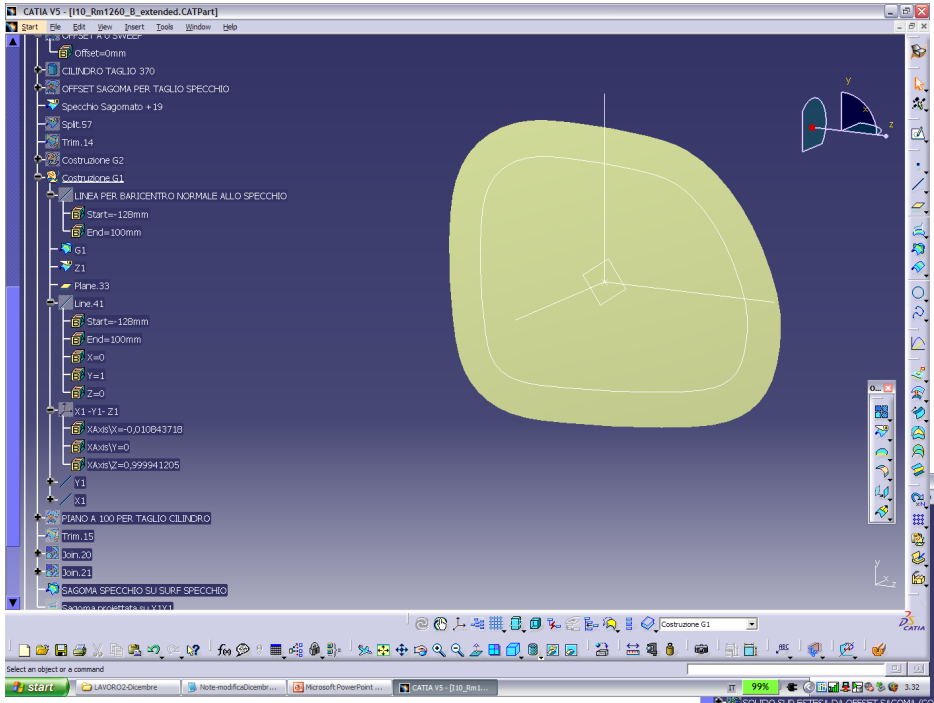
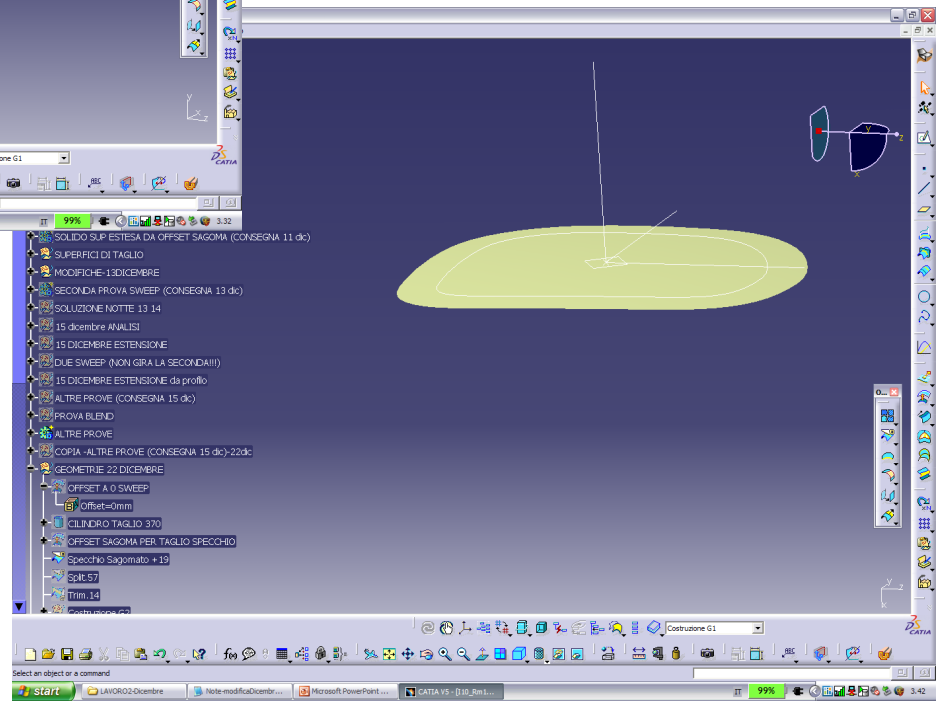
Reg. ECE 46/06

IT proposal for amendments (doc. GRSG/2020/6)

Informal document **GRSG-119-26**
(119th GRSG, 6-9 October 2020
Agenda item 4a)

This document describes a proposal of revision of Reg. ECE 46/06.
The proposal is based on studies, started twenty years ago, on non-spherical optical surfaces applied on exterior rear view mirrors. Optical surfaces are designed with the support of a dedicated software suitable to simulate the optical performances of free form mirrors.





The intention of the proposed amendment is not to replace the current spherical product (which will continue to be offered on the market), but to allow the new generation of optical reflecting mirrors being proposed to OEMs in order to improve the quality of the reflected images and optimize the mirror size for a given field of vision.

Spherical mirrors : do they represent the optimal field of view?

- Reg. ECE 46/06 requires that the reflecting surface of the mirrors be spherically convex, with allowance of mean radius deviations due to the production tolerances (+/- 15% radius)
- The Regulation establishes an experimental procedure to measure the deviation of the real surface of a mirror with respect the ideal one, and sets the limits.
- Therefore, cars should be equipped with perfectly spherical mirrors. In reality, because of production, all of the mirrors have surfaces where each point randomly deviates with respect to the position on the ideal sphere.
- External mirrors, especially those on passenger's side, are commonly far from drivers eyes and their inclination is not orthogonal. Therefore surface design shall take into consideration mirror's position and inclination effects on potential image distortion.

Main dvantages of Free Form mirrors

- Better field of view / or **smaller glass for the same field of view**

- Reducing glass housing
- Reduced costs

- **Lower c_d**
- **Less fuel consumption**

Reg. ECE 46/06: Compliance requirements

ECE R46 Standard

- The legal minimum radius is measured according to the ECE R46 Standard

That's to say :

- 3 measuring points (r_p1, r_p2, r_p3) with the Mean Radius r defined as follow :

$$r = \frac{r_p1 + r_p2 + r_p3}{3}$$

- 2 principal radii of curvature for each point

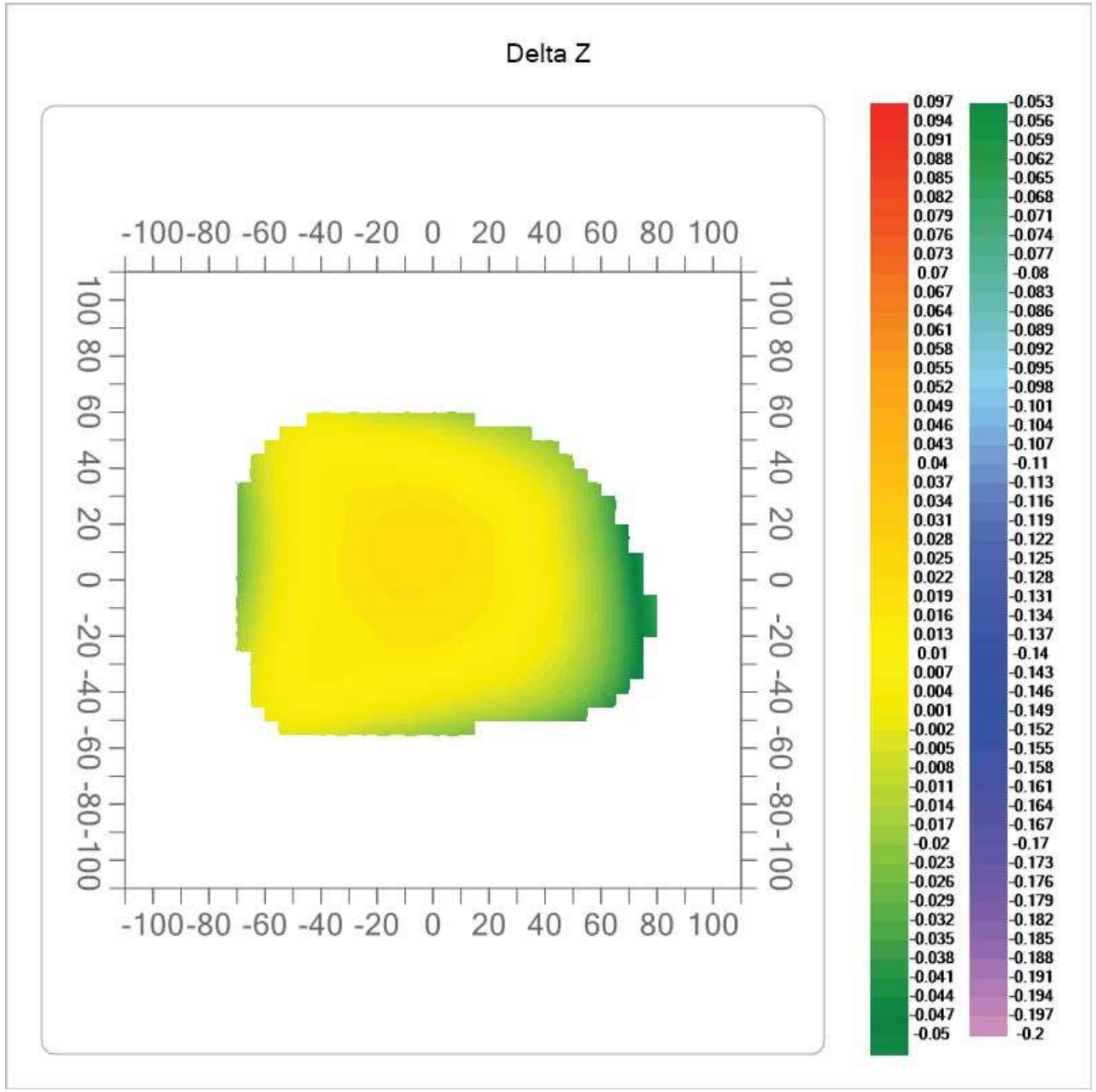
$$r_p = \frac{r_i + r_i'}{2}$$

- Mean Radius r > 1,200 mm
- For r < 3,000 mm
  - The difference between r_i or r'_i, and r_p at each reference point must not exceed 0.15 r
  - The difference between any of the radii of curvature (r_p1, r_p2, and r_p3) and r must not exceed 0.15 r

➔ **The Free form mirror uses the room allowed by this coefficient *0.15 r* in order to increase the field of view.**

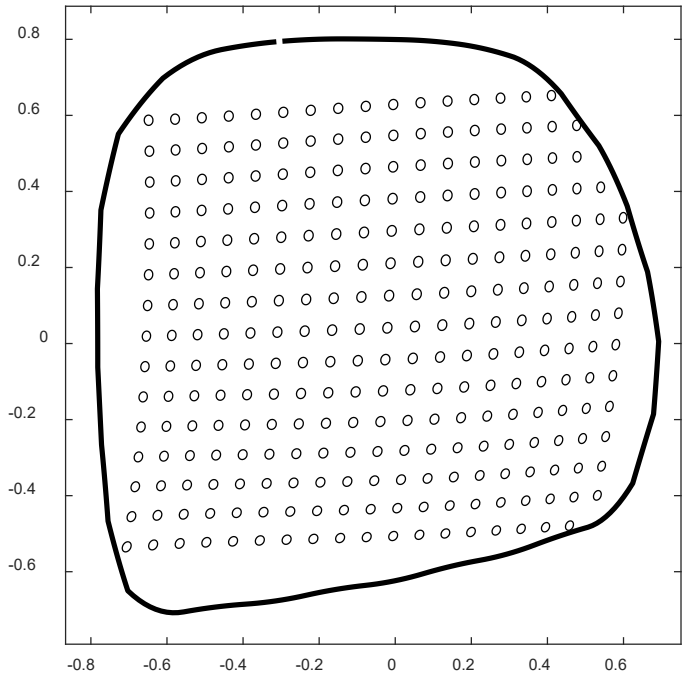
The current process of manufacturing of optical surfaces can be adopted for *Free Form Mirrors.*

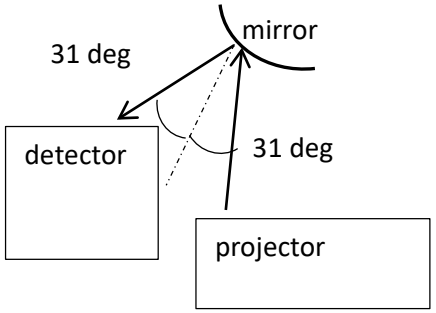
Design software and manufacturing processes of molds - CNC multi axes and optical polishing - have created the concrete conditions to reproduce complex surfaces with very affordable quality and reproducibility.



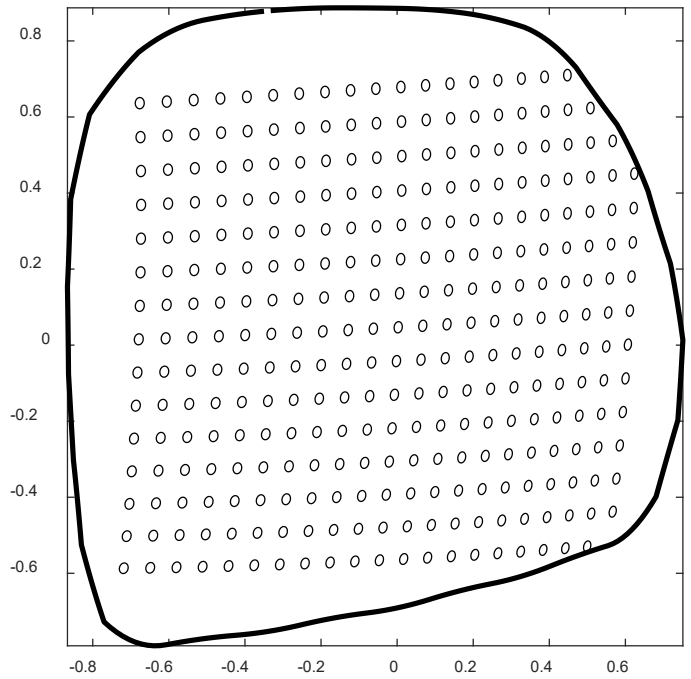
Measured samples - Actual Z axis vs Theoretical Z axis

IMAGE DISTORTION: MAP OF POINTS





mirror oriented as used on the car (3D configuration)



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D_{max}/d_{min} ratios

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D_{max}/d_{min} ratios

Free Form Mirror (passenger side)

Mean value = 1.18, standard deviation = 0.0735, min. val. = 1.05, max. val. = 1.41

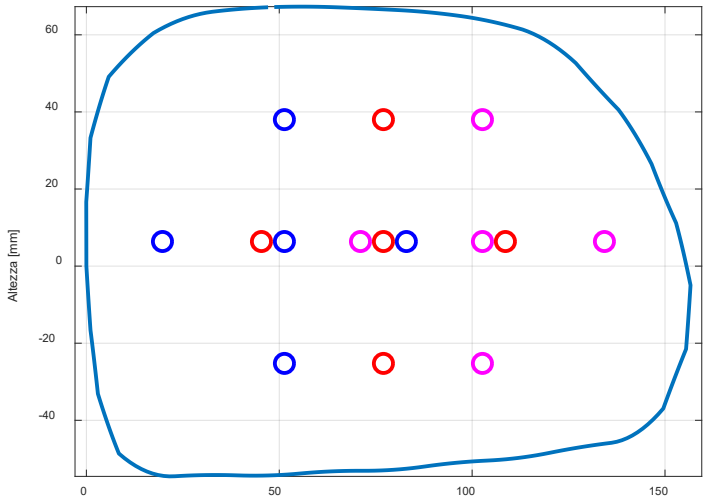
Spherical Mirror (passenger side)

Mean value = 1.38, standard deviation = 0.1015, min. val. = 1.21, max. val. = 1.59

From spherical mirror surface to free form mirrors compliant with ECE 46 Rev. 6 Regulation

RADII OF CURVATURE MEASUREMENT ACCORDING TO ECE46-rev6 REGULATION

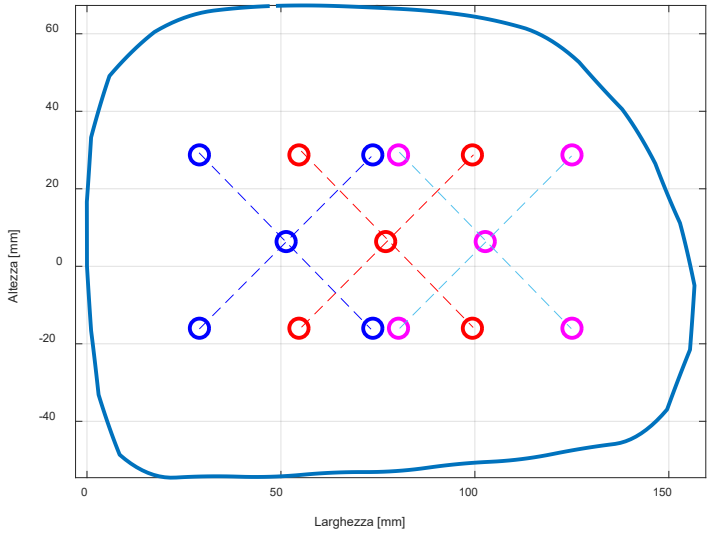
Distances between the tracing pin of the dial gauge and the fixed legs = 31.62 [mm]
tolerance = 190.34 [mm] (0.15r >>1268.91 mm.)



orientation: 0° deg. and 90° deg

Horizontal Radii	Vertical Radii	Average Radii rp
a) r1 = 1348.62[mm]	r'1 = 1114.37[mm]	rp1 = 1231.49[mm]
r1-rp1 = 117.12[mm]	r'1-rp1 = -117.12[mm]	
b) r2 = 1441.58[mm]	r'2 = 1133.67[mm]	rp2 = 1287.63[mm]
r2-rp2 = 153.96[mm]	r'2-rp2 = -153.96[mm]	
c) r3 = 1441.58[mm]	r'3 = 1133.67[mm]	rp3 = 1287.63[mm]
r3-rp3 = 153.96[mm]	r'3-rp3 = -153.96[mm]	

r = 1268.91 [mm] rp1-r = -37.42 [mm] rp2-r = 18.71 [mm] rp3-r = 18.71 [mm]



orientation: + 45 deg and 135°

45° Radii	135° Radii	Average Radii rp
a) r1 = 1231.66[mm]	r'1 = 1217.71[mm]	rp1 = 1224.68[mm]
r1-rp1 = 6.98[mm]	r'1-rp1 = -6.98[mm]	
b) r2 = 1274.97[mm]	r'2 = 1268.23[mm]	rp2 = 1271.60[mm]
r2-rp2 = 3.37[mm]	r'2-rp2 = -3.37[mm]	
c) r3 = 1268.23[mm]	r'3 = 1274.97[mm]	rp3 = 1271.60[mm]
r3-rp3 = -3.37[mm]	r'3-rp3 = 3.37[mm]	

r = 1255.96 [mm] rp1-r = -31.28 [mm] rp2-r = 15.64 [mm] rp3-r = 15.64 [mm]

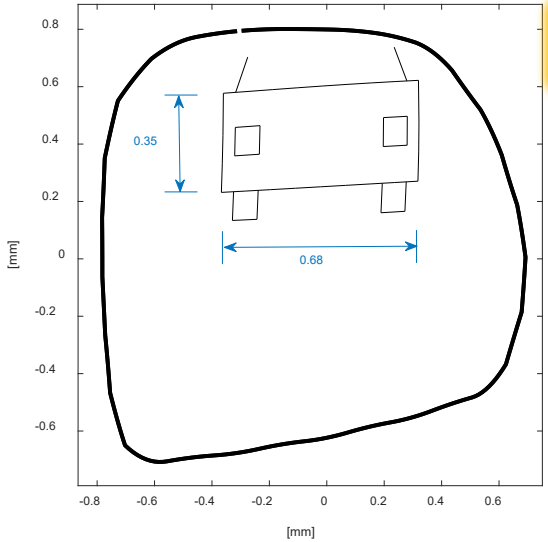
On a *free form* surface each point has been defined through an algorithm to achieve optical design targets.

QUALITY OF OBJECTS REFLECTED - MIRRORS ON VEHICLE

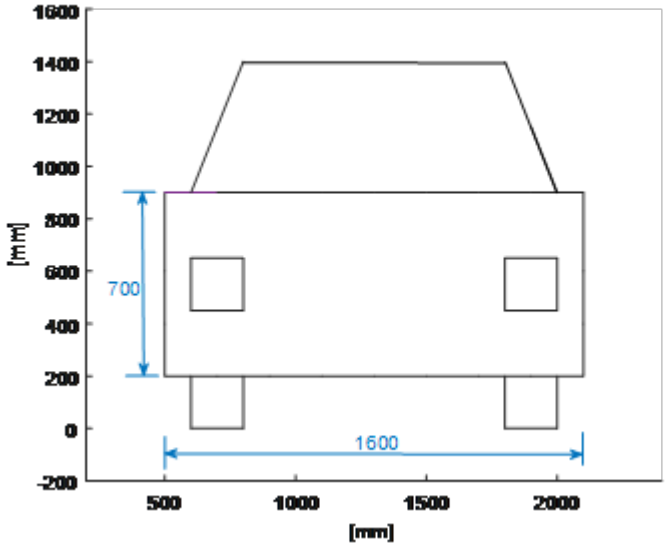
car at 10 m –

Free Form mirror on passenger side

reflected size of vehicle 238 sq.mm



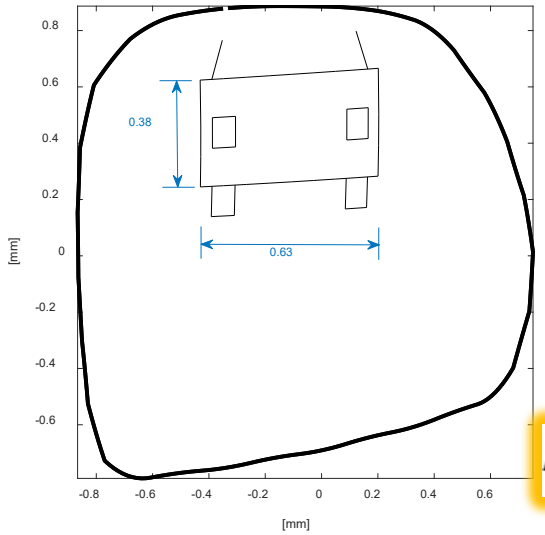
$$Ratio = \frac{length}{height} = \frac{0.68}{0.35} = 1.94$$



$$Ratio = \frac{length}{height} = \frac{1600}{700} = 2.28$$

Spherical mirror on passenger side

reflected size of vehicle 239 sq.mm

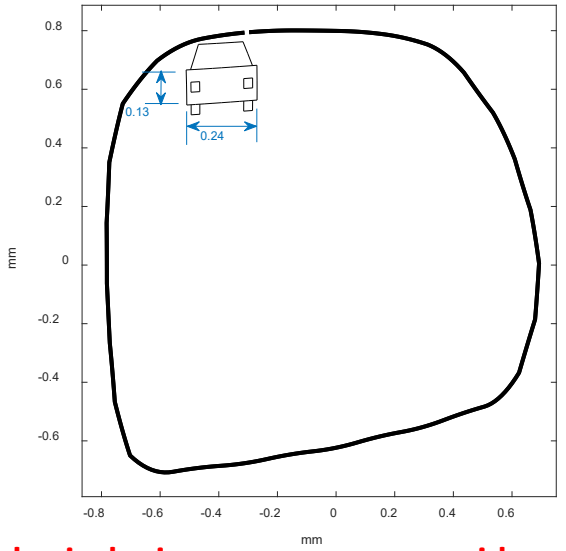


$$Ratio = \frac{length}{height} = \frac{0.63}{0.38} = 1.66$$

car at 30 m –

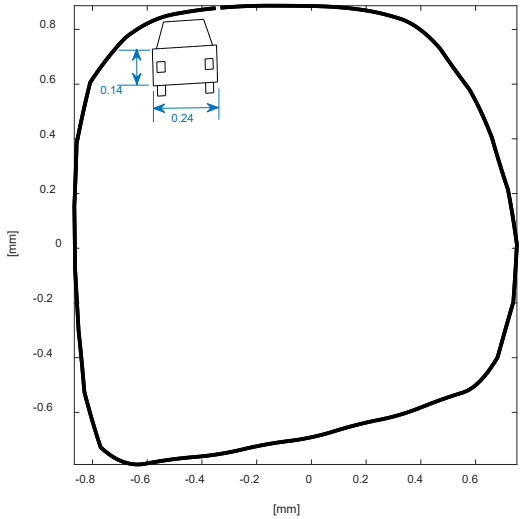
Free Form mirror on passenger side

RATIO 1,85



Spherical mirror on passenger side

RATIO 1,71



Experience of process design and manufacturing on mirrors for vehicles
DRIVING FIELD TEST

TARGET OF THE PROJECT WAS MIRROR SURFACE AREA -20%

- Application was dedicated to a passenger rear view mirror
- the *free form mirror* complied with ECE R46 and contributed to reduce volume of the mirror body, noise at wind gallery test and CX of the vehicle. Results have been validated by an car maker.
- The field of view is absolutely identical to the original mirror; the exceeding area of the overlaid spherical mirror shows the same images as the peripheral area of the free form mirror
- Comfort of view is absolutely evident; absence of distortion and perception of object sizes
- Reduction of size combined with correlated volume of the assembly makes a big difference in impact

Proposed amendments (1)

ECE-TRANS-WP.29-GRSG-2020-06e

Paragraphs 2.1.1.7. to 2.1.1.9., amend to read:

"2.1.1.7. "Spherical surface" means a **convex** surface, which has ~~a constant and equal radius in all directions~~**, in both horizontal and vertical direction, measured radii of curvature compliant with the provisions given in paragraphs 6.1.2.2.2 and 6.1.2.2.4.**

2.1.1.8. "Aspherical surface" means a **convex** surface, which ~~has only in one plane a constant radius~~ **may have variable radii of curvature both in the horizontal and vertical direction.**

2.1.1.9. "Aspherical mirror" means a mirror composed of a spherical and an aspherical part**, defined in 2.1.1.7 and 2.1.1.8 respectively,** in which the transition of the reflecting surface from the spherical to the aspherical part has to be marked. **As an example,** the curvature of the main axis of the mirrors ~~is~~ **may be** defined in the x/y coordinate system defined by the radius of the spherical primary calotte with:

$$y = R - \sqrt{(R^2 - x^2)} + k(x - a)^3$$

Proposed Amendments (2)

ECE-TRANS-WP.29-GRSG-2020-06e

$$y = R - \sqrt{(R^2 - x^2)} + k(x - a)^3$$

Where:

R: nominal radius in the spherical part

k: constant for the change of curvature

a: constant for the spherical size of the spherical primary calotte"

Paragraph 6.1.2.2.1., amend to read:

"6.1.2.2.1. The reflecting surface of a mirror shall be either flat or ~~spherically~~ convex. Exterior mirrors may be equipped with an additional aspherical part provided that the main mirror fulfils the requirements of the indirect field of vision."