Nagel)** (level of Training)
- **Control over external boundary conditions (noise level, etc.) (Fraunhofer ITWM, Rene Reinhardt)**

Experiment Design

- **Requirements for Traffic (Scenarios) (DAIMLER, Hannsjoerg Schmieder)** How important is the determinism of traffic scenarios within an experiment setup? Is the combination of deterministic and non-deterministic traffic valid within an experiment setup?
  Do certain traffic scenarios exist, that are not tolerable within an experiment setup?
  Through the use of a driving simulator, physical damage or injury of the driver can be prevented, even in a crash situation. Nevertheless, is it ok to confront drivers with crash situations? Are there any limitations concerning “reasonable” crashes? How about collecting data during crashes in the simulator, but not visualize the crash, through tremendously accelerate the crashed vehicle for example?

Driving Simulator Operational Guidelines

Simulator Design/Categorisation

- Driving simulator operation standards (DSOS) **should always be task-oriented if not task-based.** You need to know what you want to use driving simulation for, before you start looking for the suitability of a driving simulator. **(WIVW, Marcus Schmitz)**
- Die **Klassifizierung sollte eher Kategorisierung genannt werden** um allgemeingültigere Aussagen treffen zu können. **(TU BRAUNSCHWEIG, Alexander Hafner)**
- Die **Gruppierung sollte anwenderbezogen/-orientiert** sein. Es sollte nicht für den Simulator die passende Studie gesucht werden, sondern für die Studie eine Auswahl an geeigneten Simulatoren. **(TU BRAUNSCHWEIG, Alexander Hafner)**
- Eine Bewertung (gut/schlecht) sollte in jedem Fall vermieden werden. Das **Ziel sollte eher eine standardisierte Beschreibung von Simulatoren** sein als dessen Bewertung. **(TU BRAUNSCHWEIG, Alexander Hafner)**
- **Developing a common language to describe simulators and scenarios**. **Guidelines for how to describe a simulator in papers**. **Guidelines for matching fidelity to the problem being studied**. **(NADS, Omar Ahmad)**
- For human factor research, the **driver is the key tool** for measuring the validity of the driving simulator. **(WIVW, Marcus Schmitz)**
- **Classification dependent on the research question: defining minimal technical requirements for specific research questions. (FKFS, Christian Holzapfel)**
- **Matching between driving simulator and the requirements posed by the driving scenario (Fraunhofer ITWM, Rene Reinhardt)**

Driving Simulator Operational Guidelines

Simulator Fidelity

- **Requirements for Visual/Road Databases** (DAIMLER, Hannsjoerg Schmieder) How important is a high degree of realism in the visual database for the validity of experiment results? Which features are a “must” within the visual database, which are nice to have, which are unnecessary?
- **Implementing rear/side mirror** views in a driving simulator (DAIMLER, Hannsjoerg Schmieder)
  Within a driving simulator with a projection system for the out of the window view, different approaches are possible to present the rear/side mirror views:
  Using the original mirrors to look onto the projection screen or onto specifically mounted monitors, where the mirror views based upon the mirror eye points are displayed. As an alternative, the mirror views can also be projected directly onto the real mirrors, using mini-projectors.
  Instead of using real mirrors, small displays, mounted in the mirror housings, can be used.
  Are there any other possible solutions to implement the mirror views in a driving simulator?
  What are the specific pros and cons of the mentioned solutions?
  Can a ranking be defined, concerning the performance of the different solutions?
  How significant is the adjustability of the mirror views according to the specific driver?
  Is the purpose of presenting mirror views just to increase to level of realism, or do they also have to exactly meet quantitative issues, like mapping values for example?
- **Relevant Cues** (Immersion) for Presence and Perceptual Realism, Engagement **(DAIMLER, Katja Nagel)** (also: impact of earlier simulator experience)

Driving Simulator Operational Guidelines

Standardization Software/Data

- How to compare data from one simulator to another? Can we develop a **common data repository** where people have the option to deposit their data from a simulator so that it can be used by others? **(NADS, Omar Ahmad)**
- **Technical Standards (MPI, Heinrich H. Buelthoff),** technical standards to facilitate an easier exchange of software, models, motion cueing, scenery, etc. between simulators should be the basis of standardization.
  "during the discussion at DSC, it became evident that there isn't really a need to standardize anything, because almost all simulator studies are performed for internal use only. To me, standardization of operational aspects seems necessary only if you are actively sharing experimental results with each other."
- **Technical compatibility (MPI, Heinrich H. Buelthoff)** Technical compatibility should make it easier to reproduce or extend studies on different simulators.
- **Being able to drive anywhere in the world**; what tools or processes do we need to digitize a real-world location and make it drivable in a simulator? Can we utilize publicly available sources of data for the real-world locations—i.e. Google Earth or a map in the NDS standard? **(NADS, Omar Ahmad)**
- **Generalizability of the tested scenario/Transfer for relevant driving situations (Fraunhofer ITWM, Rene Reinhardt)**
- **Standardization of driving scenarios and of the simulation's boundary conditions (lighting, etc.) (Fraunhofer ITWM, Rene Reinhardt)**

Driving Simulator Operational Guidelines

Simulator Experiment Comparison

- **Round Robin Test (VTI, Arne Nabo)** The idea is to compare the outcome of a common study executed in several driving simulators. We can for example use OpenScenario, specify performance measures and criteria for test participants etc. Then we can compare results from simulators ranging from desktop solutions to advanced motion based. Or maybe three scenarios would be interesting to have, one where visual field of view is expected to be essential, one where motion feedback is expected to be essential and one where neither one is of great importance.
- For evaluating vehicle safety in crashes, standards have been established based on a **5-star score**, derived from common test scenario against which all vehicles are compared. We need to create a similar system, based on common considerations, that can be implemented in any **simulator use case**, and used to **benchmark the validity of the outcomes**. A "simulator use case" consists of the simulator setup, the scope definition and procedure of the study, the handling of participants, the scientific considerations and methodological solutions adopted. **(V2C2, Paolo Pretto)**
  Therefore, a simulator use case can be quantified according to the following categories:
  - Technical Setup: facilities and equipment, with related specific benchmarks (similar to qualification levels in flight simulators)
  - Demographics: participants sampling rules and reference population definition, informed consent, instructions specifications
  - Study validity: description of the scope and method of the study in terms of internal, external, construct, and ecological validity
  - Environmental conditions: monitoring and handling safety, well-being, discomfort of participants before, during and after the study
- In the process of standardization: **validating driving simulation against driving in road vehicles. (FKFS, Christian Holzapfel)**

Driving Simulator Operational Guidelines

Certification Standard

- **Performance** is about to check the rendering level of each perceptual cues with appropriate configuration management (software and hardware) for an efficient use of the simulator equipments. **(RENAULT, Andras Kemeny)**
- **Motion** is about motion rendering, in particular with motion based plateformes, including the major issue of motion sickness which are of considerable importance today. **(RENAULT, Andras Kemeny)**
- **Safety,** use of motion systems due to the strict operational conditions to observe for safe experimentations **(RENAULT, Andras Kemeny)**

Distributed Simulation

- **Distributed simulation**: connecting driving simulators to each other and to other modes of transportation (bicycles, pedestrian, rail, etc.) **(NADS, Omar Ahmad)**
- **Validation of pedestrian in the loop simulators (LEEDS, Richard Romano)**
- **Designing distributed simulation experiments (LEEDS, Richard Romano)**

Simulator Training

- How to **help new users of driving simulators use their simulators more effectively**? Can we work on documenting resources that they can use? (Perhaps this one can be linked to the 3rd item above on the common language) (**NADS, Omar Ahmad**)

How to get involved?

Engage in the discussion

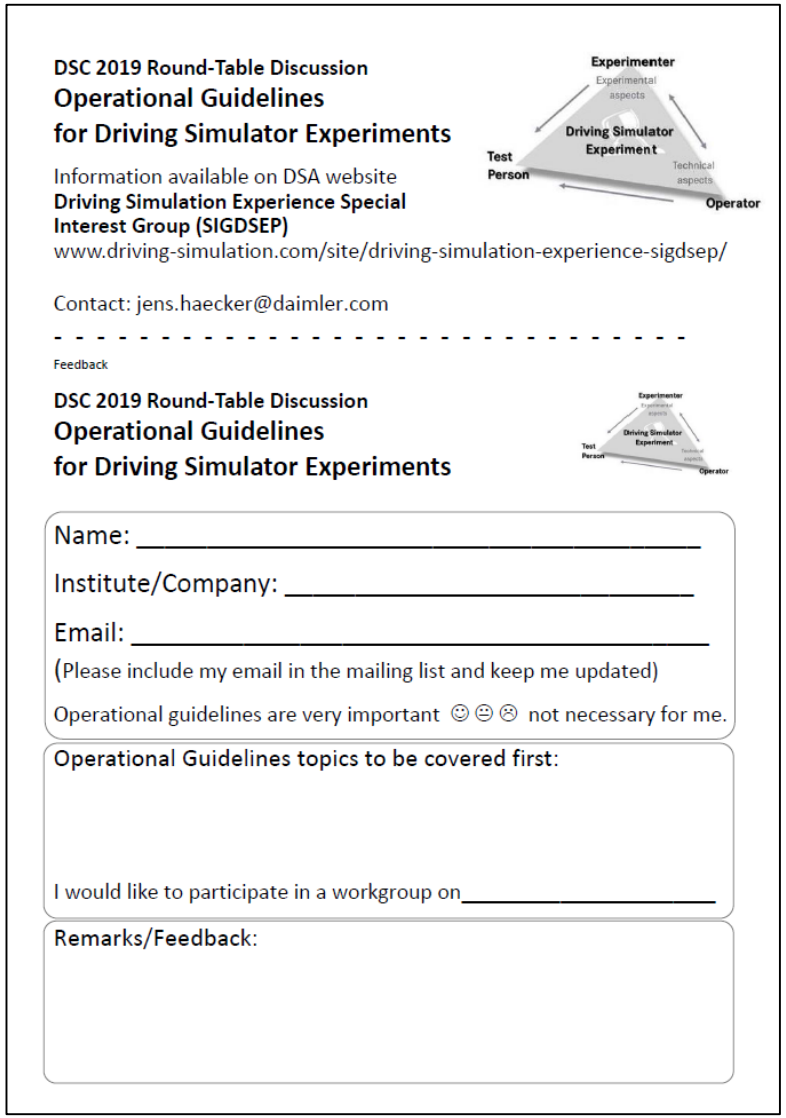
Give a feedback

Participate in a working group

Help to set up a „White Paper“ on
Operational Guidelines for Driving Simulator Experiments

Information available on DSA website:
Driving Simulation Experience
Special Interest Group (SIGDSEP)

www.driving-simulation.com/site/driving-simulation-experience-sigdsep/



DSC 2019 Round-Table Discussion
Operational Guidelines
for Driving Simulator Experiments

Information available on DSA website
Driving Simulation Experience Special Interest Group (SIGDSEP)
www.driving-simulation.com/site/driving-simulation-experience-sigdsep/

Contact: jens.haecker@daimler.com

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Feedback

DSC 2019 Round-Table Discussion
Operational Guidelines
for Driving Simulator Experiments

Name: _____

Institute/Company: _____

Email: _____

(Please include my email in the mailing list and keep me updated)

Operational guidelines are very important ☺ 😐 ☹ not necessary for me.

Operational Guidelines topics to be covered first:

I would like to participate in a workgroup on_____

Remarks/Feedback:

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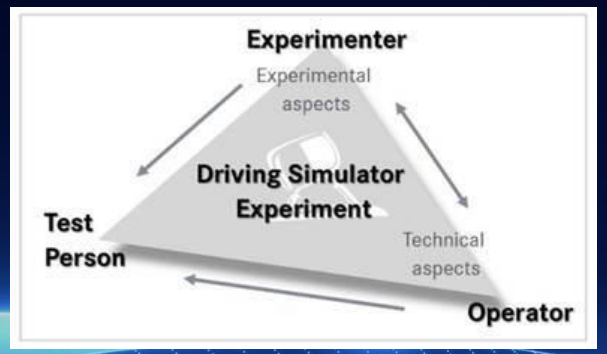

Round-Table Discussion

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Human physiological recordings in a driving simulator experiment

Catherine PONS-HIMBERT, PhD

Palais des Congrès - Strasbourg September 4, 2019

Features for good recordings in a driving simulator experiment

1. The exchange of information between the simulator and the physiological data recorder

2. The ergonomics of the data acquisition system adapted to the experimental setup

3. The preparation of the subject according to the experiment design

4. The powerful software to acquire, clean and analyze data

The exchange of information between the simulator and the physiological data recorder

Via the network using **Network Data Transfert** (NDT)
NDT is a real-time data system which allows a third party application to access the data during the acquisition

Via **TTL input** (8 or 16 bits) if the simulator is able to control a digital I/O card

Via **File importation** (or exportation).
The **BIOPAC** data acquisition software **AcqKnowledge** can manage different file formats and import & merge data files

The ergonomics of the data acquisition system adapted to the experimental setup

Smart amplifier
Wired solution

BIONOMADIX
Wireless solution

The ergonomics of the data acquisition system adapted to the experimental setup

MP160

Logger

The preparation of the subject according to the experiment design

- **Good preparation** of the subject leads to **good quality** data:

  - **Skin preparation** before sticking the electrodes
  - **Position of the transducer** (for EDA, PPG) adapted to the task

- **What** to record and **why** :
  - heart rate only or HRV…?

- Never forget the **individual variability**

The powerful software to acquire, clean and analyze data

AcqKnowledge, a powerful software

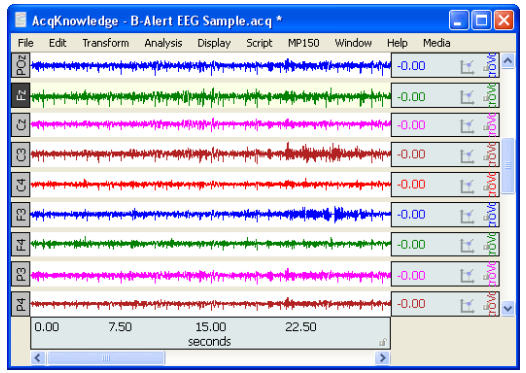
Preparing acquisition

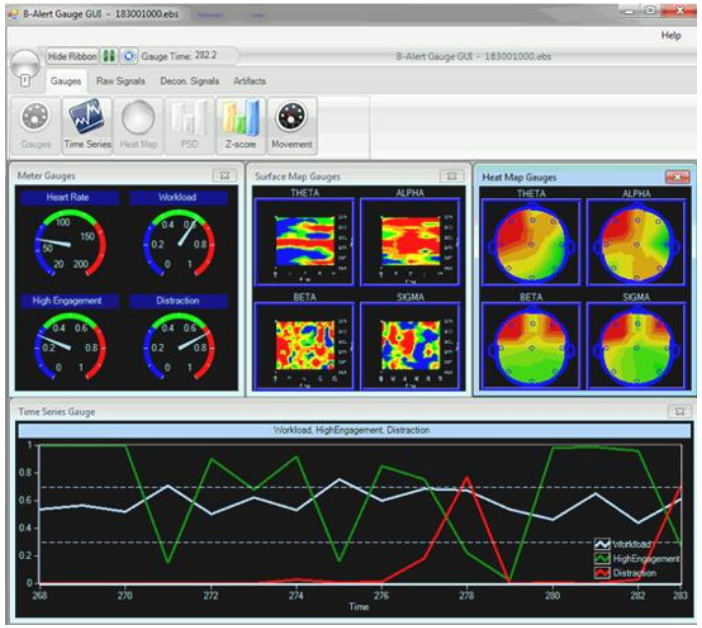
Cleaning data

Analyzing data

Developer tools: scripting, API for files and devices, Network Data Transfer....

A device specialized in the cognitive state's analysis
B-ALERT (9 EEG and 1 ECG)





B-Alert's highly validated metrics:
Engagement, Workload, Stress, Drowsiness …

Motion sickness

- You get motion sickness when there are conflicts among your senses:

  your **eyes** see one thing

  your **muscles** feel another

  your **inner ears** sense something else …

- Your **brain** can't take in all those mixed signals ...

  That's why you end up feeling dizzy and sick

Parameters involved in motion sickness

- **ECG**: Heart rate is regulated by sympathetic and parasympathetic systems (Heart Rate Variability)
- **RSP**: respiratory rate increased in motion sickness, involved in HRV
- **EDA**: sweating increased also and can be measured by electrodermal activity
- **Temperature**
- **EEG**: response time
- **EGG**

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BIOPAC Systems France

EROM

Human physiological recordings in a driving simulator experiment

THANK YOU !

Catherine PONS-HIMBERT, PhD

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Driving Simulation & Virtual Reality Conference & Exhibition

The National Advanced Driving Simulator
The University of Iowa

Round Table Discussion

Operational Standards for Driving Simulator Experiments

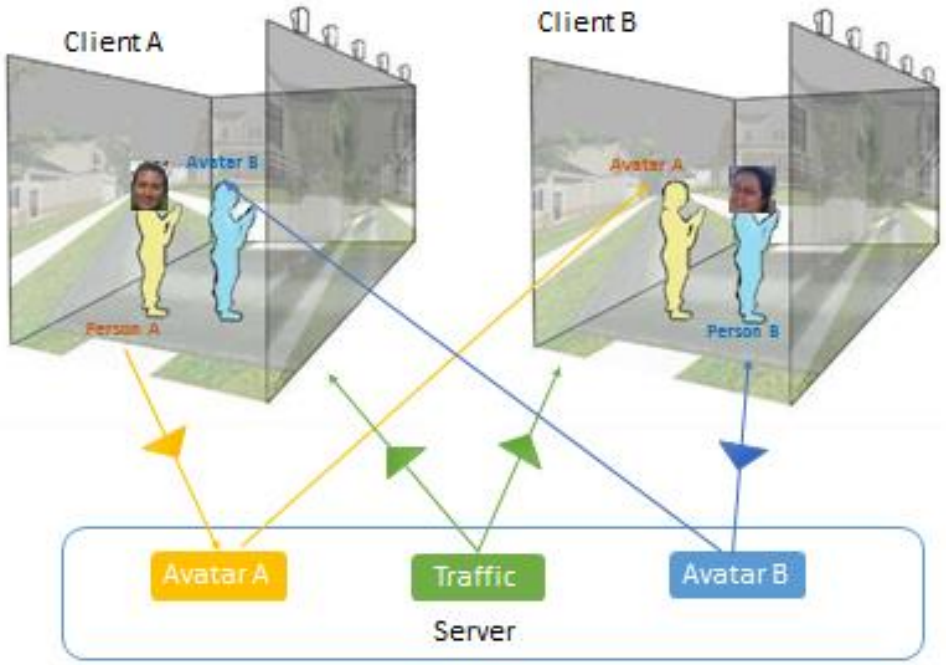
Mr. Omar Ahmad

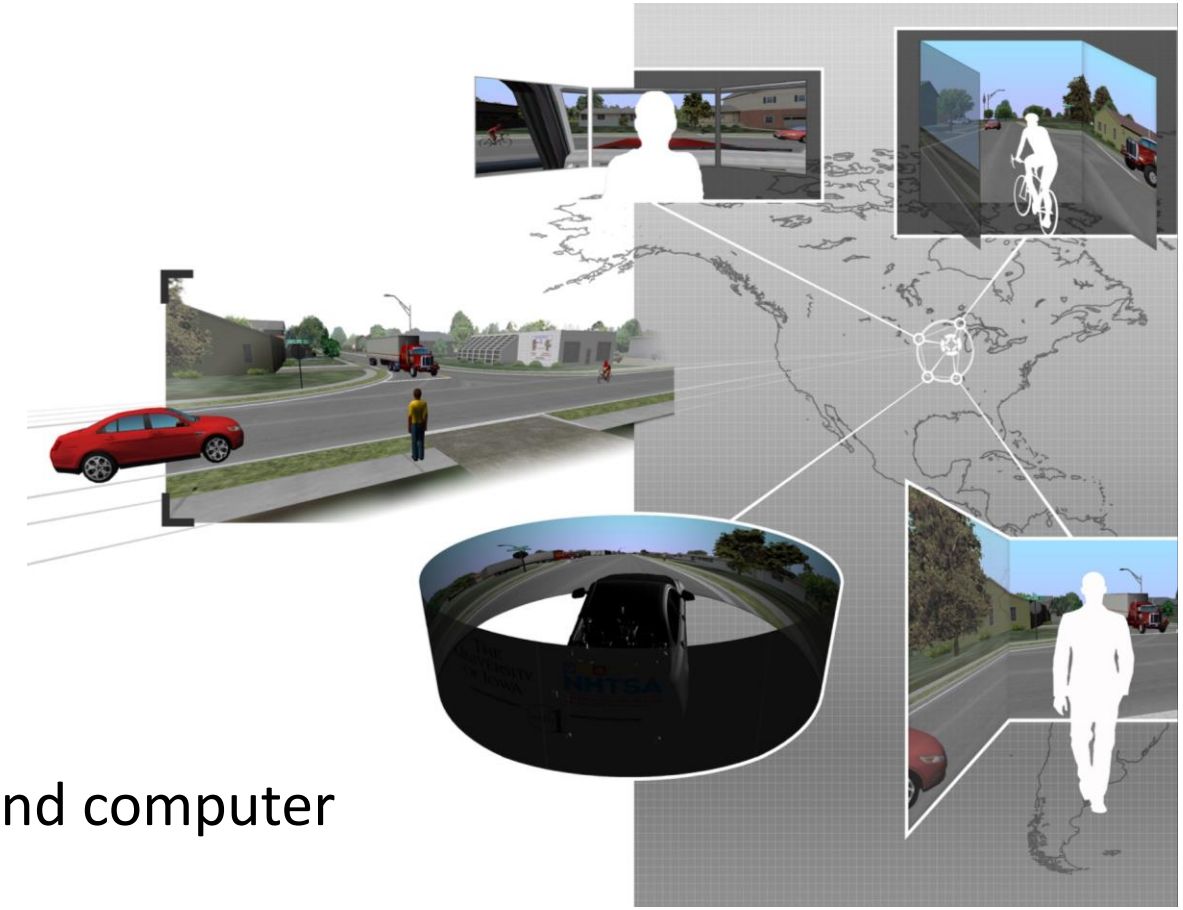
Palais des Congrès - Strasbourg September 4, 2019

20 YEARS

THE NATIONAL ADVANCED DRIVING SIMULATOR

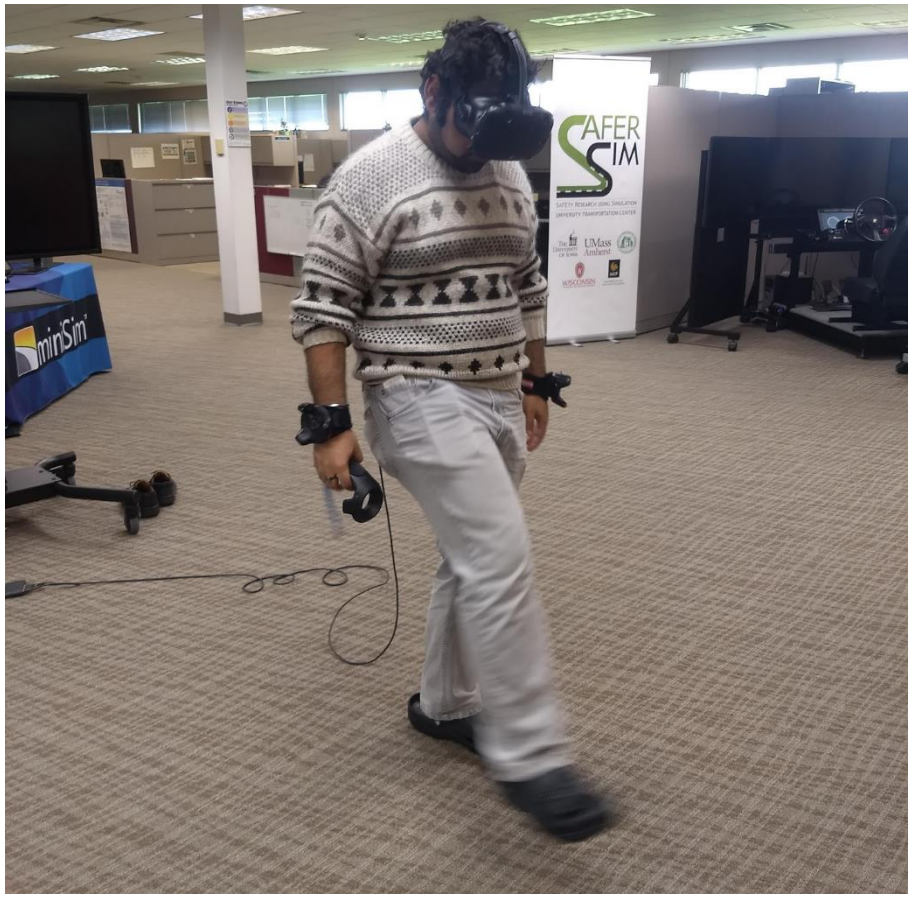
THE UNIVERSITY OF IOWA



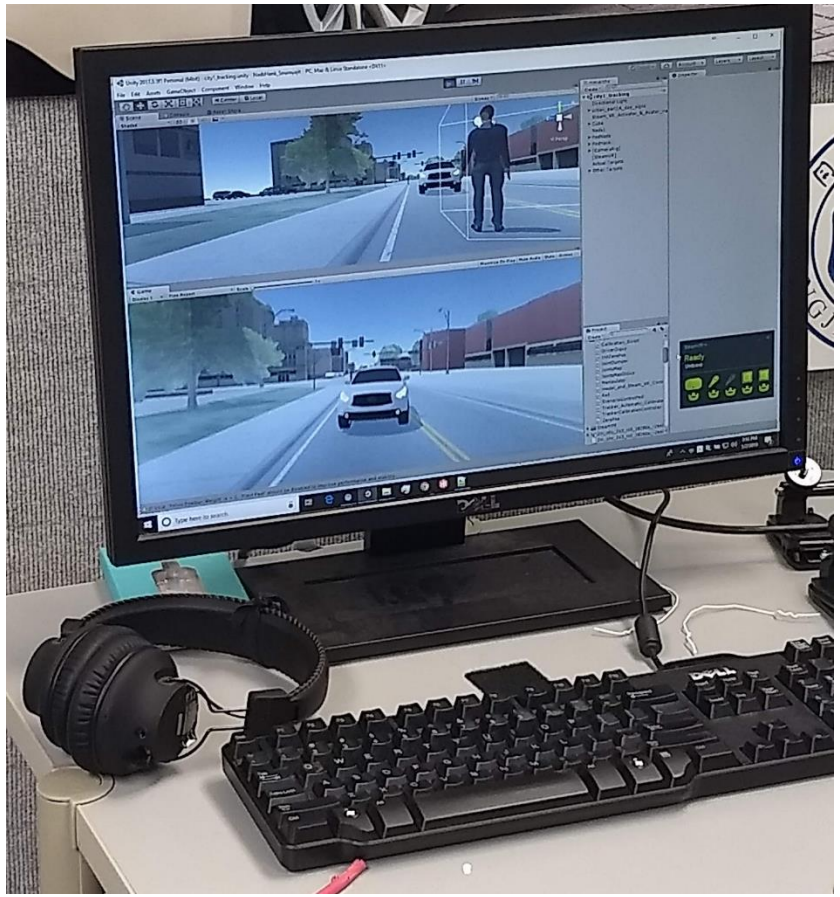


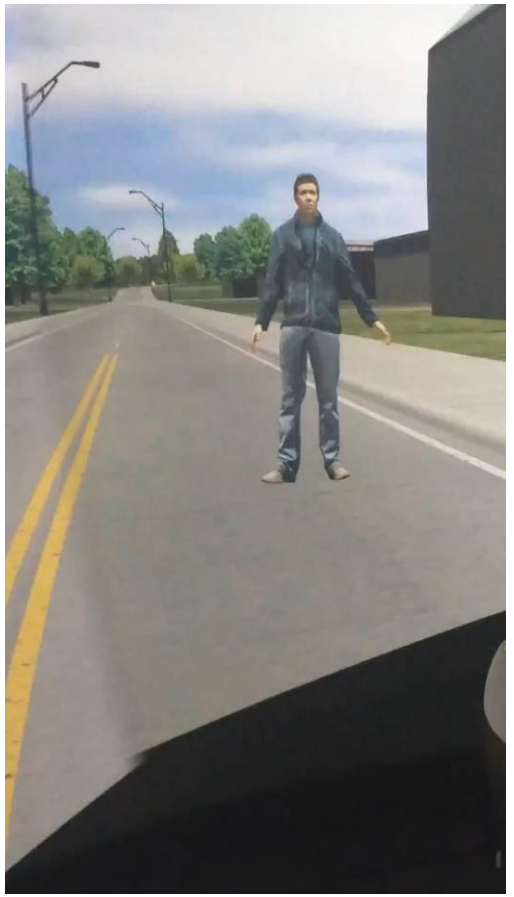
- FHWA EAR program (2017-2019)
- Connected cross-modal simulators
- Researchers from engineering, psychology and computer science

Developing Connected Simulation to Study Interactions Between Drivers and Pedestrians



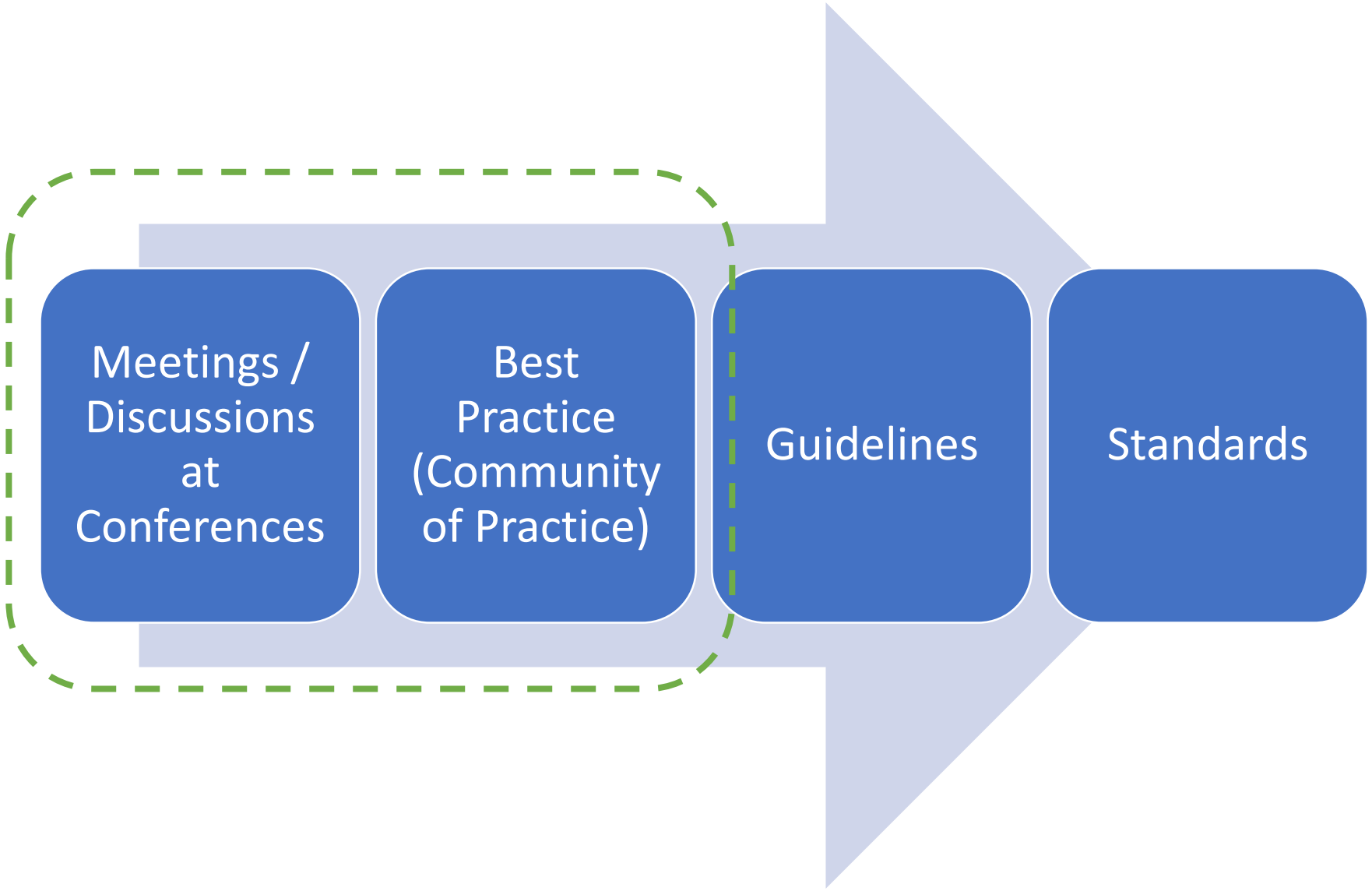
Head-Mounted Pedestrian Simulator





NADS-1 Driving Simulator

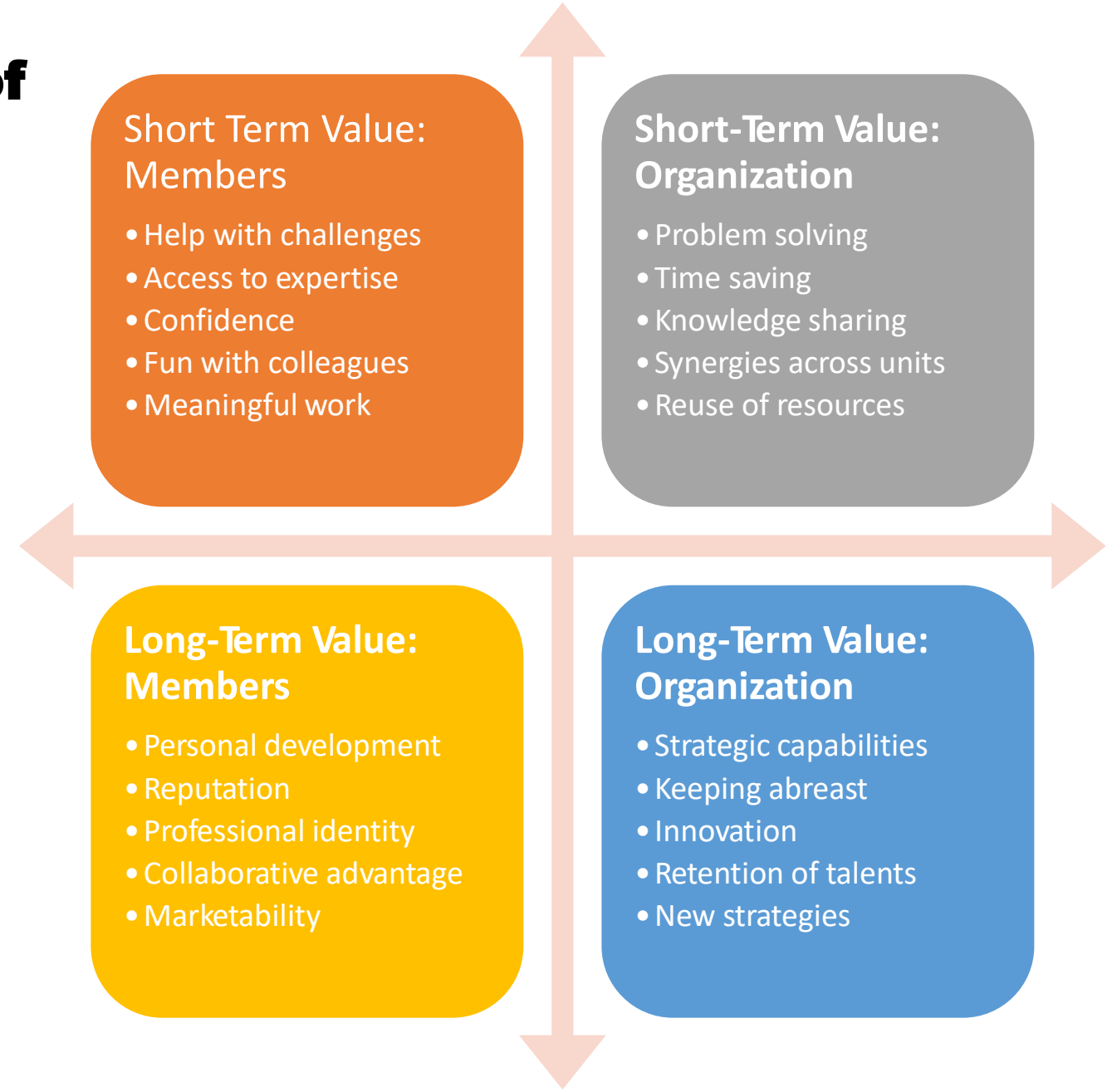
How Do We Get There?



What is a Community of Practice

- "A **community of practice** (**CoP**) is a group of people who share a craft or a profession. " *Wikipedia*

The Value of Communities of Practice (Olivier Serrat, 2016)



Basic Structure of the Community of Practice

(Olivier Serrat, 2016)

The ***core group*** manages the CoP based on an agreed coordination mandate. It provides secretarial support as necessary.

The middle serves as a steering committee with an informal structure, meeting once or twice a year. (Individual members may contact the core group on demand.

The ***outer circle*** embraces interested members, contributors, and readers in a loose network.

Basic Structure of the Community of Practice (Olivier Serrat, 2016)

Thank you

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Performance mesurmant: transport delay Streamlining the test subject experience

Marcus Hewat
Vehicle Dynamics & Motion tech lead
A.V. Simulation

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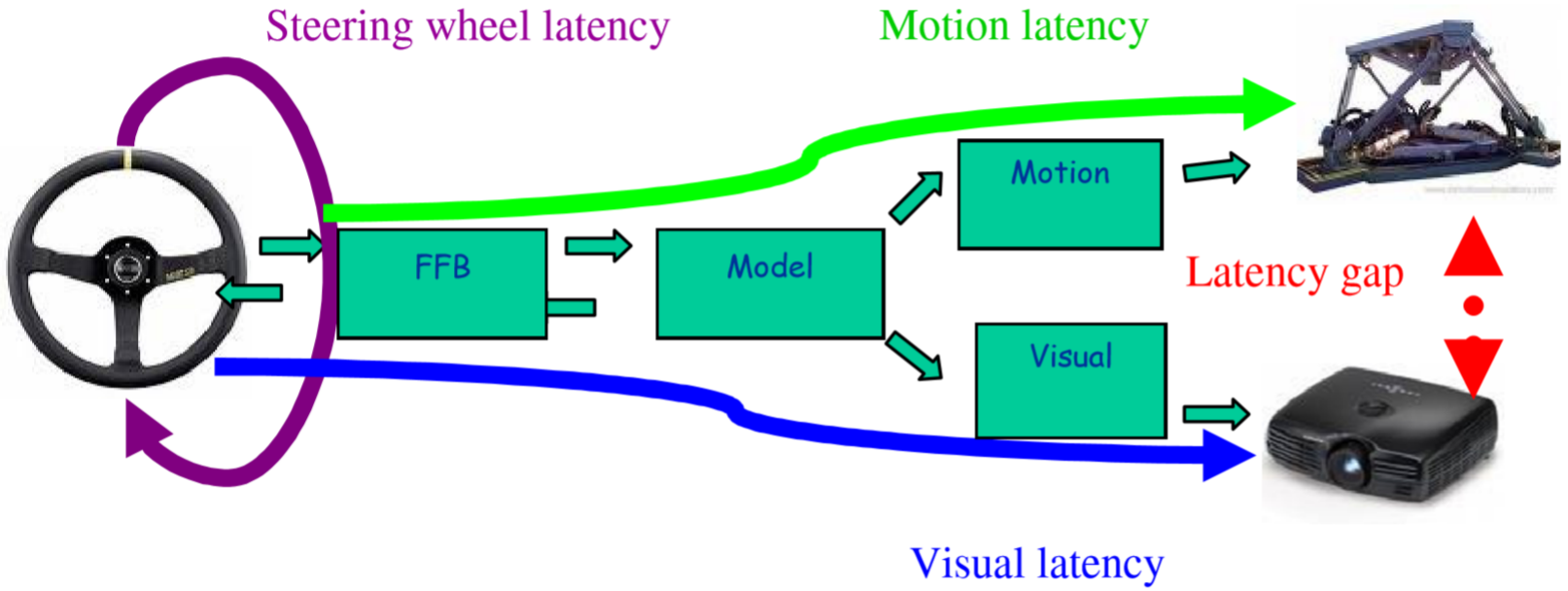
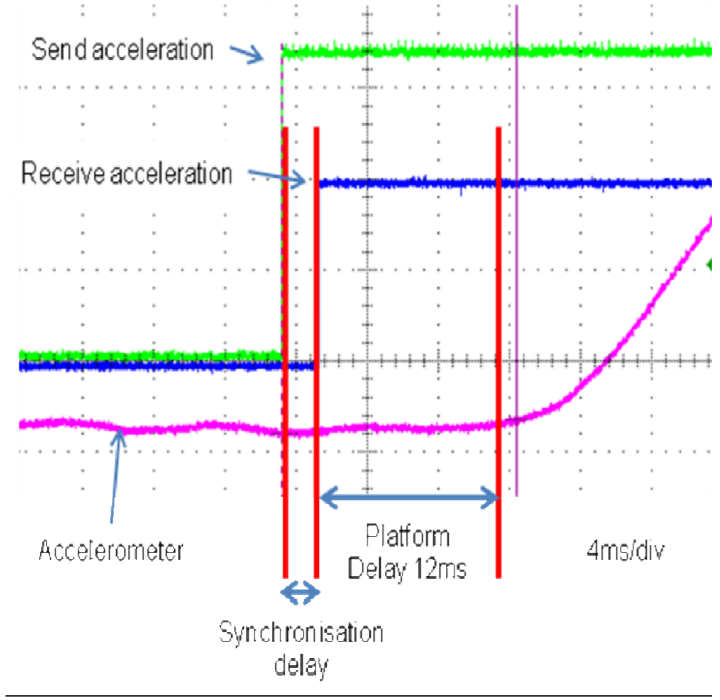
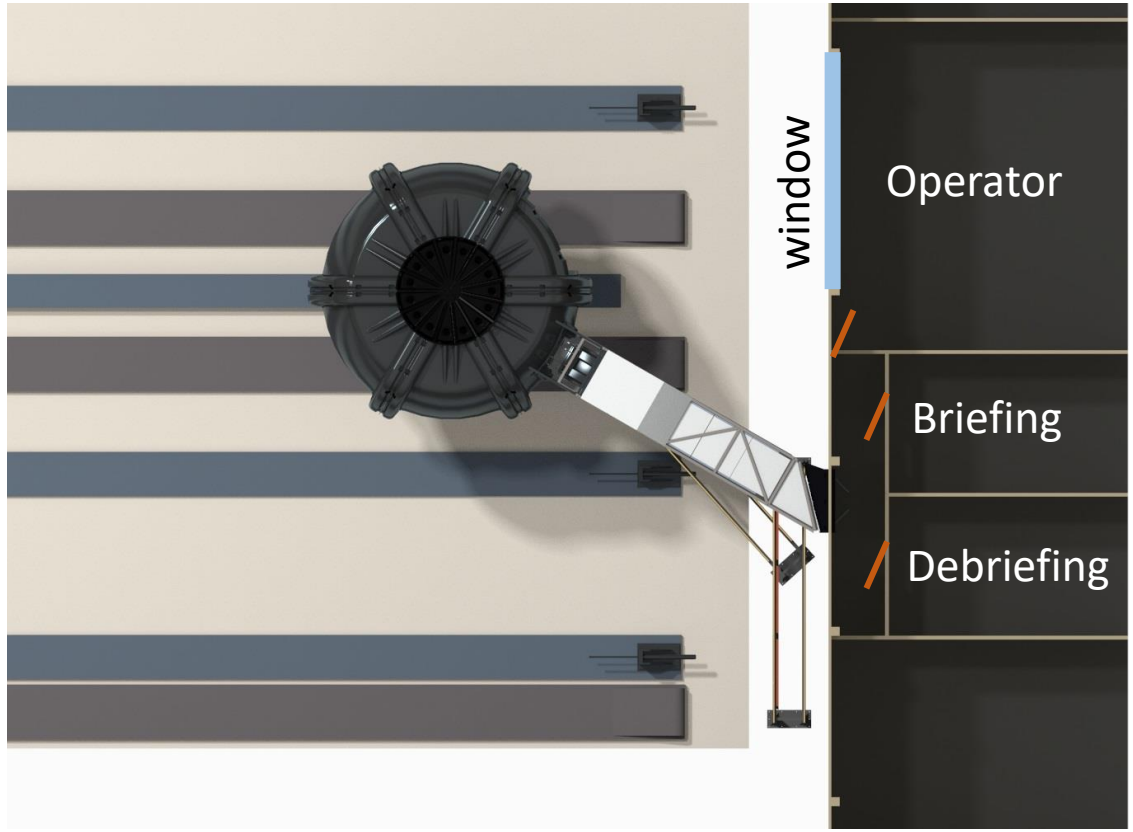
Simulator performance: transport delay





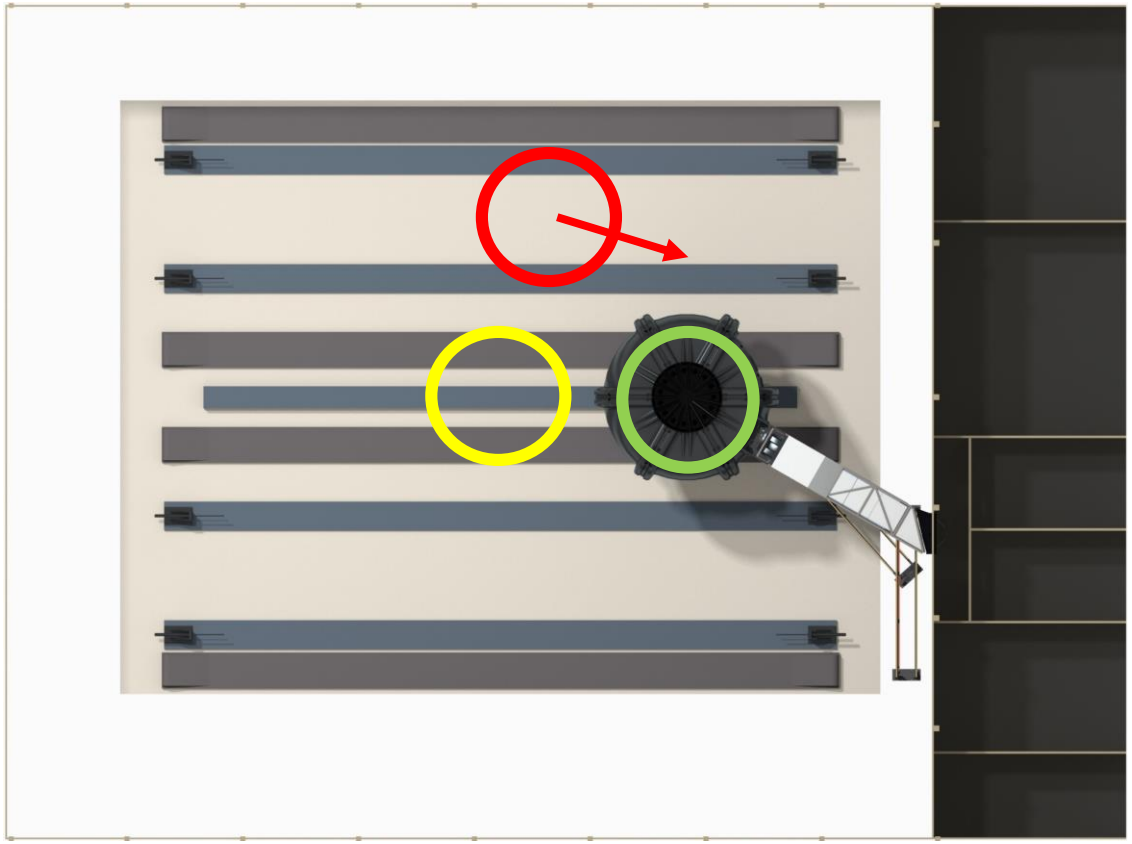
Test subject Isolation

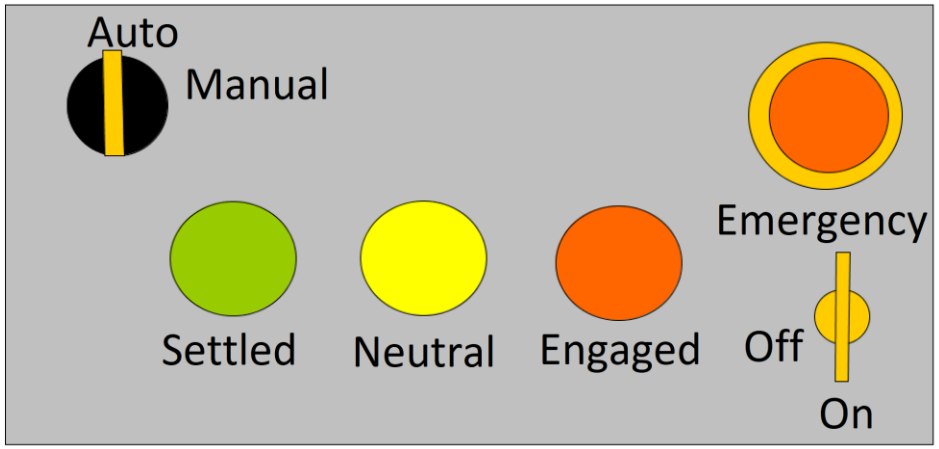
- Seperate operators, briefing and debriefing rooms
- Test subject does not see simulator, enters vehicle as if in underground parking



Steamlining simulation launch

- Decoupling motion state from the simulation state
- Bypassing « Neutral » motion state. Docked -> Engaged





DSC 2019 EUROPE VR

Driving Simulation & Virtual Reality Conference & Exhibition

GROUPE RENAULT

RENAULT NISSAN MITSUBISHI

“Operational standards for Driving simulator experiments”

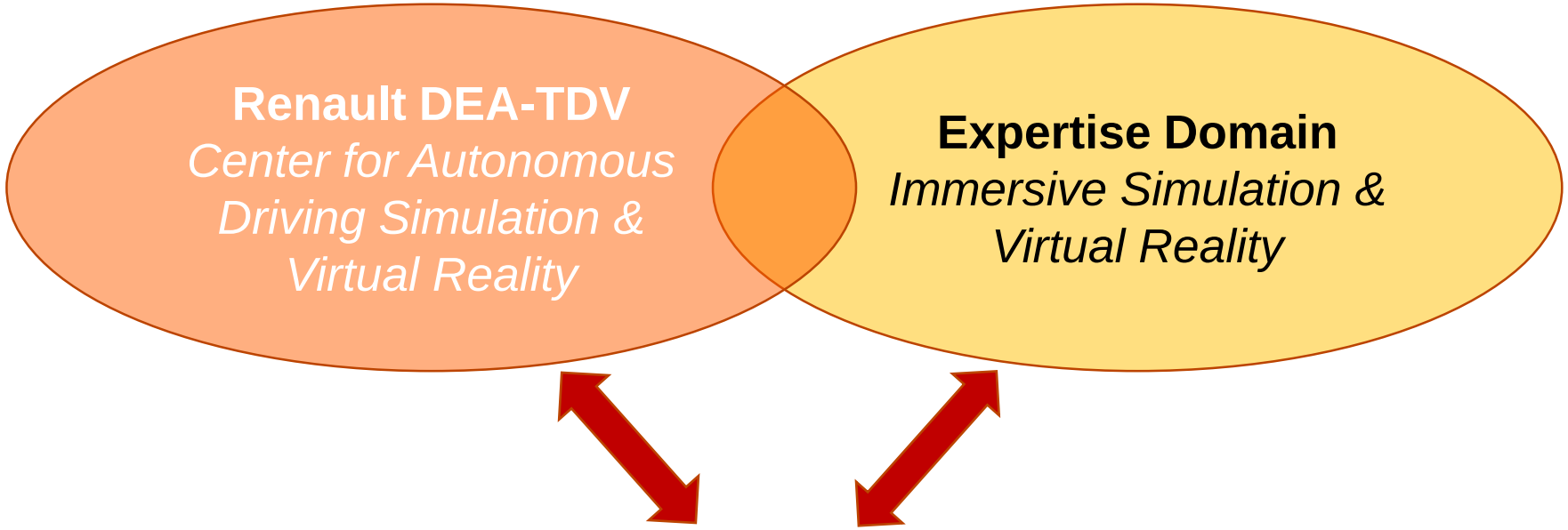
Roundtable

Dr Florent COLOMBET, Renault Group

Palais des Congrès - Strasbourg September 4, 2019

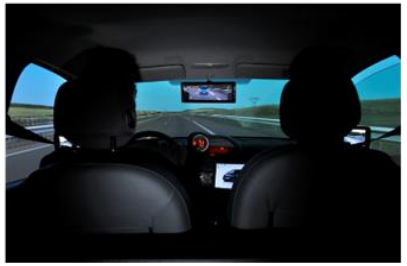
Context - Driving Simulators usage at Renault Group

- **Main Renault Driving Simulators are operated by DEA-TDV**



AD & ADAS, Powertrain, Design,
Research, CAE, …

Renault DEA-TDV Driving Simulators



&

R enault
O ptimization
A utonomous
D riving
S imulator

"Operational standards for Driving simulator experiments" Topics of interest for Renault Group

- **Technical requirements for Driving Simulators depending on tasks AND on drivers (experimented or « lambda »)**
  - Visual display: Screen or projection, luminosity, contrast, angular resolution, FOV, Stereoscopy, Head tracking, mirrors (real or LCD), etc…
  - Motion cues:
    - None, vibrations, 6 DOF, 6 DOF + horizontal linear accel
    - Delay, smoothness, accelerations level
  - Immersion: cockpit fidelity (inside & outside), motion system visible or not
  - Audio & haptic cues

- **Tuning of Motion Cueing Algorithm**
- **Requirements for Visual/Road databases**
- **Traffic realism level**

→ **When validating autonomous cars with Driver in the Loop, which level is needed on each item?**