Operational Guidelines for Driving Simulator Experiments
Collection of Topics

Dear colleagues,   (19.01.2019)

I am writing to you to follow up on our panel discussion on operational standards for driving simulator experiments that was held on the DSC2018 in Antibes.

We all agreed about the importance of the topic of defining operational guidelines, but as Omar Ahmad (NADS) pointed out the topic is a big one and we can only hope to bring it forward by breaking it into smaller challenges and defining a roadmap to give some orientation.

So I am writing to ask you to put together and send to me a set of 4 to 5 headlines that you consider the most important in the context of driving simulator operation standards so we can start setting up a priority list. It would be good to have the headlines by mid of February.
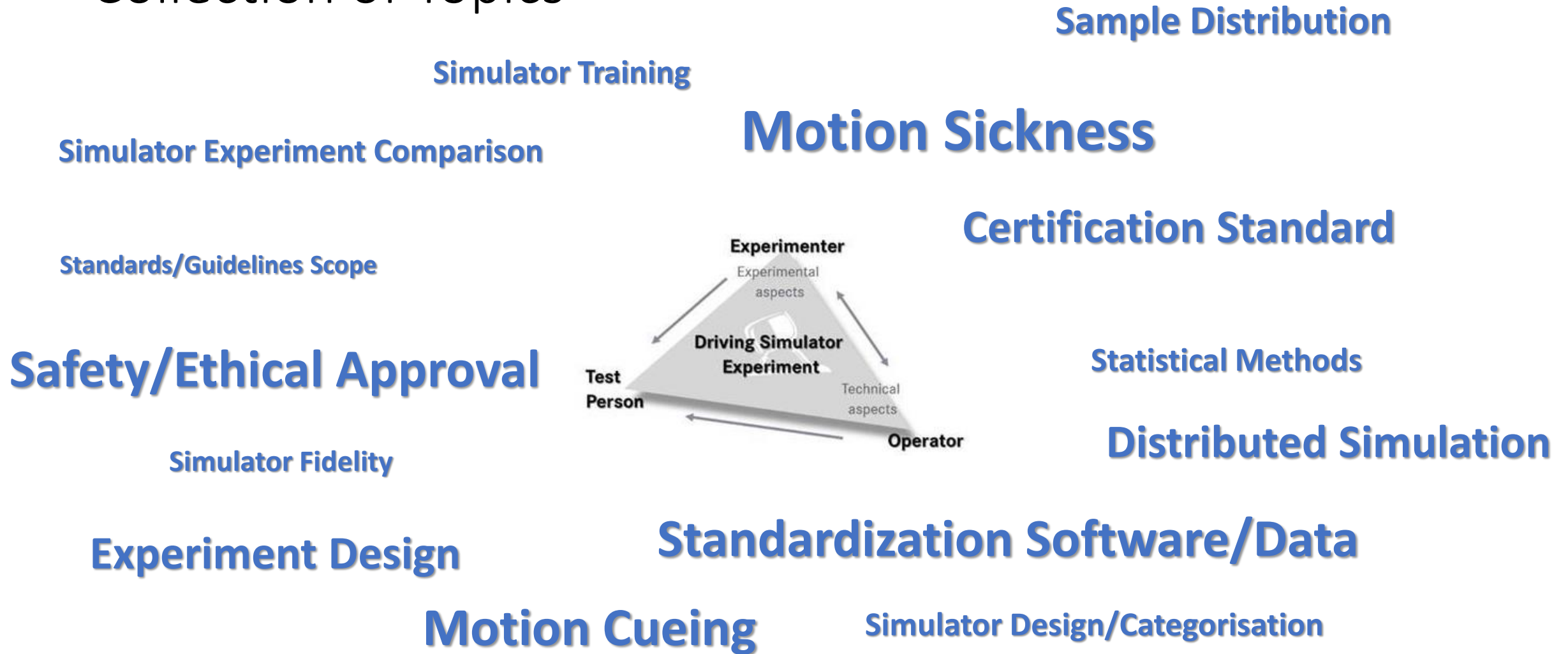
As proposed by Andras Kemeny we will set up a section for the "Driving Simulation Experience Special Interest Group (SIGDSEP)" on the DSA website to collect and publish the ideas shared in this forum. I think that might be available in the next weeks, starting with the information about the DSC 2018 round table, the people involved so far, i.e. the founding members, and a list of priority topics.

Anyway, please feel free to share your thoughts about the approach and the steps that we should take next. I am looking forward to hearing from you.

Kind Regards
Jens

Operational Guidelines for Driving Simulator Experiments

Collection of Topics

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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)**

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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)

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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)**

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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**)

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