DETERMINATION BOMBING ACCURACY FROM LEVEL DELIVERY USING THE EJECTION PRACTICAL BOMB

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Abstract: *The bombing delivery systems can improve survivability and delivery accuracy. Despite conventional, wings-level dive bomb delivery can achieve acceptable accuracy an aircraft is vulnerable during maneuvering to weapon release.*

Keywords: *practical bomb, bombing accuracy, ejection*

1. INTRODUCTION

Bombing accuracy is the combination of delivery accuracy and ballistic dispersion. The most common statistical measure from bombing accuracy is the circular error probable (CEP), which is the radius of a circle that should contain one-half (or 50%) of the total number of bomb impacts in a sample. Note that the CEP is applicable only when the distribution is equally proportioned in range and deflection, which is usually not the case when working in the ground plane. The plane where the distribution is equally proportioned is in a plane perpendicular to the bomb trajectory at the time of impact. For most cases, especially level or dive deliveries, the plane perpendicular to the line of sight (i.e., from the aircraft at the time of release to the center of impact) is an adequate approximation to the flight path normal plane to ensure that the distribution is equally proportioned. The delivery accuracy can ascertain of the formula [1, 2, 4, 5, 6]:

$$\begin{aligned} M[\Delta X_a] &= M[\Delta X_d] + M[\Delta X_b]; \\ \sigma_{Xa}^2 &= \sigma_{Xd}^2 + \sigma_{Xb}^2. \end{aligned} \tag{1}$$

where [3]:

$$\begin{aligned} \tilde{m} &= \frac{\sum_{j=1}^{N} \Delta X_j}{N}; \\ \tilde{\sigma} &= \sqrt{\frac{\sum_{j=1}^{N} \left(\Delta X_j - \tilde{m}\right)^2}{N-1}}. \end{aligned} \tag{2}$$

- ΔX_a – bombing error;

- ΔX_d – delivery error;
- ΔX_b – ballistic dispersion;
- $M[\Delta X_a] = m_a$ – sample means the bombing error;
- $M[\Delta X_d] = m_d$ – sample means the delivery error;
- $M[\Delta X_b] = m_b$ – sample means the ballistic dispersion;
- σ_{Xa} – standard deviation for bombing accuracy;
- σ_{Xd} – standard deviation for delivery accuracy;
- σ_{Xb} – standard deviation for ballistic dispersion;

2. MATHEMATICAL MODEL

The structural scheme of the model for determination bombing accuracy using the ejection practical bomb P-50-75 showed fig. 1.

The structural scheme includes these blocks:

- Model at the Aircraft;
- Model at the Aiming System;
- Model at the Bomb;
- Model Error Sources of Information
- Model Determent Ejection Velocity;
- Model Determent Bombing Accuracy.

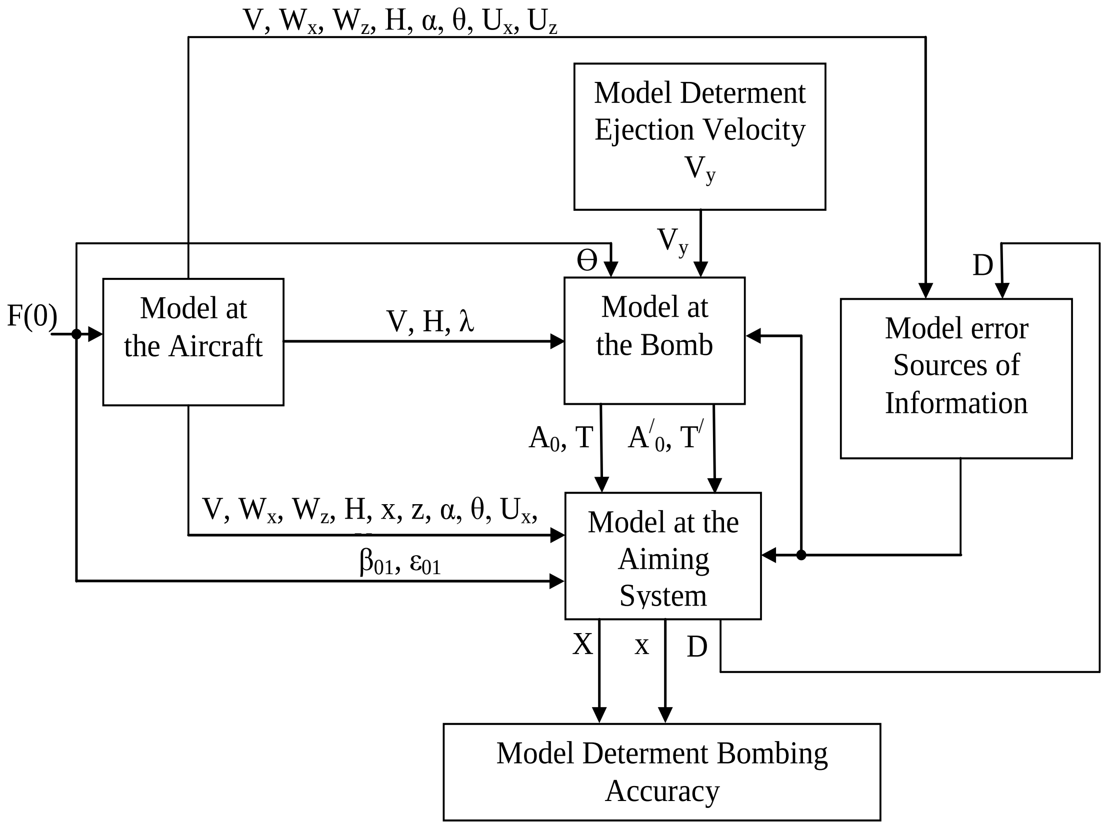

FIG. 1 Structural scheme of the model for determination bombing accuracy

The study for bomb launching in horizontal flight at height and velocity: H=500 – 1500 [m]; V=180 – 260 [m/s], initial vertical bomb velocity - V_y= 2 m/s. Practice Air bomb P-50-75 with technical characteristics: Caliber - 50 kg; Length - 1 065 mm; Body Diameter - 203 mm; Tail fin span - 245 mm; Characteristic time - 21,39 s. is used.

The sight depression angles ε_r (from the fuselage reference line to the target line of sight) at the moment of bomb launching received with mathematical modeling are given in table 1.

Table 1

Level Delivery ($\lambda = 0^0$)					
ε_r, deg	**V=180, m/s**	**200**	**220**	**240**	**260**
H=500, m	-20.30	-17.98	-16.13	-14.62	-13.36
750	-24.35	-21.76	-19.68	-17.98	-16.55
1000	-27.53	-24.76	-22.52	-20.67	-19.12
1250	-30.27	-27.37	-25.01	-23.05	-21.40
1500	-32.79	-29.79	-27.33	-25.27	-23.54

We use continuously computed impact point (CCIP) bomb launching mode in implementing the condition $|\varepsilon_r| \le 18^0$ and when $|\varepsilon_r| > 18^0$ continuously computed release point (CCRP) mode is used.

From the above and table 1 we see that when H=500 [m] and V=220 – 260 [m/s]; and H=750 [m] and V=240 – 260 [m/s] CCIP mode is used. For the remaining conditions CCRP mode is used.

The standard deviation σ_{Xd} for delivery accuracy is changed from 25.23 m to 53.20m (table 2, fig 2). With increasing the height H of bomb launching, σ_{Xd} also increase. When CCIP mode is used, with increasing the velocity V, σ_{Xd} also increase. When CCRP mode is used we see that when V increases, σ_{Xd} decreases, because the time t for velocity integration decreases.

Table 2

Level Delivery ($\lambda = 0^0$)					
σ_{Xd}, m	**V=180, m/s**	**200**	**220**	**240**	**260**
H=500, m	30.92	25.24	28.79	31.46	34.91
750	33.07	32.14	30.99	32.97	34.32
1000	37.45	36.03	35.97	35.24	34.95
1250	43.92	41.62	40.63	38.87	36.96
1500	53.20	48.79	46.18	44.08	42.52

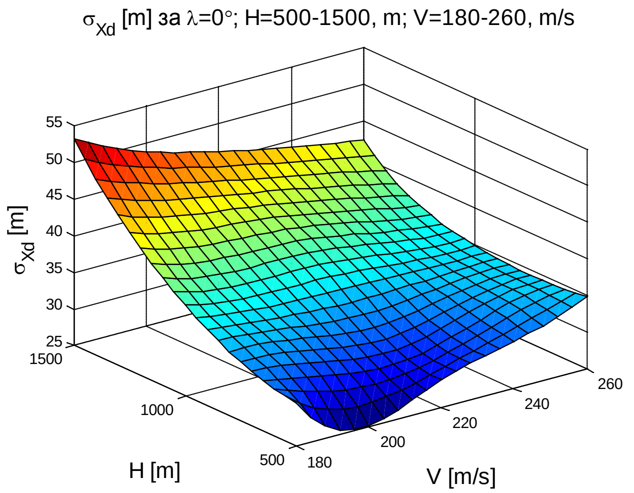

FIG. 2 Depending on σ_{Xd} from V and H

Systematic errors in the sources for information lead to systematic errors in solving bombing problem (table 3). The sample means the bombing error m_d is between 0.15 and 3.02 and the law for its change is the same as in σ_{Xd}.

Table 3

Level Delivery ($\lambda = 0^0$)					
m_d, m	**V=180, m/s**	**200**	**220**	**240**	**260**
H=500, m	0.40	0.16	0.15	0.17	0.19
750	0.97	0.93	0.68	0.69	0.67
1000	1.60	1.56	1.21	1.19	1.15
1250	2.28	2.05	1.74	1.67	1.64
1500	3.02	2.40	2.26	2.14	2.12

Standard deviation σ_{Xb}, sample means m_b determined by solving ballistic problem are shown in table 4, 5 and fig.3.

The standard deviation σ_{Xb} is amended in the range of 2.81 m to 8.94 m. The sample means m_b is amended from 0.7 m to 4.45 m. Height increasing H, σ_{Xb} leads to m_b increasing. Velocity V has slight influence on σ_{Xb} and m_b values.

Table 4

Level Delivery ($\lambda = 0^0$)					
σ_{Xb}, m	**V=180, m/s**	**200**	**220**	**240**	**260**
H=500, m	5.72	2.81	4.15	6.32	6.69
750	6.38	5.87	5.16	6.27	6.89
1000	7.38	6.55	6.47	6.20	5.97
1250	8.24	7.00	6.65	6.70	5.55
1500	8.94	8.77	8.37	7.95	7.52

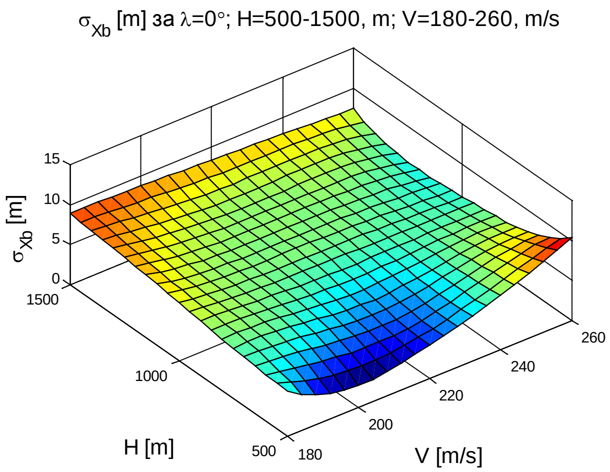

FIG. 3 Depending on σ_{Xb} from V and H

Table 5

Level Delivery ($\lambda = 0^0$)					
m_b, m	**V=180, m/s**	**200**	**220**	**240**	**260**
H=500, m	1.27	0.70	1.77	2.31	2.88
750	1.62	1.62	2.13	1.66	1.19
1000	2.13	2.40	2.53	1.80	0.43
1250	2.80	3.03	2.98	2.73	0.58
1500	3.61	3.53	3.46	4.45	1.65

The standard deviation σ_{Xa}, and sample means m_a are amended: σ_{Xa}=25.40m – 49.57 m; m_a =0.86 m – 6.58 m (table 6, 7 and fig 4).

Table 6

Level Delivery (λ= 0^0)					
σ_{Xa}, m	**V=180, m/s**	**200**	**220**	**240**	**260**
H=500, m	31.44	25.40	29.09	32.17	36.42
750	33.68	32.67	31.42	33.56	35.01
1000	38.17	36.62	36.55	35.78	35.46
1250	44.68	42.21	41.17	39.44	37.38
1500	53.95	49.57	46.93	44.79	43.18

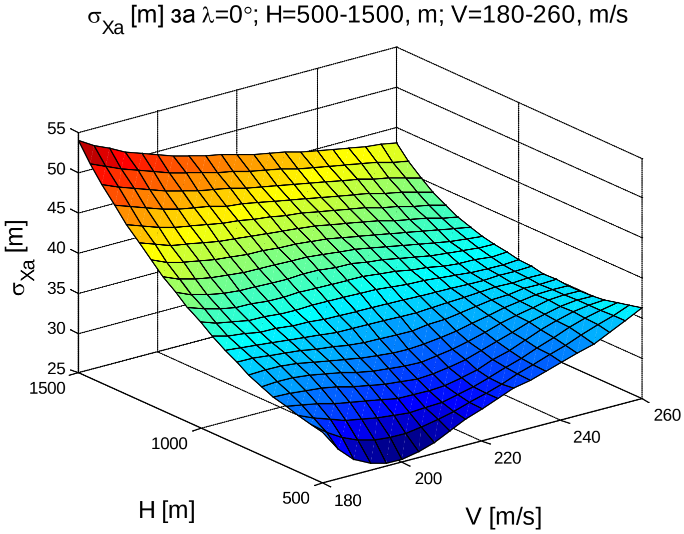

FIG. 4 Depending on σ_{Xa} from V and H

Table 7

Level Delivery (λ= 0^0)					
m_{Xa}, m	**V=180, m/s**	**200**	**220**	**240**	**260**
H=500, m	1.67	0.86	1.92	2.48	3.07
750	2.60	2.55	2.82	2.35	1.86
1000	3.73	3.96	3.75	2.99	1.58
1250	5.08	5.09	4.71	4.40	2.22
1500	6.63	5.92	5.72	6.58	3.78

3. CONCLUSIONS

Standard deviation σ_{Xa} for bombing accuracy, standard deviation σ_{Xd} for delivery accuracy, standard deviation σ_{Xb} for ballistic dispersion for practical bomb P-50-75 pushed out with vertical velocity V_y=2 m/s from horizontal flight for velocity V=180 – 260 [m/s] and height H=500 – 1500 [m] are estimated.

The standard deviation σ_{Xd} for delivery accuracy is changed in the range of 25.23 m to 53.20 m.

The standard deviation σ_{Xb} is amended in the range of 2.81 m to 8.94 m.

The standard deviation σ_{Xa}, and sample means ma are amended: σ_{Xa}=25.40m – 49.57 m.

For practical bomb P-50-75, ballistic dispersion is relatively small; therefore bombing accuracy and delivery accuracy are nearly the same.

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