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EFFECTIVENESS STUDIES OF MISSILE SYSTEMS AGAINST GROUND TARGET

Part II Spherical Damage Patterns vs. Point Targets

(c) Application to Specific Missiles Systems (U)

by

Don Mittleman

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Data and conclusions contained herein are not necessarily final. Additional copies may be obtained through the Mathematical Consultant Branch, 01.21, X7347

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INTRODUCTION: The formulae developes in (Part II a) of this report are applied to the following situation. A ballistic missile carrying a thermonuclear warhead is fired against a point target, i.e. perhaps a launching site of an enemy ballistic missile. The terminal ballistic characteristics of our missile suggests that with a perfect altimeter the distribution of burst points about the arming point is an uncorrelated bivariate normal distribution in range and defection. If σ_r and σ_d denote the standard deviations of burst points about the mean in range and deflection respectively and σ_A the standard deviation about the mean value zero of an assumed normal distribution of fuze function errors for an altimeter type fuze, then the parameters needed to effect the calculations are obtained by means of the formulae:

$$\sigma_x^2 = \sigma_r^2 + \sigma_A^2 \cot^2 \theta$$

$$\sigma_y^2 = \sigma_d^2$$

$$\sigma_z^2 = \sigma_A^2$$

$$\rho_{xz} = \frac{\rho_{xz}}{\sigma_x \sigma_z} = \frac{\sigma_A^2 (\cot \theta)}{\sigma_x \sigma_z} = \frac{\sigma_A \cot \theta}{\sqrt{\sigma_r^2 + \sigma_A^2 \cot^2 \theta}}$$

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The mean burst height $\bar{z}$ was chosen so that the probability that the fireball touches the ground does not exceed 5%; i.e.

$$\bar{z} = b + k\,\sigma_z$$

where b, the fireball radius was calculated from the formula

$$b = 180\sqrt[3]{Y},$$

Y is the yield in kilo-tons and $k = 1.65$ assures the 5% level.

In this particular application, the mean range was left as a parameter, because we wished to discover if overshooting or undershooting the target (in range) would increase the probability of damage. Thus, $\bar{x} = 0$ corresponds to shooting so that the mean burst point is directly over the target, $\bar{x} > 0$ correspondings to overshooting by the amount $\bar{x}$ and $\bar{x} < 0$ to undershooting by the amount $\bar{x}$.

Input Data: the following values of the parameters were used as input data:

Y = 1 megaton, which implies b = 1800 feet

σ_r = 6,000, 12,000 feet

σ_d = $1/3\ \sigma_r$

σ_A = 0, 500, 1000, 1500 feet

θ = 340°, 330°, 320°

$\bar{x}$ = -2000, -1000, 0, +1000, +2000 feet.

s = 4000, 5000, 6000 feet

Output Data: The results of the calculations are given in the following table: graphs are included to illustrate the effect of certain parameters.

TABLE I

$\sigma_r = 6000, \quad \sigma_d = 2000$

θ	$\bar{x}$	s	$\sigma_A = 0$	$\sigma_A = 500$	$\sigma_A = 1000$	$\sigma_A = 1500$
340°	-2000	4000	.34457	.26048	.14470	.07871
	-1000		.35785	.26835	.14244	.07295
	0		.36239	.26969	.13690	.06604
	+1000		.35785	.26439	.12843	.05837
	+2000		.34457	.25283	.11760	.05038
	-2000	5000	.48047	.42568	.31104	.19786
	-1000		.49761	.43956	.31446	.19138
	0		.50346	.44362	.31104	.18117
	+1000		.49761	.43757	.30095	.16780
	+2000		.48047	.42182	.28478	.15202
	-2000	6000	.59269	.55196	.46342	.34651
	-1000		.61182	.56929	.47370	.34504
	0		.61833	.57499	.47477	.33708
	+1000		.61182	.56868	.46648	.32298
	+2000		.59269	.55071	.44923	.30341
330°	-2000	4000	.34457	.26221	.14793	.08831
	-1000		.35785	.27108	.14839	.08499
	0		.36239	.27323	.14515	.07978
	+1000		.35785	.26848	.13645	.07305
	+2000		.34457	.25719	.12876	.06524
	-2000	5000	.48047	.43425	.31895	.21072
	-1000		.49761	.44933	.32544	.20839
	0		.50346	.45405	.32436	.20134
	+1000		.49761	.44819	.31576	.19002
	+2000		.48047	.43221	.30019	.17515
	-2000	6000	.59269	.55768	.47912	.36598
	-1000		.61182	.57573	.49218	.36892
	0		.61833	.58175	.49491	.36405
	+1000		.61182	.57534	.48706	.35159
	+2000		.59269	.55689	.46908	.33224

TABLE I (continued)

$\sigma_r = 6000, \quad \sigma_d = 2000$

θ	$\bar{x}$	s	$\sigma_A = 0$	$\sigma_A = 500$	$\sigma_A = 1000$	$\sigma_A = 1500$
320°	-2000	4000	.34457	.26253	.14799	.09085
	-1000		.35785	.27191	.15008	.08945
	0		.36239	.27450	.14836	.08537
	+1000		.35785	.27009	.14294	.08036
	+2000		.34457	.25902	.13423	.07331
	-2000	5000	.48047	.43638	.32071	.21377
	-1000		.49761	.45243	.32397	.21441
	0		.50346	.45772	.32942	.20995
	+1000		.49761	.45215	.32199	.20068
	+2000		.48047	.43623	.30720	.18723
	-2000	6000	.59269	.55967	.48435	.37152
	-1000		.61182	.57800	.49881	.37749
	0		.61833	.58416	.50249	.37513
	+1000		.61182	.57773	.49513	.36453
	+2000		.59269	.55912	.47714	.34632

TABLE II

$\sigma_r = 12000$, $\sigma_d = 4000$

θ	$\bar{x}$	s	$\sigma_A = 0$	$\sigma_A = 500$	$\sigma_A = 1000$	$\sigma_A = 1500$
340°	-2000	4000	.11732	.08394	.04534	.02683
	-1000		.11852	.08457	.04508	.02621
	0		.11893	.08465	.04453	.02543
	+1000		.11852	.08415	.04369	.02451
	+2000		.11732	.08309	.04258	.02347
	-2000	5000	.18659	.16171	.11135	.07116
	-1000		.18847	.16420	.11152	.07025
	0		.18910	.16532	.11096	.06890
	+1000		.18847	.16511	.10969	.06714
	+2000		.18659	.16361	.10772	.06501
	-2000	6000	.25932	.23510	.19205	.13988
	-1000		.26187	.23727	.19306	.13920
	0		.26273	.23791	.19285	.13767
	+1000		.26187	.23700	.19142	.13530
	+2000		.25932	.23457	.18879	.13215
330°	-2000	4000	.11732	.08408	.04566	.02788
	-1000		.11852	.08480	.04566	.02756
	0		.11893	.08495	.04536	.02706
	+1000		.11852	.08453	.04475	.02639
	+2000		.11732	.08354	.04386	.02556
	-2000	5000	.18659	.16150	.11217	.07280
	-1000		.18847	.16467	.11269	.07245
	0		.18910	.16649	.11246	.07163
	+1000		.18847	.16693	.11149	.07034
	+2000		.18659	.16602	.10979	.06862
	-2000	6000	.25932	.23582	.19396	.14256
	-1000		.26187	.23807	.19532	.14261
	0		.26273	.23876	.19541	.14173
	+1000		.26187	.23790	.19424	.13995
	+2000		.25932	.23549	.19181	.13730

TABLE II (continued)

$\sigma_r = 12000$, $\sigma_d = 4000$

θ	$\bar{x}$	s	$\sigma_\Lambda = 0$	$\sigma_\Lambda = 500$	$\sigma_\Lambda = 1000$	$\sigma_\Lambda = 1500$
320°	-2000	4000	.11732	.08409	.04567	.02813
	-1000		.11852	.08486	.04582	.02800
	0		.11893	.08506	.04566	.02767
	+1000		.11852	.08468	.04519	.02716
	+2000		.11732	.08372	.04442	.02649
	-2000	5000	.18659	.16233	.11233	.07317
	-1000		.18847	.16607	.11304	.07315
	0		.18910	.16849	.11300	.07264
	+1000		.18847	.16953	.11221	.07166
	+2000		.18659	.16916	.11067	.07022
	-2000	6000	.25932	.23606	.19451	.14324
	-1000		.26187	.23834	.19606	.14371
	0		.26273	.23906	.19633	.14324
	+1000		.26187	.23822	.19531	.14183
	+2000		.25932	.23583	.19301	.13952

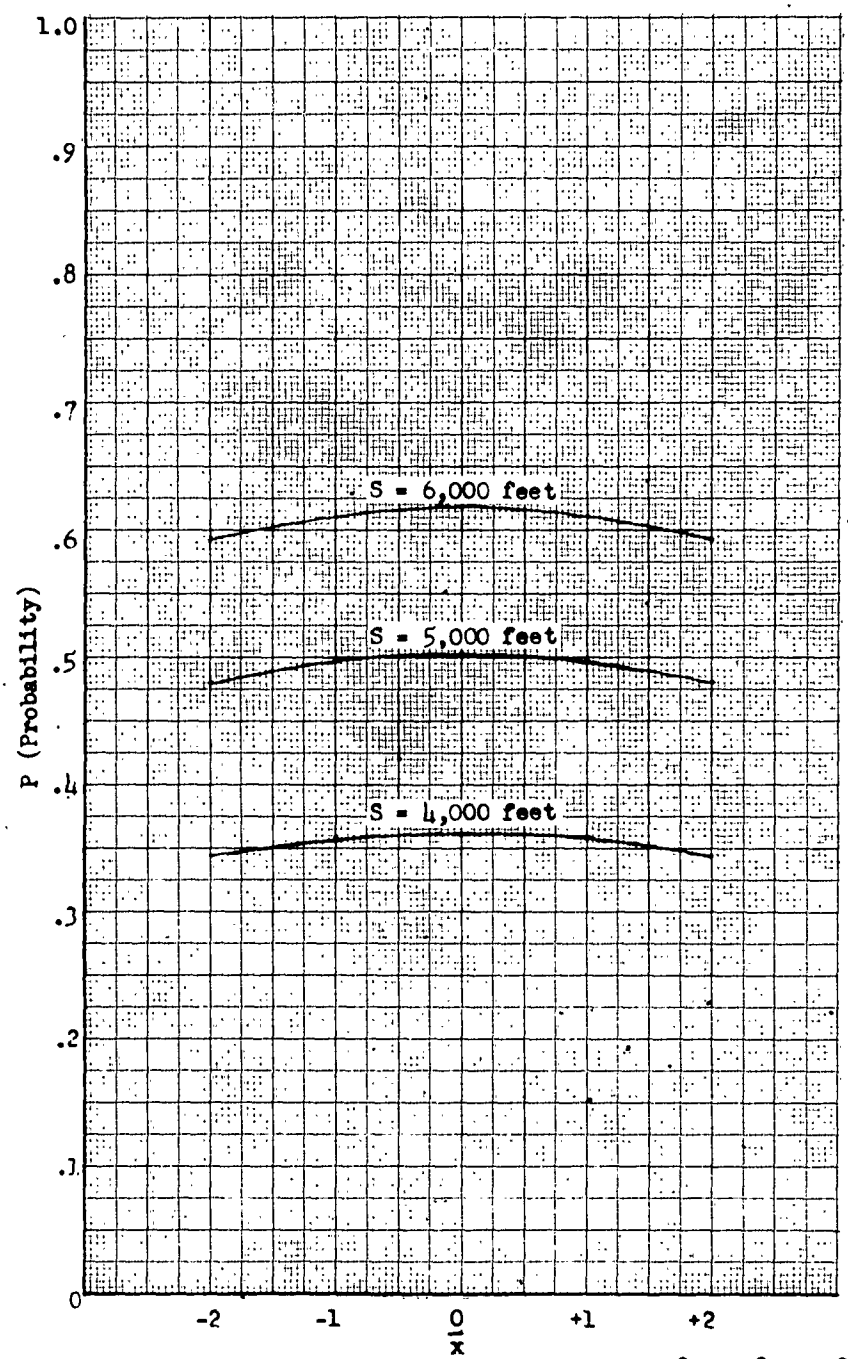

Figure 1. $\sigma_A = 0$ $\sigma_r = 6.0$ $\sigma_d = 2.0$ $\theta = 340^\circ, 330^\circ, 320^\circ$

All distances ($\bar{x}$, σ_A, σ_r, σ_d) in units of 10^3 feet

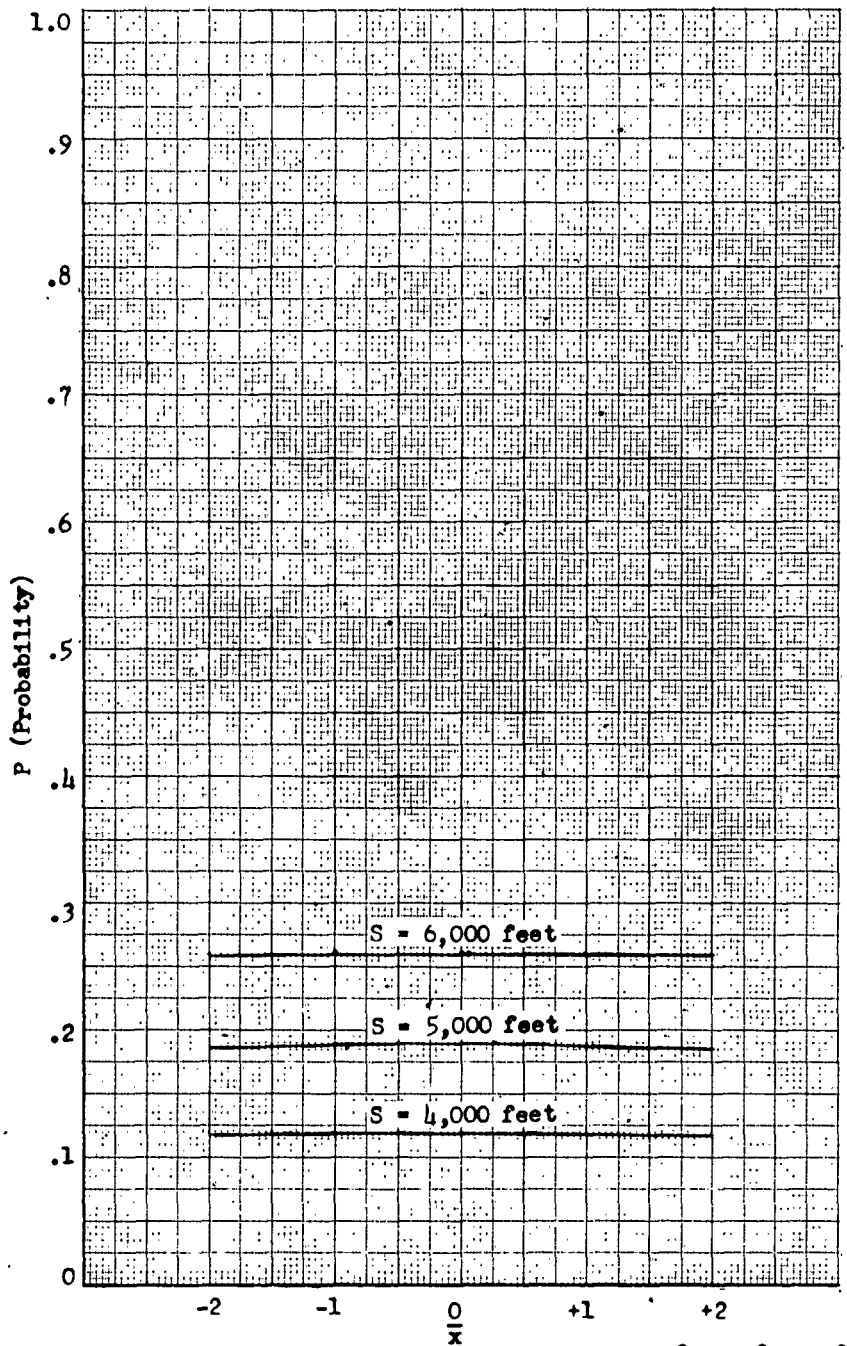

Figure 2. $\sigma_A = 0$ $\sigma_r = 12.0$ $\sigma_d = 4.0$ $\theta = 340^\circ, 330^\circ, 320^\circ$

All distances ($\bar{x}$, σ_A, σ_r, σ_d) in units of 10^3 feet

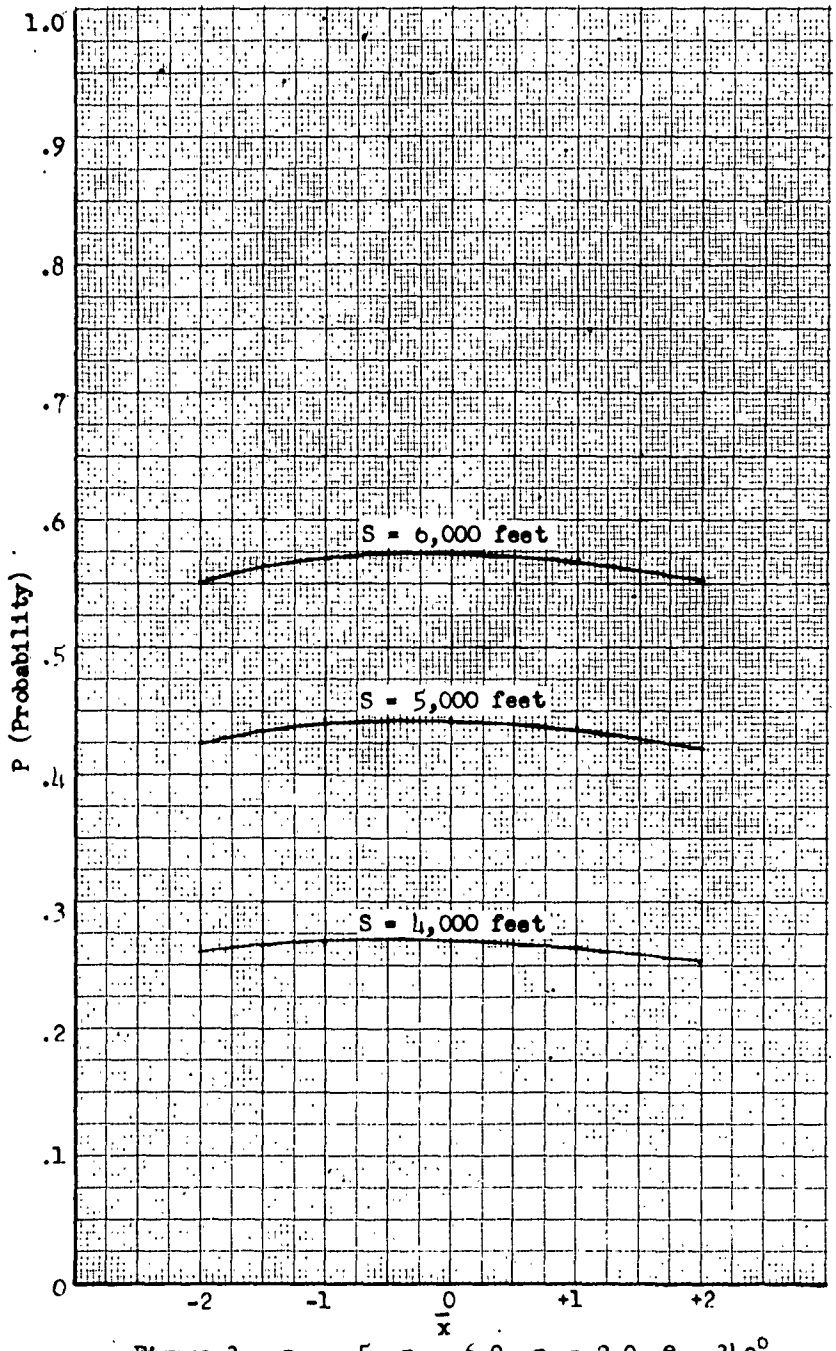

Figure 3. $\sigma_A = .5$ $\sigma_r = 6.0$ $\sigma_d = 2.0$ $\theta = 340^\circ$
All distances ($\bar{x}$, σ_A, σ_r, σ_d) in units of 10^3 feet

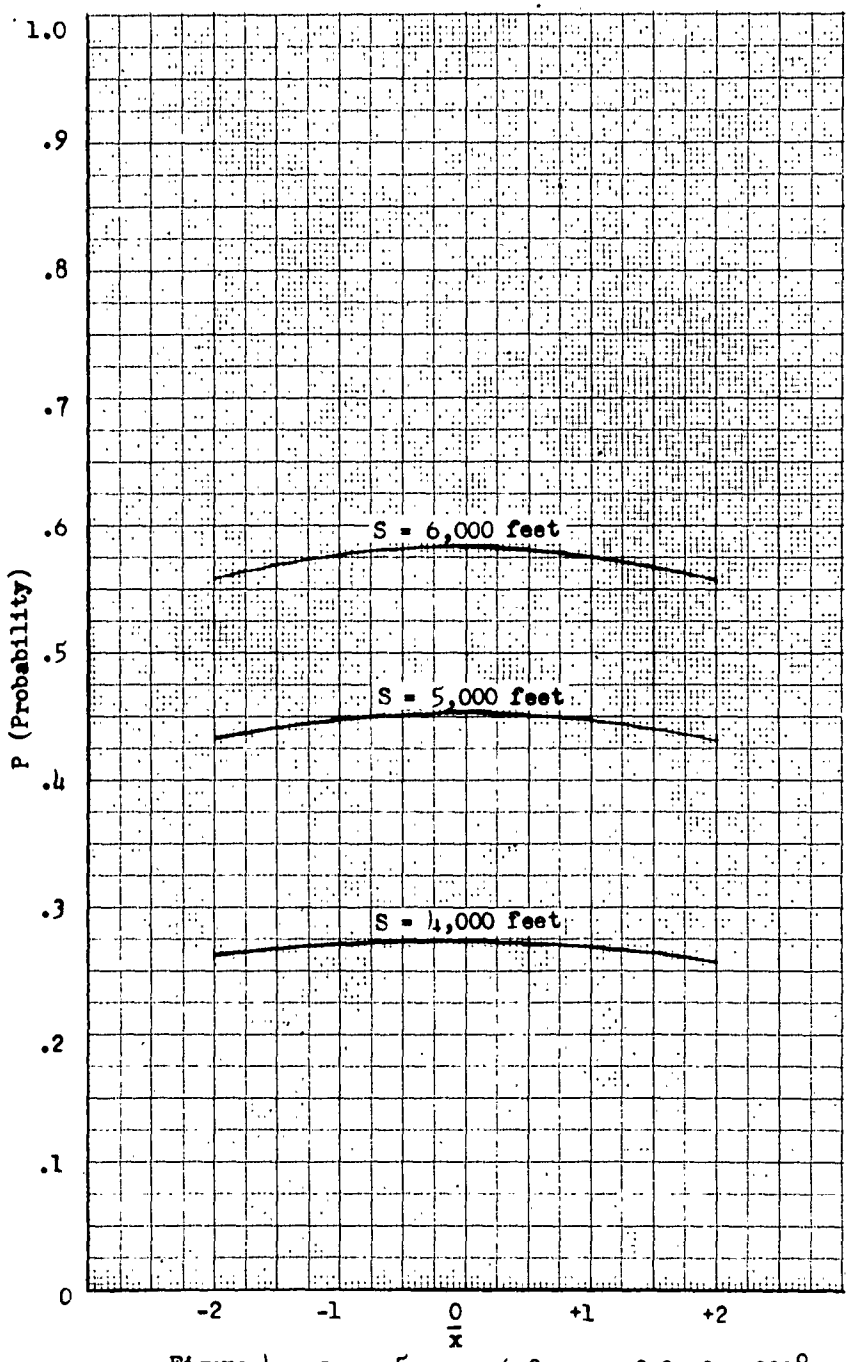

Figure 4, $\sigma_A = .5$ $\sigma_r = 6.0$ $\sigma_d = 2.0$ $\theta = 330^\circ$

All distances ($\bar{x}$, σ_A, σ_r, σ_d) in units of 10^3 feet

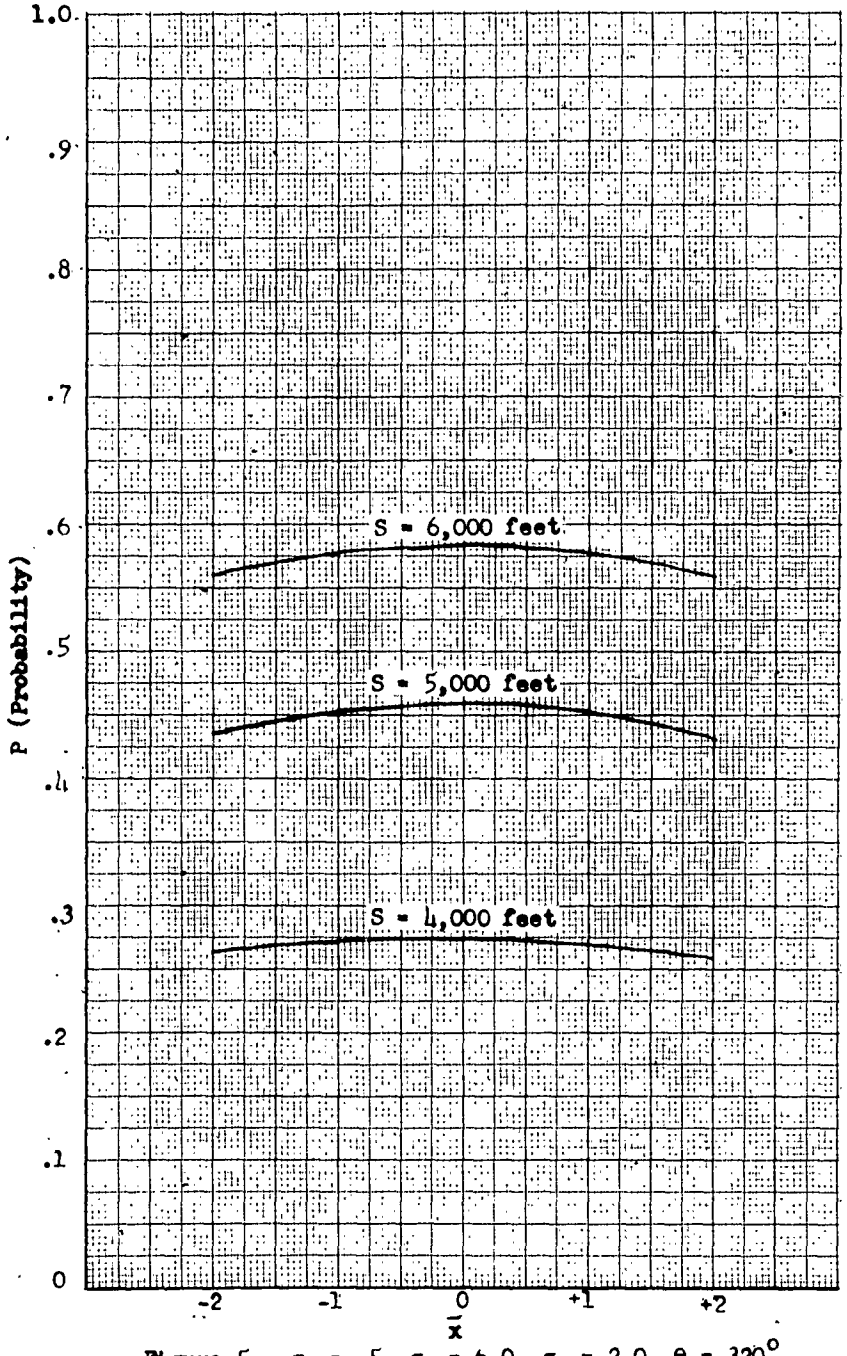

Figure 5. $\sigma_A = .5$ $\sigma_r = 6.0$ $\sigma_d = 2.0$ $\theta = 320^\circ$
All distances ($\bar{x}$, σ_A, σ_r, σ_d) in units of 10^3 feet

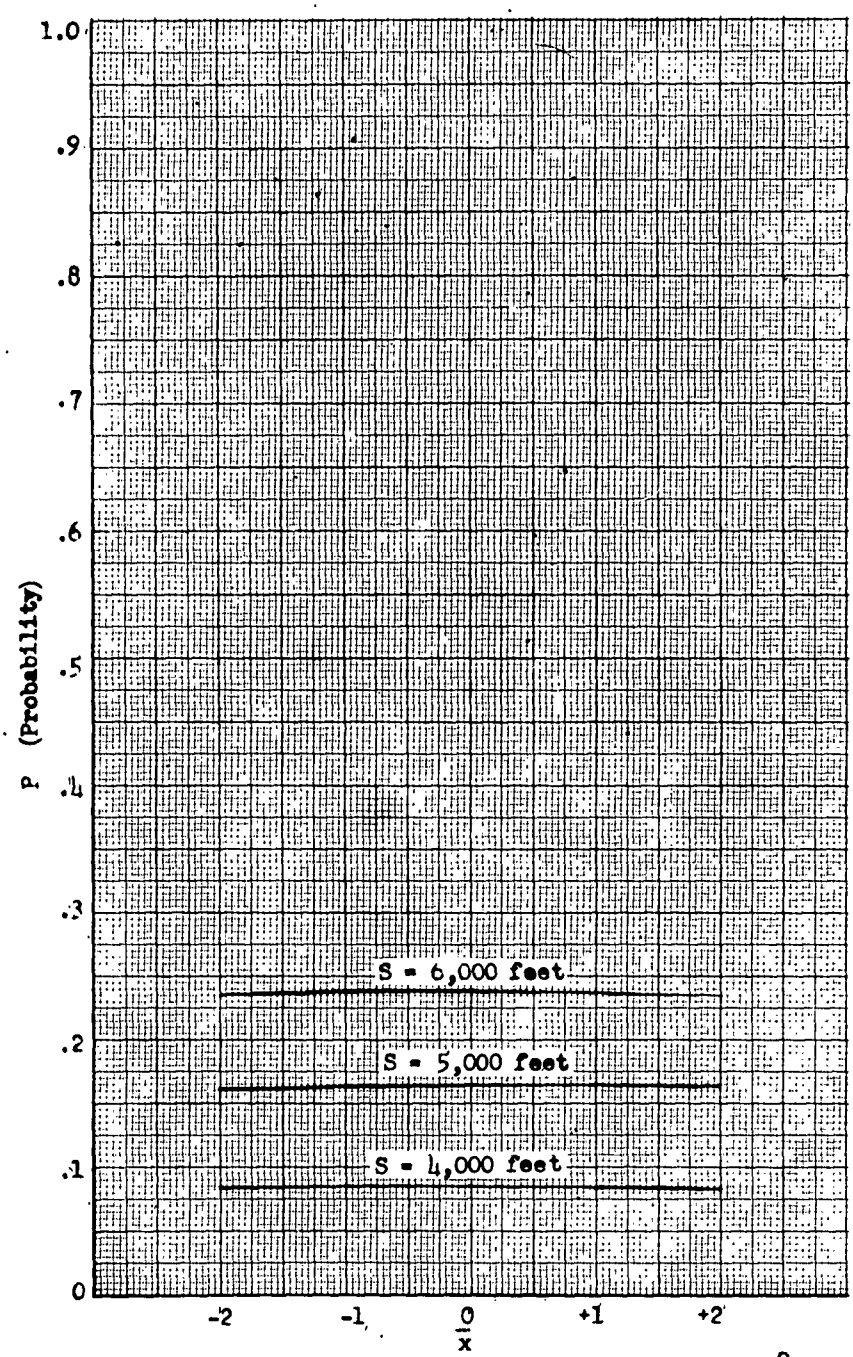

Figure 6. $\sigma_A = .5$ $\sigma_r = 12.0$ $\sigma_d = 4.0$ $\theta = 340^\circ$
All distances ($\bar{x}$, σ_A, σ_r, σ_d) in units of 10^3 feet

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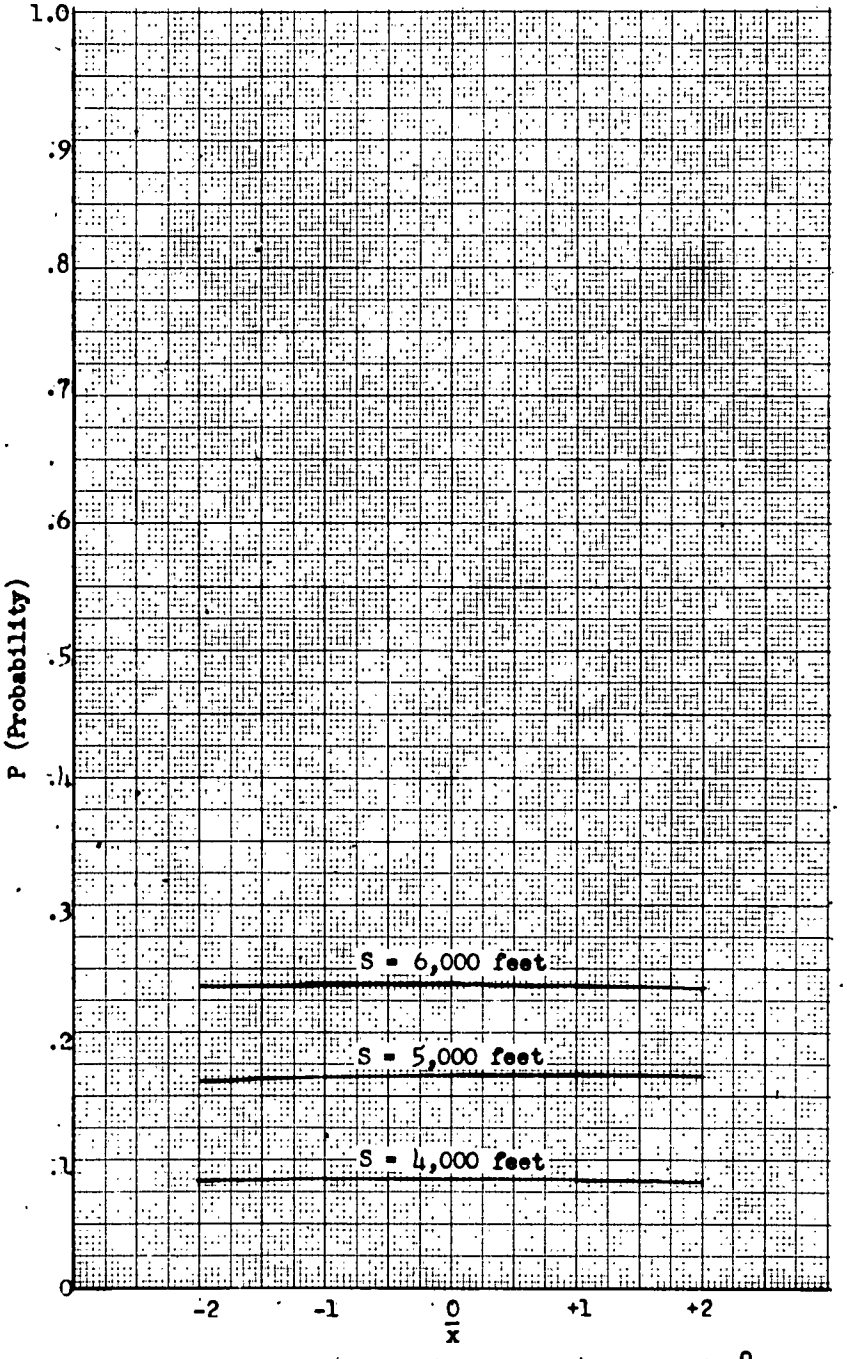

Figure 7. $\sigma_A = .5$ $\sigma_r = 12.0$ $\sigma_d = 4.0$ $\theta = 330^\circ$
All distances ($\bar{x}$, σ_A, σ_r, σ_d) in units of 10^3 feet

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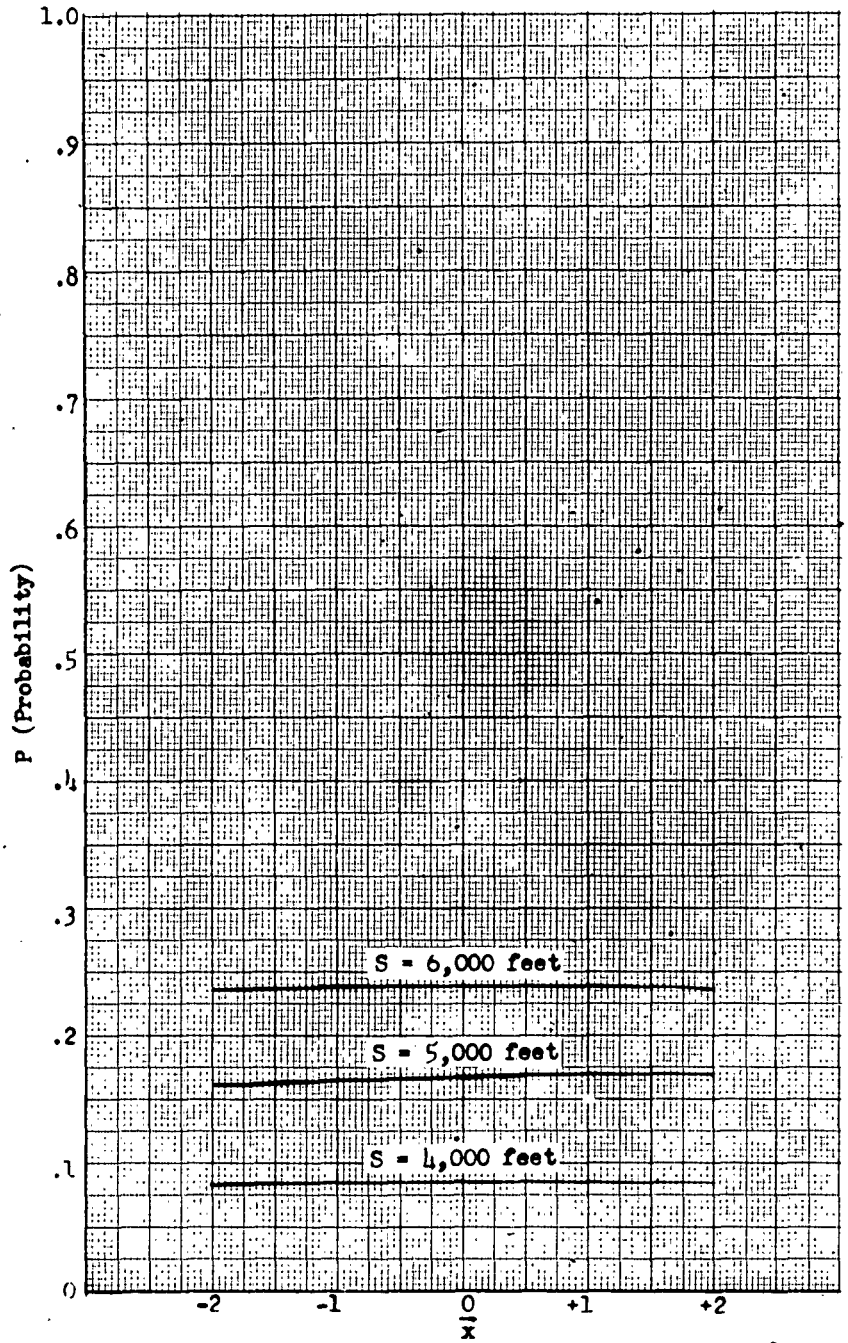

Figure 8. $\sigma_A = .5$ $\sigma_r = 12.0$ $\sigma_d = 4.0$ $\theta = 320^\circ$

All distances ($\bar{x}$, σ_A, σ_r, σ_d) in units of 10^3 feet

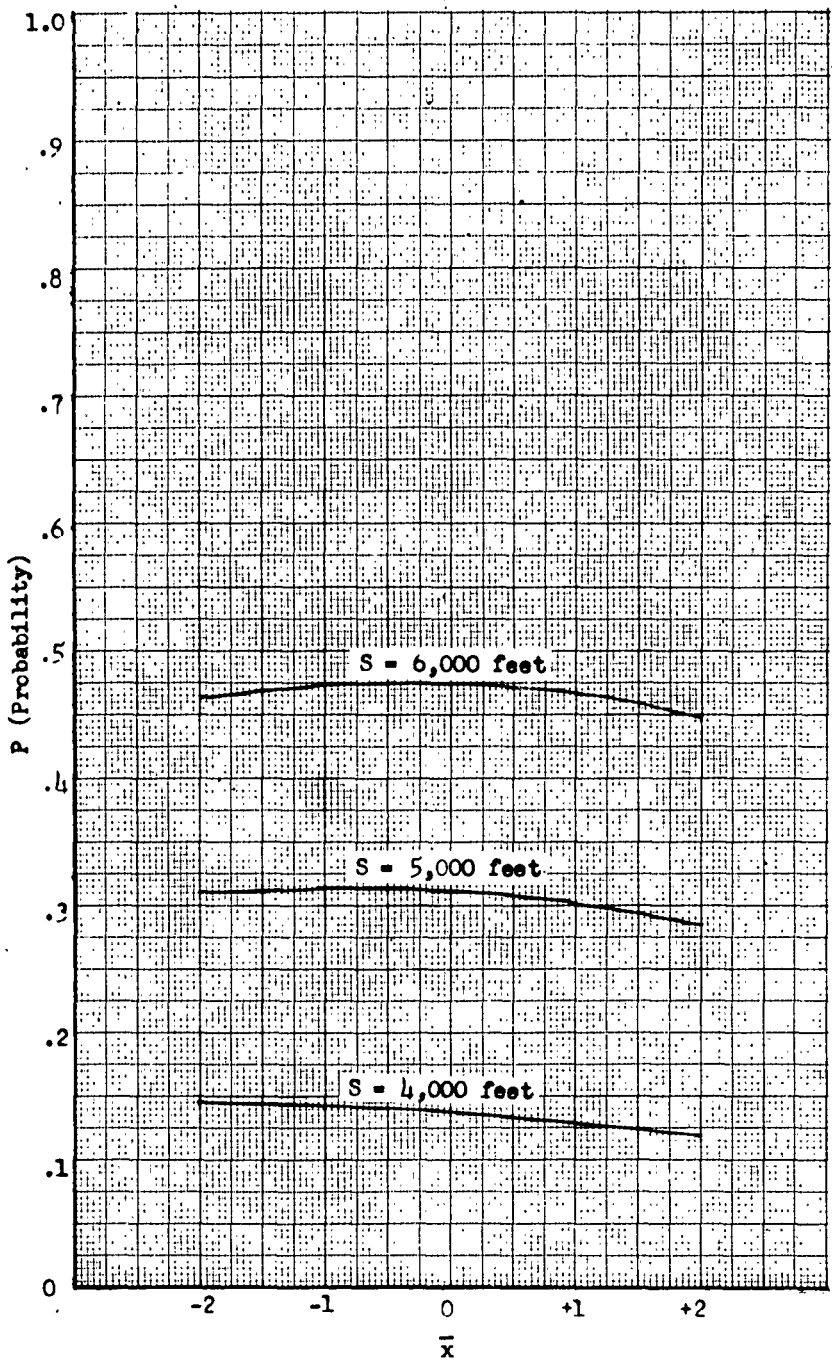

Figure 9. $\sigma_A = 1.0$ $\sigma_r = 6.0$ $\sigma_d = 2.0$ $\theta = 340^\circ$

All distances ($\bar{x}$, σ_A, σ_r, σ_d) in units of 10^3 feet

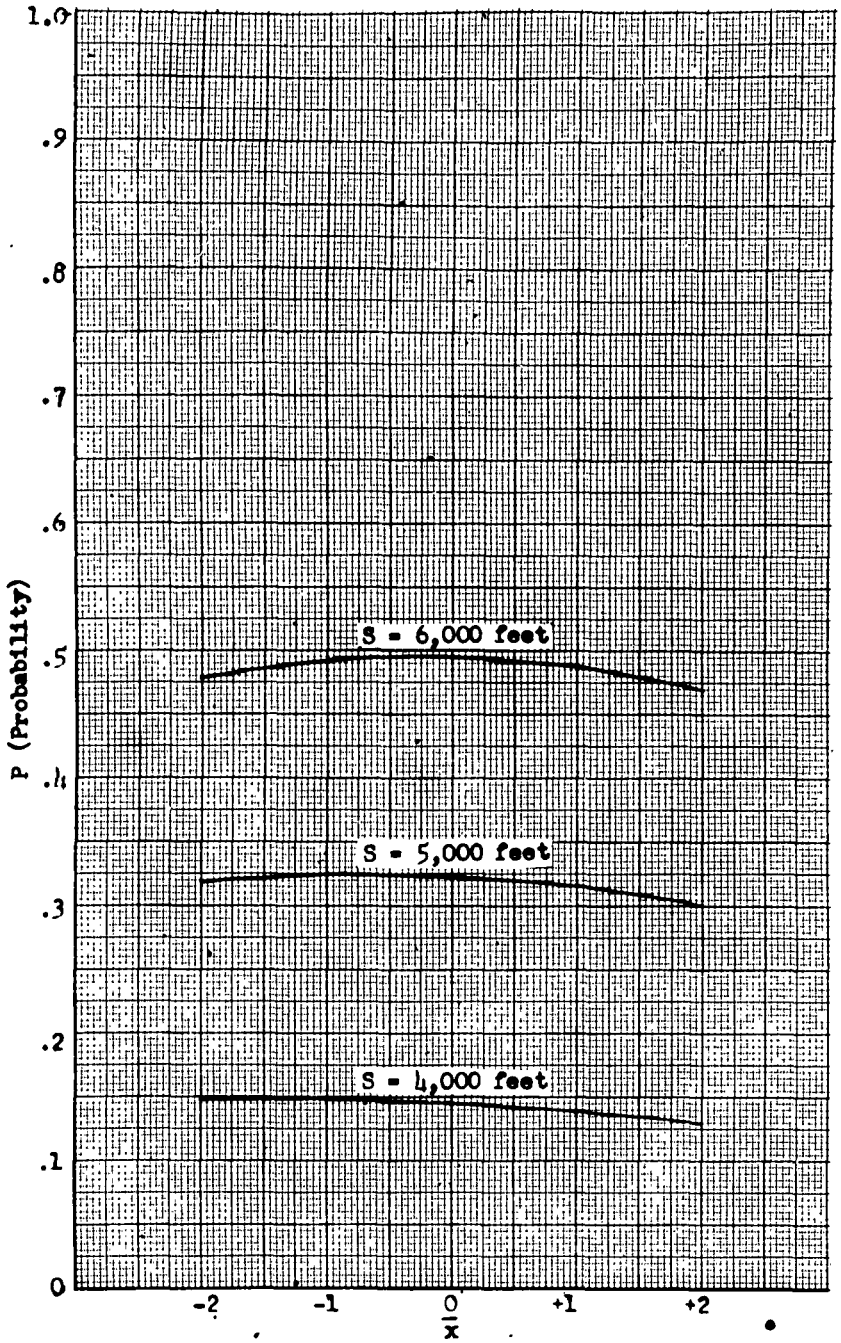

Figure 10. $\sigma_A = 1.0$ $\sigma_r = 6.0$ $\sigma_d = 2.0$ $\theta = 330^\circ$

All distances ($\bar{x}$, σ_A, σ_r, σ_d) in units of 10^3 feet

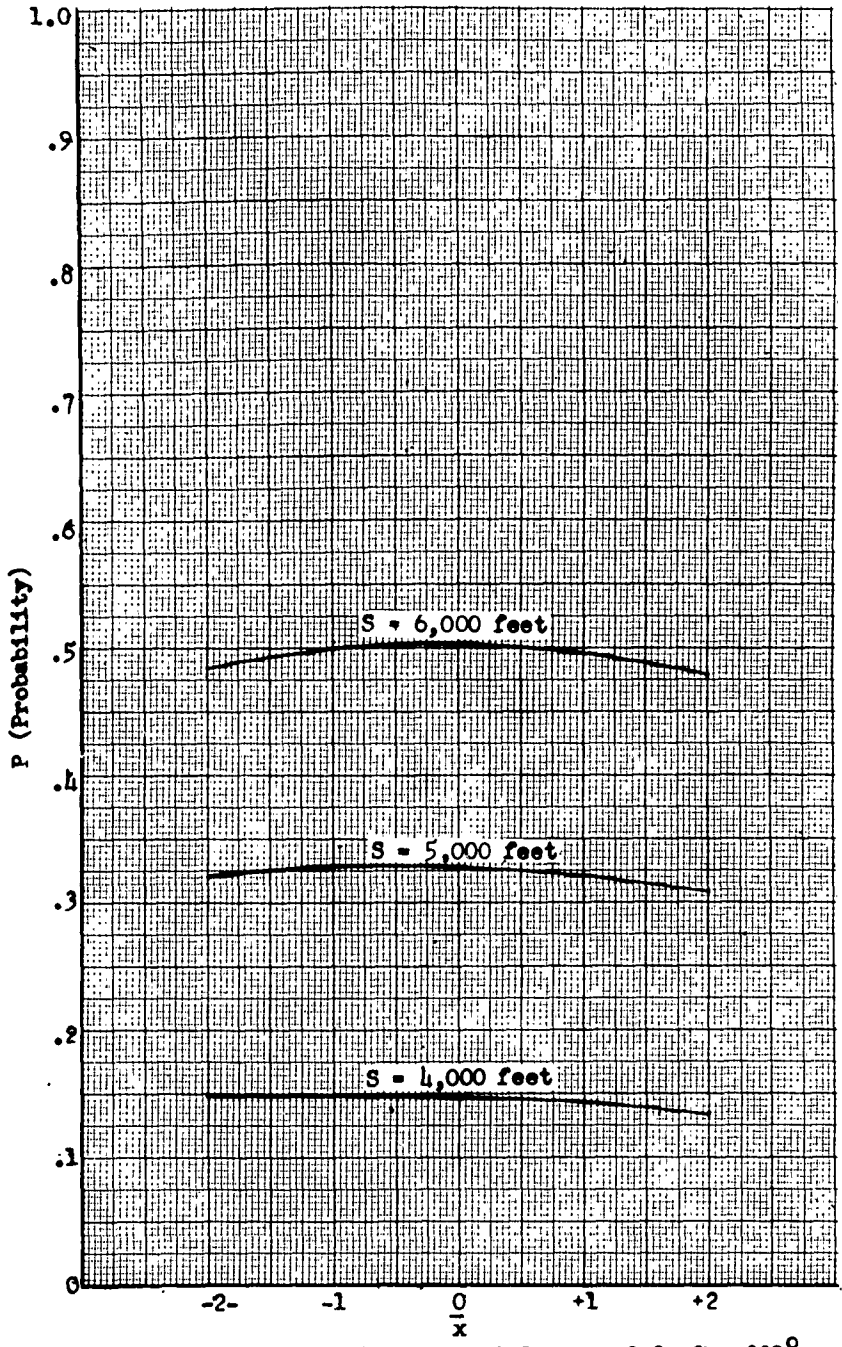

Figure 11. $\sigma_A = 1.0$ $\sigma_r = 6.0$ $\sigma_d = 2.0$ $\theta = 320^\circ$

All distances ($\bar{x}$, σ_A, σ_r, σ_d) in units of 10^3 feet

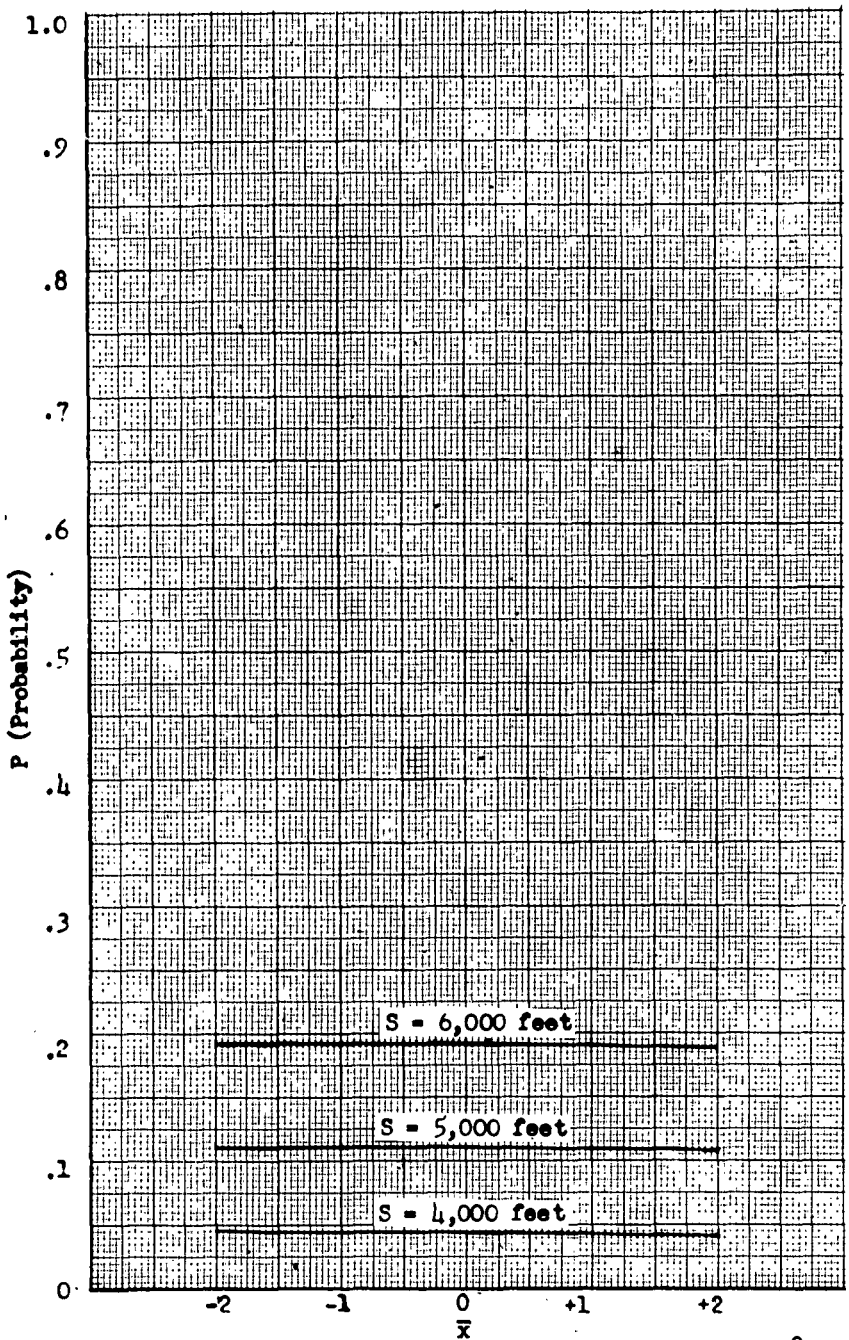

Figure 12. $\sigma_A = 1.0$ $\sigma_r = 12.0$ $\sigma_d = 4.0$ $\theta = 340^\circ$
All distances ($\bar{x}$, σ_A, σ_r, σ_d) in units of 10^3 feet

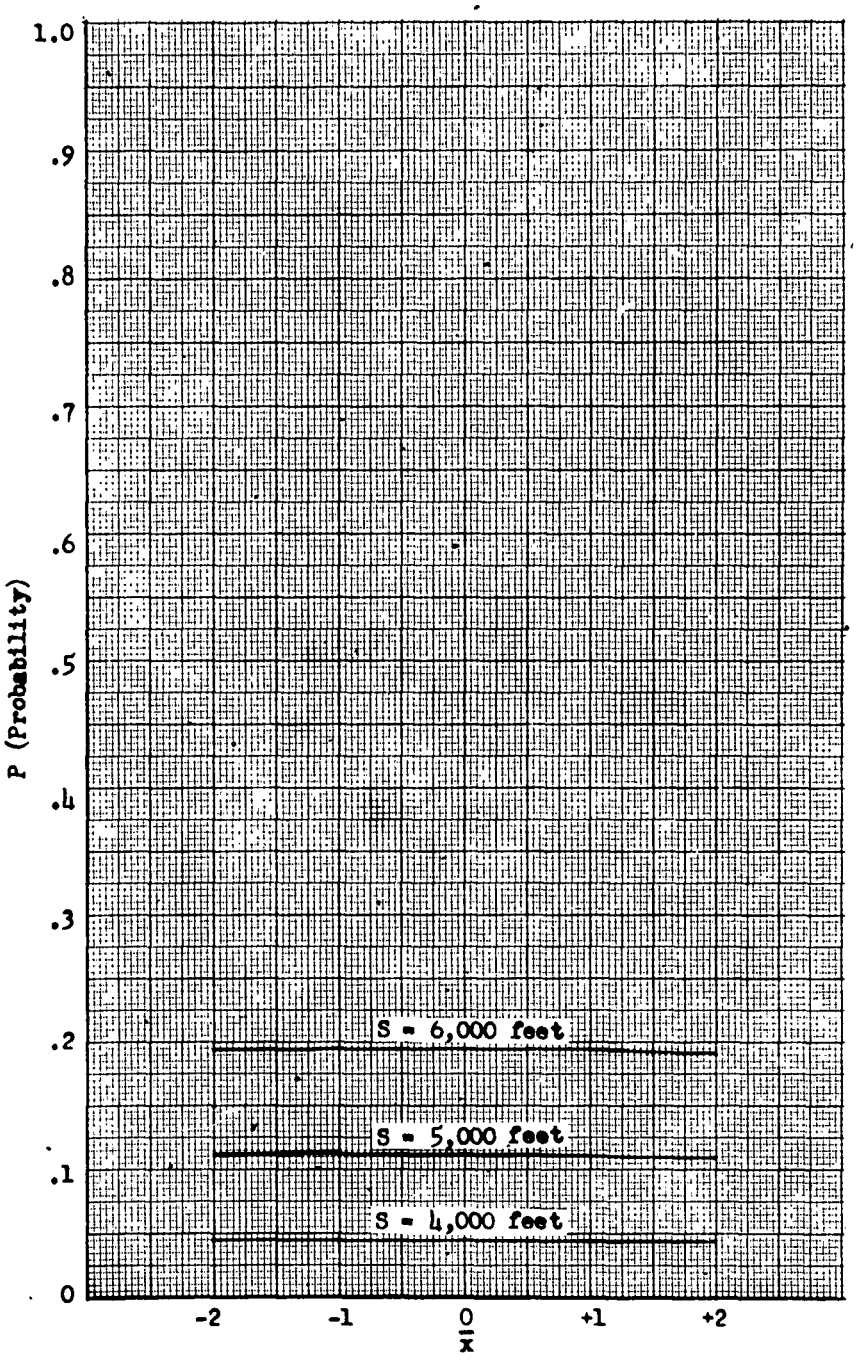

Figure 13. $\sigma_A = 1.0$ $\sigma_r = 12.0$ $\sigma_d = 4.0$ $\theta = 330^\circ$
All distances ($\bar{x}$, σ_A, σ_r, σ_d) in units of 10^3 feet

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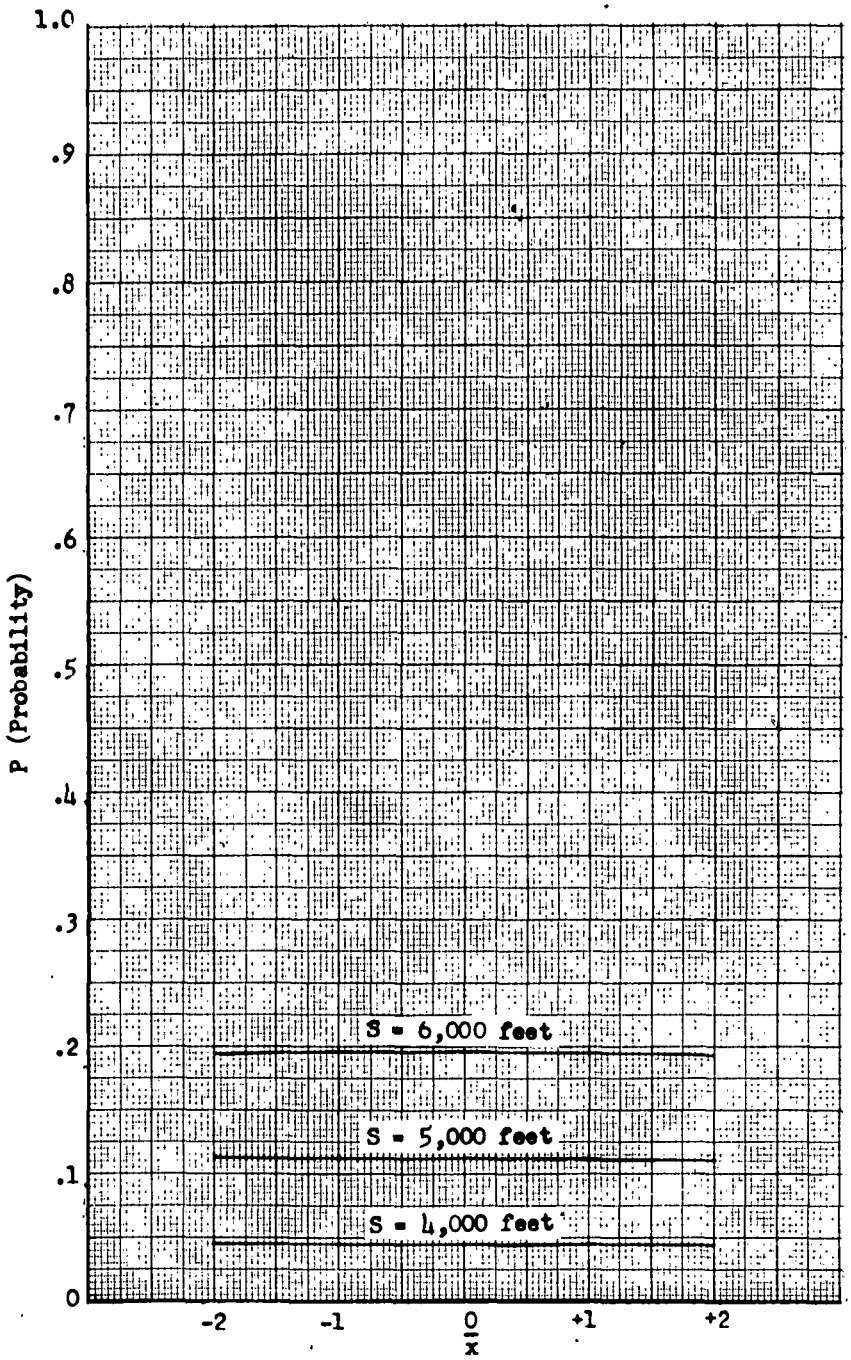

Figure 14. $\sigma_A = 1.0$ $\sigma_r = 12.0$ $\sigma_d = 4.0$ $\theta = 320^\circ$

All distances ($\bar{x}$, σ_A, σ_r, σ_d) in units of 10^3 feet

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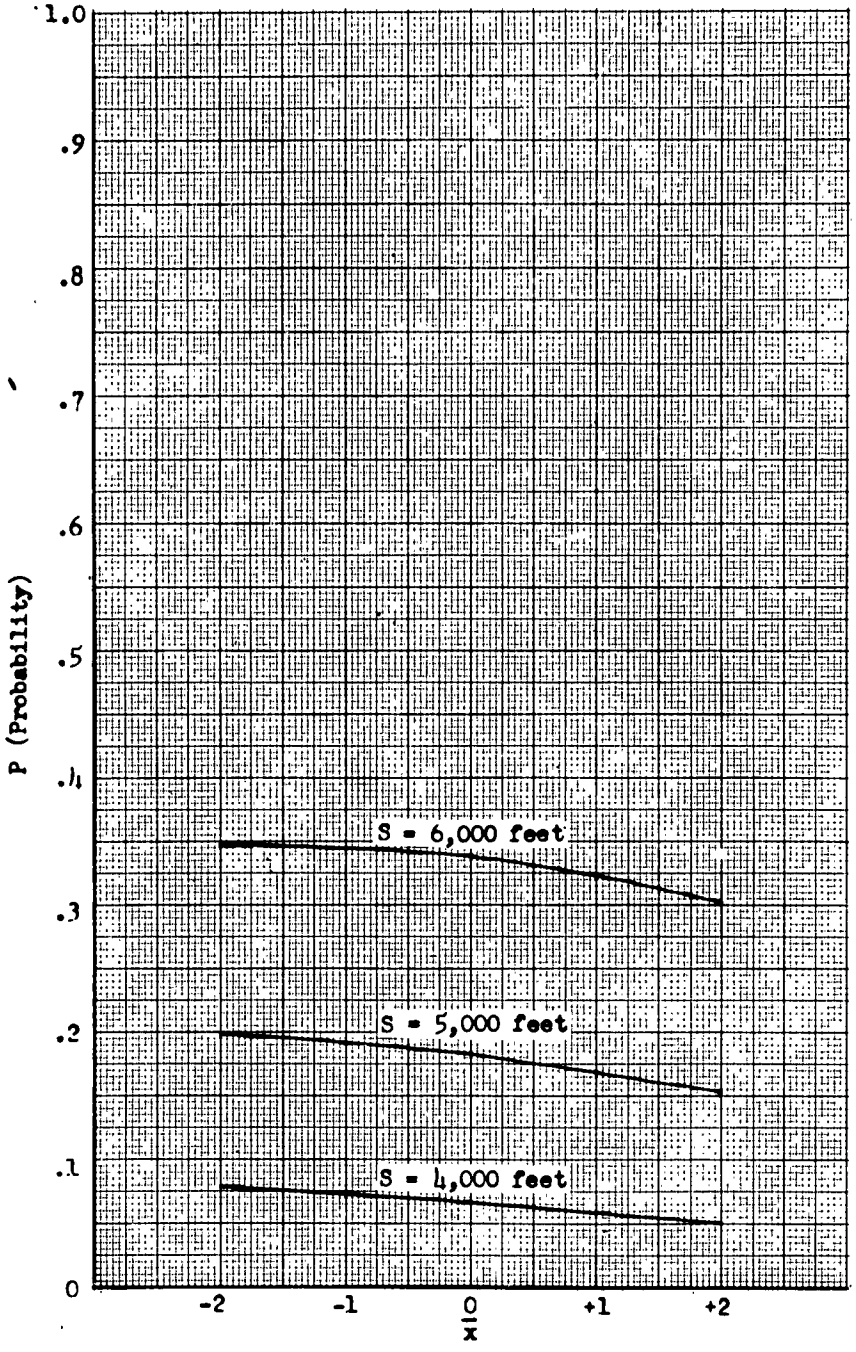

Figure 15. $\sigma_A = 1.5$ $\sigma_r = 6.0$ $\sigma_d = 2.0$ $\theta = 340^\circ$

All distances ($\bar{x}$, σ_A, σ_r, σ_d) in units of 10^3 feet

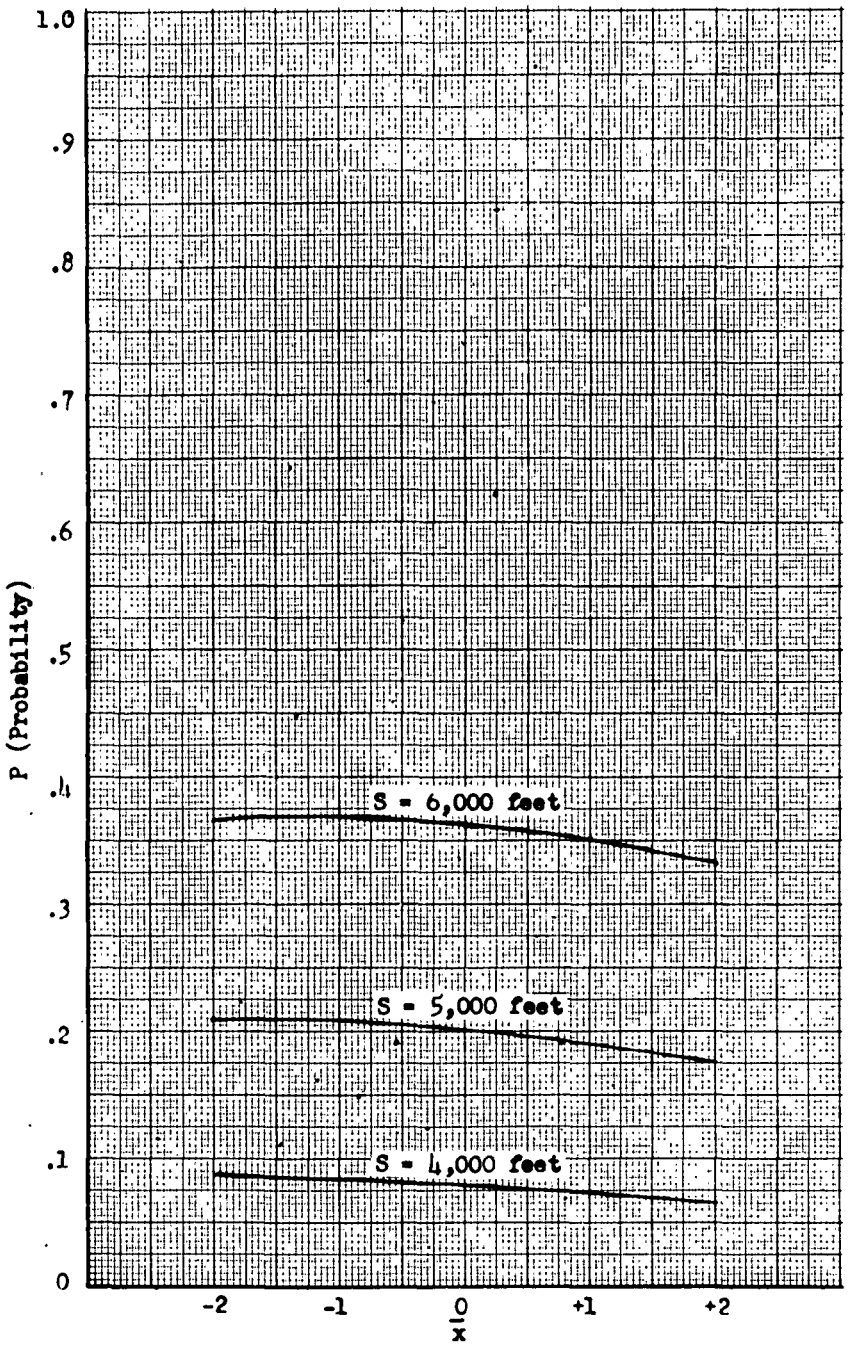

Figure 16. $\sigma_A = 1.5$ $\sigma_r = 6.0$ $\sigma_d = 2.0$ $\theta = 330^\circ$

All distances ($\bar{x}$, σ_A, σ_r, σ_d) in units of 10^3 feet

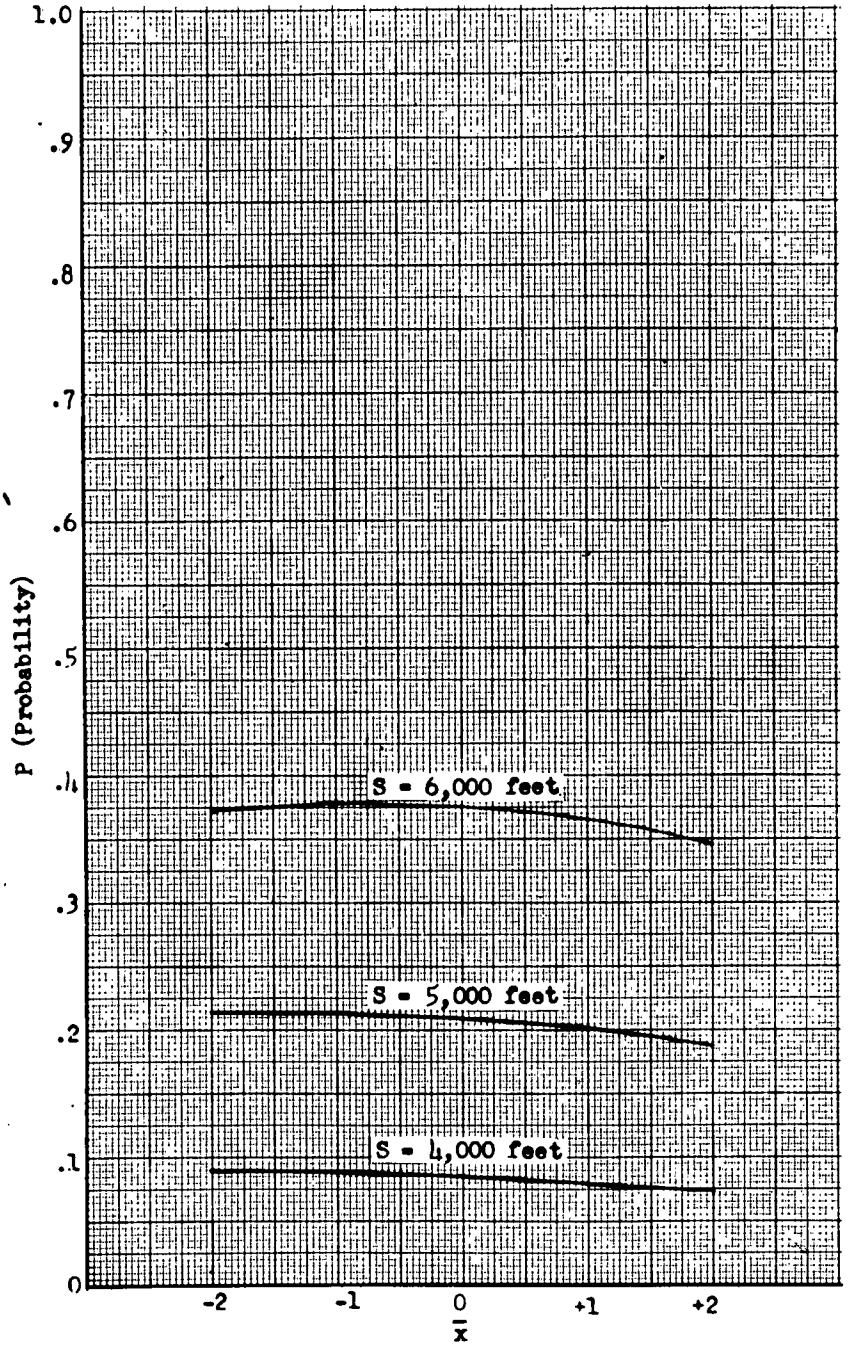

Figure 17. $\sigma_A = 1.5$ $\sigma_r = 6.0$ $\sigma_d = 2.0$ $\theta = 320^\circ$

All distances ($\bar{x}$, σ_A, σ_r, σ_d) in units of 10^3 feet.

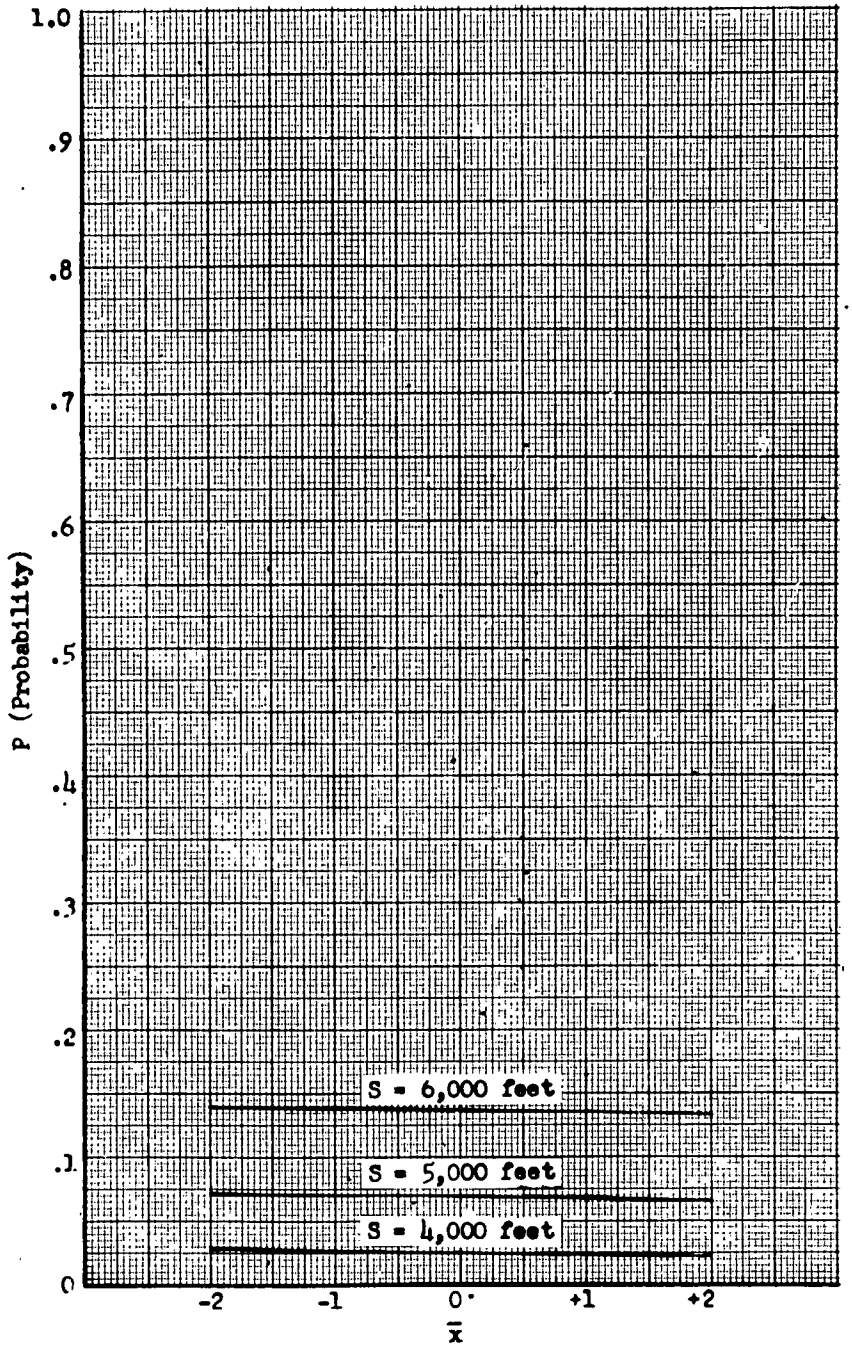

Figure 18. $\sigma_A = 1.5$ $\sigma_r = 12.0$ $\sigma_d = 4.0$ $\theta = 340°$

All distances ($\bar{x}$, σ_A, σ_r, σ_d) in units of 10^3 feet

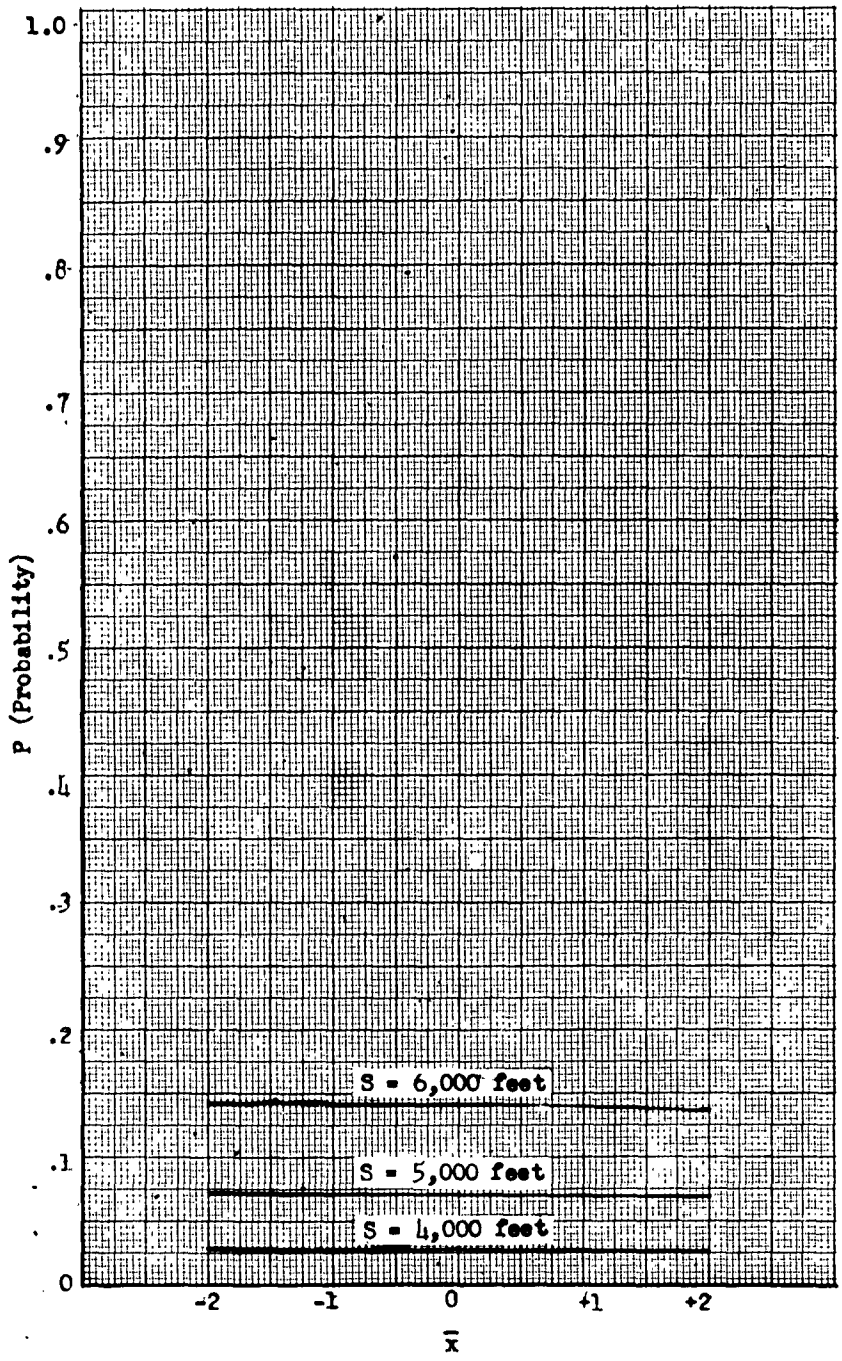

Figure 19. $\sigma_A = 1.5$ $\sigma_r = 12.0$ $\sigma_d = 4.0$ $\theta = 330^\circ$

All distances ($\bar{x}$, σ_A, σ_r, σ_d) in units of 10^3 feet

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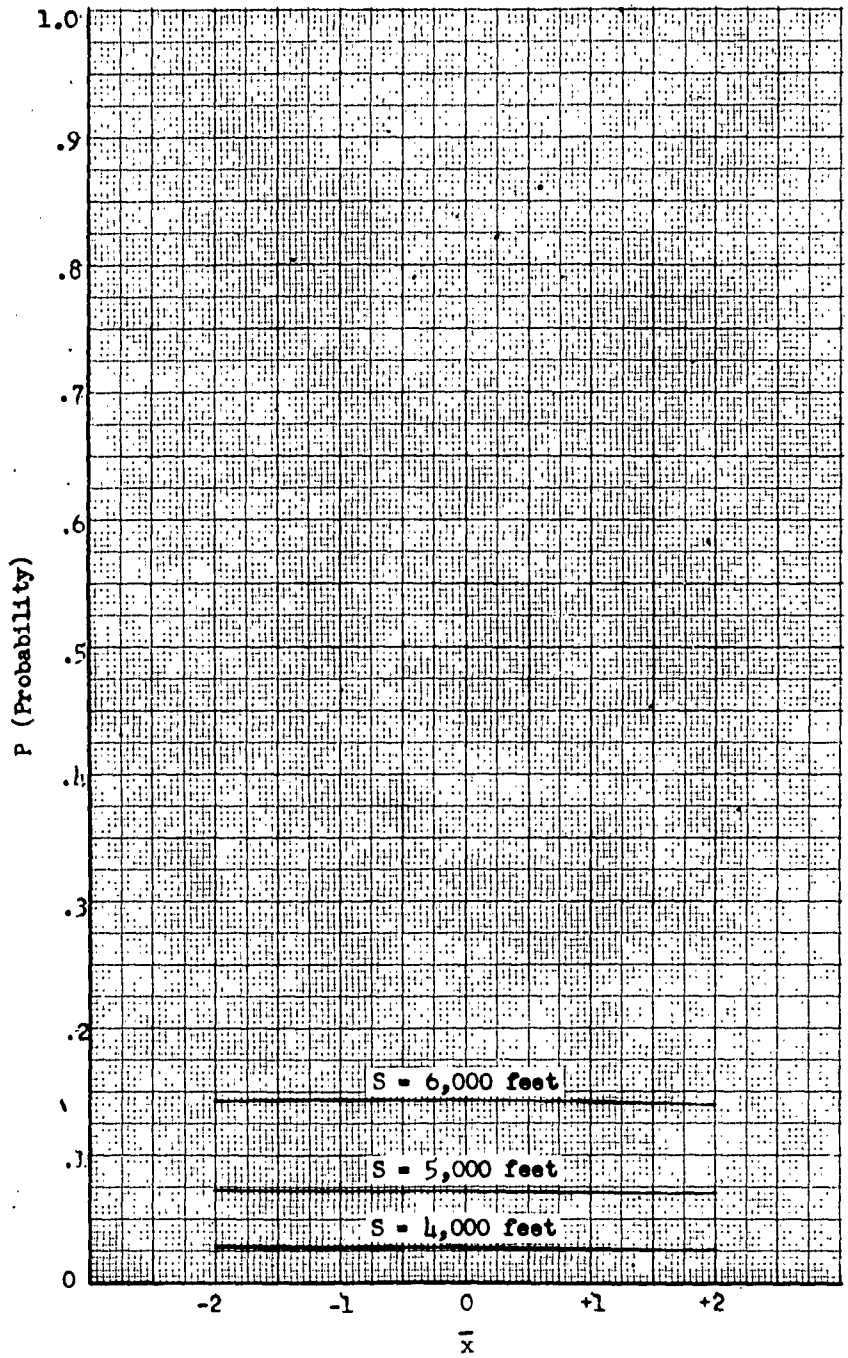

Figure 20. $\sigma_A = 1.5$ $\sigma_r = 12.0$ $\sigma_d = 4.0$ $\theta = 320^\circ$

All distances ($\bar{x}$, σ_A, σ_r, σ_d) in units of 10^3 feet

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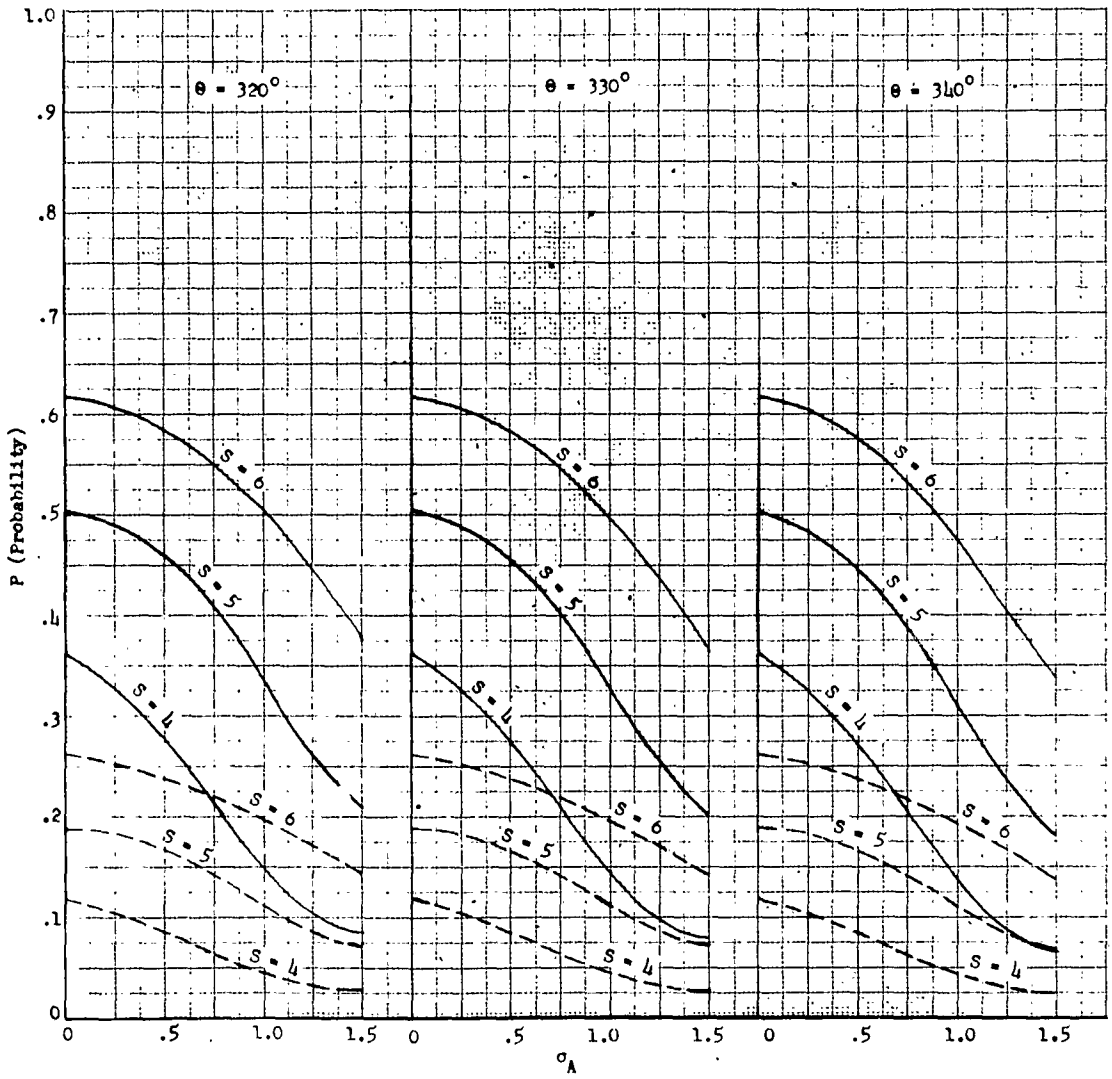

Figure 21. $\bar{x} = 0$ —— $\sigma_r = 6$, $\sigma_d = 2$ ---- $\sigma_r = 12$, $\sigma_d = 4$

All distances (s, $\bar{x}$, σ_A, σ_r, σ_d) in units of 10^3 feet.