

# Multidimensional Presentation of Radar Image

**M. Waz**

*Polish Naval Academy, Gdynia, Poland*

**T. Stupak & A. Szklarski**

*Gdynia Maritime University, Gdynia, Poland*

**ABSTRACT:** The modern navigation radar has no 3D visualization creation possibility. Digital signal processing technology progress gave the new possibilities in radar data transforming process to many kinds of digital picture representation. The picture saving method was upgraded last time and tools used during picture transformation become popular and useful. For instance the RSC (Radar Scan Converter) – digital radar picture recording and transforming tool can be used to create new picture on line. The 3D radar picture creating become easy and fast because of modern computer graphic techniques. The radar 3D digital picture creating should be standardized with 3D digital chart creating by IMO, because the navigation near future will be probably based on digital information created in digital devices.

## 1 INTRODUCTION

The 3 dimension visualization is used in marine navigation systems. Echosounders and sonars working in hydroacoustic systems under water environment present in three dimensions.

Often vector map used multidimensional presentation occurs. This presentation is used in aviation and under water navigation. The producers offered wider package of 3D chart conform to IMO requirements. In the nearest future 3 dimensions presentation maybe obligatory presentation on navigation systems display. Part of these systems work with radar and radiolocation data is sending in digital form. 3D presentation of radar picture require new technology of radar target build. In first step is necessary compile digital form of radar signal.

## 2 DIGITAL RADAR PICTURE

The most of modern marine radars present digital visualization in Cartesian coordinate axes. R

The radar picture is projected on computer or liquid screen in form of square matrix with the same numbers of pixel in lines and columns. This is the raster form and it is reading in computer memory

like bitmap. BMP- is the bitmap net presenting one or three color layer (one – 256 level of gray; three – 256 level of: red – R, green – G, blue – B). In CMYK computer graphic is possible to picture record in four layers of colors. In modern marine radars are used two or three basic color for marine radar elements (target, water) and eventually one to rest information (movement vector, boundary of acquisition...).

Radar picture storage in computer memory like raster is continues data compilation which is observation place function and it is changing with hydro meteorological conditions, seaside line and different objects. Continuous data compilation may be a regular point net presentation, recorded like a vector. Net points take steady balance on radar screen and have steady geographical coordinates. Each point of radar picture is shown like following vector coordinate which gives information about target. More convenient is radar picture built like un regular points net with discreet value, which in next step can create lines or areas.

All coastal lines and points describes characteristic elements of the marine area create representative radar picture matrix [3], [4], [5], [6]. The basic task to 3 dimension picture create is digital radar signal storage which each pixel

coordinates give. This radar picture will be storage like vector collection for 3D representative:

$$O^k \rightarrow R \quad (1)$$

where:

$$O^k = \left\{ \begin{array}{l} (\varphi, \lambda, W) : \varphi \in \langle 0, 90^0 \rangle, \lambda \in \langle 0, 180^0 \rangle, \\ W \in \langle 0, K \rangle \wedge \varphi, \lambda, W \in R \wedge K \in N \end{array} \right\}$$

$\varphi, \lambda$  – pixel coordinate;

$W$  – gain level of radar target.

Or for picture in pole coordinate system:

$$O^b \rightarrow R \quad (2)$$

where:

$$O^b = \left\{ \begin{array}{l} (\alpha, d, W) : \alpha \in \langle 0, 360^0 \rangle, d \in \langle 0, Z \rangle, \\ W \in \langle 0, K \rangle \wedge \alpha, d, W \in R \wedge Z, K \in N \end{array} \right\}$$

$\alpha$  – bearing (NR);

$d$  – distance ( $d_r$ ).

M.U. in Gdynia) used can take digital information about altitude characteristics from true object. Digital analyze of these information give possibility of plotting, tracking or searching object. Modern computer visualization technique facility this process. Radar picture can be stored in digital form like vector with coordinates  $(\alpha, d, W)$ , where  $\alpha$  and  $d$  is bearing and distance to the elementary cell of radar signal and  $W$  coordinate is amplitude of pixel identity like radar target.[1]

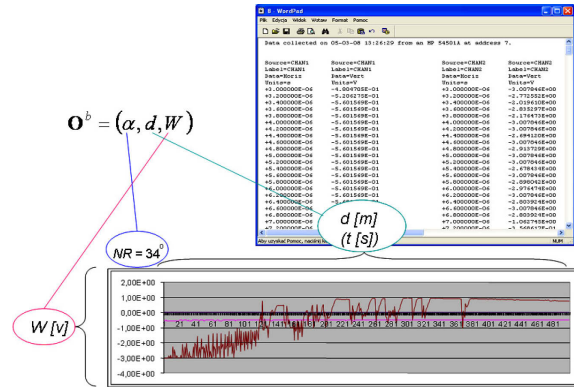


Fig. 2. Video radar signal and its digital form

### 3 THIRD RADAR PICTURE COORDINATE

The basic task during 3D radar picture create will be third coordinate build. Marine radiolocation station gives information about altitude coordinate of observed and tracked targets, but the radar picture is created in 2D coordinate system map with target altitude information. The sample of 3D screen is small dimension mobile radiolocation station MMSR 3D (made by RADWAR) shown on Fig. 1. 3 dimension radar presentations required digital form signal transformation and 3 dimension graphic application (i.e. OpenGL)

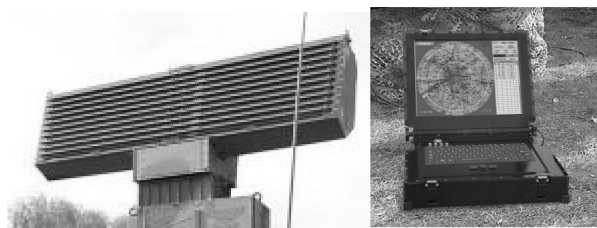


Fig. 1. Radiolocation station MMSR 3D (RADWAR)

Modern navigational radar is working like 2D unit. In this unit isn't possible to altitude information used. Is target altitude information necessary for marine navigation purpose? Gain of target echo depends of cross section. This parameter non linear depends from target dimensions. Third dimension of target can be received radiolocation power signal. This solution gives better capability of radar picture visualization and presentation. Digital signal registration (i.e. HP 54501A – Navigation Department

### 4 MULTIDIMENSIONAL RADAR PICTURE VISUALISATION

Radar picture digital form storage gives possibility of its visualization. Present computer visualization technique opens a wide range of its solution. Presented picture can be shown with important elements gain from research or used points of view (special color). In multidimensional visualization important points are well visible on the screen by operator.[2]

Bellow (Fig.3) 3D radar form of Gulf of Gdansk is compared with its 2D radar screen form. There are shown weak and strong target. On the 3D picture weak echo created by sea waves (noise) is visible and it isn't detected on 2 d screen. Gain level on both figures is the same. Probably part of radar picture elements important for research will be easier detect on multidimensional presentation.

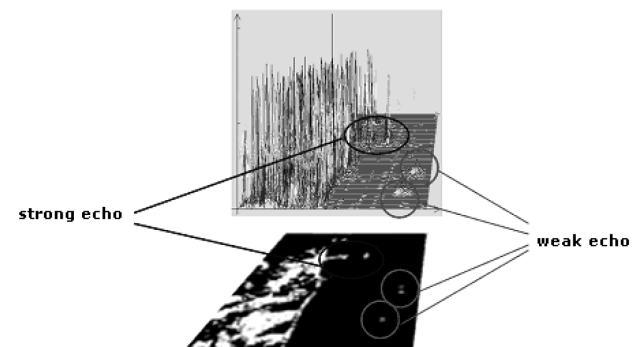


Fig. 3. 3D radar form

Multidimensional visualisation must be done in real time. Its need computer program created 3D pictures shorter than one radar scanner rotation (3 s). The usage of OpenGL, DirectX library makes this process possible.

## 5 DIRECTX TECHNOLOGY

If the radar signal is storage in 3D form for created 3D visualisation are used packed and programmable interface (API – Application Programming Interface). Thanks for it is possible 3D code application create working operation system control. These API are DirectX graphic library made by Microsoft It working in accordance with vector graphic principles. One object is described by same triangular (in program DirectX) and its coordinates.

The most important is order all objects from farthest to nearest. DirectX program offered Z-Buffer algorithm done this task. It is memory structure storage coordinate Z (W for radar picture) each pixel. For each screen parameter W in the pixel is compared with this value from previous screen. Next step is texture mapping its mean added 2D bitmap to 3D triangular objects. Minimum two different dimension bitmap are used. When objects closed to observatory is used bigger bitmap and when distance to the object growing up the bitmap is changing for smaller. The library builds faster radar pictures in 3D structure.



Fig. 4. Gulf of Gdańsk 3D radar screen

## 6 SUMMARY

Modern navigational radar gives possibility 3D radar picture visualization. Digital transformation of electronic signals programs development created possibility of radar data transformation to the different digital form.

Used Radar Scan Converter radar picture can be registered and transformed in real time.

Computer graphic application created easy transformation radar picture to 3 dimension form.

3 dimension radar signal maybe used to radar chart build in important for navigation safety areas.

These applications are needed to improve radar visibility of small objects during meteorological disturbances and created improvement of marine safety used radar.

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