Informal document **GRSG-101-14**
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Agenda item 5.)
Submitted by the expert from Japan

Research on the Admissible Range of Use of Camera Monitor Systems for Indirect Fields of Vision

1. Background

Since the 96th GRSG, proposals on camera monitor systems (CMS) have been the subject of discussion. The ISO is currently discussing the technical aspects of these systems including safety issues. In Japan, too, a technical review of safety concerns with CMS is in progress. This review is based on the assumption that CMS basically must have performance equivalent or superior to that of mirrors. The important functions of mirrors include allowing the driver to *recognize a reflected object (identification)* and *get a sense of distance to the object (sense of distance)*. When used on motor vehicles, CMS must have these functions equivalent or superior to those of mirrors.

2. Purpose

This report takes up the door mirrors from among the principle external rearview mirrors in the range prescribed in the regulations. In the tests conducted, the subject drivers were asked to check for an object behind the vehicle through the door mirror and the CMS and compare and evaluate their images. Based on the results of the evaluation, we examined what it takes for CMS to have performance equivalent or superior to door mirrors in identification of and giving a sense of distance to objects coming from behind.

Research on the admissible range of use of CMS for indirect fields of vision

Experimental items *1	Object	Assumed circumstance	Purpose of survey
1. Identification of an object	Bicycle	Checking left rear before turning left	Survey on the size of the object (angle of vision) on the projected plane that is recognizable as well as through mirrors
	Car	Checking rear before changing lanes (to the left/to the right)	
2. Sense of distance to an object	Bicycle	Checking left rear before turning left	Survey on the size of the object (angle of vision) on the projected plane that gives a sense of distance equivalent or superior to that through mirrors
	Car	Checking rear before changing lanes (to the left/to the right)	
3. Sense of distance to an object (Influence of short-time learning from directly seeing the object)	Car	Checking rear before changing lanes (to the left/to the right)	Influence of short-time learning (correction of the sense of distance by comparing direct sight of the object and sight through a monitor) on the sense of distance

*1: All the experiments were conducted with both the driver's vehicle and the object at a standstill.

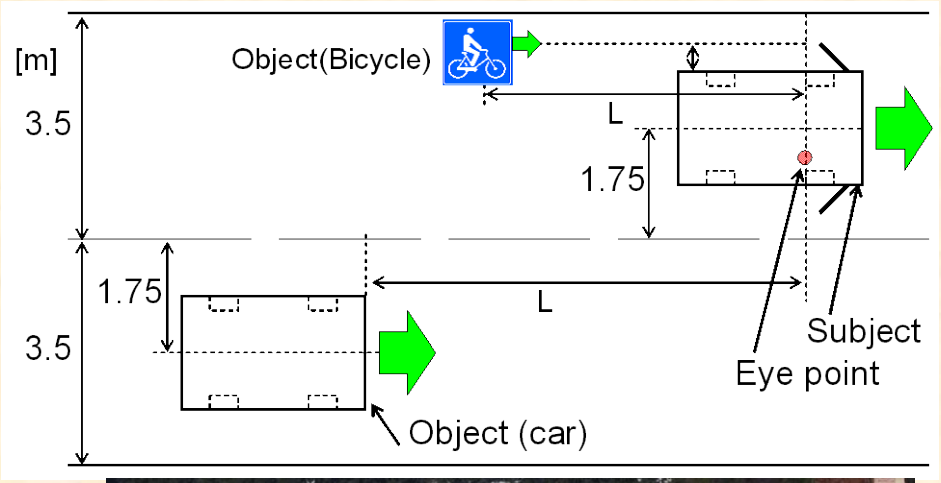
⇒ As an example of the results of the research, let us see the results of the test 2 above.

3. Basic Conditions in the Experiment (1)

(1) Assumed circumstances

	Traffic circumstances	Object	Width x Height [m]
A	Turning left with a bicycle approaching from rear	Bicycle	0.54 x 1.70
B	Changing lanes to the left	Car	1.77 x 1.45
C	Changing lanes to the right	Car	

Positions of Bicycle and Cars



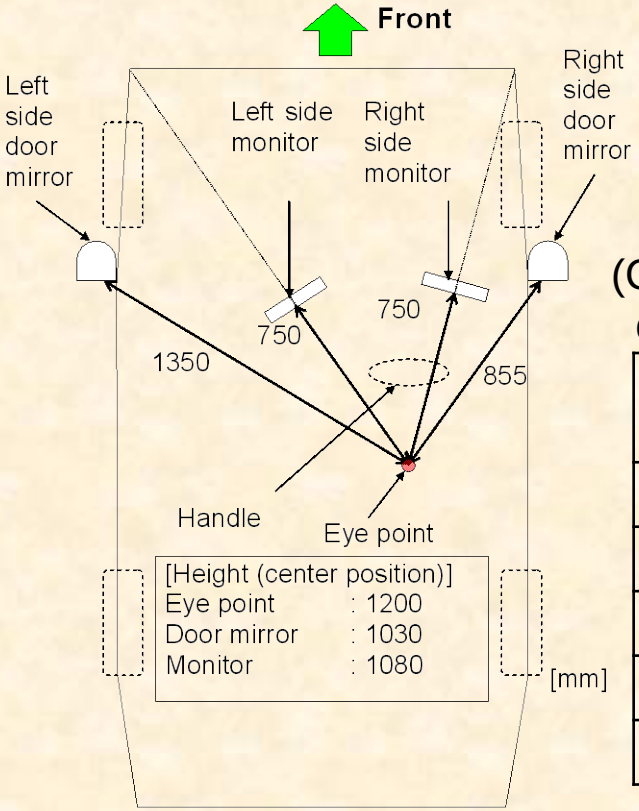
(2) Experimental conditions

- The driver's car and the object were at a standstill.
- To simulate the driver checking the object while driving, checking time through the door mirror and the monitor was both limited to one second.
- The curvature of the mirror was 1320R.
- The eye point was 635 mm immediately above the reference point, with the driver's seat slid to the rearmost position.
- The zoom lens of the camera was fixed in a position that gave the monitor the same range of display as the mirror.
- The subject drivers were:
  - Fifteen in total (with a binocular visual acuity of 0.7 or over)
  - In their 20's to 60's.
  - With driving experience of 3 years or more, being at least once a week behind the wheel.

Device limiting the time to check the door mirror.

4. Basic Conditions in the Experiment (2)

(3) Settings of the door mirror and the monitor



Monitor sizes (Carried out in the 5 conditions below)

Rate	Monitor size [inch]
1.00	7.00
0.81	5.67
0.66	4.59
0.53	3.72
0.43	3.01

5. Outline of the Test on the Sense of Distance and the Experimental Conditions (1)

In this experiment, the subject driver was asked to first check the distance to an actual object positioned at a standstill behind his/her car through the left or right door mirror and then check the distance through the monitor in the same way.

Then, they were asked to evaluate the sense of distance they got through the CMS by comparing that with the sense of distance they got through the door mirror. From the results of this evaluation, we identified the size of image that gave the driver the same sense of distance as the door mirror. The images displayed on the monitor varied with different parameters in distances to the object and monitor sizes.

Based on the result of the examination, we tried to find out the size of the monitor that would give the driver the same sense of distance as the door mirrors to objects located at the same distance.

<Test Conditions>

*1: The door mirror and the monitor each displayed the object for one second only.

Case	Device*1	Object	Assumed circumstance	Distance [m]
[7]-[9]	Door Mirror (1320R)	Bicycle Car	Turning left Changing lanes (to the left/to the right)	30
[7]	CMS*2 (five sizes)	Bicycle	Turning left	15, 20, 25, 30, 35, 40
[8]		Car	Changing lanes (to the left)	15, 20, 25, 30, 35, 40, 60
[9]			Changing lanes (to the right)	

*2: The sizes of the images and distances of the object displayed on the monitor were changed in random order.

6. Conditions of the Test on Sense of Distance

<Evaluation Rating>

Rating	Description
1	Felt much farther than through the mirror
2	Felt farther than through the mirror
3	Felt slightly farther than through the mirror
4	Felt at the same distance as through the mirror
5	Felt slightly nearer than through the mirror
6	Felt nearer than through the mirror
7	Felt much nearer than through the mirror

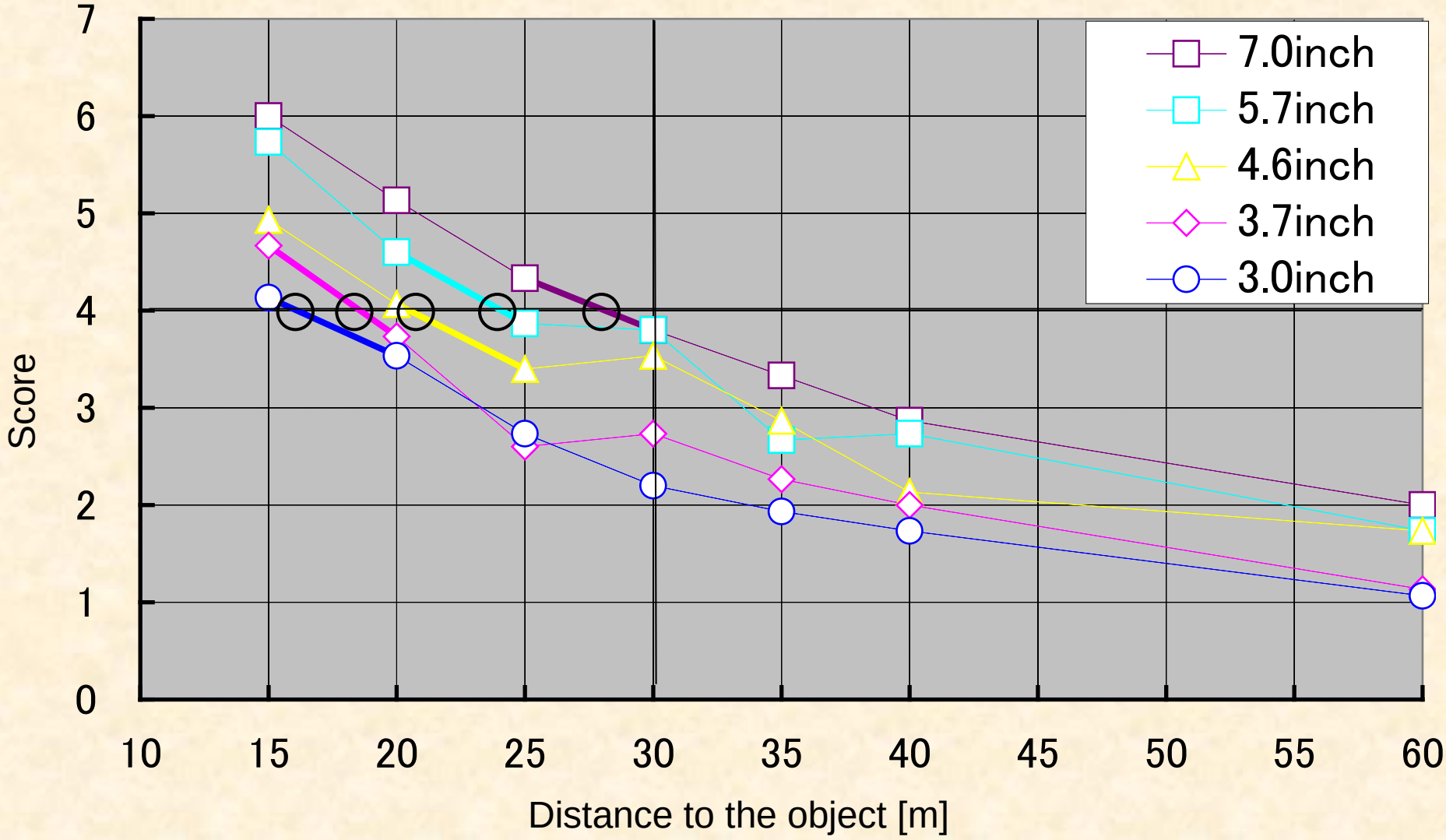
* The results of evaluation were data obtained by averaging the results of evaluation by the 15 subject drivers at each distance of the object.

<Experimental Procedure>

Step	Description
①	The driver sits on the set (fixes the eye point).
②	Checks the sense of distance to the object through the door mirror.
③	Checks the sense of distance to the object through the monitor.
④	The subject evaluates the sense of distance he/she gets through the monitor.
⑤	The settings of the monitor display (monitor size and distance) changed and the subject repeats the steps 2 to 4.

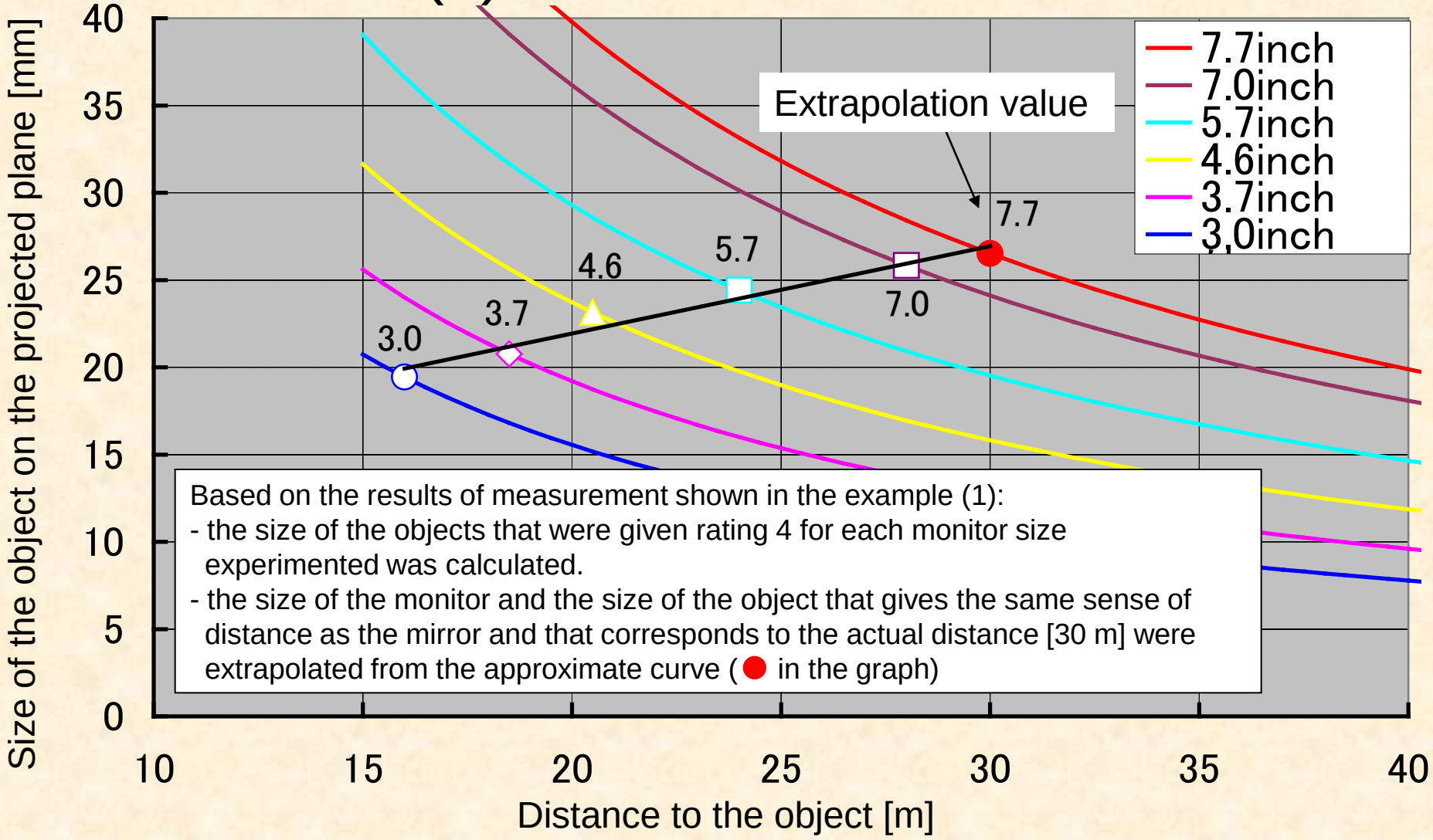
*2: The sizes of the images and distances of the object displayed on the monitor were changed in random order.

7. Example of the Results of the Test on Sense of Distance (1)



Conditions (Right, 1320R, Car, Changing lanes, Case [9])

8. Example of the Results of the Test on Sense of Distance (2)



Conditions (Right, 1320R, Car, Changing lanes, Case [9])

9. Example of the Results of the Experiment on Sense of Distance (3)

The results of extrapolation of the sizes of the monitor and the object from the approximate curve of rating 4 that would give the same sense of distance as the mirror and correspond to the actual distance [30 m]

Case	Distance [m]	Size of the monitor evaluated as giving the same sense of distance as the door mirror	Size of the image on the monitor assumed as same as that on the door mirror *1
		[inch]	Size [mm]
			[deg]
[7] Bicycle	30	6.4	21.3
			1.63
[8] Car, Left	30	5.9	22.7
			1.73
[9] Car, Right	30	7.7	26.5
			1.77

*1: Distance between the eye point and the monitor = 750 mm

10. Conclusion*1

- The results of the research suggest that the sense of distance to an object that the driver gets is strongly influenced by the size of the object image reflected on the mirror or projected on the monitor.
- The size of the object image on the monitor that gives the same sense of distance as the door mirror is about 1.77deg or larger.

[*1 The conclusion of this report concerns only the range of the conditions assumed in this test.]

The data on the results of the survey so far conducted will be shared with the ISO if required.