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防空反导预警装备覆盖能力推演分析

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摘要：
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Coverage Ability Deduction Analysis of Air Defense and Anti-missile Early Warning Equipment

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Abstract: In response to the air and space threats in the new era, the coverage of the air defense and anti-missile early warning equipment is deduced. Firstly, analyzes the characteristics of the aerospace threat target and its challenges to the early warning detection system. Then in a setting of deductive needs of air defense and anti-missile early warning equipment coverage ability, define 2 main evaluation indicators, regional coverage and multiple coverage ratios, establish their calculation methods. Then take the US air defense and anti-missile system as a typical case, analyze its equipment coverage capability and the equipment deployment features are summarized. The results show that the study is effective and feasible, and can provide timely and reliable information for missile defense system.

Keywords: air defense warning; missile warning; regional coverage; multiple coverage; radar visual range

0 引言

[3]

[4]

2

“ ”

[5]

(defense support program DSP)

(space based infrared system SBIRS)

(space tracking and surveillance system STSS) SBIRS 4

6 [6]

2018 1 20

3

[1]

(overhead persistent infrared OPIR) [2]

2 [7-8] STK

(geosynchronous earth orbit GEO) (highly elliptical

(spacebased kill assessment SKA)

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orbit HEO)

[9] /

RCS 20 dB

Ma 1.8

18 km

1 装备覆盖能力推演分析方法

1.1 威胁目标及其特点

1)

14 000 km

7.4 km/s(22) 1 400 km

2)

2 000 3 000 km 150 m RCS 0.1 m^2 BGM-109“ ” AGM-158 /

3)

F-22 F-35 T-50 B-2

1.2 装备覆盖能力的主要评估指标

2

1)

S_0 S $P=S_0/S$

2)

S_n S

$P_n=S_n/S(n \geq 2)$

1.3 覆盖区域的计算方法

1.3.1 单传感器覆盖区域计算方法

3

3 3 (x_0,y_0,z_0)

(R) (A) (E) R A E R_{max} A_{max} E_{max}

2

1

(ENU) x y

z

$x_1y_1z_1$ $x_2y_2z_2$

(x_0,y_0,z_0)

$x_1y_1z_1$

2

[10]

$x_2y_2z_2$ [11]

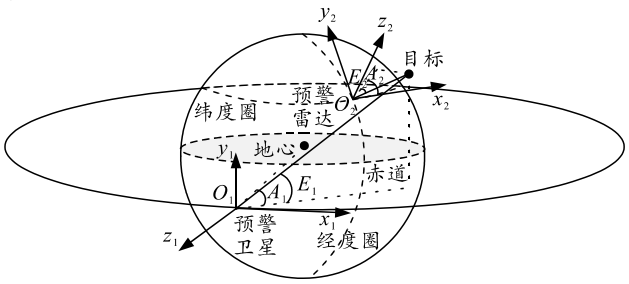

图 1 传感器量测坐标系

$$A_1=\arctan\frac{x_1}{z_1}$$
$$E_1=\arctan\left(y_1\Big/\sqrt{x_1^{\,2}+z_1^{\,2}}\right) \quad (1)$$

$A_{1\max}$( )×$E_{1\max}$( )

$$\left.\begin{aligned}|A_1|&\le\frac{A_{1\max}}{2}\\ |E_1|&\le\frac{E_{1\max}}{2}\end{aligned}\right\} \quad (2)$$

$$R=\sqrt{x_2^{\,2}+y_2^{\,2}+z_2^{\,2}} \quad (3)$$

$$A=\begin{cases}180-\arcsin\left(y_2\Big/\sqrt{x_2^{\,2}+y_2^{\,2}}\right) & x\le 0\\ \arcsin\left(y_2\Big/\sqrt{x_2^{\,2}+y_2^{\,2}}\right) & x\ge 0,y\ge 0\\ 360+\arcsin\left(y_2\Big/\sqrt{x_2^{\,2}+y_2^{\,2}}\right) & x\ge 0,y\le 0\end{cases} \quad (4)$$

$$E=\arctan\left(z_2\Big/\sqrt{x_2^{\,2}+y_2^{\,2}}\right) \quad (5)$$

$R_{\max}$(

)×$A_{2\max}R_{\max}$( )×$E_{2\max}R_{\max}$( )

$$\left.\begin{aligned}&R\le R_{\max}\\ &|A_2|\le A_{2\max}/2\\ &|E_2|\le E_{2\max}/2\end{aligned}\right\} \quad (6)$$

1.3.2 多传感器覆盖区域计算方法

1) S

ΔL_{on} ΔL_{at} 2

2) N $i(i=1,2,\ldots,N)$

1 0

3) N

1

S_0

$n(n\ge 2)$

S_n P_n

1.3.3 雷达视距计算方法

(6)

$R_{\max}$

/

2

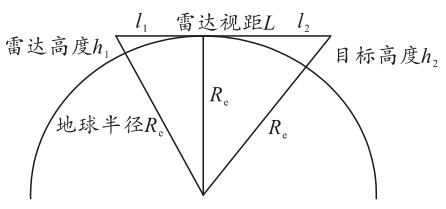

图 2 地球曲率影响下雷达视距几何模型

2 R_e h_1
h_2 L h_1
h_2

$$\left.\begin{aligned} L &= l_1 + l_2 \\ (R_e + h_1)^2 &= R_e^{\,2} + l_1^2 \\ (R_e + h_2)^2 &= R_e^{\,2} + l_2^2 \end{aligned}\right\} \tag{7}$$

(7)

$$L = \sqrt{h_1^2 + 2h_1R_e} + \sqrt{h_2^2 + 2h_2R_e} \approx \sqrt{2R_e}\left(\sqrt{h_1} + \sqrt{h_2}\right) \tag{8}$$

[12]

a_e a
k

$$a_e = ka \tag{9}$$

k

$$k = 1/\left[1 + a\left(\mathrm{d}n/\mathrm{d}h\right)\right] \tag{10}$$

dn/dh
6 371 km -39 km k 1.33
4/3 “ ”
(9) (10)
(8)

$$L \approx \sqrt{2\times(4/3)\times R_e}\left(\sqrt{h_1} + \sqrt{h_2}\right) \tag{11}$$

R_e 6 371 km (8)

$$L \approx 4.12\left(\sqrt{h_1} + \sqrt{h_2}\right) \tag{12}$$

h_1 h_2 m
L km

2 典型案例分析

2.1 防空预警装备覆盖能力分析

144

[13-14]

3

150 m 18 km
1 20 km 2
1
0 1 km
130 km 20 km
580 km

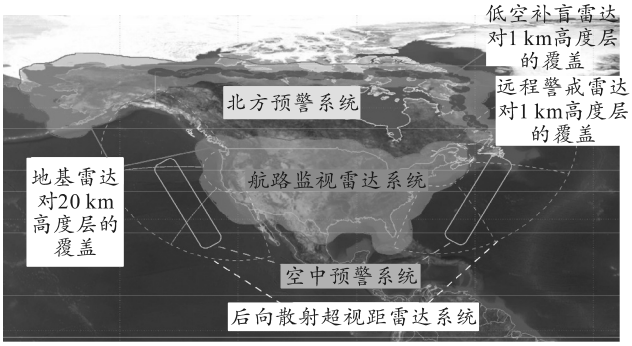

图 3 美国防空预警装备覆盖效果

表 1 美国典型防空预警雷达参数 km

	/		1 km		20 km	
AN/FPS-118	/1 /1	HF	900	3 300	900	3 300
AN/FPS-117	/11 /10 /5	L	130		370	
AN/FPS-124	/37 /3	L	110		110	
AN/FPS-130 (ARSR-4)	/44	L	130		470	
TARS	/12	L	320		320	
E-3 (AN/APY-2)	/20	S	270		650	

3

900 3 300 km
[14]

L
4 600 m
3 000 m 270

km[14] E-3
500 600 km 300
400 km 270 km[15]
70°
0.2°
14 445
20 km
AN/FPS-117
94.63% 1 km
130 km AN/FPS-117
1 km
70° 31.7%
AN/FPS-117 AN/FPS-124
70°
68.57%
0.1°
112 015
20 km
98.66%

2.2 导弹预警装备覆盖能力分析

3

2

表 2 美国典型导弹预警雷达参数 km

/				
UEWR 1 5		P	5 800(RCS= 10 m^2) 3 260(RCS= 1 m^2)
“ ” AN/FPS-108	/1	L	4 800
X SBX 1	/	X	2 000
AN/TPY-2 2	/1 /	X	1 600 660

DSP [7]
SBIRS-GEO SBIRS-HEO STSS [16]
X AN/TPY-2 [14]
RCS

$$R \propto \sigma^{1/4} \tag{13}$$

σ RCS
RCS 10 m^2
RCS
10 m^2 RCS
10 m^2 5 800 km (13)
RCS 1 m^2
3 260 km
SBIRS
4
1°
43 424 4
83.74%

810
100% 99.38%
71.19%

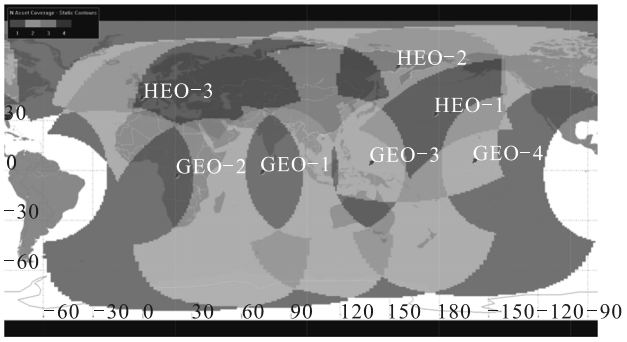

图 4 天基高轨红外预警卫星对地覆盖

5 5

RCS 10 m^2
RCS 1 m^2
UEWR

UEWR

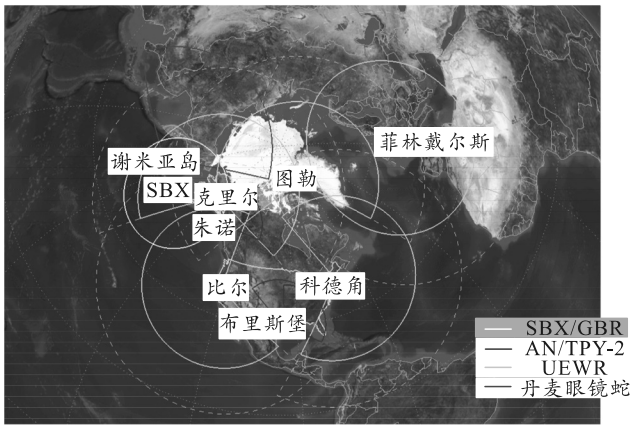

图 5　美国导弹预警雷达覆盖效果

3　结束语

3.1　防空预警装备特点

1)

2 500 km

70°

2)

3)

3.2　导弹预警装备特点

1)

(6GEO+4HEO)

24 h

2)

P/L

X

2020 S

(LRDR)

P L S X

3)

X

AN/TPY-2

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