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MEASUREMENT OF THE RESOLUTION OF THE MOUNTED PERISCOPE OF THE ARMOURED VEHICLE

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Abstract: Resolution measurement of the night branch of the mounted device is investigated in this article. Measuring optical parameters of a mounted devices is a real problem that can improve the overall battle performance and effectivity of the armoured vehicle. The experimental verification is designed to be performed in field conditions with accessible equipment. To measure the resolution, it is needed to design corresponding test targets. To protect image intensifier from damage, it is necessary to use protection cover which attenuate incoming illumination. With decreased illumination the resolution of the imager also decreases, this hypothesis is demonstrated on experimental measurement.

Keywords: Night vision device; Night vision metrology; Optics, Fire-control system; Optical measurement

1 INTRODUCTION

Today, armoured vehicles are parts of every modern armed forces. They are equipped with a weapon turret which have a variety of reconnaissance optical devices that serve to obtain information about the target for fire-control system.

In the shadow of the weapon station optics, there are driver's periscopes. Driver's periscopes are used for driving the armoured vehicles when the driver needs to drive when covered. These periscopes consist of day periscope and night vision device with an image intensifier. (CHRZANOWSKI, 2015)

It is needed to give enough attention to the diagnostics of the driver periscopes because their failure can cause fatal damage to the vehicle and the crew. This is especially important in case of night branch.

Driver needs to have precise information about the road and its surroundings to be able to fulfil required tasks. Diagnostics of the periscopes is needed to be done on mounted devices because of the adjustment of the periscope itself. (Chrzanowski, 2022)

2 DETERMINATION OF BASICS PARAMETERS

For the beginning it is needed to set the basic parameters which are required for periscope to fulfil.

The day branch range when consists of an optical scope depends on the driver and his abilities and experience.

Night branch based on image intensifier range depends on image intensifies parameters and performance. In night conditions there is usually no backup way how to drive the vehicle when night branch fails.

Testing of image intensifier night devices during the day is complicated because it is needed to significantly decrease illumination of the device to prevent its damage. To solve this complication, it is possible to use a grey filter to decrease incoming illumination. (CHRZANOWSKI, 2015)

To be able to measure the parameters it is needed to set the measure conditions according to expected values.

For measured device, there are designed performance parameters from Tab. 1

Tab. 1 Device parameters

VIS branch	
Magnification	1x
Resolution	1' (standard human eye resolution)
Night branch	
Resolution	4' (standard temperature)
Range	recc straight road and terrain
3 mlx	120 m
50 mlx	400 m

Source: authors.

It is needed to transfer these values to corresponding resolution value.

From the designer information the maximal resolution is $x = 4' \approx 1.63$ mrad.

For reconnaissance it is needed to have 4 periods in the target width, then $x_r = 4x = 6.52$ mrad.

Then the minimal recognizable width of the road on the distance is

$$d = l \cdot x_r = [m], \qquad (1)$$

where l is the range in km and x_r is angular width in mrad.

With decreasing irradiation of the imager, the resolution decreases.

3 RESOLUTION MEASUREMENT

To measure resolution on field conditions, there are used testing target images. These images have known properties which enables the measurement of the resolution of an imager. The most used images are Siemens star and USAF 1951 test. Tests are evaluated according to Johnson's criterion.

3.1 Siemens star

Siemens star consists of circle with black and white periods pattern that go from the centre and become wider on the edge of the circle. These periods have same angular size, and their count is the main parameter of the star. The resolution of the image is measured as a diameter of the unrecognizable grey middle circle in the picture. It can measure resolution in more directions at once, but it is needed to have captured image to evaluate the resolution from the image.

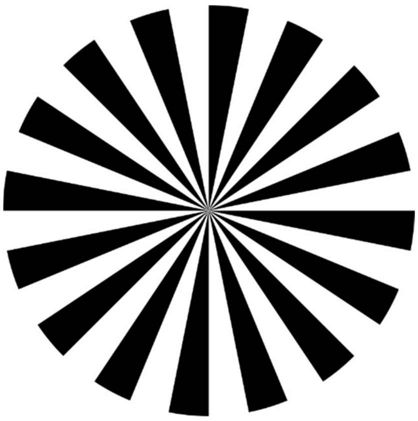

Fig. 2 Siemens star 16period
Source: [3].

Captured image with measured circle is shown in Fig. 2.

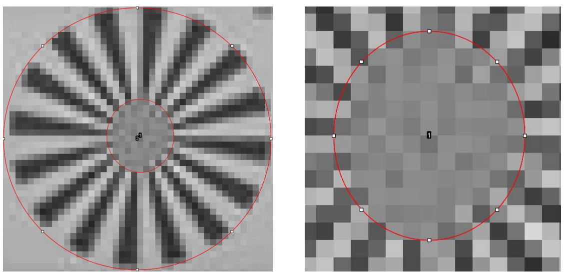

Fig. 2 Captured image of Siemens star
Source: authors.

Resolution of imager is then

$$h = \frac{\pi}{p} d_1, \quad (2)$$

where h is resolved period, p is number of periods of the star, d_1 is measured diameter of the unresolvable circle.

Resolution x in lp/mrad then

$$x = l/h \text{ [lp/mrad]} \quad (3).$$

where l is the distance to the target in m.

3.2 USAF test

The USAF 1951 resolution test (USAF test) according to MIL-STD-150A is a three-line test that is used to determine the resolution of a given imager. It consists of several groups of elements divided into 6 per group, arranged so that the even groups are in the left part of the test, except for the first element of the group, which is in the lower right corner, and the odd groups are in the right part of the test. Lower numbered groups are in the outer part and towards the center the groups get smaller.

Element dimensions are shown in Fig. 3.

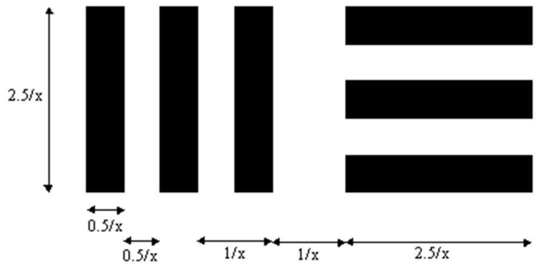

Fig. 3 Dimensions of an element in USAF 1951 test
Source: [3].

The whole test chart is shown in Fig. 4.

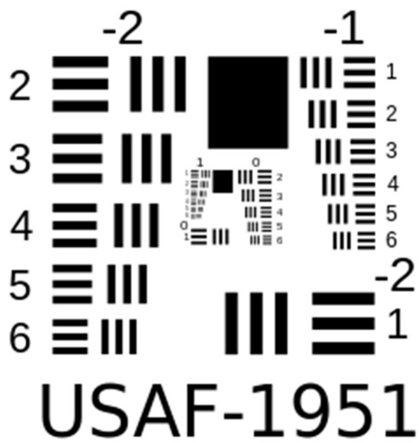

Fig. 4 USAF 1951 resolution test
Source: [4].

Resolution x of an imager is determined by the smallest resolved element in the chart.

$$x = 2^{\left(g+\frac{e-1}{6}\right)}\ [\mathrm{lp/mm}], \tag{4}$$

where g is group of the element and e is element number in the group.

This test can be evaluated directly using a naked eye without any need for capturing and computer evaluating. However, for objective evaluation and comparison with other tested imagers it is necessary to capture the image of testing chart.

3.2 Range calculation

When resolution is measured then range to certain target can be determined. There is wide-used criterion called Johnson's criterion which determines the range to the certain target according to width of the period in the required direction when the target is converted to black and white periods. (Sjaardema, Smith, & Birch, 2015)

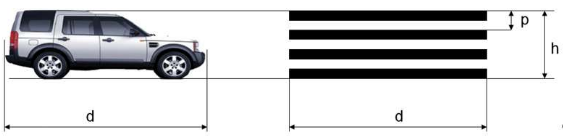

Fig. 5 Target conversion to period test
Source: [6].

According to number of the periods which can be resolved there are levels of the resolution of the target within certain probability. Usually there are 3 categories for 50 % probability of resolution. (Sjaardema, Smith, & Birch, 2015)

- 1 period for detection,
- 4 periods for reconnaissance,
- 8 periods for identification.

4 EXPERIMENTAL RESOLUTION MEASUREMENT

The goal of the experiment is to describe the effect of illumination decrease to resolution of the NV imager. (CHRZANOWSKI, 2015)

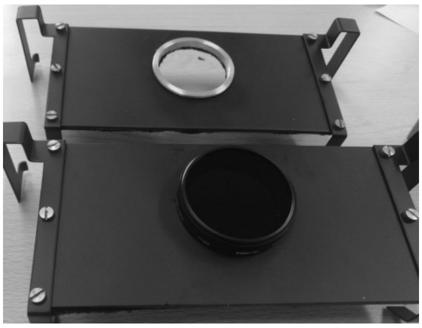

Fig. 6 Protective cover with off/on grey filters
Source: authors.

To demonstrate measuring of resolution change when illumination is decreased it was needed to make a protective cover to prevent damage of the device caused by daylight. The cover has in the optical axis of the objective a window which can be filled with grey filter of a known extinction ratio.

The cover protects the whole objective, the window has diameter of 58 mm and decreases the overall illumination of the objective 6 times without any filter. There are used grey filters that decreases the incoming illumination 8 or 64 times. When they are stacked, the combined decrease multiply. For the experiment is used total filter extinction from 2^{12} to 2^{21} (from 4096 to 2mil times). The illumination of the objective is 3.6 klx, the distance to the target is 4 m.

To control measurement is captured image from the day branch.

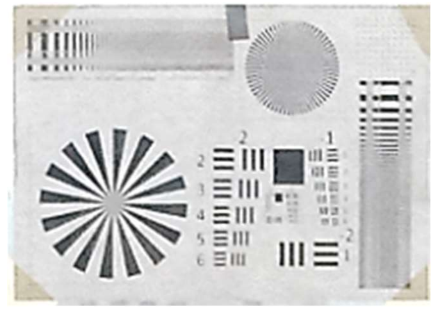

Fig. 7 Captured image from the day branch of the imager
Source: authors.

The Siemens star circle centre diameter is 18 mm which corresponds according to eq. (3) resolution of $x = 1.13$ lp/mrad. With USAF test the resolution was measured $x = 1.27$ lp/mrad.

For the measurement of the night branch USAF test was not usable, because even the biggest element was hardly resolvable. Only Siemens star resolution was used.

In the Tab. 2 there is resolution of the night branch with extinction filters applied.

Tab. 2 Measured values of Siemens star

Extinction	Ilumination	Siemens diameter	Resolution
ratio	mlx	mm	lp/mrad
4069	878,906	53	0,38
32768	109,863	76	0,27
262144	13,733	122	0,17
2097152	1,717	Non resolvable	0

Source: authors.

When the extinction coefficient decreased the illumination under 3 mlx, the image had become unresolvable

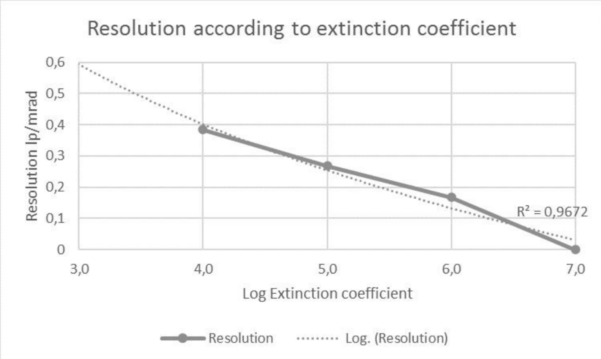

Fig. 8 Graph of the influence of the extinction ratio to the resolution of an imager
Source: author.

5 CONCLUSION

In this article, there was demonstrated the possibility of measuring the resolution of mounted night vision device in field conditions.

The ability to measure this property in real condition is necessary for analysis of performance of an armoured vehicle in real conditions. The research of these properties increases the combat capability and safety of the crew of the combat vehicle.

In this article it is presented the way of measuring the image intensifier device with variable extinction ratio of an incoming illumination. It is possible to simulate the threshold conditions of the device usage in field conditions.

There is demonstrated decreasing resolution with increasing extinction ratio. It was experimentally verified the lower threshold limit of needed incoming illumination is in the assumed interval.

In this article experimental measurement of resolution of night vision device was done. To develop this problematic further, it is needed to perform this measurement on widespread variety of devices.

References

[1] CHRZANOWSKI, K. Review of night vision metrology. In *Opto-Electronics Review,* vol. 23, no. 2, 2015, pp. 149-164. Available at: https://doi.org/10.1515/oere-2015-0024.

[2] CHRZANOWSKI, K. *Computerized station for testing night vision devices.* Inframet.com. [Online] 2022. [Citace: 20. 05 2022.] Available at: https://www.inframet.com/Data_sheets/NIMAX.pdf.

[3] ZEMAN, P. *Návrh pracoviště pro testování kvality OE přístrojů v podmínkách AČR.* [Diplomová práce] Brno: Univerzita Obrany v Brně, 2019.

[4] Arme forces supply support center. Military standard photographic lenses. Washington DC : Standardization division, Arme forces supply support center, 1959. MIL-STD-150A.

[5] SJAARDEMA, T. A., C. S. SMITH and G. C. BIRCH. *History and Evolution of the Johnson Criteria.* [online] United States: Available at: https://doi.org/10.2172/1222446.

[6] BALÁŽ, T. a Z. REHOŘ. *Dosahy OE přístrojů v reálných podmínkách.* [Online]. [Citace: 09. 05 2022] Available at: https://docplayer.cz/68745505-Dosahy-oe-pristroju-v-realnych-podminkach.html

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