The Evaluation of Experimental Variables for Virtual Road Safety Audits

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Contents

1. Introduction

1. Definitions

- **Road safety audit(RSA):** A formal and proactive examination of road safety by expert teams.

  (checking safety issues of existing or future roads, suggesting remedial measures)

- **Driving simulator(DS):** Integrated technologies represent reality with visual display and vehicle motions.

- **Virtual road safety audit(VRSA):** Newly proposed approaches to practice design decisions and safety reviews on an existing or future road using a driving simulator.

1. Definitions

- Road safety audit

- Field review
- Team discussion
- Project data review
- Conduct analysis
- Reporting of findings

Step 1: Identify project or existing road to be audited

Step 2: Select RSA Team

Step 3: Conduct a pre-audit meeting to review project information

Step 4: Perform field reviews under various conditions

Step 5: Conduct audit analysis and prepare report of findings

Step 6: Present audit findings to Project Owner/Design Team

Step 7: Prepare formal response

Step 8: Incorporate findings into the project when appropriate

Cite：FHWA(2006)

1. Definitions

▪ Driving simulator

Hardware platform and software

1) a desktop, single monitor or narrow field of view configuration (NFOVD)

2) a desktop three monitor or wide field of view configuration (WFOVD)

3) an instrumented cab with projected wide field of view display (WFOVC).

- Terrain mode
- Scenario mode
- Simulation mode
- Vehicle mode
- Analysis mode

In the VRSA previous study,
VRSA fidelity from low-end(Dynamic survey) to high-end(full-scale DS).

Cite : Wade Allen et al. (2007), Innosimulation pamphlet (2019)

1. Definitions

- Driving simulator

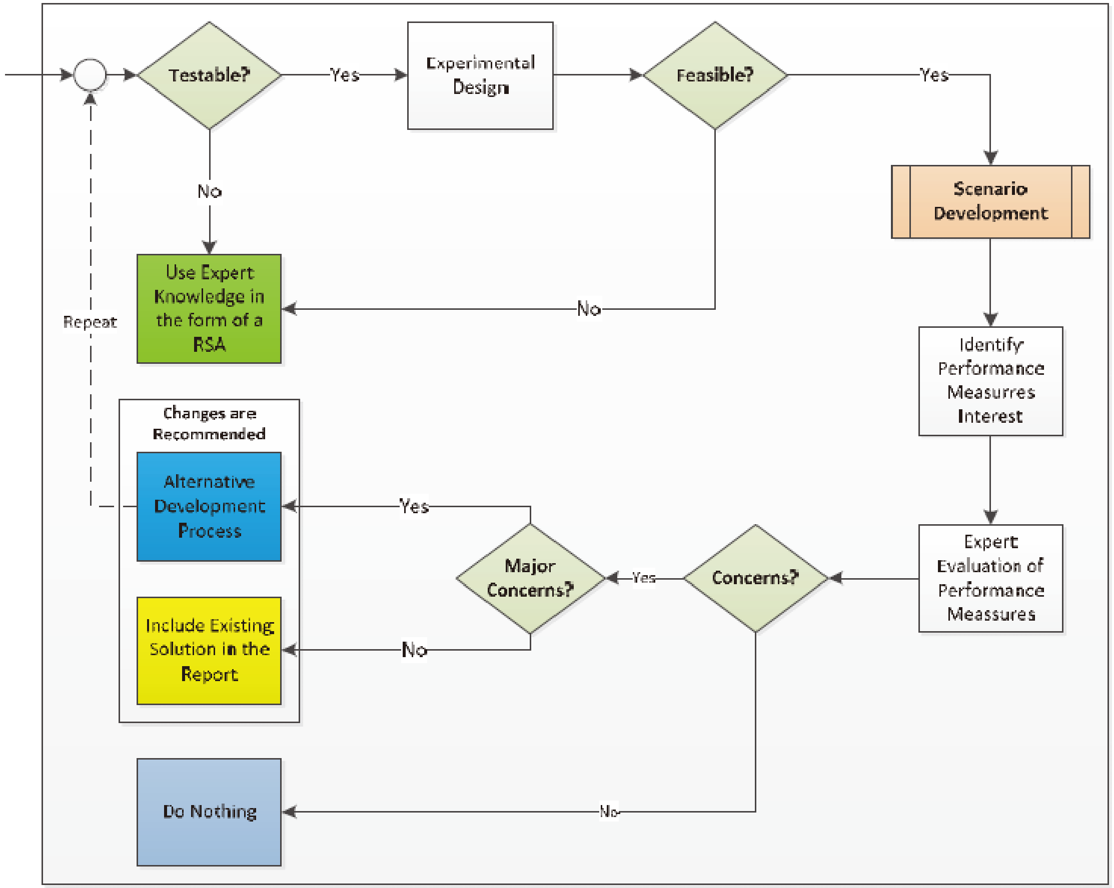
Cite : Korea Expressway Corporation

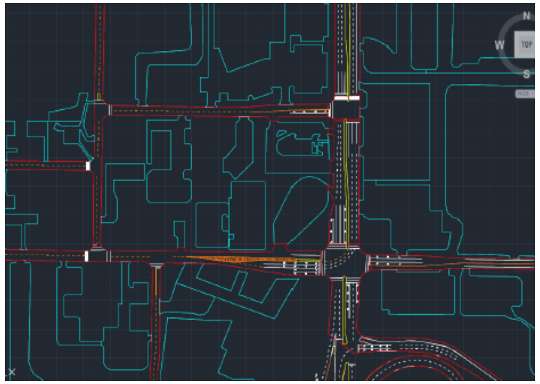
1. Definitions

- ## Virtual road safety audit

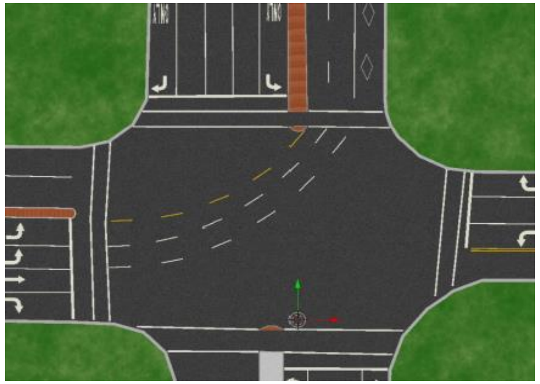
In the other related works,
Selecting, identifying a candidate site, and selecting experiment fidelity.
Also, experimental procedures and iteration.

Conceptual Framework

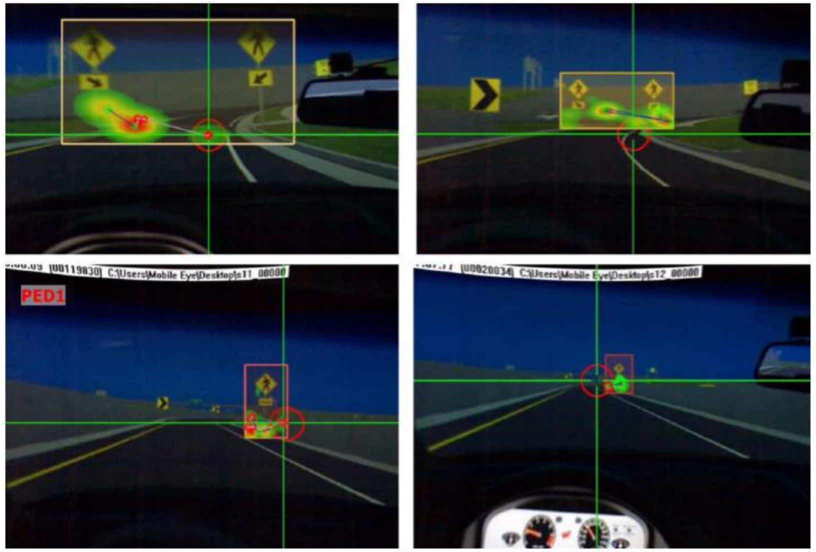




conversion
2D to 3D



VRSA Case study
with full-scale DS and eye-tracking



Cite : Santiago-Chaparro et al. (2011)

Cite : Noyce et al. (2018)

1. Definitions

- Virtual road safety audit

case study

2. Introduction

- As DSs have developed and advanced, **there is an attempt to apply DSs to RSAs.**
- **VRSAs is a newly proposed concept**, so there are little researches for it.
- **Previous studies** have suggested the framework, scenario creation methods, and practical applications of VRSAs
- **Limitations of previous studies:** All RSAs items cannot be experimental variables of VRSAs because of the gap between DSs environment and real road environment. It is necessary to determine whether a specific road object can be tested using DSs for VRSAs.
- **In our previous study,** we evaluated the priority of experimental variables based on testability and feasibility by using AHP. But just qualitative analysis, not practical experiments.
- Therefore, this study focuses on **evaluating experimental variables for VRSAs by comparing practical DS experiments and field reviews**

2. Categorizing Experimental Variables for VRSAs

1. Categorizing Experimental Variables for VRSAs

This study suggests VRSAs experimental variables based on the literature reviews.

Category	Experimental variables
Static road environments	Roadway layout(including road geography elements), Sidewalk, Bicycle route, Shoulder(roadside)
	Tunnel, Bridge, Underpass, Footbridge
	Other road types(Rail track, etc.)
	Road pavement
	Drainage
	Traffic light
	Traffic island
	Median barrier
	Landscaping
	Sign
	Lane, Road marking
	Lighting
	Road furniture(Fence, Delineator, Cushion, Hump, Parking, Rest area, Bus bay, Soundproofing, etc.)
Dynamic road environments	Vehicle
	Pedestrian
	Bicycle
	Traffic condition
	Accident
	Work zone
	Weather
	Hazard event(Disaster, Animal, etc.)

3. Method

1. Materials and Methods

- **Participants :** 4 professionals, all between the ages of 40 and 59, with more than 10 years of work experience
  driving experience for at least 20 years, also driving simulators experience
- **Driving simulator, Field reviews :** sequentially performed on November 4, 2020
  The DS is the advanced full-scale DS in Korea Expressway Corporation.
  Field reviews with actual vehicle driving in the same area and route as the experiment

(a) the DS experiment


(b) the full-scale DS


(c) the field review

1. Materials and Methods

- **Net promoter score(NPS) :** The likelihood of recommendation for VRSAs is evaluated based on NPS.
  - The NPS is a **methodology to measure customers' willingness to recommend a product or service** to their friends and was published in 2003 by Frederick F. Reichheld.
  - The way to calculate NPS uses **the 11-point scale** from a 0 to 10 rating in survey responses.

Promoters: respondents with 9–10 points

Detractors: respondents with 0–6 points

Passively satisfied: respondents with a score of 7 or 8

The result: the promoter ratio - the detractor ratio

(-100 to +100)

Q. How likely is it that you would recommend the VRSA experimental variables to a colleague?

Experimental variables		Not at all likely										Extremely likely
Static road environments	Roadway layout, Sidewalk, Bicycle route, Shoulder(roadside)	0	1	2	3	4	5	6	7	8	9	10
	Tunnel, Bridge, Underpass, Footbridge	0	1	2	3	4	5	6	7	8	9	10
	Other road types(Rail track, etc.)	0	1	2	3	4	5	6	7	8	9	10
	Road pavement	0	1	2	3	4	5	6	7	8	9	10
	Drainage	0	1	2	3	4	5	6	7	8	9	10
	Traffic light	0	1	2	3	4	5	6	7	8	9	10
	Traffic island	0	1	2	3	4	5	6	7	8	9	10
	Median barrier	0	1	2	3	4	5	6	7	8	9	10
	Landscaping	0	1	2	3	4	5	6	7	8	9	10
	Sign	0	1	2	3	4	5	6	7	8	9	10
	Lane, Road marking	0	1	2	3	4	5	6	7	8	9	10
	Lighting	0	1	2	3	4	5	6	7	8	9	10
	Road furniture(Fence, Delineator, Barrier, Hump, Glare screening, Parking area, Rest area, Bus bay, etc.)	0	1	2	3	4	5	6	7	8	9	10
Dynamic road environments	Vehicle	0	1	2	3	4	5	6	7	8	9	10
	Pedestrian	0	1	2	3	4	5	6	7	8	9	10
	Bicycle	0	1	2	3	4	5	6	7	8	9	10
	Traffic condition	0	1	2	3	4	5	6	7	8	9	10
	Accident	0	1	2	3	4	5	6	7	8	9	10
	Work zone	0	1	2	3	4	5	6	7	8	9	10
	Weather	0	1	2	3	4	5	6	7	8	9	10
	Hazard event(Disaster, Animal, etc.)	0	1	2	3	4	5	6	7	8	9	10

1. Materials and Methods

- **Case study :** The experiment area is about 3km in Sangam-dong, Seoul, Korea.

  The 3D scenario was developed for the DS experiment, including all VRSAs variables.

  The scenario consists of two situations, day and night, and each takes about 10 minutes.

2. Analysis Procedures

Step 1

- **Explaining** the experiment and NPS survey.
- **Test driving** on different roads before the experiment.
- **Conducting a DS experiment of day and night scenarios for a total of 20 minutes.** (the drivers can drive autonomously following the route)

Step 2

- **Field reviewing by driving a real car**.

Step 3

- **Responding to the survey and interview.** (The DS experiment and field review are compared to determine how similar reality each variable of the DSs scenarios for VRSA.)

4. Results and Discussion

1. Results

NPS results

Experimental variables	NPS score	Experimental variables	NPS score
Roadway layout, Sidewalk, Bicycle route, Shoulder	0	Lighting	-50
Tunnel, Bridge, Underpass, Foot bridge	50	Road furniture (Fence, Delineator, etc.)	25
Other road types(Rail track, etc.)	0	Vehicle	-25
Road pavement	-50	Pedestrian	-50
Drainage	-100	Bicycle	-50
Traffic light	25	Traffic condition	25
Traffic island	50	Accident	-50
Median barrier	25	Work zone	0
Landscaping	0	Weather	0
Sign	50	Hazard event (Disaster, Animal, etc.)	-25
Lane, Road marking	50		

Experts interviews

Briefly,

- **Recommended variables** can evaluate driver behavior (also route), safety, driver perception, and the impact of traffic congestion with providing a more realistic scenario.
- **Non recommended variables** are challenging to represent realistic driving environments and difficult to render with traditional DSs software.

2. Discussion

- **Comparison of this study results with other related studies:**
  - It is similar to the result of the study evaluating VRSA experimental variables by the AHP method.
  - Previous studies have also mentioned non-recommended variables as a limitation of the DS experiment or a problem to be overcome in the previous study.

- **Limitation of this study**
  - Only four experts were the participants; therefore, the experiment results are challenging to generalize, and their scientific value is less significant.

- **Nevertheless, the meaning of this study**
  - This study was the first attempt to conduct a DS experiment and field review in VRSAs.
  - Moreover, it can evaluate the visual experiential validity of performing VRSA using the DS simulator.
  - Also, it identifies and categorizes the VRSA variables and evaluates them.

5. Conclusion

1. Conclusion

First

- "Tunnel," "Bridge," "Underpass," "Footbridge," "Traffic island," "Sign," "Lane," "Road marking," "Traffic light," "Median barrier," "Road furniture," and "Traffic condition" are the recommended variables.
- They can be **realistically developed on DSs display** also be **installed by the traditional DSs software**. Moreover, road characteristics variables are **essential for vehicle behavior and driving path analysis.**

Second

- the non-recommended variables are as follows: "Road pavement," "Drainage," "Lighting," "Vehicle," "Pedestrian," "Bicycle," "Accident," "Hazard event" variables.
- These variables' **realism is poor** and **challenging to render precisely to reflect the real world**. In addition, These dynamic variables **require much time and cost in developing a realistic scenario.**

Finally

- the study suggests **the recommended variables and decision-making considerations** for scenario development in conducting sustainable VRSAs in the future.

Thank you

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