

**DIRECTED ENERGY WEAPONS**

**and**

**ACTIVE PROTECTION SYSTEMS**

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## Report Documentation Page

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## 1. Principle of operation

Geometric optics:-

Paraboloid mirror focuses point source

Pair of surfaces direct area or volume source

Not diffraction limited !

## 2. Single stage

Defining mirror chosen (typically spherical)

Defining rays chosen (collimated, focussed or whatever)

Defined mirror's shape is a solution to a differential equation

Further rays partially directed

Angular input aperture allows area or volume source

Out-of-plane rays

Reflective and/or refractive surfaces

### 3. Multiple stages in series

Stage multiplication  $\propto 1 / \text{angular input aperture squared}$

$$\tan \beta_3 = - \tan (\theta_2 - \theta_1) \tan 0.75 (\theta_2 - \theta_1) \tan 0.5 (\theta_2 + \theta_1)$$

$\theta_1$	145	142.2	100.000
$\theta_2$	160	140.0	100.034
$\beta$	23	8	0
$0.5 (\theta_2 + \theta_1) - \beta$	129.5	133.1	100.017
$2 \theta_2 - 2 \theta_1$	30	4.4	0.068
$\beta_3$	3.699	0.0678	$8.57 \times 10^{-5}$
$\tan \beta_3$			$1.49 \times 10^{-6}$

## 4. Beam adjustment and rotation

Moveable 3rd stage defined mirror

Axial movement focuses beam

Transverse movement corrects atmospheric distortion

40ms search to find target

High agility

## 5. Main advantages

Blackbody radiation - 1.5 MW<sub>e</sub> arc lamps  
(spatially but not temporally coherent)

Power increases as wavelength decreases (0.2 - 1.4 μm)

Wein's displacement law :-  $\lambda_m T = \text{constant}$

Stefan - Boltzmann law :-  $P_{\text{tot}} = \sigma T^4$

Wide waveband - No Stimulated Raman Scattering

No lenses, lasing medium or inhomogeneities to distort beam

Power  $\propto$  mirror size  $\propto$  cooling

## 6. Dynamic kill on a continuous basis

Optimum range cusp

Effects of lower wavelengths:-

Smaller spots

Higher power

Poor reflectivity

Reduced dynamic kill threshold

More absorption and scattering



## 7. Typical applications

Combat aircraft	- 0.6m turret	$3.5\text{MW}_e / 1.4\text{MW}_{\text{opt}}$
	- 0.5m pod	$3.5\text{MW}_e / 1.4\text{MW}_{\text{opt}}$
	- 0.5m pod with APU &HPG	$15\text{MW}_e / 6\text{MW}_{\text{opt}}$
Transport aircraft	- 0.6m turret	$3.5\text{MW}_e / 1.4\text{MW}_{\text{opt}}$
Future Combat System	- 0.75m flush turret	$15\text{MW}_e / 6\text{MW}_{\text{opt}}$
Airborne DEW	- 3.6m turret	$200\text{MW}_e / 80\text{MW}_{\text{opt}}$
Space based DEW	- 2m diamond turning	$240\text{MW}_e / 100\text{MW}_{\text{opt}}$
	- 4.5m diamond turning	$1000\text{MW}_e / 400\text{MW}_{\text{opt}}$

## 8. Active protection

All types of platform

All types of target

Rate of fire exceeds all but LAA - typical 200ms engagement

Protection of accompanying forces:- APCs, dismounted infantry

Relation to countermeasures & jamming

## 9. Combat aircraft

BASIC    1600 lbs

3.5 MW<sub>e</sub> iron rotor homopolar generator

Two 24in diameter DEW turrets

4 UV+ fire control sensor turrets

12 MWIR sensors

OPTIONAL

24in diameter pod for longer range DEWs

ALTERNATIVE POWER SUPPLY

136 kW APU + 11 MJ IED HPG

## 10. Number of Targets Engaged

1st DEW	$n((R-r)/v+0.1)$		
2nd DEW	$n(R-r)/v$		
n	pulses/sec	5 for missiles	3.3 for hittiles
R	metres	effective range	
r	metres	minimum range	
v	metres/sec	relative velocity	

## Turret

IRGMs head - on	1st DEW	2nd DEW
Clear at sea level	6	5
Median haze at sea level	2	2

## Pod

Head - on	1st DEW	2nd DEW
Clear/Radar guided missiles	11	11
Median Haze/Beam-riding hittiles	3	2

## 11. All Types of Target

### IRGMs

Active, semi-active and passive radar guided missiles

Beam-riding or command guidance hittiles

### Aircraft

### HAA

LAA (All shells or selected)

KE long-rod penetrators

## 12. Relation to Countermeasures

DEW as jammer at very long range

Counter to imaging IR seekers distinguishing flares

Vulnerability of launch operation in beam-riding system

No point in weight penalty for stealth

ARMs vulnerable to DEWs using commercial sources

Shoulder fired DEWs with chemical rounds

## 13. Radar Jamming

Invulnerable stand forward jamming platform

3.5 MW<sub>e</sub> available

Barrage jamming over a wider waveband counters LPI

Room for high power jammers in same pod

“Moving” chaff by illumination

Escorting cruise missiles using DEWs and jammers