ANALYSIS OF RCS PROBLEMS IN SHIPS

EMC Studio/EMCoS Antenna VLab

Introduction

The radar range equation expresses the range at which a target may be detected with a given probability by a radar having a given set of parameters. This equation includes the target's radar cross section (RCS), which is a measure of the proportion of the incident energy reflected back to the radar. This returned energy varies with a multitude of parameters such as transmitted wavelength, target geometry, orientation, and reflectivity. The radar cross section of an object is proportional to the far-field ratio of reflected to incident power density, that is:

$$\sigma = \frac{power\ reflected\ back\ to\ receiver / unit\ solid\ angle}{incident\ power\ density / 4\pi}$$

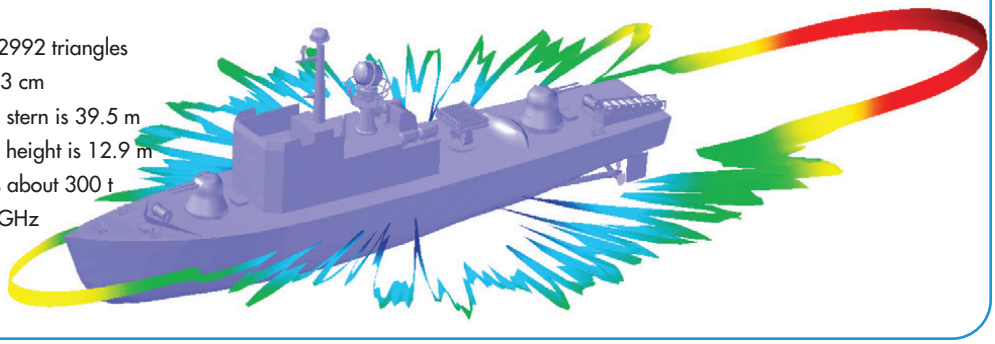
Radar cross section can be efficiently estimated using PO solution (ray-tracing algorithm) in EMC Studio and EMCoS Antenna VLab software.

Simulation Model Description

This application note demonstrates calculation of Radar Cross Section of ship and comparison with analytical solution and RCS typical values.

Simulation Model

- Ship model contains 822992 triangles
- Average triangle size 4.3 cm
- Ship length from bow to stern is 39.5 m
- Ship width is 7.3 m and height is 12.9 m
- Approximate tonnage is about 300 t
- Simulation frequency 3 GHz



Typical Values of RCS for Ships

RCS of ship depends on overall size and Gross/displacement tonnage of ship. Typical values for ships are known and described below:

Ship RCS Table

(Source: Williams/Cramp/Curts, "Experimental Study of the Radar Cross Section of Maritime Targets", Electronic Circuits and Systems, Volume 2, No 4, July 1978)

Target Ship			Median radar cross section of target vessel, m^2								
Type	Overall length (m)	Cross tonnage	10	100	1.000	10.000	100.000	1.000.000	10.000.000	approx. min. RCS	approx. max. RCS
Inshore fishing vessel	9	5	Q							3	10
Small coaster	40-46	200-250		S	B/Q					20	800
Coaster	55	500								40	2.000
Coaster	55	500			S	BW/Q				300	4.000
Coaster	57	500				Q	BW			1.000	16.000
Large coaster	67	836-1.000				BW	Q			1.000	5.000
Collier	73	1.570			nB	BW				300	2.000
Warship (frigate)	103	2000*				BW	B			5.000	100.000
Cargo liner	114	5.000					BW Q			10.000	16.000
Cargo liner	137	8.000					BW/Q Q			4.000	16.000
Bulk carrier	167	8.200				BW	B/Q			400	10.000
Cargo	153	9.400				BW	BW			1.600	12.500
Cargo	166	10.430				BW	Q			400	16.000
Bulk carrier	198	15.000-20.000				nB	B/Q			1.000	32.000
Ore carrier	206	25.400				BW	nB			2.000	25.000
Container carrier	212	26436**					BW Q/B/BW			10.000	80.000
Medium tanker	213-229	30.000-35.000					nB Q			5.000	80.000
Medium tanker	251	44.700					nB	B		16.000	1.600.000

* Displacement
** Considerable deck cargo

S = stern on
Q = quarter
B = broadside
BW = bow
BWO = bow on
n = near

Median values for ship with approximate tonnage from 200-500 t are from 13 dBsm to 36 dBsm (highlighted rows).

EMCoS Ltd.
27 Pekin Street, Tbilisi, 0160, Georgia
Phone: +995-32-2389091
E-mail: info@emcos.com
www.emcos.com

EMCoS Consulting and Software

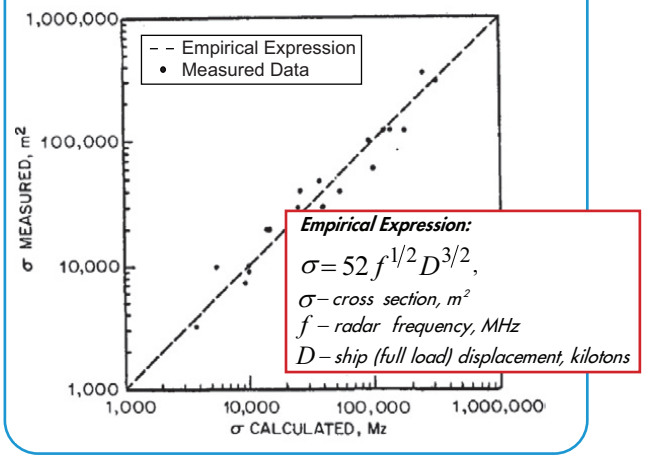
ANALYSIS OF RCS PROBLEMS IN SHIPS

EMC Studio/EMCoS Antenna VLab

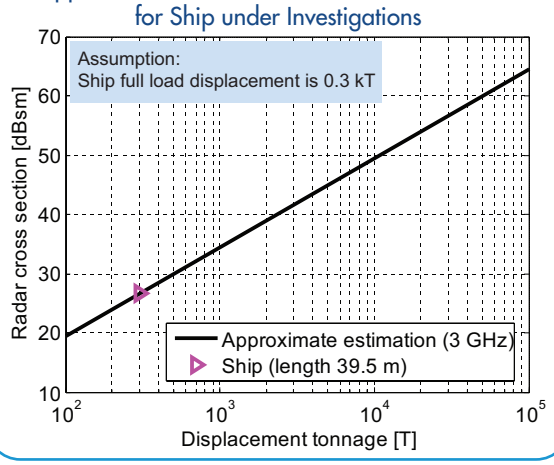
Analytic Prediction of Radar Cross Section

Results calculated from empirical expression are in very good agreement with measured data. Analytical solution can be efficiently used for validation of simulation results.

Comparison between Measured and Empirical Results

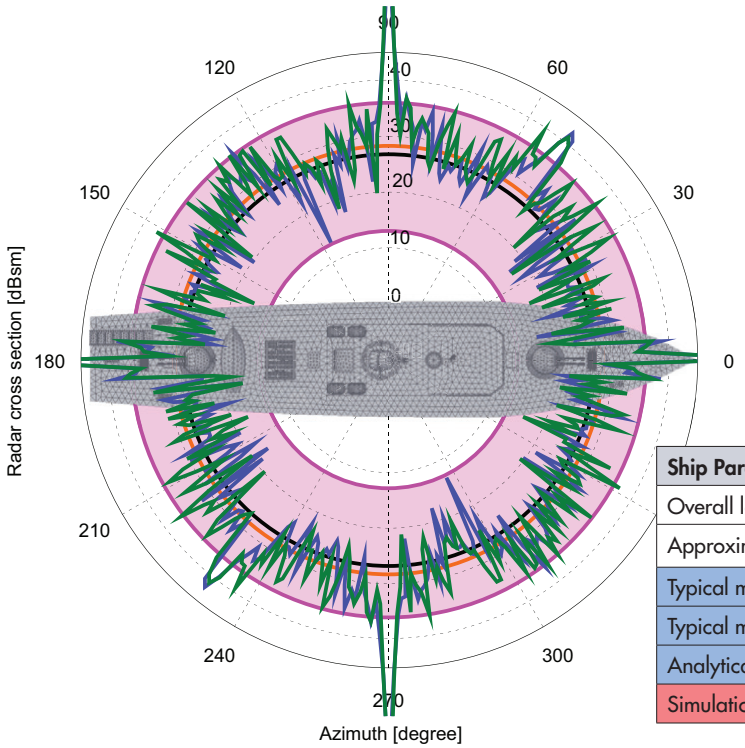


Approximate Estimation of RCS Median Values for Ship under Investigations



Results

Comparison of Simulation Results with Typical Values and Empirical Expression (3 GHz)



Ship Parameters	
Overall length, [m]	39.5
Approximate tonnage, [T]	300
Typical minimal median RCS value, [dBsm]	13
Typical maximum median RCS value, [dBsm]	36
Analytical estimation, [dBsm]	26.7
Simulation results. Median values, [dBsm]	28.3

From the obtained results it can be seen that simulation results are in very good agreement with typical RCS values and analytical expression.

Conclusions

According to performed investigation the main conclusions are:

- EMC Studio and EMCoS Antenna VLab provide the powerful tools for analysis of Radar Cross Section problems in ship
- For calculation of radar cross section PO solution (ray-tracing algorithm) is considered
- Simulation results were compared with typical RCS values and approximate analytical solution

EMC Studio/EMCoS Antenna VLab Application Note: #19

References

- Skolnik in Eustace, H.F. (Ed.). The international Countermeasures Handbook, 3rd ed., pp. 278-279, 1977, 78. Courtesy Cardiff Publ. Co.
- Williams/Cramp/Curts, "Experimental Study of the Radar Cross Section of Maritime Targets", Electronic Circuits and Systems, Volume 2, No 4, July 1978

EMCoS Consulting and Software

EMCoS Ltd.
27 Pekin Street, Tbilisi, 0160, Georgia
Phone: +995-32-2389091
E-mail: info@emcos.com
www.emcos.com