Checklist for verification of correct calibration

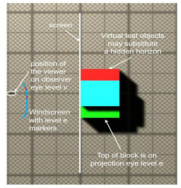
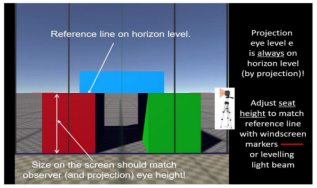
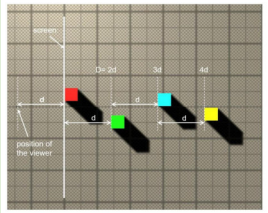
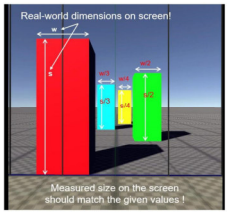
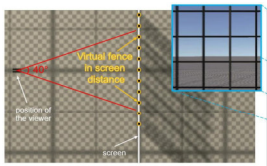
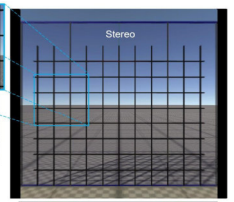
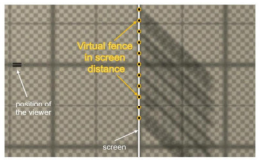
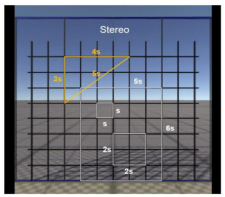
This document refers to: Schöner HP, Schmieder H, Chardonnet JR, Colombet F, Kemeny A (2022).
Verification of Stereoscopic Projection Systems for Quantitative Distance and Speed Perception Tasks.
Driving Simulation Conference , Strasbourg.
The extended version can be downloaded at
https://driving-simulation.org/activity-domains/Stereoscopy and distance perception

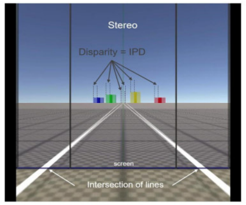
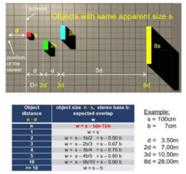
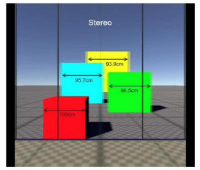
Simulator facility	
Nominal screen distance / geometry	cm
Date	
Experiment	
Test person #	
in situ eye distance from screen d	cm
in situ eye height e	cm
interpupillary distance IPD = b	mm
brightness of the image	LUX (by light meter

frequency of inspection:
- for every single participant
- for new installation or revision

useful tools:

options:
- direct measurement
- verification test number

Test No.	frequency of inspection	subject	feature	influence on	to be checked	method of verification (see reference text)	OK ?	test objects	sketch of test scene
1	The verification should be performed for every single participant of a simulator test drive.	**correct location of the observer's eye point**	a real-world horizon is always (automatically) on eye level. Eye point must be in nominal screen distance.	monocular and binocular distance cues	Measure the height of the horizon (or of the reference edge) above the horizontal ground plane. Both should have the same value as the eye height (v) of the observer above ground plane. Adjust seat height to fit. Alternative: Match eye level with the horizon marker on the windshield (or the levelling light) and horizon on the screen. **Adjust seat height to fit.** Verify observer's eye distance from the screen by comparing with a marker when observing the person from the side. **Adjust longitudinal seat position / inclination to fit.**	Test #1	☐ ☐	virtual object with a distinct reference edge at projection eye level (e), with its front located in screen distance. • Permanent markers on the windshield at the projection eye level • projected markers by levelling light beamer adjusted to projection eye level, beaming from the side to the face of the observer; this can be judged by an outside operator, or by the observer himself, looking into a mirror. • projected or physical marker of correct eye position in longitudinal direction.	 
2	Test has to be performed only for a new installation, or for a revision of the system.	**size-change with varying distance**	Correctly projected objects in n times larger distance should have a 1/n times smaller size on the screen.	monocular and binocular distance cues	For the reference objects in distance n x d, their size on the screen should be s/n. Measure the size of the objects on the projection screen and compare with their expected size.	Test #2	☐	set of reference objects, all with height or width s, in multiples of screen distance d	 
3	Test has to be performed only for a new installation, or for a revision of the system.	**squint angle for objects in screen distance**	A point or object in the virtual world with a distance equivalent to the screen distance d should be projected exactly onto the same point of the screen for both left and right image.	monocular and binocular distance cues	An observer should perceive such an object correctly in the distance of the screen. the poles and bars of the fence should not produce any double images on the screen due to the right and left image projection. An observer may check this fact by taking off the stereoscopic glasses. The observer should perceive the fence (in stereo mode) at the same location as the screen (without stereo glasses).	Test #3	☐	a see-through 'fence' of the exact size and location of the (flat or cylindrical) screen with a square pattern on its inner surface ('poles' and 'bars')	  For objects on the screen, ideally both stereo images should be identical; this assures a natural squint angle, and the objects are perceived at screen distance. This is relevant in the human stereoscopic range of ≈40°. correct stereoscopic viewing
4	Test has to be performed only for a new installation, or for a revision of the system.	**proportions and size in screen distance**	on the screen, the virtual world and the real world 'intersect'. Objects on the screen surface should have the same dimensions as in the real world	monocular and binocular distance cues	Vertical and horizontal objects in screen distance should have the same height and width as in reality. A square object of the size s x s in screen distance can be measured on the screen and should have exactly the same vertical and horizontal size s x s in the virtual as in the real world. Pythagoraic triangles are also easy to verify this way. Left and right image should superimpose each other exactly for approximately the range of the panum; an observer may check the full overlap of the two pictures when the stereoscopic glasses are shut off or taken off.	Test #4	☐	a see-through 'fence' of the exact size and location of the (flat or cylindrical) screen with a square pattern on its inner surface ('poles' and 'bars')	  For objects on the screen, like this virtual fence, rectangles should remain rectangles in all dimensions. A square pattern allows easy verification by measurement.

5	The verification should be performed for every single participant of a simulator test drive.	**stereoscopic convergence**	several reference points **located far away**, roughly in forward direction should be seen with parallel eyes the left and right images of lines extending from the observer **towards the horizon** should converge in front of and diverge beyond the screen	binocular distance cues	Squint angle zero is attained, if projected distance on the screen of L/R images is equal to IPD of the observer for *distant* objects. **Correct IPD setting, if necessary.** road markings on the road ahead should converge in front of the screen distance, should cross at screen distance, and diverge beyond screen distance; in the far distance they should not diverge to more than the IPD of the observer The observer is expected to perceive an object on the horizon as far outside of the simulator room. The screen itself should turn invisible in stereoscopic mode. For objects beyond the screen distance, the right image should be farther to the right.	Test #5	☐ ☐ ☐ ☐	distant objects (close to the horizon) in the virtual world, and straight lines on the ground plane from the observer towards the horizon	For objects close to the horizon, the disparity between left and right image should be equal to individual interpupillary distance (IPD). Measure between reference edges! Corresponding lines in left and rigth images should intersect in distance of the screen. 
6	Test has to be performed only for a new installation, or for a revision of the system (if Test #4 and #5 are passed for one IPD).	**stereoscopic intermediate distance cues**	verify linear size reduction and stereoscopic convergence in **intermediate distances**	binocular distance cues	all reference boxes should have a projection size of s x s on the screen, with the same size for both eyes, but with an overlap w of the two squares according to table 1	Test #6	☐	boxes with a front area of ns x ns in a distance of nd (i.e. n times the screen distance d, "growing boxes") in the virtual world.	 
7	The verification should be performed for every single participant of a simulator test drive.	**grasping distance**	The ability to grasp a real object based on the visual direction and distance cues (without help of any haptic cues) uncovers incorrect calibrations of individual body measures **in the near field**	binocular distance cues	virtual object in reaching distance can be grasped at the location where it is expected from its visual appearance in a stereoscopic display. The observer should be able to grasp the knob or touch the screen at the correct location on the first try.	Test #7	☐	a real object (gear shift knob, touch screen) in reaching distance, and displayed equivalently in the virtual world on the stereoscopic display