TABLE OF CONTENTS

INTRODUCTION

1. The maximum range for harmonization used in this Manual is 2000 feet. Although the effective range for actual firing is 1200 feet maximum, a harmonization based on 1200 feet would result in the same bullet patterns as for 2000-foot harmonization, and the latter has the added advantage of the aircraft being harmonized for the extra 800 feet should the tactical requirements necessitate firing at the longer range.

2. The phase "angle of attack" *(αp)* referred to herein is defined as that angle between the fuselage leveling lugs and the flight path of the aircraft. The data on angle of attack used were derived from the following sources, from which the lift coefficient curves were computed and the angle of attack figures worked out for the various weights, speeds, and "g's" required.

a. Wright Field.

b. Technical Orders.

c. Manufacturer's Data.

3. The boresight targets shown are for 1000 inches and for 500 feet. If the demand for targets at longer ranges presents itself, these additional targets will be furnished at a later date.

4. All ballistic data were obtained from Ballistic Research Laboratory, Aberdeen Proving Ground, Aberdeen, Md., and any questions or discrepancies concerning these data should be referred to that source.

5. The ballistic characteristics of caliber 0.50 M2 and A.P.I. M8 ammunition are essentially the same, and even though the harmonization charts are computed for M2, the A.P.I. M8 can be used. However, new data will be supplied based on A.P.I. M8 at a later date.

6. Section C is included primarily as a technical explanation of the method used in computing the harmonization charts, and is not intended to be used in the field unless a specific duty of harmonization is made.

SECTION A
HARMONIZATION NOTES

1. INTRODUCTION.

a. The following study shows the method used to arrive at a practical arrangement of fixed guns on fighter aircraft. The data and results obtained are derived from various sources including Technical Orders, test reports, ballistics from Aberdeen, flight missions, discussions with gunnery officers, and the experience of combat pilots.

2. TYPES OF HARMONIZATION.

a. It is found that the type known as "Point Harmonization" does not make the most efficient use of the available fire power. In its place, it is recommended that "Pattern Harmonization" be used; that is, that the fixed guns be boresighted so that their trajectories produce a desirable pattern as near uniform as possible in shape and projectile density over the entire range of fire. A range of 2000 feet is considered maximum for harmonization.

b. This harmonization is such that the sight line is always approximately in the center of the projectile pattern throughout the 2000-foot range, when flying at the Basic Harmonization. Consequently the pilot is relieved of any mental calculation of range versus projectile drop.

c. The necessity for computing the proper "lead" is not eliminated by this harmonization. The subject of lead is well covered by other sources and, therefore, will not be considered here.

3. BALLISTIC DATA.

a. Ballistic data are procured from Aberdeen Proving Ground, but interpolation is necessary in some cases to obtain the necessary ballistic curves for specific altitudes or air speeds not covered by Aberdeen. This interpolation can readily be computed to an accuracy sufficient for all practical purposes and will serve as a mathematical basis for figuring harmonization.

b. In the use of published ballistic data, a complete understanding of phraseology is required. The data under the phrases "Present Range" or "Air to Ground" should be used for forward firing fixed guns, and can be interpolated from data under "Future Range" or "Air to Air."

4. ANGLE OF ATTACK.*

a. The angle of attack of the fighter aircraft for all speeds, loading conditions, and "g's" should be found as accurately as possible. The angle of attack is the angle between the fuselage leveling lugs and the flight path. The harmonization data in this Manual is based on the best available data on angle of attack.

*For harmonization purposes.

b. Since the guns on the fighter aircraft are fixed in relation to the fuselage leveling lugs, the angle of attack therefore governs the angle the guns make with the flight path. This angle in turn determines the "Effective Bore" and is, therefore, a critical factor in figuring the harmonization of the sight line and the projectile patterns.

5. EFFECTIVE BORE.

a. When a fixed gun is so set as to make an angle with the flight path, the projectile has two forces acting upon it. One is the muzzle velocity, or the force with which the powder explosion sends the projectile from the muzzle, and the other force is the forward velocity of the firing aircraft. These two forces resolve into one which is the resultant, and is known as the "Effective Bore." In order to harmonize correctly, this effective bore must be computed. This action holds true in both vertical and plan harmonization.

6. PROJECTILE DROP.

a. When harmonization is figured, the projectile drop due to gravity to be used is based on the desired speed and altitude for this harmonization. Then, if the aircraft fires at some other speed or altitude, there is naturally a difference in projectile drop between that used for the harmonization and that at the other speed or altitude. But this difference is of a negligible quantity, the magnitude of the error in caliber 0.50 A.P. M2 being ½ mil at 1000-foot range.

b. When the firing aircraft is in a dive and the wing tips are parallel to the earth, the drop of the projectile measured at right angles to the extended bore is approximately equal to the drop in level flight multiplied by the cosine of the angle of dive. This change is of such small magnitude up to 30-degree dive that it may be disregarded.

c. No matter what the attitude of the firing aircraft, the projectile drop is in a vertical plane perpendicular to the earth, measured from the extended effective bore.

d. Projectile drop itself is not affected by the aircraft pulling "g's." But any action of the aircraft that changes its angle of attack, that is, changes in indicated air speed or number of "g's," affects the angle between the gun bore and flight path and brings into play the "Effective Bore" action previously discussed, and this indirectly causes the trajectory shift in relation to the sight line.

7. BASIC HARMONIZATION.

a. Basic harmonization is figured for altitude, air speed, aircraft weight, and number of "g's" which con-

stitute the average condition at which combat firing will probably occur. In basic harmonization it is of vital importance to obtain as great an angle of visibility as possible over the nose of the aircraft. To accomplish this, the sight line has to be raised to its maximum, limited only by the amount that the guns can be elevated. The guns are elevated to their maximum and the sight is set so as to harmonize with the effective trajectory curve. This method will give the sight its greatest angle over the nose of the aircraft. From this basic harmonization, the mil angle of trajectory shift, shown as "μ" in the harmonization charts, and which is due to flying under any other condition that causes a change in angle of attack, can be computed.

8. GENERAL.

a. It is recommended that for most cases the included harmonization charts be used, unless specific tactical requirements necessitate a deviation. All possible care should be taken to align the guns as accurately as possible to the boresight targets, and all mounts, etc., checked so as to eliminate any error due to movement of guns.

b. Even though the aircraft is harmonized perfectly, there is no substitute for accuracy in shooting and estimating lead. Pattern boresighting will be a great help in deflection shooting and firing at longer ranges, and yet will be just as satisfactory for the close-range shots.

SECTION B

A BORESIGHTING PROCEDURE FOR FIXED GUNS IN FIGHTER AIRCRAFT

(A) BY USE OF THE 1000-INCH BORESIGHT TARGET

1. Select a level strip of ground and place a boresight target 1000 inches (83 feet, 4 inches) from the approximate mean of the gun trunnion bolts of the aircraft.

2. Level the aircraft on both axes and fix firmly by the means of weights, jacks, etc. (Level fuselage by placing level on fuselage leveling lugs.)

3. Draw a vertical line on the target, in line with the center line of the aircraft, by attaching plumb bobs to the aircraft centers and sighting along the plumb bob cords. On aircrafts with nose wheels, allowances must be made for the plumb bobs not being on the center line of the aircraft.

4. Place a sight line level indicator on gun-sight glass reflector and, without turning on reticle light, project a level point from sight to target. Draw a horizontal line on 1000-inch target through this point and through the vertical line as found in step 3. This intersection will be a point from sight parallel to fuselage leveling lugs.

5. With the point found in step 4 already located on boresight board as a starting point, mark off to proper dimensions the points where the fixed sight line and guns are to be aimed, copying data from included harmonization diagram, or from data figured by a responsible officer.

6. With sight line level indicator removed from gun sight, next turn on reticle light and adjust sight so that reticle pip points to mark on boresight target for sight pip. The gun sight will now be aligned in azimuth and zenith for the basic harmonization.

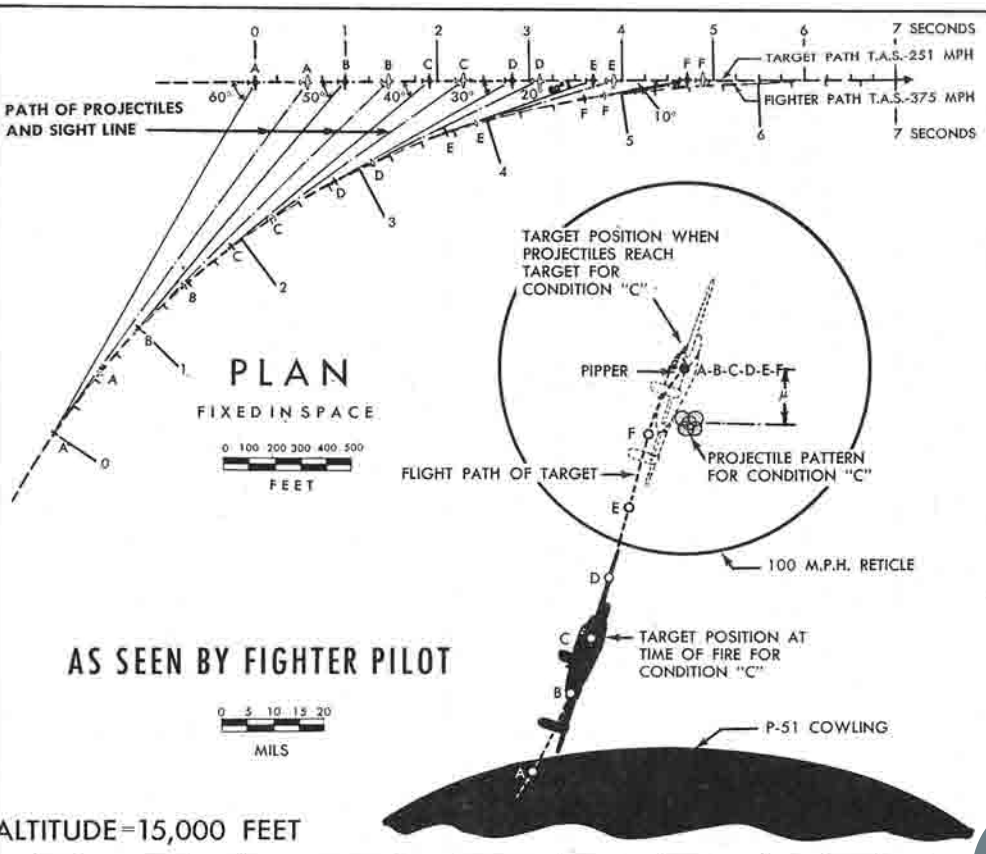
7. With boresight tool, align the guns to point at their respective targets.

(B) BY THE USE OF THE 500-FOOT BORESIGHT AND FIRE-IN TARGET

8. In using the 500-foot target the same procedure as outlined in steps 1 through 7 is to be followed, with the exception that the target is to be 500 feet from the aircraft.

9. Fire a burst of 10 rounds. The center of impact of these hits should fall on the predicted center of impact previously marked on the target, thus giving the correct boresighting. If these points do not coincide, adjust the guns until such is accomplished.

10. Either the 1000-inch boresight target or the 500-foot boresight and fire-in target may be used, but the 500-foot target method is found to be more accurate.



ALTITUDE=15,000 FEET

a	b	c	d	e	f	g	h	i	Fighter		Target		j	k	l	m	n
	Deg.	Deg.	Feet	Feet	Feet	Feet	Sec.	Mils	IAS	TAS	IAS	TAS	Feet	"g"	Deg.	Mils	Deg.
A	60	54.00	1642	1758	215	319	.583	116.9	300	373	200	251	3227	3.05	70.85	13.8	9.71
B	50	44.90	1298	1409	172	255	.466	93.0	300	373	200	251	2969	3.29	72.28	15.5	10.56
C	40	35.80	1053	1148	139	207	.378	77.4	300	373	200	251	2914	3.35	72.60	15.8	10.76
D	30	26.80	834	925	111	165	.302	60.1	300	373	200	251	3047	3.21	71.85	14.9	10.29
E	20	17.80	635	710	84	125	.228	44.4	300	373	200	251	3455	2.87	69.61	12.6	9.07
F	10	8.85	421	475	55	82	.150	29.2	300	373	200	251	4579	2.26	63.77	8.5	6.85
1	30	24.66	600	719	125	125	.229	87.2	300	373	300	373	1724	5.48	79.48	30.2	18.17
2	20	16.75	600	721	128	128	.233	61.5	300	373	300	373	2505	3.85	74.92	19.2	12.51
3	10	8.25	600	726	129	129	.235	30.7	300	373	300	373	5024	2.10	61.62	7.4	6.21
4	0	0	600	729	129	129	.236	0	300	373	300	373	0	1	0	0	0
5	30	26.60	600	670	79	118	.217	59.0	300	373	200	251	2224	4.30	76.55	22.3	14.10
6	20	17.70	600	675	80	119	.217	40.4	300	373	200	251	3296	2.99	70.47	13.4	9.51
7	10	8.83	600	678	80	119	.218	20.9	300	373	200	251	6545	1.74	54.87	5.0	4.79
8	0	0	600	680	80	119	.218	0	300	373	200	251	0	1	0	0	0
9	45	37.77	900	1039	187	187	.341	127.3	300	373	300	373	1696	5.57	79.67	30.8	18.48
10	30	24.87	900	1070	193	193	.352	89.1	300	373	300	373	2546	3.78	74.68	18.7	12.31
11	20	15.50	900	1068	195	195	.357	58.1	300	373	300	373	4059	2.50	66.40	10.2	7.72
12	10	8.28	900	1090	196	196	.358	31.2	300	373	300	373	5958	1.58	57.33	4.0	4.11
13	0	0	900	1095	196	196	.359	0	300	373	300	373	0	1	0	0	0
14	45	40.20	900	986	119	177	.323	85.3	300	373	200	251	2272	4.21	76.27	21.6	13.79
15	30	26.56	900	1007	121	180	.329	60.5	300	373	200	251	3343	2.95	70.22	13.1	9.34
16	20	17.63	900	1016	122	182	.332	41.3	300	373	200	251	4997	2.11	61.73	7.5	6.27
17	10	8.82	900	1019	123	182	.333	21.2	300	373	200	251	9888	1.57	43.78	2.5	1.00
18	0	0	900	1022	123	183	.334	0	300	373	200	251	0	1	0	0	0
19	60	50.85	1200	1349	246	246	.449	159.4	300	373	300	373	1728	5.47	79.47	30.1	18.14
20	45	37.62	1200	1390	252	252	.461	129.3	300	373	300	373	2278	4.20	75.97	21.6	13.73
21	30	24.80	1200	1431	260	260	.475	91.0	300	373	300	373	3417	2.90	69.82	12.7	9.17
22	15	12.31	1200	1457	265	265	.484	47.1	300	373	300	373	6835	1.59	53.6	4.6	4.59
23	0	0	1200	1466	266	266	.486	0	300	373	300	373	0	1	0	0	0
24	60	53.85	1200	1287	157	233	.425	104.6	300	373	200	251	2371	4.05	76.68	20.6	13.22
25	45	40.00	1200	1320	161	239	.436	86.1	300	373	200	251	3047	3.21	71.85	15.0	10.29
26	30	26.53	1200	1345	164	244	.446	61.2	300	373	200	251	4469	2.31	64.32	8.8	7.01
27	15	13.17	1200	1363	166	146	.450	31.5	300	373	200	251	8853	1.45	46.38	3.0	3.54
28	0	0	1200	1366	166	247	.451	0	300	373	200	251	0	1	0	0	0
29																	
30																	

a = Condition.

b = Angle in degrees the Target is off from the Fighter.

c = Angle in degrees the Aim Point is off from Fighter at time of fire.

d = Feet distance between Target and Fighter at time of fire.

e = Feet distance between Aim Point and Fighter at time of fire.

f = Feet distance Target travels between time of fire and time when projectile hits Target.

g = Feet distance Fighter travels between time of fire and time when projectile hits Target.

h = Projectile time of flight in Seconds.

i = Mils lead required.

j = Radius of Pursuit Curve in feet.

k = Resultant or "Seat of Pants" g.

l = Angle in degrees-between the Fighter's wingtips and horizontal.

m = Mil angle the projectile Patterns shifts.

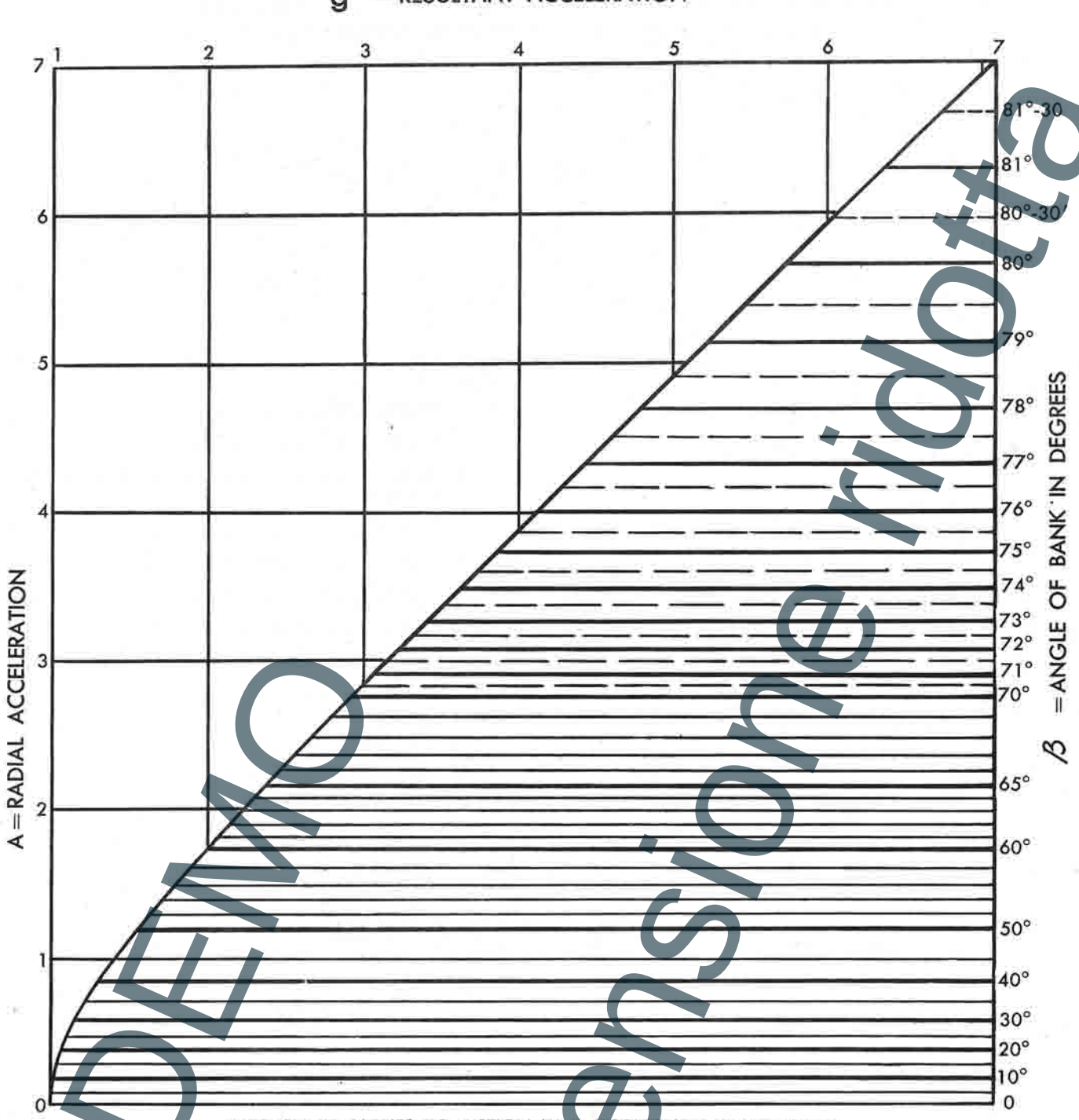
μ = See Page 5A, Section H, "Miscellaneous Data on Aircraft Harmonization and Ballistics," compiled by Applied Ballistics and Design Section.

n = Rate of turn expressed in degrees per Second. Divide by three to get "needle width."

PURSUIT CURVES

THIS CHART IS APPLICABLE IN A HORIZONTAL PLANE ONLY

APPLIED BALLISTICS AND DESIGN SECTION
PROOF DIVISION, A.A.F.P.G.C., EGLIN FIELD, FLA.
DATE 11-24-44



THIS CHART APPLIES TO ACTION IN A HORIZONTAL PLANE ONLY.

APPROXIMATE

APPLIED BALLISTICS AND DESIGN SECTION
PROOF DIV., A.A.F.P.G.C. EGLIN FIELD, FLA.
DATE: 17 NOV '44

FORMULAE FOR COMPUTING THE FORCES ON AN AIRCRAFT WHEN IN A PURSUIT CURVE IN HORIZONTAL FLIGHT

$$A = \frac{(V_f)(V_t)(\sin\phi)}{(32.2)(R)};\quad A = \sqrt{g^2-1};\quad A = \frac{V_f^2}{(32.2)(r)}$$

$$A = (V_f)(W_n)(.001626);\quad W_n = \frac{A}{(V_f)(.001626)};\quad W = \frac{(3)(A)}{(V_f)(.001626)} = \frac{(1845.02)(A)}{(V_f)}$$

$$W_n = \frac{\sqrt{g^2-1}}{(V_f)(.001626)};\quad W = \frac{(3)(\sqrt{g^2-1})}{(V_f)(.001626)} = \frac{(1845.02)(\sqrt{g^2-1})}{(V_f)}$$

$$A = (.000795)(W)(V_{fm});\quad W = \frac{A}{(.000795)(V_{fm})} = \frac{\sqrt{g^2-1}}{(.000795)(V_{fm})} = \frac{(1257.9)(\sqrt{g^2-1})}{V_{fm}}$$

$$W_n = (3)(W);\quad W = \frac{W_n}{3}$$

$$g = \sqrt{A^2+1};\quad g = \sqrt{\left(\frac{(V_f)^2}{(32.2)(r)}\right)^2+1}$$

$$r = \frac{(V_f)^2}{(32.2)(\sqrt{g^2-1})};\quad r = \frac{(V_f)^2}{(32.2)(A)}$$

$$\text{Tangent } \beta = \frac{(V_f)^2}{(32.2)(r)}$$

THESE FORMULAE ARE APPLICABLE FOR FLIGHT IN A HORIZONTAL PLANE ONLY

APP. Ballistics & Design Sect.
Proof Div. A.A.F.P.G.C.
Eglin Field, Fla.

WHEN

A =Radial acceleration

g =Resultant acceleration

R =Range in feet at time of fire, from fighter to aim point

r =Radius in feet of pursuit curve at time of fire

V_f =Fighter TAS in feet per second

V_{fm}=Fighter TAS in miles per hour

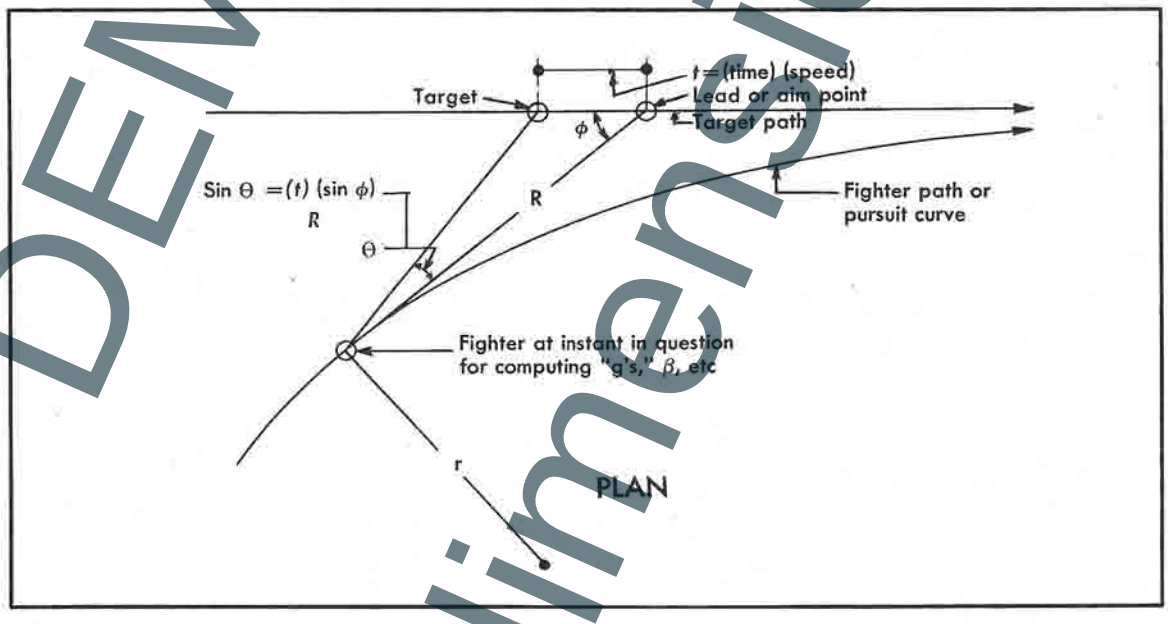
V_t =Target TAS in feet per second

W =Degrees turn in one second

W_n =One needle width=3° per second

β =Angle in degrees, between the fighter's wing tips and horizontal

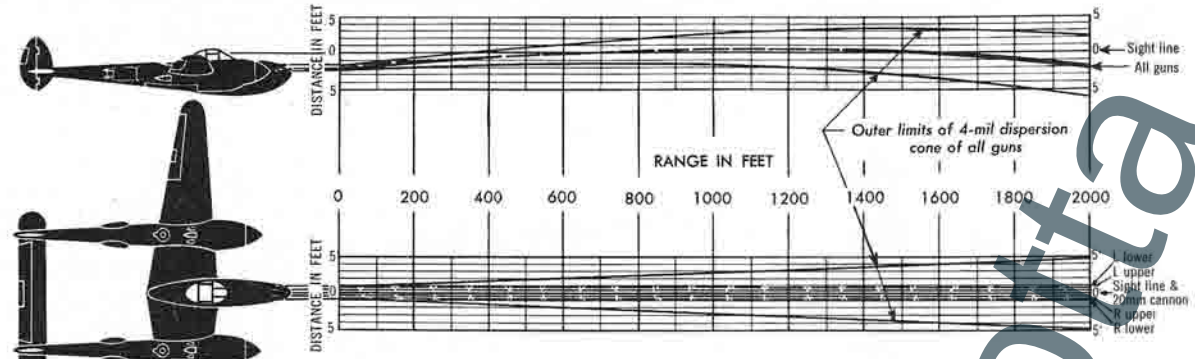
ϕ =Angle in degrees, fighter to aim point to target



SECTION H
FIGHTER HARMONIZATION CHARTS

SIDE VIEW OF TRAJECTORIES

PLAN VIEW OF TRAJECTORIES

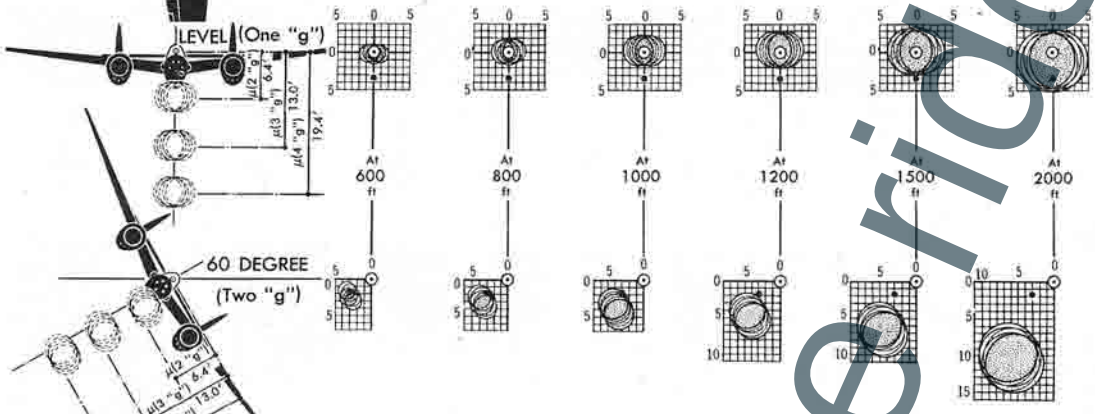


DISPERSION PATTERNS

Based on 4-mil dispersion cone

⊙ *SIGHT PIP*

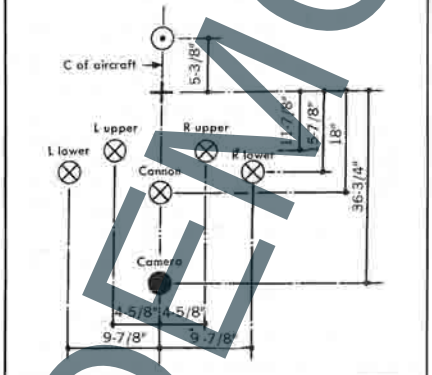
• *CAMERA OR CENTER OF PICTURE FRAME*



NOTE

Dotted circles are bullet patterns of 1000-ft range when firing is done at various "gs" shown

1000-IN. BORESIGHT TARGET



Gun Location at Aircraft	Vert*	Horiz†
.50 cal L&R upr guns	21.94"	4.53"
.50 cal L&R lwr guns	26.44	9.34
20mm cannon	28.95	0.
Camera	42.16	0.

*From sight. †From plane center line.

Targets shown are for harmonization under the following conditions (base harmonization):

Cal IAS: 300 mph Alt: 15,000 ft
TAS: ±373 mph Wt: 14,700±200 lb
Angle of attack(α_B): 4 mils nose down
Level flight: (1 "g")

+ Mark where line from sight is parallel to fuselage leveling lugs.

⊙ Mark where sight pip is aimed for harmonization with bullet patterns (sight setting for harmonization).

⊗ Mark where bore is aimed for 1000-in. and 500-ft. targets.

○ Mark for center of impact of 10 rounds at 500-ft. target.

● Mark where camera is aimed making camera parallel to sight line. This point represents the center of the picture frame.

Applied Ballistics & Design Sec., Proof Div., A.A.F.P.G.C., Eglin Field, Fla., Date: 8-8-44.

TRAJECTORY DATA
Forward Fire

Gun: 20mm Cal .50
Am.: HE T23 PD, fuse T71E4 AMP-2
Muz vel, ft/sec: 2750 2700

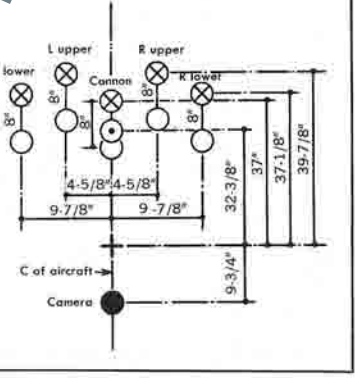
Authority: Aberdeen data FT. 20 AC. I-1; FT. 50 AC-M-1, and 1st ind. to letter from Ord. Dept. Eglin Field, Fla., April 15, 1944, to Chief of Ordnance, Washington, D.C.

BASIC HARMONIZATION
300 mph Cal IAS

FP: Flight path
FSL: Fixed sight line

At 307 mph, Cal IAS, FSL is parallel to FP

500-FT. FIRE-IN AND BORESIGHT TARGET



Flight Angle: LEVEL FLIGHT						
Alt.	Cal IAS	= TAS	Mil Angle "μ" 1 "g"	2 "g"	3 "g"	4 "g"
0'	250	250	+1.7	+8.3	+15.0	+21.6
	300	300	−0.2	+5.1	+10.6	+15.9
	350	350	−1.5	+2.8	+7.3	+11.5
	400	400	−2.8	+1.0	+4.9	+8.6
	450	450	−3.9	−0.6	+2.7	+5.1
7000'	200	222	+4.8	+14.1	+23.3	—
	250	276	+2.0	+9.1	+16.4	+23.6
	300	331	−0.1	+5.7	+11.6	+17.4
	350	386	−1.5	+3.2	+8.0	+12.5
	400	440	−2.9	+1.1	+5.4	+9.4
15000'	200	251	+5.5	+15.8	+26.1	—
	250	313	+2.3	+10.3	+18.5	+26.5
	300	373	0	+6.4	+13.0	+19.4
	350	434	−1.6	+3.6	+8.9	+13.9
	400	493	−3.1	+1.4	+6.0	+10.4
30000'	150	242	+13.0	—	—	—
	200	320	+7.0	+19.7	+32.5	—
	250	398	+3.1	+12.9	+22.8	+32.6
	300	471	+0.2	+8.0	+15.9	+23.8
	350	543	−1.6	+4.5	+10.9	+16.8

Flight Angle: LEVEL FLIGHT					
Cal IAS	α_B (Wt. = 14700 Lbs.) 1 "g"	2 "g"	3 "g"	4 "g"
150	+111	—	—	—
200	+44	+130	+216	—
250	+13	+68	+124	+179
300	−4	+34	+73	+111
350	−13	+14	+42	+68
400	−20	+1	+23	+44
450	−25	−8	+9	+26

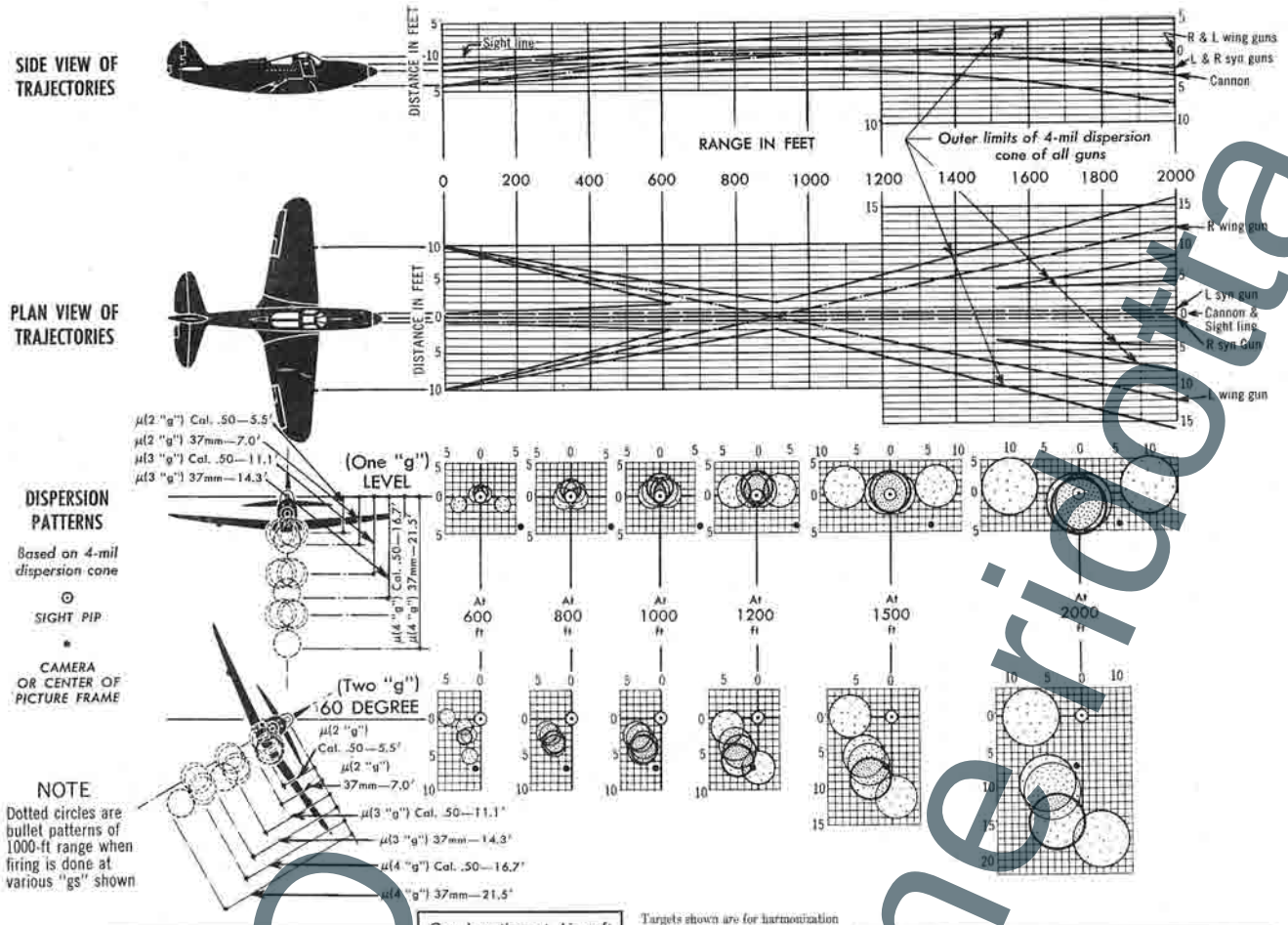
Flight Angle: 30° DIVE OR CLIMB					
Cal IAS	α_B (Wt. = 14700 Lbs.) 1 "g"	2 "g"	3 "g"	4 "g"
150	+90	+223	—	—
200	+32	+107	+181	—
250	+7	+57	+108	+155
300	−9	+24	+57	+90
350	−18	+7	+31	+55
400	−24	−5	+14	+32
450	−27	−13	+2	+17

α_B = Mil angle between the fuselage leveling lugs and the flight path. This data is derived from the best available angle of attack charts, but is not guaranteed. The boresight targets and μ angles are based on this angle of the attack chart.

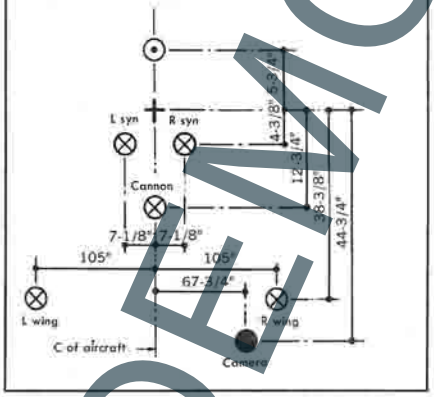
μ = Mil angle between the sight line and the projectiles at any range out to 2000 feet. When the mil angle is minus the projectiles are above the sight line; when plus they are below. This mil angle acts along the vertical axis of the sight. The mil angle μ is only applicable when the aircraft is harmonized as shown in the above boresight and fire-in targets.

Flight Angle: 30° DIVE OR CLIMB					
Alt.	Cal IAS	= TAS	Mil Angle "μ" 1 "g"	2 "g"	3 "g"	4 "g"
0'	250	250	+1.0	+7.0	+13.1	+18.7
	300	300	−0.9	+3.7	+8.4	+13.0
	350	350	−2.3	+1.7	+5.5	+9.4
	400	400	−3.5	−0.1	+3.3	+6.5
	450	450	−4.3	−1.6	+2.0	+4.3
7000'	200	222	+3.5	+11.6	+19.5	—
	250	276	+1.2	+7.7	+14.4	+20.5
	300	331	−0.9	+4.2	+9.2	+14.2
	350	386	−2.4	+2.0	+6.1	+10.3
	400	440	−3.7	0	+3.6	+7.1
15000'	200	251	+4.0	+13.0	+21.9	—
	250	333	+1.5	+8.7	+16.1	+23.0
	300	373	−0.8	+4.7	+10.3	+15.8
	350	434	−2.5	+2.3	+6.8	+11.4
	400	493	−3.9	+0.1	+4.1	+7.9
30000'	150	242	+10.6	+26.0	—	—
	200	320	+5.2	+16.3	−27.3	—
	250	398	+2.0	+10.9	+20.0	+28.3
	300	471	−0.8	+5.9	+12.7	+19.4
	350	543	−2.8	+2.9	+8.4	+13.8

Harmonization Chart: P-38J Airplane



1000-IN. BORESIGHT TARGET



Gun Location at Aircraft	Vert*	Horiz†
L&R wing guns	50.705"	117.939"
L&R syn guns	12.906	7.215
Cannon	24.781	0
Camera	50.5	67.8

*From sight. †From plane center line.

Targets shown are for harmonization under the following conditions (basic harmonization):

Cal IAS: 300 mph Alt: 7,000 ft
TAS: ±331 mph Wt: 7,500±200 lb
Angle of attack (αp): 12 mils nose down
Level flight: (1 "g")

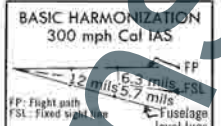
- Mark where line from sight is parallel to fuselage leveling lugs.
- Mark where sight pip is aimed for harmonization with bullet patterns (sight setting for harmonization).
- Mark where bore is aimed for 1000-in. and 500-ft. targets.
- Mark for center of impact of 10 rounds at 500-ft target.
- Mark where camera is aimed making camera parallel to sight line. This point represents the center of the picture frame.

Applied Ballistics & Design Sec., Proof Div., A.A.F.P.G.C., Eglin Field, Fla. Date: 8-8-44

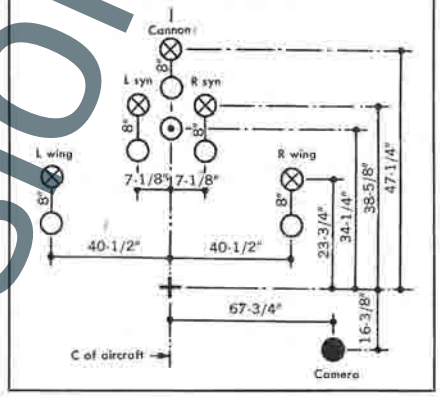
TRAJECTORY DATA Forward Fire		
Gun	37mm M4	Cal .50
Am:	HE M54, fuse M56	APM-2
Muz vel, ft/sec:	2000	2700

Authority: Aberdeen data FT. 37 AC-AO-1: FT. 50 AC-M-1; and 1st ind. to letter from Ord. Dept., Eglin Field, Fla., April 15, 1944, to Chief of Ordnance, Washington, D.C.

BASIC HARMONIZATION 300 mph Cal IAS



500-FT. FIRE-IN AND BORESIGHT TARGET



Alt.	Cal IAS	± TAS	Flight Angle: LEVEL FLIGHT — Mil Angle μ Cal. 0.50 1"g"	2"g"	3"g"	4"g"	Mil Angle "μ" 37 MM 1"g"	2"g"	3"g"	4"g"
0'	250	250	+1.9	+8.3	+14.5	+20.8	+2.5	+10.7	+18.	+27.0
	300	300	0	+6.0	+12.2	+15.4	0	+6.5	+13.2	+19.8
	350	350	−1.5	+2.7	+7.0	+11.3	−1.8	+3.5	+9.0	+14.5
	400	400	−2.9	+0.8	+4.2	+7.8	−3.6	+1.1	+5.7	+10.0
	450	450	−4.0	−0.9	+2.5	+5.6	−5.0	−1.0	+3.2	+7.2
7000'	200	222	+5.0	+13.8	+22.7	—	+6.4	+17.9	+29.5	—
	250	276	+2.1	+9.0	+15.8	+22.7	+2.7	+11.6	+20.4	+29.3
	300	331	0	+5.5	+11.1	+16.7	0	+7.0	+14.3	+21.5
	350	386	−1.6	+2.9	+7.6	+12.2	−2.0	+3.7	+9.7	+15.7
	400	440	−3.2	+0.9	+4.7	+8.4	−3.9	+1.2	+6.1	+10.7
15000'	150	189	+10.2	+23.9	—	—	+13.3	+31.2	—	—
	200	251	+5.5	+15.4	+25.3	—	+7.1	+19.9	+32.8	—
	250	313	+2.3	+10.0	+17.6	+25.3	+3.0	+12.9	+22.6	+32.5
	300	373	−0.1	+6.0	+12.2	+18.5	0	+7.7	+15.7	+23.6
	350	434	−1.8	+3.2	+8.3	+13.5	−2.2	+4.1	+10.6	+17.1
20000'	150	242	+12.7	+29.8	—	—	+16.4	+38.6	—	—
	200	320	+6.8	+18.9	+31.2	—	+8.7	+24.3	+40.1	—
	250	398	+2.8	+12.2	+21.4	+30.9	+3.6	+15.6	+27.3	+39.3
	300	471	−0.1	+7.2	+14.8	+22.3	0	+9.2	+18.7	+28.2
	350	543	−2.2	+3.7	+9.9	+16.0	−2.6	+4.8	+12.5	+20.2

Cal IAS	Flight Angle: LEVEL FLIGHT — αp (Wt.=7500 Lbs.) 1"g"	2"g"	3"g"	4"g"
150	+97	+244	—	—
200	+34	+116	+199	—
250	+4	+57	+109	+162
300	−12	+24	+61	+98
350	+21	+5	+32	+59
400	−28	−7	+13	+32
450	−32	−16	+1	+17

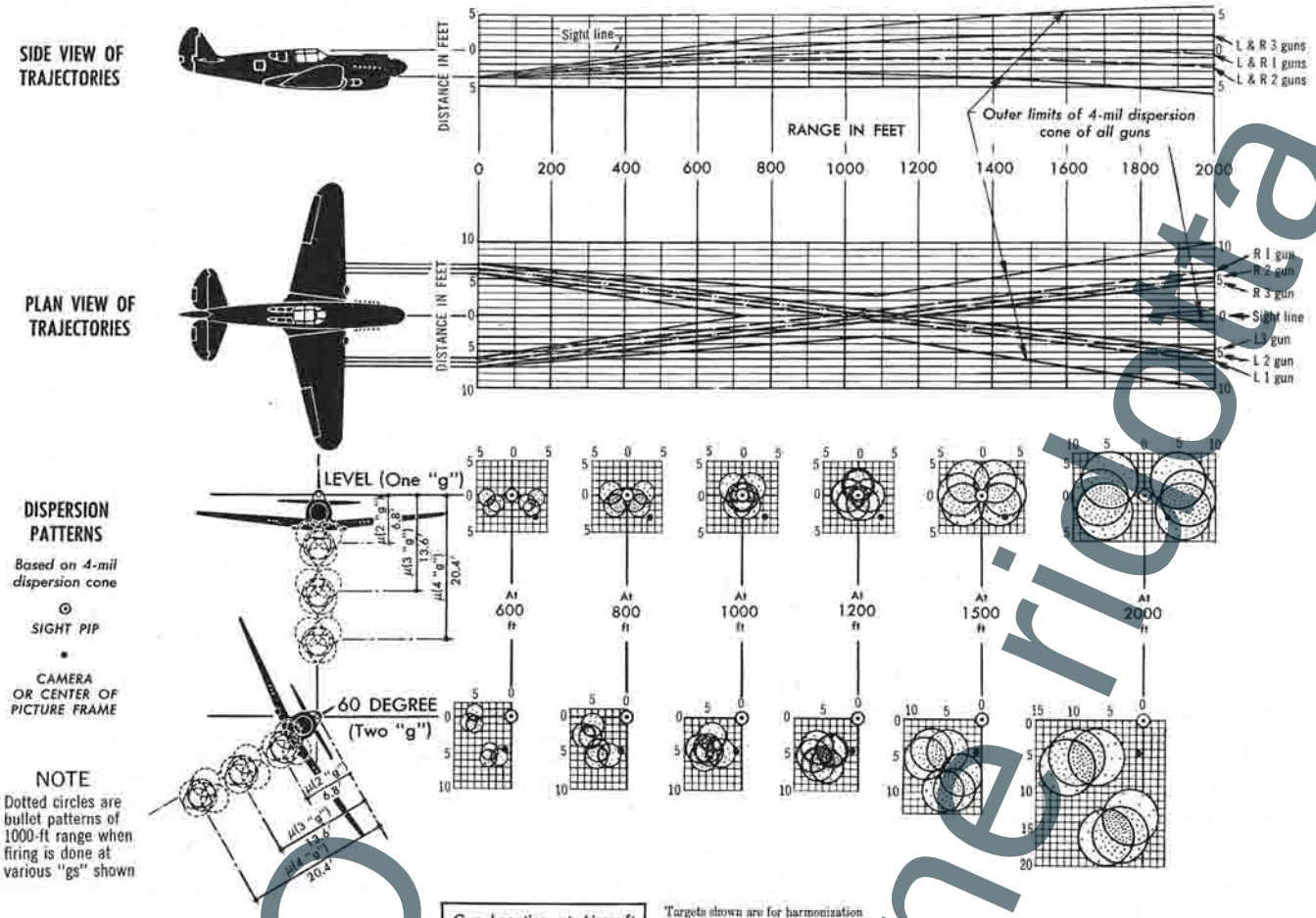
Cal IAS	Flight Angle: 30° DIVE OR CLIMB — αp (Wt.=7500 Lbs.) 1"g"	2"g"	3"g"	4"g"
150	+78	+205	—	—
200	+23	+94	+165	+237
250	−3	+43	+89	+134
300	−17	+15	+46	+77
350	−26	−2	+21	+44
400	−31	−12	+5	+23
450	−35	−21	−5	+8

αp=Mil angle between the fuselage leveling lugs and the flight path. This data is derived from the best available angle of attack charts, but is not guaranteed. The boresight targets and μ angles are based on this angle of the attack chart.

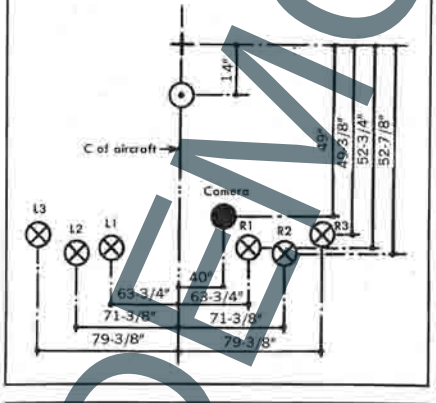
μ=Mil angle between the sight line and the projectiles at any range out to 2000 feet. When the mil angle is minus the projectiles are above the sight line; when plus they are below. This mil angle acts along the vertical axis of the sight. The mil angle μ is only applicable when the aircraft is harmonized as shown in the above boresight and fire-in targets.

Alt.	Cal IAS	± TAS	Flight Angle: 30° DIVE OR CLIMB — Mil Angle "μ" Cal. 0.50 1"g"	2"g"	3"g"	4"g"	Mil Angle "μ" 37 MM 1"g"	2"g"	3"g"	4"g"
0'	250	250	+1.1	+6.6	+12.1	+17.5	+1.4	+8.5	+15.6	+22.6
	300	300	−0.7	+3.8	+8.1	+12.5	−0.9	+4.9	+10.5	+16.0
	350	350	−2.3	+1.6	+5.2	+8.9	−2.9	+2.0	+6.7	+11.4
	400	400	−3.5	+0.2	+3.0	+6.2	−4.3	−0.2	+3.9	+7.9
	450	450	−4.6	−1.9	+1.1	+3.8	−5.7	−2.2	+1.7	+5.0
7000'	200	200	+3.8	+11.4	+19.1	+26.8	+4.9	+14.8	+24.8	+34.9
	250	276	+1.2	+7.2	+13.2	+19.0	+1.5	+9.3	+17.0	+24.6
	300	331	−0.8	+4.1	+8.7	+13.5	−1.0	+5.3	+11.3	+17.4
	350	386	−2.5	+1.7	+5.7	+9.6	−3.1	+2.2	+7.3	+12.4
	400	440	−3.8	−0.3	+3.2	+6.7	−4.6	−0.2	+4.1	+8.5
15000'	150	189	+8.4	+20.3	—	—	+11.0	+26.4	—	—
	200	251	+4.2	+12.7	+21.3	+29.9	+5.4	+16.5	+27.5	+38.7
	250	313	+1.3	+8.0	+14.7	+21.2	+1.7	+10.3	+18.9	+27.3
	300	373	−0.9	+4.5	+9.7	+14.9	−1.1	+5.8	+12.5	+19.1
	350	434	−2.8	+1.8	+6.2	+10.6	−3.4	+2.4	+8.0	+13.5
30000'	150	242	+10.5	+25.2	—	—	+13.6	+32.7	—	—
	200	320	+5.2	+15.7	+26.2	+36.9	+6.6	+20.1	+33.6	+47.3
	250	398	+1.5	+9.7	+17.9	+25.9	+2.0	+12.4	+22.8	+33.0
	300	471	−1.1	+5.4	+11.7	+18.0	−1.3	+6.9	+14.9	+22.8
	350	543	−3.3	+2.1	+7.4	+12.6	−4.0	+2.8	+9.4	+15.9

Harmonization Chart: P-39Q Airplane



1000-IN. BORESIGHT TARGET



Gun Location at Aircraft		
Cal .50	Vert*	Horiz†
L&R No. 1 guns	45.43"	69.68"
L&R No. 2 guns	44.39	77.18
L&R No. 3 guns	43.39	85.16
Camera	35.0	40.0

*From sight. †From plane's center line.

Targets shown are for harmonization under the following conditions (basic harmonization):
Cal IAS: 250 mph Alt: 7,000 ft
TAS: ±276 mph Wt: 8,500±200 lb
Angle of attack (αp): 15 mils nose up
Level flight: (1 "g")

- Mark where line from sight is parallel to fuselage leveling lugs.
- Mark where sight pip is aimed for harmonization with bullet patterns (sight setting for harmonization).
- Mark where bore is aimed for 1000-in. and 500-ft. targets.
- Mark for center of impact of 10 rounds at 500-ft. target.
- Mark where camera is aimed making camera parallel to sight line. This point represents the center of the picture frame.

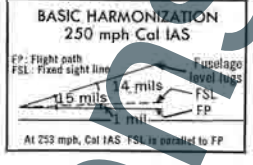
Applied Ballistics & Design Sec., Proof Div., A.A.F.P.G.C., Eglin Field, Fla. Date: 8-8-44.

TRAJECTORY DATA
Forward Fire

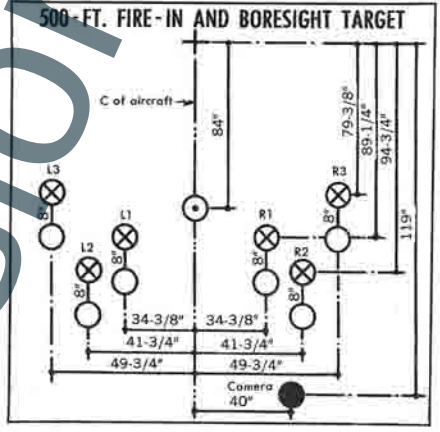
Gun: Cal..50
Ammunition: APM-2
Muz vel, ft/sec: 2700

Authority: Aberdeen data FT. 50 AC M 1; and 1st ind. to letter from Ord. Dept., Eglin Field, Fla., April 15, 1944, to Chief of Ordnance, Washington, D. C.

BASIC HARMONIZATION
250 mph Cal IAS



500-FT. FIRE-IN AND BORESIGHT TARGET



Flight Angle: LEVEL FLIGHT						
Alt.	Cal IAS	± TAS	Mil Angle "μ" 1 "g"	2 "g"	3 "g"	4 "g"
0'	200	200	+2.6	+10.5	+18.5	—
	250	250	−0.1	+6.1	+12.4	+18.6
	300	300	−2.0	+3.0	+8.1	+13.1
	350	350	−3.6	+0.4	+4.4	+8.4
	400	400	−5.0	−1.4	+2.2	+5.6
7000'	200	222	+3.0	+11.7	+20.4	—
	250	276	0	+6.8	+13.6	+20.4
	300	331	−2.1	+3.4	+8.9	+14.4
	350	386	−3.8	+0.5	+4.9	+9.2
	400	440	−5.3	−1.4	+2.4	+6.1
15000'	150	189	+8.1	+22.1	—	—
	200	251	+3.4	+13.1	+22.9	—
	250	333	+0.1	+7.7	+15.2	+22.8
	300	373	−2.2	+3.9	+9.9	+16.0
	350	434	−4.1	+0.7	+5.4	+10.2
30000'	150	242	+10.4	+27.8	—	—
	200	320	+4.4	+16.4	+28.4	—
	250	398	+0.4	+10.5	+18.9	+28.1
	300	471	−3.5	+4.9	+12.2	+19.5
	350	543	−4.7	+1.0	+6.7	+12.4

Flight Angle: LEVEL FLIGHT				
Cal	αp (Wt.=8500 Lbs.)			
IAS	1 "g"	2 "g"	3 "g"	4 "g"
150	+105	+255	—	—
200	+44	+125	+206	—
250	+15	+67	+119	+171
300	0	+36	+72	+105
350	−9	+16	+41	+66
400	−15	+5	+25	+44

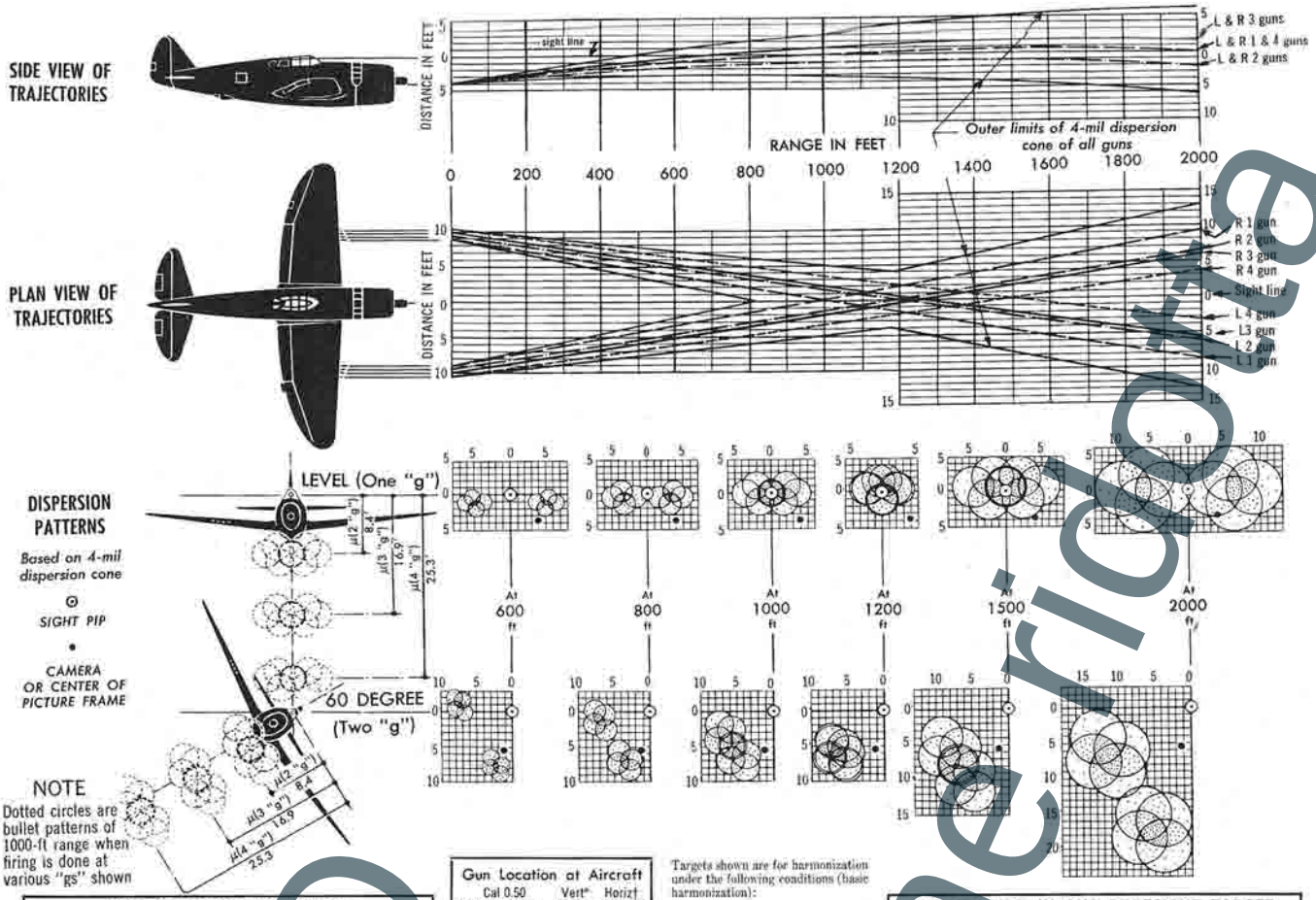
Flight Angle: 30° DIVE OR CLIMB				
Cal	αp (Wt.=8500 Lbs.)			
IAS	1 "g"	2 "g"	3 "g"	4 "g"
150	+89	+216	—	—
200	+32	+102	+172	+241
250	+9	+54	+99	+144
300	−3	+26	+56	+86
350	−13	+8	+29	+50
400	−19	−3	+14	+31

αp=Mil angle between the fuselage leveling lugs and the flight path. This data is derived from the best available angle of attack charts, but is not guaranteed. The boresight targets and μ angles are based on this angle of the attack chart.

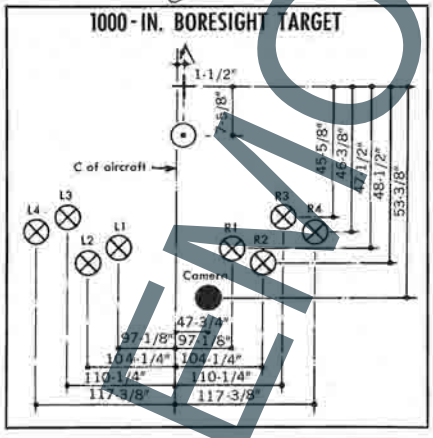
μ=Mil angle between the sight line and the projectiles at any range out to 2000 feet. When the mil angle is minus the projectiles are above the sight line; when plus they are below. This mil angle acts along the vertical axis of the sight. The mil angle μ is only applicable when the aircraft is harmonized as shown in the above boresight and fire-in targets.

Flight Angle: 30° DIVE OR CLIMB						
Alt.	Cal IAS	± TAS	Mil Angle "μ" 1 "g"	2 "g"	3 "g"	4 "g"
0'	200	200	+1.4	+8.3	+15.1	+21.9
	250	250	−0.8	+4.6	+10.0	+15.4
	300	300	−2.7	+1.6	+5.8	+10.0
	350	350	−4.2	−0.9	+2.5	+5.8
	400	400	−5.7	+2.8	+0.2	+3.2
7000'	200	222	+1.7	+9.2	+16.7	+24.2
	250	276	−0.8	+5.1	+11.0	+16.8
	300	331	−2.9	+1.9	+6.4	+11.0
	350	386	−4.5	−0.9	+2.8	+6.4
	400	440	−6.1	−3.0	+0.3	+3.6
15000'	150	189	+6.6	+18.4	—	—
	200	251	+2.0	+10.4	+18.8	+27.1
	250	313	−0.7	+5.8	+12.3	+18.9
	300	373	−3.1	+2.2	+7.2	+12.3
	350	434	−4.9	−0.8	+3.2	+7.2
30000'	150	242	+8.5	+23.3	—	—
	200	320	+2.7	+13.0	+23.4	+33.6
	250	398	−0.7	+7.3	+15.3	+23.3
	300	471	−3.5	+2.8	+8.9	+15.1
	350	543	−5.6	−0.8	+4.0	+8.7

Harmonization Chart: P-40 Airplane



1000-IN. BORESIGHT TARGET



Gun Location at Aircraft		
Cal .50	Vert*	Horiz†
L&R No. 1 guns	47.344"	107.875"
L&R No. 2 guns	46.969	113.844
L&R No. 3 guns	46.594	119.813
L&R No. 4 guns	46.219	125.78"
Camera	45.750	47.813

*From sight. †From plane center line.

Targets shown are for harmonization under the following conditions (basic harmonization):

Cal IAS: 300 mph Alt: 15,000 ft

TAS: ±373 mph Wt: 14,000±250 lb

Angle of attack (exp): 11 mils nose up

Level flight: (1 "g")

Mark where line from sight is parallel to fuselage leveling lugs.

Mark where sight pip is aimed for harmonization with bullet patterns (sight setting for harmonization).

Mark where bore is aimed for 1000-in. and 500-ft. targets.

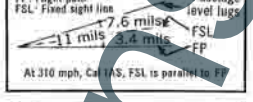
Mark for center of impact of 10 rounds at 500-ft target.

Mark where camera is aimed making camera parallel to sight line. This point represents the center of the picture frame.

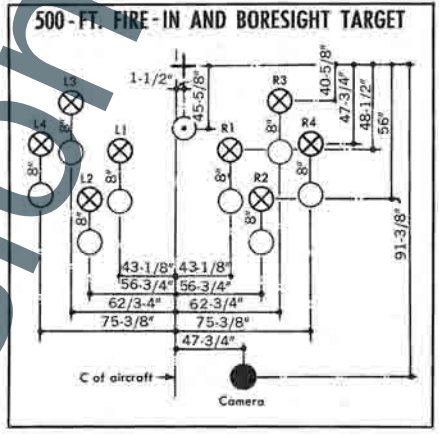
Applied Ballistics & Design Sec., Proof Div., A.A.F.P.G.C., Eglin Field, Fla. Date: 8-8-44.

TRAJECTORY DATA Forward Fire	
Gun:	Cal .50
Ammunition	APM-2
Muz vel, ft/sec:	2700

Authority: Aberdeen data FT. 50 AC-M-1; and 1st ind. to letter from Ord. Dept., Eglin Field, Fla., April 15, 1944, to Chief of Ordnance, Washington, D.C.



500-FT. FIRE-IN AND BORESIGHT TARGET



Flight Angle: LEVEL FLIGHT						
Alt.	Cal .50 IAS	± TAS	Mil Angle "μ" 1 "g"	2 "g"	3 "g"	4 "g"
0'	250	250	+2.1	+10.7	+19.2	+27.8
	300	300	−0.3	+6.8	+13.7	+20.7
	350	350	−2.2	+3.8	+9.5	+15.4
	400	400	−3.8	+0.8	+6.2	+11.2
	450	450	−5.0	−0.7	+3.7	+8.0
7000'	200	222	+6.1	+18.1	—	—
	250	276	+2.5	+11.9	+21.1	+30.5
	300	331	−0.2	+7.5	+15.1	+22.7
	350	386	−2.2	−4.2	+10.5	+16.7
	400	440	−4.0	+1.1	+6.8	+12.2
15000'	200	251	+7.1	+20.4	—	—
	250	313	+3.0	+13.4	+23.7	+34.2
	300	373	0	+8.4	+16.9	+25.3
	350	434	−2.2	+4.8	+11.7	+18.8
	400	493	−4.2	+1.3	+7.7	+13.6
30000'	150	242	+16.9	—	—	—
	200	320	+9.1	+25.6	—	—
	250	398	+4.0	+16.8	+29.5	+42.3
	300	471	+0.4	+10.6	+20.8	+31.0
	350	543	−2.3	+6.1	+14.3	+22.8

Flight Angle: LEVEL FLIGHT				
Cal .50 IAS	exp (Wt.=14000 Lbs.) 1 "g"	2 "g"	3 "g"	4 "g"
150	+161	—	—	—
200	+74	+185	—	—
250	+33	+105	+176	+248
300	+11	+61	+111	+161
350	−2	+35	+71	+108
400	−11	+15	+45	+73
450	−16	+6	+28	+50

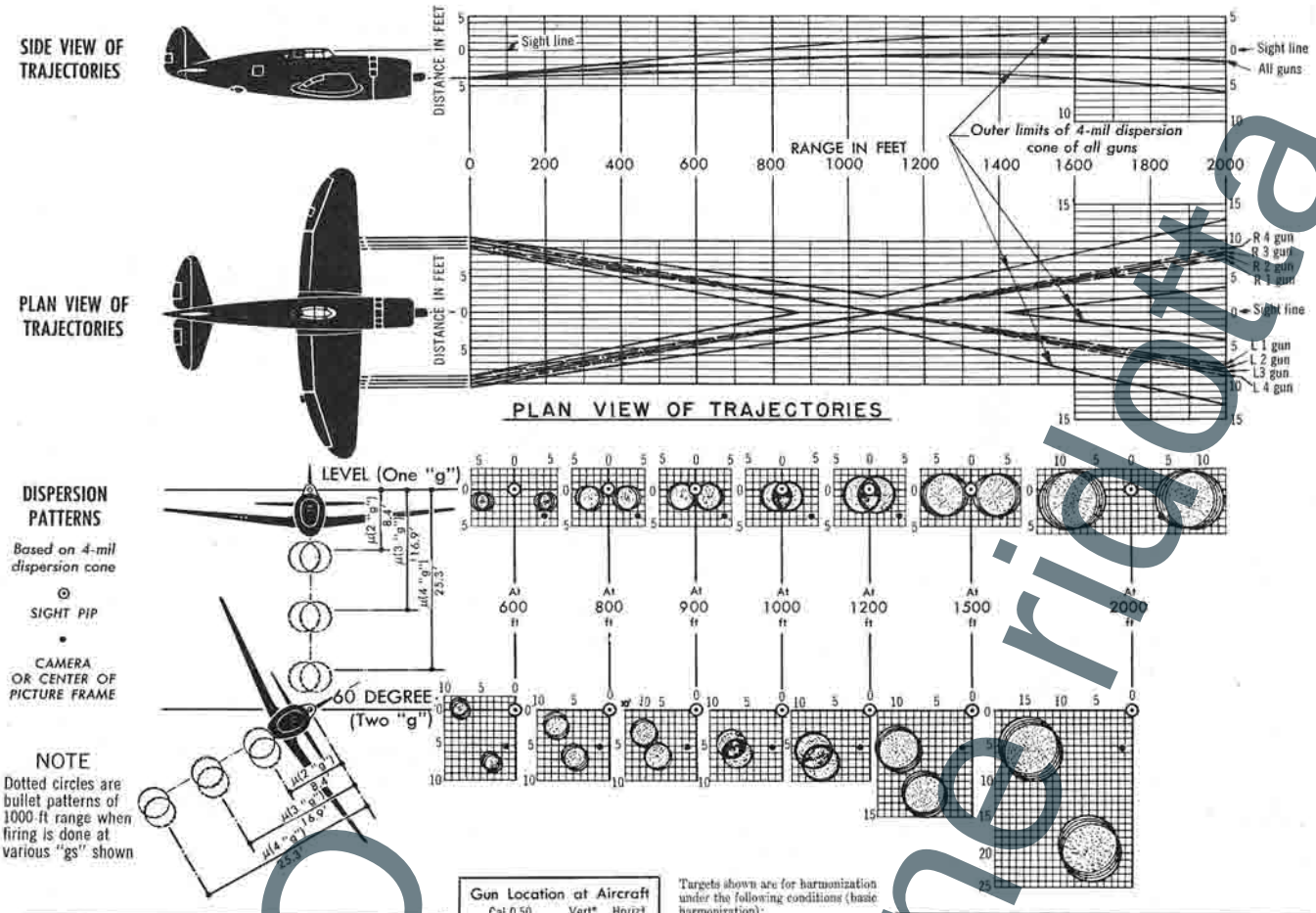
Flight Angle: 30° DIVE OR CLIMB				
Cal .50 IAS	exp (Wt.=14000 Lbs.) 1 "g"	2 "g"	3 "g"	4 "g"
150	+137	—	—	—
200	+59	+159	+251	—
250	+23	+86	+148	+207
300	+5	+48	+92	+134
350	−7	+28	+56	+89
400	−14	+10	+34	+59
450	−19	0	+19	+38

$a.p.$=Mil angle between the fuselage leveling lugs and the flight path. This data is derived from the best available angle of attack charts, but is not guaranteed. The boresight targets and μ angles are based on this angle of the attack chart.

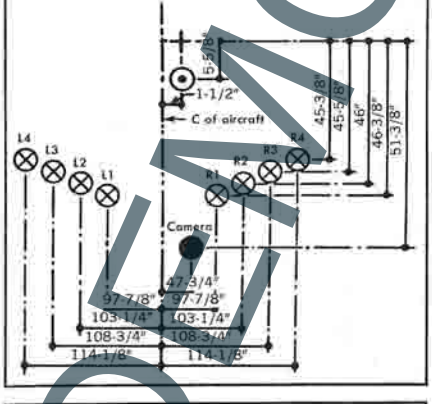
μ=Mil angle between the sight line and the projectiles at any range out to 2000 feet. When the mil angle is minus the projectiles are above the sight line; when plus they are below. This mil angle acts along the vertical axis of the sight. The mil angle μ is only applicable when the aircraft is harmonized as shown in the above boresight and fire-in targets.

Flight Angle: 30° DIVE OR CLIMB						
Alt.	Cal .50 IAS	± TAS	Mil Angle "μ" 1 "g"	2 "g"	3 "g"	4 "g"
0'	250	250	+0.9	+8.5	+15.9	+22.9
	300	300	−1.1	+4.9	+11.1	+16.9
	350	350	−3.0	+2.2	+7.3	+12.4
	400	400	−4.3	−0.1	+4.2	+8.7
	450	450	−5.6	+1.8	+1.9	+5.6
7000'	200	222	+4.5	+14.9	+25.2	—
	250	276	+1.2	+9.4	+17.5	+25.2
	300	331	−1.1	+5.5	+12.2	+18.6
	350	386	−3.0	+2.5	+8.0	+13.6
	400	440	−4.5	+0.1	+4.7	+9.5
15000'	200	251	+5.3	+16.8	+28.3	—
	250	313	+1.5	+10.7	+19.7	+28.3
	300	373	−1.0	+6.3	+13.7	+20.7
	350	434	−3.2	+2.9	+9.0	+15.1
	400	493	−4.8	+0.3	+6.3	+10.6
30000'	150	242	+13.4	—	—	—
	200	320	+6.9	+21.1	+35.3	—
	250	398	+2.3	+13.5	+24.5	+35.0
	300	471	+0.8	+7.9	+16.9	+25.5
	350	543	−3.4	+3.8	+11.1	+18.4

Harmonization Chart P-47 Airplane



1000-IN. BORESIGHT TARGET



Gun Location at Aircraft		
Cal 0.50	Vert*	Horiz†
L&R No. 1 guns	47.344"	107.875"
L&R No. 2 guns	46.969	113.844
L&R No. 3 guns	46.594	119.813
L&R No. 4 guns	46.219	125.78
Camera	45.750	47.813

*From sight. †From plane center line.

Targets shown are for harmonization under the following conditions (basic harmonization):

Cal IAS: 300 mph Alt: 15,000 ft

TAS: ±373 mph Wt: 14,000±250 lb

Angle of attack (αp): 11 mils nose up

Level flight: (1 "g")

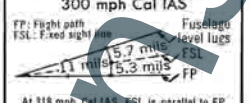
- Mark where line from sight is parallel to fuselage leveling lugs.
- Mark where sight pip is aimed for harmonization with bullet patterns (sight setting for harmonization).
- Mark where bore is aimed for 1000-in. and 900-ft. targets.
- Mark for center of impact of 10 rounds at 900-ft. target.
- Mark where camera is aimed making camera parallel to sight line.
- This point represents the center of the picture frame.

Applied Ballistics & Design Sec., Proof Div., A.A.F.P.G.C., Eglin Field, Fla. Date: 6-5-44

TRAJECTORY DATA Forward Fire	
Gun:	Cal .50
Ammunition:	APM-2
Muz vel, ft/sec:	2700

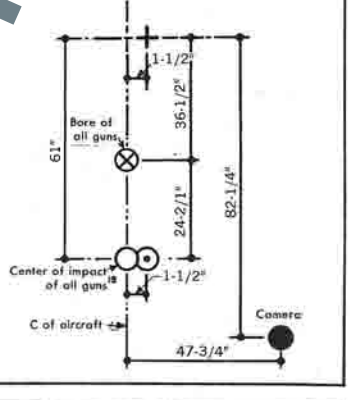
Authority: Aberdeen data FT. 50 AC-M-1; and 1st ind. to letter from Ord. Dept., Eglin Field, Fla., April 15, 1944 to Chief of Ordnance, Washington, D.C.

BASIC HARMONIZATION 300 mph Cal IAS



At 318 mph, Cal IAS, FSL is parallel to FP

900-FT. FIRE-IN AND BORESIGHT TARGET



Flight Angle: LEVEL FLIGHT

Alt	Cal IAS	± TAS	Mil Angle "μ" 1 "g"	2 "g"	3 "g"	4 "g"
0'	250	250	+2.1	+10.7	+19.2	+27.8
	300	300	−0.3	+6.7	+13.7	+20.7
	350	350	−2.2	+3.8	+9.5	+15.4
	400	400	−4.0	+0.9	+6.2	+11.2
	450	450	−4.9	−0.6	+3.7	+8.0
7000'	200	222	+6.1	+18.0	—	—
	250	276	+2.4	+11.8	+21.1	+30.5
	300	331	−0.2	+7.4	+15.1	+22.7
	350	386	−2.2	+4.2	+10.5	+16.9
	400	440	−4.0	+1.1	+6.9	+12.3
15000'	200	251	+7.0	+20.3	—	—
	250	313	+2.9	+13.4	+23.7	+34.2
	300	373	0	+8.4	+16.9	+25.3
	350	434	−2.2	+4.9	+11.7	+18.8
	400	493	−4.0	+1.4	+7.7	+13.6
30000'	150	242	+16.8	—	—	—
	200	320	+9.1	+25.5	—	—
	250	398	+4.0	+16.8	+29.5	+42.3
	300	471	+0.4	+10.6	+20.8	+31.0
	350	543	−2.2	+6.2	+14.4	+22.8

Flight Angle: LEVEL FLIGHT

Cal IAS	αp (Wt. = 14000 Lbs.) 1 "g"	2 "g"	3 "g"	4 "g"
150	+161	—	—	—
200	+74	+185	—	—
250	+33	+105	+176	+248
300	+11	+61	+111	+161
350	−2	+35	+71	+108
440	−11	+15	+45	+73
450	−16	+6	+28	+50

Flight Angle: 30° DIVE OR CLIMB

Cal IAS	αp (Wt. = 14000 Lbs.) 1 "g"	2 "g"	3 "g"	4 "g"
150	+131	—	—	—
200	+59	+155	+251	—
250	+23	+86	+148	+207
300	+5	+48	+92	+134
350	−7	+25	+56	+89
400	−14	+10	+34	+59
450	−19	0	+19	+38

αp = Mil angle between the fuselage leveling lugs and the flight path. This data is derived from the best available angle of attack charts, but is not guaranteed. The boresight targets and μ angles are based on this angle of the attack chart.

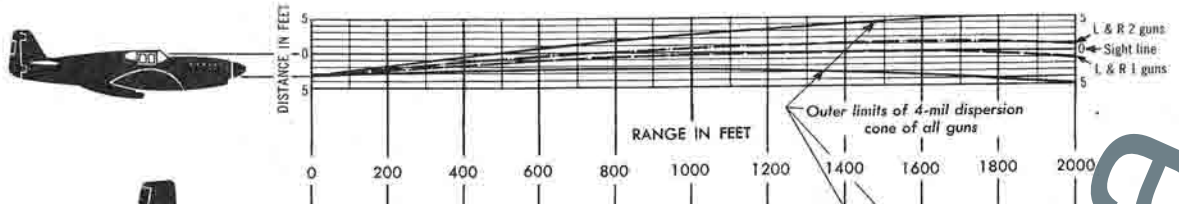
μ = Mil angle between the sight line and the projectiles at any range out to 2000 feet. When the mil angle is minus the projectiles are above the sight line; when plus they are below. This mil angle acts along the vertical axis of the sight. The mil angle μ is only applicable when the aircraft is harmonized as shown in the above boresight and fire-in targets.

Flight Angle: 30° DIVE OR CLIMB

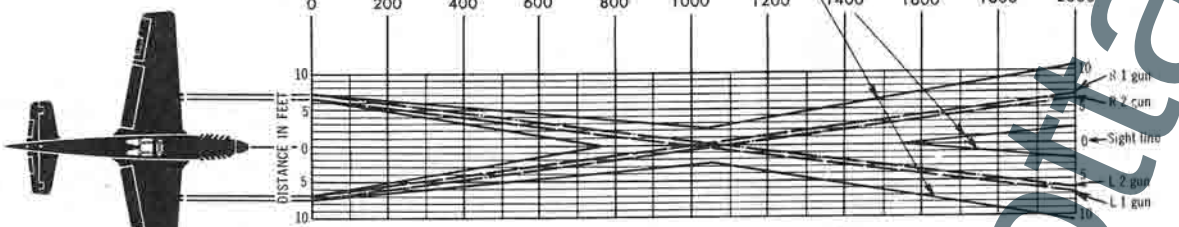
Alt.	Cal IAS	± TAS	Mil Angle "μ" 1 "g"	2 "g"	3 "g"	4 "g"
0'	250	250	+0.9	+8.4	+15.8	+22.9
	300	300	−1.2	+4.9	+11.0	+16.9
	350	350	−3.0	+2.2	+7.3	+17.4
	400	400	−4.3	0	+4.2	+8.7
	450	450	−5.5	−1.8	+1.9	+5.7
7000'	200	222	+4.5	+14.8	+25.1	—
	250	276	+1.1	+9.3	+17.4	+25.1
	300	331	−1.1	+5.5	+12.2	+18.6
	350	386	−3.0	+2.5	+8.1	+13.6
	400	440	−4.5	−0.1	+4.8	+9.6
15000'	200	251	+5.2	+16.7	+28.2	—
	250	313	+1.5	+10.6	+19.7	+28.2
	300	373	−1.0	+6.3	+13.7	+20.7
	350	434	−3.1	+3.0	+9.1	+15.2
	400	493	−4.7	+0.3	+5.4	+10.7
30000'	150	242	+13.3	—	—	—
	200	320	+6.9	+21.1	—	—
	250	398	+2.3	+13.5	+24.5	+35.0
	300	471	−0.8	+8.0	+16.9	+25.5
	350	543	−3.4	+3.9	+11.2	+18.5

Harmonization Chart: P-47 Airplane

SIDE VIEW OF TRAJECTORIES



PLAN VIEW OF TRAJECTORIES

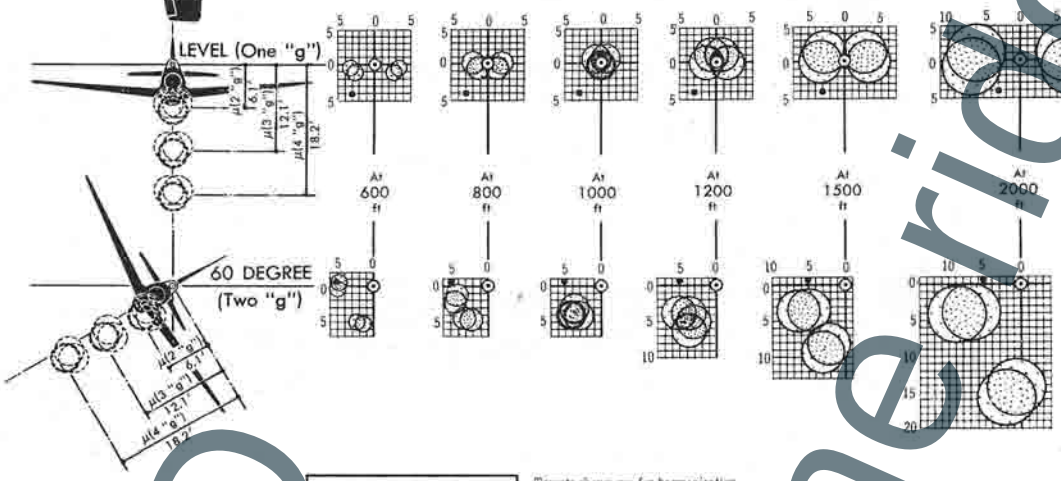


DISPERSION PATTERNS

Based on 4-mil dispersion cone

⊙ *SIGHT PIP*

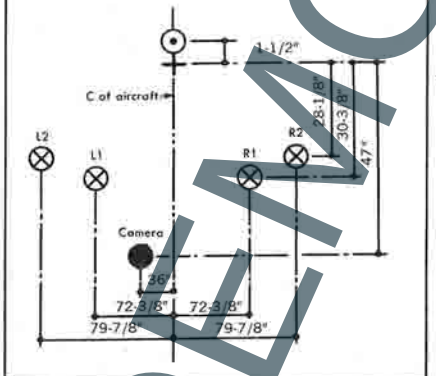
• *CAMERA OR CENTER OF PICTURE FRAME*



NOTE

Dotted circles are bullet patterns of 1000-ft range when firing is done at various "gs" shown

1000-IN. BORESIGHT TARGET



Gun Location at Aircraft

	Cal 0.50 Vert*	Horiz†
L&R No. 1 guns	40.238"	80.508"
L&R No. 2 guns	40.124	87.998
Gun Camera	48.543	35.953

*From sight. †From plane center line.

Targets shown are for harmonization under the following conditions (basic harmonization):

Cal IAS: 300 mph Alt: 15,000 ft
TAS: ±373 mph Wt: 9,500±200 lb
Angle of attack (αp): 12 mils nose up
Level flight: (1 "g")

- Mark where line from sight is parallel to fuselage leveling lugs.
- ⊙ Mark where sight pip is aimed for harmonization with bullet patterns (sight setting for harmonization).
- ⊗ Mark where bore is aimed for 1000-in. and 500-ft. targets.
- ○ Mark for center of impact of 10 rounds at 500-ft target.
- ● Mark where camera is aimed making camera parallel to sight line. This point represents the center of the picture frame.

Applied Ballistics & Design Sec., Proof Div., A.A.F.P.G.C., Eglin Field, Fla. Date: 8-8-44.

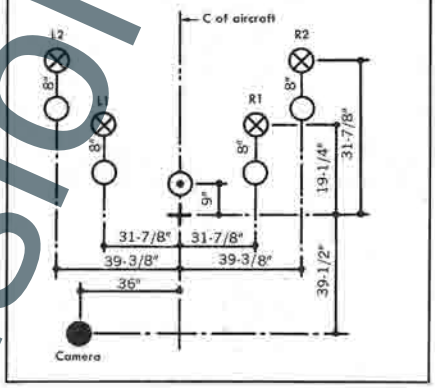
TRAJECTORY DATA
Forward Fire

Gun:	Cal .50
Ammunition:	APM-2
Muz vel, ft/sec:	2700

Authority: Aberdeen data FT: 50 AC-M-1; and 1st ind. to letter from Ord. Dept., Eglin Field, Fla., April 15, 1944, to Chief of Ordnance, Washington, D.C.

BASIC HARMONIZATION
300 mph Cal IAS

500-FT. FIRE-IN AND BORESIGHT TARGET



Flight Angle: LEVEL FLIGHT

Alt.	Cal. IAS	± TAS	Mil Angle "μ" 1 "g"	2 "g"	3 "g"	4 "g"
0′	250	250	+0.8	+7.0	+13.1	+19.2
	300	300	−0.6	+4.4	+9.4	+14.5
	350	350	−1.6	+2.5	+6.7	+11.0
	400	400	−2.6	+1.1	+4.7	+8.2
	450	450	−3.3	−0.2	+3.2	+6.1
7000′	200	222	+3.5	+12.1	+20.7	—
	250	276	+1.2	+8.0	+14.6	+21.3
	300	331	−0.4	+5.1	+10.6	+16.1
	350	386	−1.5	+3.0	+7.6	+12.2
	400	440	−2.5	+1.5	+5.4	+9.2
15000′	200	251	+4.3	+13.9	+23.5	—
	250	313	+1.8	+9.4	+16.8	+24.2
	300	373	0	+6.1	+12.1	+18.2
	350	434	−1.2	+3.7	+8.7	+13.8
	400	493	−2.4	+2.0	+6.2	+10.5
30000′	150	242	+11.2	+27.9	—	—
	200	320	+6.2	+18.0	+29.9	—
	250	398	+3.0	+12.3	+21.4	+30.4
	300	471	+0.8	+8.1	+15.5	+22.8
	350	543	−0.7	+5.2	+11.1	+17.3

Flight Angle: LEVEL FLIGHT

Cal. IAS	αp (Wt.=9500 Lbs.) 1 "g"	2 "g"	3 "g"	4 "g"
150	+119	+262	—	—
200	+57	+137	+217	—
250	+28	+80	+131	+182
300	+12	+48	+84	+120
350	+3	+29	+55	+82
400	−4	+17	+37	+57
450	−8	+8	+25	+40

Flight Angle: 30° DIVE OR CLIMB

Cal. IAS	αp (Wt.=9500 Lbs.) 1 "g"	2 "g"	3 "g"	4 "g"
150	+100	+224	—	—
200	+45	+115	+185	+254
250	+21	+66	+111	+155
300	+7	+38	+69	+100
350	−1	+22	+45	+68
400	−5	+11	+29	+46
450	−10	+4	+18	+32

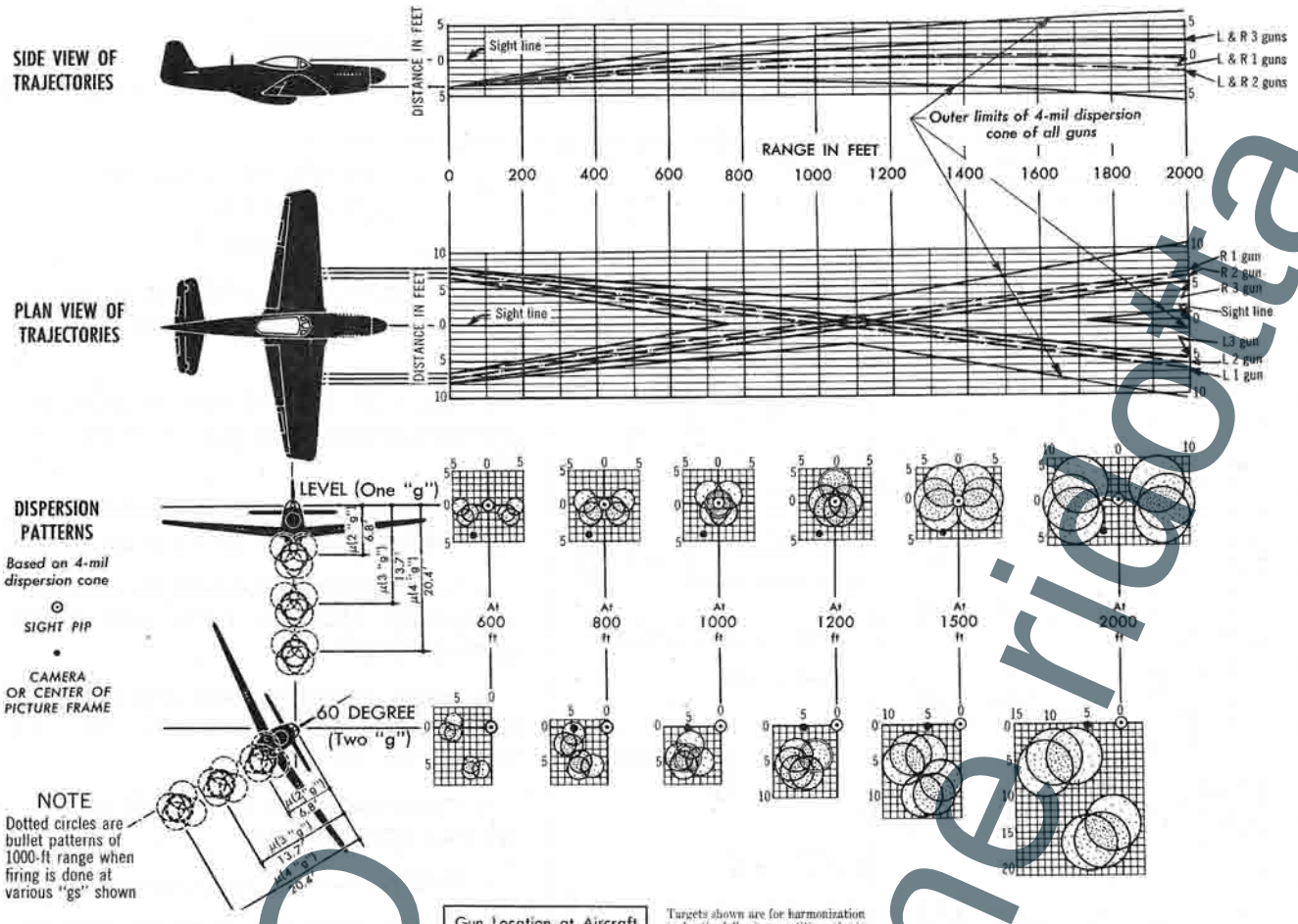
αp = Mil angle between the fuselage leveling lugs and the flight path. This data is derived from the best available angle of attack charts, but is not guaranteed. The boresight targets and μ angles are based on this angle of the attack chart.

μ = Mil angle between the sight line and the projectiles at any range out to 2000 feet. When the mil angle is minus the projectiles are above the sight line; when plus they are below. This mil angle acts along the vertical axis of the sight. The mil angle μ is only available when the aircraft is harmonized as shown in the above boresight and fire-in targets.

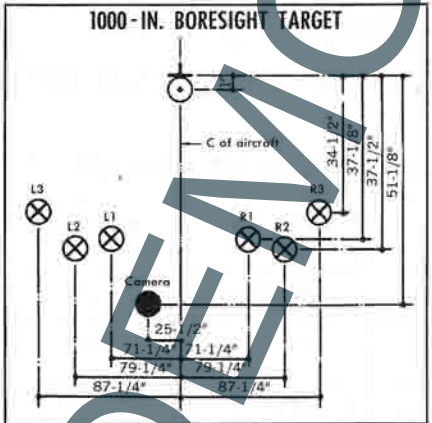
Flight Angle: 30° DIVE OR CLIMB

Alt.	Cal. IAS	± TAS	Mil Angle "μ" 1 "g"	2 "g"	3 "g"	4 "g"
0′	250	250	0	+5.3	+10.7	+16.0
	300	300	−1.3	+3.0	+7.3	+11.7
	350	350	−2.3	+1.4	+5.1	+8.7
	400	400	−3.0	0	+3.3	+6.3
	450	450	−3.8	−1.0	+1.8	+4.5
7000′	200	222	+2.3	+9.7	+17.2	+24.7
	250	276	+0.3	+6.2	+12.0	+17.8
	300	331	−1.1	+3.6	+8.3	+13.0
	350	386	−2.2	+1.8	+5.8	+9.8
	400	440	−3.0	+0.3	+3.8	+7.1
15000′	200	251	+3.0	+11.3	+19.7	+27.9
	250	313	+0.8	+7.3	+13.3	+20.2
	300	373	−0.9	+4.4	+9.6	+14.8
	350	434	−2.0	+2.4	+6.8	+11.2
	400	493	−2.8	+0.7	+4.5	+8.1
30000′	150	242	+9.0	+23.4	—	—
	200	320	+4.6	+14.8	+25.2	+35.4
	250	398	+1.8	+9.8	+17.8	+25.6
	300	471	−0.2	+6.1	+12.4	+18.7
	350	543	−1.6	+3.6	+8.8	+14.1

Harmonization Chart: P-51B & C Airplanes



1000-IN. BORESIGHT TARGET



Gun Location at Aircraft

Cal 0.50	Vert*	Horizt
L&R No. 1 guns	44.732"	79.123"
L&R No. 2 guns	44.002	87.091
L&R No. 3 guns	43.493	95.076
Camera	50.140	25.561

*From sight. †From plane center line.

Targets shown are for harmonization under the following conditions (basic harmonization):

Cal IAS: 300 mph Alt: 15,000 ft
TAS: ±373 mph Wt: 9,500±200 lb
Angle of attack (αp): 13 mils nose up
Level flight: (1 "g")

Mark where line from sight is parallel to fuselage leveling lugs.
Mark where sight pip is aimed for harmonization with bullet patterns (sight setting for harmonization).
Mark where bore is aimed for 1000-in. and 500-ft. targets.
Mark for center of impact of 10 rounds at 500-ft. target.
Mark where camera is aimed making camera parallel to sight line. This point represents the center of the picture frame.

Applied Ballistics & Design Sec., Proof Div., A.A.F.P.G.C., Eglin Field, Fla. Date: 8-8-44

TRAJECTORY DATA
Forward Fire

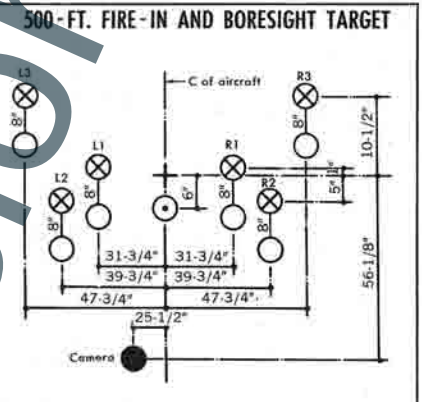
Gun: Cal .50
Ammunition: APM-2
Muz vel, ft/sec: 2700

Authority: Aberdeen data FT 50 AC-M-1; and 1st ind. to letter from Ord. Dept., Eglin Field, Fla., April 15, 1944, to Chief of Ordnance, Washington, D.C.

BASIC HARMONIZATION
300 mph Cal IAS

At 355 mph, Cal IAS, FSL is parallel to FP

500-FT. FIRE-IN AND BORESIGHT TARGET



Flight Angle: LEVEL FLIGHT

Alt	Cal IAS	± TAS	Mil Angle "μ" 1 "g"	2 "g"	3 "g"	4 "g"
0'	250	250	+1.0	+8.1	+15.0	+22.1
	300	300	−0.6	+5.0	+10.8	+16.4
	350	350	−1.9	+2.9	+7.5	+12.3
	400	400	−3.1	+1.1	+5.1	+9.2
	450	450	−3.9	−0.4	+3.2	+6.7
7000'	200	222	+4.1	+14.0	+23.8	—
	250	276	+1.5	+9.1	+16.7	+24.4
	300	331	−0.3	+5.8	+12.0	+18.1
	350	386	−1.8	+3.4	+8.5	+13.7
	400	440	−3.1	+1.5	+5.8	+10.2
15000'	200	251	+5.0	+16.1	+27.0	—
	250	313	+2.0	+10.6	+19.0	+27.6
	300	373	0	+6.8	+13.7	+20.4
	350	434	−1.6	+4.1	+9.5	+15.4
	400	493	−3.1	+2.0	+6.6	+11.5
30000'	150	242	+13.0	+31.8	—	—
	200	320	+7.0	+20.6	+34.1	—
	250	398	+3.3	+13.7	+24.1	+34.5
	300	471	+0.8	+8.9	+17.3	+25.4
	350	543	−1.3	+5.6	+12.2	+19.0

Flight Angle: LEVEL FLIGHT

Cal IAS	αp (Wt.=9500 Lbs.) 1 "g"	2 "g"	3 "g"	4 "g"
150	+134	+296	—	—
200	+63	+155	+246	—
250	+30	+89	+147	+206
300	+13	+53	+94	+134
350	+2	+32	+61	+91
400	−6	+18	+40	+63
450	−10	+8	+26	+44

Flight Angle: 30° DIVE OR CLIMB

Cal IAS	αp (Wt.=9500 Lbs.) 1 "g"	2 "g"	3 "g"	4 "g"
150	+112	+252	—	—
200	+51	+136	+210	+288
250	+23	+73	+124	+175
300	+/-	+42	+77	+113
350	−2	+24	+50	+76
400	−9	+12	+31	+51
450	−13	+3	+19	+34

αp=Mil angle between the fuselage leveling lugs and the flight path. This data is derived from the best available angle of attack charts, but is not guaranteed. The boresight targets and μ angles are based on this angle of the attack chart.

μ=Mil angle between the sight line and the projectiles at any range out to 2000 feet. When the mil angle is minus the projectiles are above the sight line; when plus they are below. This mil angle acts along the vertical axis of the sight. The mil angle μ is only applicable when the aircraft is harmonized as shown in the above boresight and fire-in targets.

Flight Angle: 30° DIVE OR CLIMB

Alt.	Cal IAS	± TAS	Mil Angle "μ" 1 "g"	2 "g"	3 "g"	4 "g"
0'	250	250	+0.2	+6.2	+12.3	+18.4
	300	300	−1.4	+3.5	+8.4	+13.5
	350	350	−2.5	+1.6	+5.8	+9.9
	400	400	−3.7	+0.2	+3.5	+7.0
	450	450	−4.9	−1.3	+1.8	+4.7
7000'	200	222	+2.8	+11.4	+20.0	+28.4
	250	276	+0.5	+7.1	+13.7	+20.4
	300	331	−1.2	+4.1	+9.5	+14.9
	350	386	−2.5	+2.0	+6.6	+11.1
	400	440	−3.7	+0.4	+4.0	+7.9
15000'	200	251	+3.6	+13.1	+22.9	+32.0
	250	313	+1.0	+8.3	+15.7	+23.1
	300	373	−1.0	+4.9	+10.8	+16.9
	350	434	−2.4	+2.6	+7.6	+12.5
	400	493	−3.7	+0.7	+4.7	+9.0
30000'	150	242	+10.4	+26.7	—	—
	200	320	+5.2	+16.9	+28.8	+39.1
	250	398	+2.0	+10.9	+20.0	+29.0
	300	471	−0.4	+6.7	+13.8	+21.2
	350	543	−2.1	+3.8	+9.7	+15.6

Harmonization Chart: P-51D Airplane