M.G. Use 1/2 mil lead for each mph of estimated target speed.

1/2 mil / mph of wind

SAMPLE

CALIBER 50

MACHINE GUN PROBLEM

JOV-1C

ARMED MOHAWK

3/1965

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To understand the sight angle setting computations for the cal 50 machine gun the following assumptions are made:

1. Boresight range is 1200 feet.
2. Muzzle velocity 2900 fps.
3. Table I (Trajectory Drop).

Airspeed (mph)	D at 1200 feet	D at 3000 feet
0	38"	297"
150	32"	252
300	28"	216
450	25"	188

Assuming the center line of the weapons (Gun Bore Line) are boresighted to coincide with the zero sight line at 1200 feet, the weapon when fired would deliver the round to a point 38 inches below the sight point if the aircraft were standing still. (See figure 1).

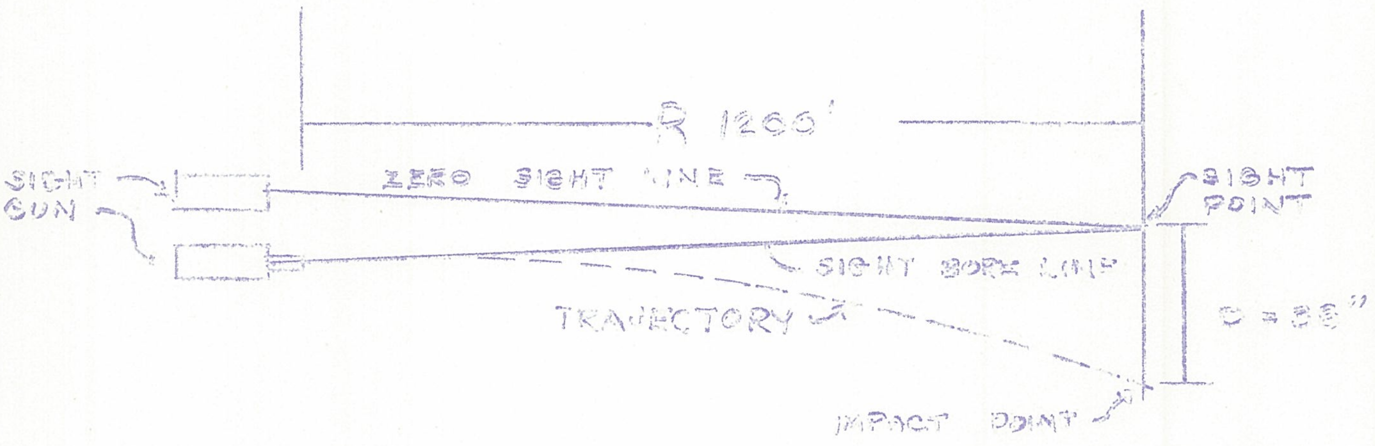


FIGURE 1

It is assumed that the zero sight line and the gun bore line (center line gun) are parallel.

It is apparent that if the weapon is fired while the sight is set at zero, under a no wind condition, the impact point would be below the pipper.

To determine the amount of mils below the pipper the following equation must be solved.

$$\text{TAN ANGLE} = \frac{\text{OPP}}{\text{ADJ}} \text{ or } \frac{D}{R}$$

therefore:

$$\text{TAN ANGLE} = \frac{38''}{1200'} = \frac{38}{1200X12} = \frac{38}{14,400}$$

$$\text{TAN ANGLE} = .0026 = 2.64$$

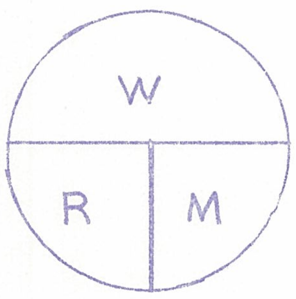
$$\text{ANGLE} = 3 \text{ mils (from natural trig table).}$$

A simpler solution is:

where W = D (trajectory drop)

R = Range

M = Mils (ɱ)



This reduced means to determine mils divide the trajectory drop in feet by the range in thousands of feet, i.e.,

$$\text{mil} = \frac{3.18}{1.2} = 2.65 \text{ or } 3 \text{ mil}$$

From the above discussion and the illustration shown in Figure 1, it is apparent that in order to place the pipper on the impact point in Figure 1, the sight must be set on a sight angle setting of 3 mils. This of course is assuming proper boresight, zero airspeed and firing in a horizontal direction.

Since trajectory drop is determined as a measurement in inches or mils from the extension of the gun bore line it is apparent that if the weapon is fired at an angle to the horizontal the trajectory drop will decrease. (See Figure 2.)

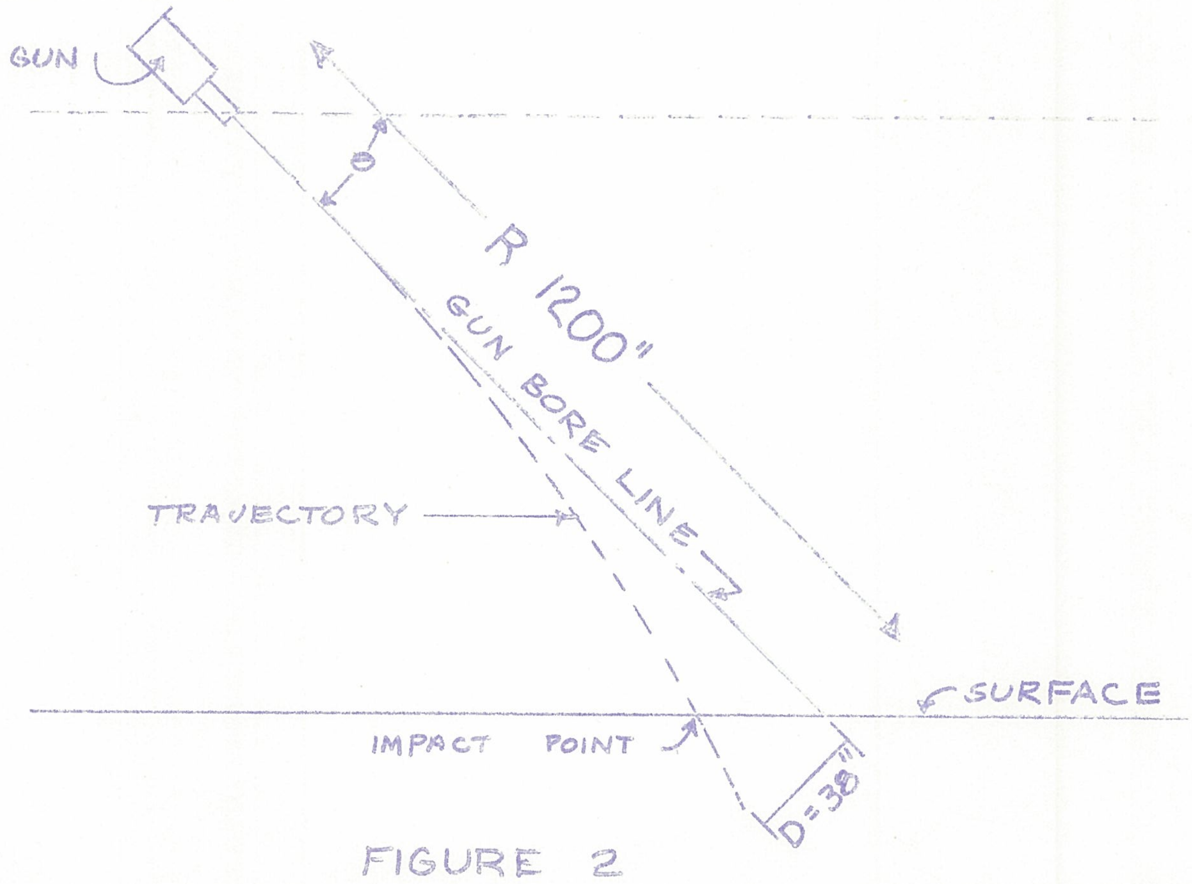


FIGURE 2

It is apparent from Figure 2, that D' is less than D. The amount of difference is, of course, dependent upon the Θ and Range. The effect of Θ and Range on D (trajectory drop) will be discussed later in more detail.

Table II was extracted from AFM 335-25 and shows the effect of Range and airspeed on trajectory drop and is valid from sea level to 7000 feet.

TABLE II

(Trajectory Drop in inches)

Range (feet)	AIRSPEED 0	150mph/131 kts	300mph/261 kts	450mph/392 kts
200	.9	.8	.7	.6
400	3.8	3.3	2.9	2.5
600	8.8	7.6	6.6	5.8
800	16.0	13.7	11.9	10.5
1000	25.5	21.9	19.1	16.7
1200	37.6	32.3	28.0	24.6
1400	52.4	45.0	39.0	34.1
1600	70.2	60.1	52.0	45.5
1800	91.0	77.8	67.3	58.8
2000	115.2	98.4	85.0	74.2
2200	143.1	122.0	105.3	96.8
2400	174.9	148.9	128.4	111.8
2600	210.9	179.3	154.3	134.2
2800	251.6	213.6	183.5	159.4
3000	297.2	251.9	216.1	187.5
3200	348.3	294.6	252.4	218.6

Range (feet)	AIRSPEED 0	150mph/131 kts	300mph/261 kts	450mph/392 kts
3400	405.3	342.2	292.7	253.2
3600	468.6	395.0	337.3	291.3
3800	538.9	453.5	386.6	333.3
4000	616.7	518.2	440.9	379.6

From the previous discussion and the information in Table II, the following table can be developed and shows trajectory drop in mils for various ranges and airspeeds.

TABLE III

(Trajectory Drop in mils)

Range (feet)	AIRSPEED 0	150mph/131 kts	300mph/261 kts	450mph/392 kts
200	.4	.33	.3	.25
400	.8	.69	.6	.52
600	1.2	1.06	.9	.8
800	1.7	1.4	1.2	1.1
1000	2.1	1.8	1.6	1.4
1200	2.6	2.2	1.9	1.7
1400	3.1	2.7	2.3	2.0
1600	3.7	3.1	2.7	2.4
1800	4.2	3.6	3.1	2.7
2000	4.8	4.1	3.5	3.1
2200	5.4	4.6	4.0	3.6
2400	6.1	5.2	4.5	3.9
2600	6.8	5.8	4.9	4.3
2800	7.5	6.3	5.5	4.7

Range (feet)	AIRSPEED			
	0	150mph/131 kts	300mph/261 kts	450mph/392 kts
3000	8.3	7.0	6.0	5.2
3200	9.1	7.7	6.6	5.7
3400	9.9	8.4	7.2	6.2
3600	10.8	9.2	7.8	6.7
3800	11.8	10.0	8.5	7.3
4000	12.8	10.8	9.2	7.9

Table III shows the effect of Range on D (trajectory drop). The effect of Θ (Dive Angle) on D (trajectory drop) can be envisioned by consulting Figure 2. In Figure 2 where D' intersects the gun bore line it is apparent that Range has decreased. Assume the range from the gun to D' is 200 feet less than the range to D. By consulting Table III we find that a 200 foot decrease in range yields a mil setting change of approximately .5 ₥ for zero and 150 mph airspeed, .4 ₥ for 300 mph and .3 ₥ for 450 mph. (Difference between 1200 feet mil drop and 1000 feet mil drop.)

Since the range estimate is dependent on the aviator's ability to judge distances, and in view of the small error achieved by a 10 or 20 degree dive angle (Θ), the effect of Θ on trajectory drop can be assumed to be zero for strafing missions.

With an understanding of the previous discussion it is now possible to develop a sight angle setting for strafing with the caliber 50 machine guns.

The fundamental equation to be solved is:

$$S = D + E + P$$

Each term in this equation will be treated separately and discussed in detail.

S is defined as the sight angle for the given firing conditions.

D is defined as a trajectory drop and is found by entry in Table III with the attack range and airspeed. The result is in mils.

P is the sighting allowance for parallax. As we previously learned in the rocket and bomb problem, on the JOV-1C, P is zero.

E is defined as the sighting allowance for the gun angle of attack.

From the sample 2.75" problem to determine a value for E the following equation required solution.

$$E = f(A + L)$$

In this equation f is a launching factor determined from ballistic data tables. This factor is required to compensate for trajectory jump or "bullet hop" which occurs when the bullet is fired at some angle to the direction of flight.

At present there is no ballistic data for this value of f for the caliber 50 machine gun. In view of this, the above equation for E is invalid for machine gun firing.

Therefore, the following equation must be used to determine E for machine gun firing:

$$E = \frac{Vf \times A}{Vf + V.}$$

In this equation the following definitions apply:

Vf is the velocity of the aircraft in feet per second (fps). To determine this value use:

$$Vf = 1.69 \times \text{airspeed in knots.}$$

A is the armament angle of attack. The evolution of this quantity is derived from the WAV Graph. The required information for entry into this graph is the aircraft gross weight at the time of attack and the calibrated airspeed in knots.

V. is the muzzle velocity in feet per second (fps) of the machine gun. (This is 2935 fps for the AN-M2 machine gun used on the JOV-1C Armed Mohawk.)

To demonstrate the use of the equation for E the following example applies:

Airspeed - - - - - - - - - - - - - -	280 kts
Angle A - - - - - - - - - - - - - -	12 mils

Therefore:

$$E = \frac{Vf \times A}{Vf + V.}$$

$$E = \frac{(280 \times 1.69) \times 12}{(280 \times 1.69) + 2935}$$

$$E = \frac{473 \times 12}{473 + 2935} = \frac{5676}{3408}$$

$$E = 1.66 \text{ mils}$$

To demonstrate the use of Table III and the above information for determining sight angle settings machine gun firing the following practical problem is offered as an example:

Dive Angle Θ - - - - - - - - - - - - - - - - - - -	10°	5°
Calibrated Airspeed - - - - - - - - - - - - -	280 kts	210 Kts.
Range to Target - - - - - - - - - - - - - - - -	500 yds	1200
Target Height Above Sea Level - - - - - - -	1430 feet	500' Alt.
Aircraft Gross Weight at ~~Take Off~~ Firing - - - -	15000 pounds	13,000#
Fuel Consumption Rage - - - - - - - - - - -	500#/hour	
Time of Flight to Target Area - - - - - -	2 hours	

Determination of Sight Angle:

$$S = D + E$$

S = 2 + 4

S = 6

D is Trajectory Drop = 2 mils

E = gun ∠ of Att.

$$E = \frac{V_{(ft/sec)} \times A \text{ (armament ∠ of att...)}}{V + 2935}$$

$$= \frac{355 \times 35.5}{355 + 2935} = \frac{12780}{3290}$$

E = 4

D = 2.5 mils. (From Table III, 261 knots column and 1/2 of the way between the 1400 and 1600 foot value.)

$$E = \frac{Vf \times A}{Vf + V.}$$

Vf = 280 X 1.69 = 473 fps

A = 12 mils (WAV Graph) Enter with CAS of 280 knots, Gross weight 14000 pounds. (Take-off weight minus fuel consumed to the target area)

V^o = 2935 fps (Muzzle velocity of the weapon)

$$E = \frac{473 \times 12}{473 + 2935}$$

$$E = \frac{5676}{3408}$$

E = 1.7 mils.

Therefore:

S = D + E

S = 2.5 + 1.7

S = 4.2 mils or 4 mils.

An important point to remember when firing machine guns is the fact that this is an area weapon and the impact of the projectile should be adjusted on the desired area by observing the tracers and point of impact.

A good rule to use is to start short of the target and "walk" the projectiles onto the target area and hold them in the desired location as long as possible.