

6M Es Single Hop Range Estimates (WA5IYX and K1SIX with k Factor)

Use these values for: 55.90 miles (90 km) Es Height1. ENT MUF							50.1
ANGLE ¹	MILES	KM	foEs ²	Angle b°	M-Factor	k-Factor (MI) ³	KM
90.000	0	0	50.10	0.0000	1.0000	0	0
47.620	100	161	37.43	41.6562	1.3384	100	161
28.300	200	322	24.86	60.2523	2.0154	200	322
19.220	300	483	18.27	68.6092	2.7418	300	483
14.060	400	644	14.61	73.0453	3.4292	400	644
10.700	500	805	12.39	75.6805	4.0432	500	805
8.300	600	966	10.97	77.3559	4.5684	604	973
6.470	700	1,127	10.02	78.4632	5.0001	705	1,135
5.000	800	1,287	9.38	79.2114	5.3423	807	1,298
3.762	900	1,449	8.94	79.7215	5.6043	909	1,463
2.710	1,000	1,609	8.65	80.0550	5.7903	1,012	1,629
1.770	1,100	1,771	8.47	80.2670	5.9152	1,119	1,801
0.930	1,200	1,932	8.37	80.3832	5.9859	1,236	1,989
0.163	1,300	2,093	8.33	80.4264	6.0127	1,502	2,417
0.040	1,317	2,120	8.33	80.4277	6.0135	1,521	2,448

Use these values for: 65.00 miles (105 km) Es Height2 and MUF							50.1
ANGLE ¹	MILES	KM	foEs ²	Angle b°	M-Factor	k-Factor (MI) ³	KM
90.000	0	0	50.10	0.0000	1.0000	0	0
51.850	100	161	39.79	37.4266	1.2592	100	161
32.090	200	322	27.68	56.4630	1.8100	200	322
22.170	300	483	20.65	65.6591	2.4262	300	483
16.420	400	644	16.57	70.6862	3.0235	400	644
12.650	500	804	14.03	73.7326	3.5699	500	804
9.950	600	966	12.37	75.7077	4.0507	603	971
7.900	700	1,126	11.24	77.0356	4.4574	704	1,133
6.250	800	1,288	10.45	77.9592	4.7937	806	1,296
4.890	900	1,448	9.90	78.5985	5.0586	907	1,459
3.720	1,000	1,609	9.52	79.0442	5.2617	1,009	1,623
2.690	1,100	1,771	9.26	79.3464	5.4092	1,113	1,791
1.780	1,200	1,931	9.10	79.5369	5.5066	1,218	1,961
0.950	1,300	2,092	9.01	79.6446	5.5632	1,334	2,148
0.180	1,400	2,254	8.97	79.6862	5.5854	1,584	2,549
0.040	1,419	2,284	8.97	79.6877	5.5862	1,639	2,638

Note ¹: MOST Angles only from previous table by WA5IYX. The MILES column uses the supplied angular values to recalculate corrected values based upon E-Layer height using Spherical Geometry with the MS Excel formula used shown on the last page. Note ²: FoEs values recalculated for MUF value entered in cell H2. Note ³: BEST CASE Earth (Radio) radius adjustment for "standard" 4/3 "k factor" to account for accepted values of atmospheric refraction for path segments below 3 km which could *extend the range* by a factor of the SQUARE ROOT of 4/3 or 15.4%. *Please see clarification on page 2!* KM values are simply converted from the mileage values used in the computation.

6M Es Single Hop Range Estimates (WA5IYX and K1SIX with k Factor)

Use these values for: **74.50** miles (120 km) Es Height3 and MUF **50.1**

ANGLE ¹	MILES	KM	foEs ²	Angle b°	M-Factor	k-Factor (MI) ³	KM
90.000	0	0	50.10	0.0000	1.0000	0	0
55.520	100	161	41.65	33.7563	1.2028	100	161
35.700	200	322	30.25	52.8525	1.6560	200	322
25.110	300	483	22.96	62.7191	2.1817	300	483
18.800	400	644	18.52	68.3049	2.7051	400	644
14.630	500	805	15.69	71.7512	3.1934	500	805
11.640	600	966	13.80	74.0172	3.6317	600	966
9.370	700	1,126	12.49	75.5656	4.0117	703	1,132
7.550	800	1,287	11.56	76.6606	4.3343	804	1,295
6.050	900	1,448	10.90	77.4384	4.5979	905	1,457
4.761	1,000	1,610	10.42	77.9987	4.8092	1,007	1,621
3.650	1,100	1,770	10.08	78.3896	4.9688	1,109	1,785
2.653	1,200	1,932	9.85	78.6600	5.0857	1,213	1,952
1.760	1,300	2,092	9.70	78.8329	5.1634	1,319	2,122
0.934	1,400	2,254	9.62	78.9318	5.2089	1,436	2,311
0.172	1,500	2,415	9.59	78.9694	5.2265	1,693	2,724
0.040	1,519	2,444	9.58	78.9707	5.2271	1,753	2,822

Note ¹: MOST angles only from previous table by WA5IYX. The MILES column uses the supplied angular values to recalculate corrected values based upon E-Layer height using Spherical Geometry with the MS Excel formulas used shown below. Note ²: FoEs values are recalculated for MUF value entered in cell H2.

Note ³: BEST CASE Earth (Radio) radius adjustment for "standard" 4/3 "k factor" to account for accepted values of atmospheric refraction for path segments below 3 km which could extend the range by a factor of the SQUARE ROOT of 4/3 or 15.4%. k factors < 1 will reduce range.

The full benefit for extremely low takeoff angles is unlikely as local terrain, clutter and obstruction losses become an increasing factor!

KM values are simply converted from the mileage values used in the computation.

Earth Radius Used: **3,959** miles (the r input to the formula). Use **6,371** if km units is desired.

MS Excel Converted Formulas used:

d= distance or range result (miles used here, can be km if desired)

h= height of E-Layer refraction (miles used here, change to km units if desired)

r= Earth's Radius (miles used here. MUST be in same units as the values used for d and h)

a= The takeoff **ANGLE** in degrees from an observer on the surface of the earth

"MILES"=**d**= $r * 2 * (90 - a - \text{DEGREES}(\text{ASIN}(r * \text{SIN}(\text{RADIANS}(a + 90)) / (r + h)))) / 57.3$

"k-Factor (MI)" =Kf ONLY FOR Takeoff angles =< 10° and full path k-Factor at 0° to avoid an error. Thus Kf= $\text{MIN}(d * \text{SQRT}(4/3), (d - (2 * 1.86411 / \text{SIN}(\text{RADIANS}(a))) + (2 * 1.86411 / \text{SIN}(\text{RADIANS}(a))) * \text{SQRT}(4/3)), d * \text{SQRT}(4/3))$

"Angle b°"= $\text{DEGREES}(\text{ASIN}((r / (r + h)) * \text{SIN}(\text{RADIANS}(a + 90))))$

"M-Factor"= $1 / \text{SIN}(\text{RADIANS}(90 - \text{Angle } b))$

This spreadsheet version is included in the Es_Predict utility versions 3.30 and above

REFERENCES and LINKS

A related article may be found here: [Elevation Angles Required for 6M Sporadic E](#)
M-Factor- What is it and how do you calculate it: [K9LA M-Factor](#)
An F-Layer M(3000) Paper may be found here: [Lockwood 1983](#)
Some basics on k Factor can be found at this link: [Y. Carrazana](#)
ITU Paper on Atmospheric Refraction found here: [ITU-R P.834.3](#)

MINI CALCULATOR

Enter an operating frequency (MUF): **50.0** Mhz
Enter E-Layer Height (h): **65.00** Miles (55.9 - 65.0 mi. typical, above 68 mi. is rare)
Enter a **positive** Takeoff Angle (a): **1.000** ° **If 0° the ENTIRE path is extended to avoid an error!**

ANGLE	MILES	KM	foEs ²	Angle b°	M-Factor	k-Factor (MI) ³	KM
1.000	1,293	2,082	8.99	79.6399	5.5607	1,326	2,135

[Click HERE for a listing of IONOGRAMS](#)

Enter Es height (h`Es) in km here: **104.60** Converted Miles to enter above: **65.00**

Spreadsheet protection password is: grandma8274 This allows critical formulas to be protected from being overwritten by the user. Only legitimate entry cells are unlocked.

[Main Screen](#)