

## WVGA Lens Charts

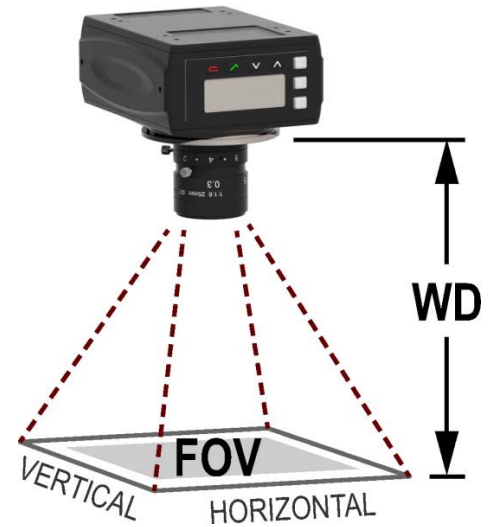
This paper offers information useful for selecting a C-mount lens for the VE Series WVGA smart camera. Other documents are available for the 2 MP and 1.3 MP models.

### Working Distance and Field of View

The two main variables involved when discussing a camera's lens choice are the **Working Distance** and the **Field of View** size. The Working Distance, or WD, is the distance from the camera to the target object. In the case of this collection of lens charts, the Working Distance is measured from the front surface of the threaded lens cover mount. The distance is not measured from the end of the lens because different lenses from different manufacturers, even with the same focal length, can vary in length.

The Field of View, or FOV, is the real world size of the picture the camera takes. This can also be broken down into a horizontal FOV size and a vertical FOV size. Note that the picture taken by a VE Series vision sensor is not square. The imager used in the WVGA VE sensor is  $752 \times 480$  pixels, making a rectangular image where the vertical FOV is about 64% the size of the horizontal FOV.

The Working Distance and Field of View sizes are related by linear equations determined by the focal length of the lens. Choosing the correct lens for a given application might be a matter of selecting the desired size of the FOV, then seeing which of the options for focal length result in a good fit for camera Working Distance. The situation might also be reversed, where the desired mounting location of the camera is known (and thus the Working Distance is fixed) and the various focal length lenses give a range of FOV sizes to choose from. In all cases, only one of these two variables may be freely selected. The second variable then becomes a function of the first. This is the reason why we offer a broad range of lens focal lengths—to provide as many options as possible to suit different WD/FOV size requirements.



### Multiple Manufacturers and Format Size

Banner does not manufacture any C-mount lenses used by our vision sensors. Instead we offer a range of lenses from different suppliers.

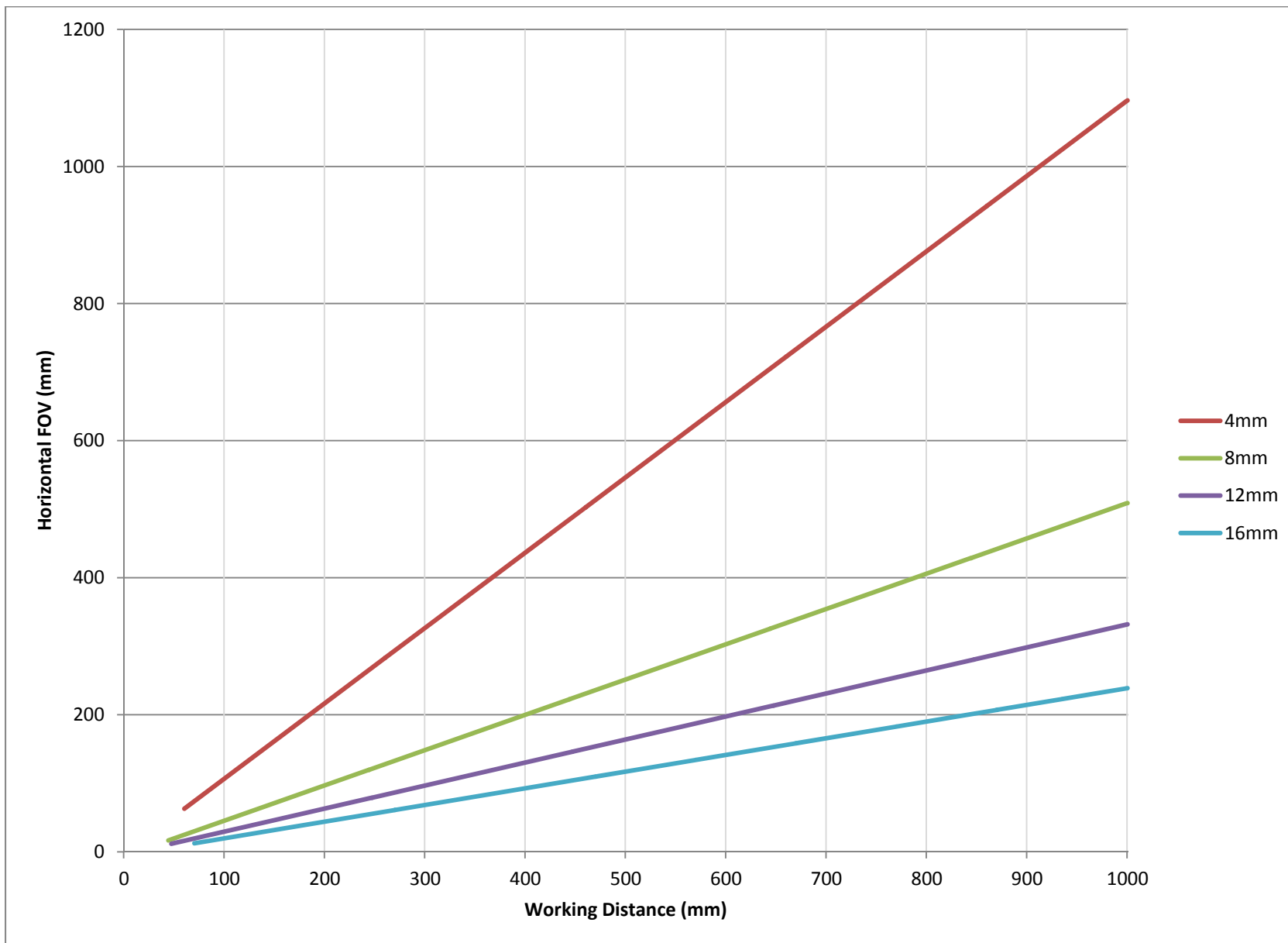
<p><b>Imager Resolution:</b> 752 px (H) <math>\times</math> 480 px (W)</p> <p><b>Pixel Size:</b> 5.3 <math>\mu\text{m}</math> <math>\times</math> 5.3 <math>\mu\text{m}</math></p> <p><b>Image Size:</b> 4.1 mm (H) <math>\times</math> 2.6 mm (W), 4.9 mm (diagonal)</p>
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### Off the Charts

In the pages that follow, graphical views of the Working Distance versus Horizontal FOV relationships are shown, out to a maximum working distance of 1 meter. These graphs offer a quick and easy way to estimate the FOV size for a given Working Distance and lens focal length. Also provided are two tables with entries out to 1.5 meters. The first shows FOV size as a function of Working Distance and the second shows Working Distance as a function of FOV size. The mathematical equations that describe the relationship between these two variables are also provided, allowing for calculations beyond what the chart and tables offer.

Each lens has a natural minimum Working Distance. If a camera using this lens were to move closer to the target than this minimum distance, the image would be out of focus and the lens alone would not be able to fix it. This is where extension tubes and shims are used. Extension tubes allow a lens to come into focus at a Working Distance closer than the minimum. The relationship between Working Distance and FOV size remains in effect as extension tubes are added, and so extension tubes are usually used to generate very small FOVs. A microscope is basically a high focal length lens with a large amount of extension tubes applied.

### Standard Resolution C-mount Lenses on WVGA VE Series



Standard C-mount Lenses on WVGA VE Series, FOV as a function of WD Chart

WD (mm)	FOV (mm)															
	4mm				8mm				12mm				16mm			
	Minimum		@ 60mm		16 x 10		@ 44mm		11 x 7		@ 47mm		11 x 7		@ 70mm	
20																
40																
60						25 x 16		16 x 10								
80	85 x 54			35 x 22				23 x 15		15 x 9						
100	107 x 68			46 x 29				30 x 19		20 x 13						
120	129 x 82			56 x 36				36 x 23		25 x 16						
140	151 x 96			66 x 42				43 x 27		29 x 19						
160	173 x 110			76 x 49				50 x 32		34 x 22						
180	195 x 124			87 x 55				56 x 36		39 x 25						
200	217 x 138			97 x 62				63 x 40		44 x 28						
220	239 x 152			107 x 68				70 x 45		49 x 31						
240	261 x 167			118 x 75				77 x 49		54 x 34						
260	283 x 181			128 x 82				83 x 53		59 x 37						
280	305 x 195			138 x 88				90 x 57		64 x 41						
300	327 x 209			148 x 95				97 x 62		68 x 44						
320	349 x 223			159 x 101				103 x 66		73 x 47						
340	371 x 237			169 x 108				110 x 70		78 x 50						
360	393 x 251			179 x 115				117 x 75		83 x 53						
380	415 x 265			190 x 121				124 x 79		88 x 56						
400	437 x 279			200 x 128				130 x 83		93 x 59						
420	459 x 293			210 x 134				137 x 87		98 x 62						
440	481 x 307			221 x 141				144 x 92		102 x 65						
460	503 x 321			231 x 147				151 x 96		107 x 69						
480	525 x 335			241 x 154				157 x 100		112 x 72						
500	547 x 349			251 x 161				164 x 105		117 x 75						
520	569 x 363			262 x 167				171 x 109		122 x 78						
540	591 x 377			272 x 174				177 x 113		127 x 81						
560	613 x 391			282 x 180				184 x 118		132 x 84						
580	635 x 405			293 x 187				191 x 122		137 x 87						
600	657 x 419			303 x 193				198 x 126		141 x 90						
620	679 x 433			313 x 200				204 x 130		146 x 93						
640	701 x 447			324 x 207				211 x 135		151 x 96						
660	723 x 461			334 x 213				218 x 139		156 x 100						
680	745 x 475			344 x 220				224 x 143		161 x 103						
700	767 x 489			354 x 226				231 x 148		166 x 106						
720	789 x 503			365 x 233				238 x 152		171 x 109						
740	811 x 517			375 x 239				245 x 156		176 x 112						
760	833 x 531			385 x 246				251 x 160		180 x 115						
780	855 x 545			396 x 253				258 x 165		185 x 118						
800	877 x 559			406 x 259				265 x 169		190 x 121						
820	899 x 574			416 x 266				271 x 173		195 x 124						
840	920 x 588			427 x 272				278 x 178		200 x 128						
860	942 x 602			437 x 279				285 x 182		205 x 131						
880	964 x 616			447 x 285				292 x 186		210 x 134						
900	986 x 630			457 x 292				298 x 190		214 x 137						
920	1008 x 644			468 x 299				305 x 195		219 x 140						
940	1030 x 658			478 x 305				312 x 199		224 x 143						
960	1052 x 672			488 x 312				319 x 203		229 x 146						
980	1074 x 686			499 x 318				325 x 208		234 x 149						
1000	1096 x 700			509 x 325				332 x 212		239 x 152						
1020	1118 x 714			519 x 331				339 x 216		244 x 156						
1040	1140 x 728			530 x 338				345 x 220		249 x 159						
1060	1162 x 742			540 x 345				352 x 225		253 x 162						
1080	1184 x 756			550 x 351				359 x 229		258 x 165						
1100	1206 x 770			560 x 358				366 x 233		263 x 168						
1120	1228 x 784			571 x 364				372 x 238		268 x 171						
1140	1250 x 798			581 x 371				379 x 242		273 x 174						
1160	1272 x 812			591 x 377				386 x 246		278 x 177						
1180	1294 x 826			602 x 384				392 x 250		283 x 180						
1200	1316 x 840			612 x 391				399 x 255		287 x 183						
1220	1338 x 854			622 x 397				406 x 259		292 x 187						
1240	1360 x 868			633 x 404				413 x 263		297 x 190						
1260	1382 x 882			643 x 410				419 x 268		302 x 193						
1280	1404 x 896			653 x 417				426 x 272		307 x 196						
1300	1426 x 910			663 x 423				433 x 276		312 x 199						
1320	1448 x 924			674 x 430				439 x 281		317 x 202						
1340	1470 x 938			684 x 437				446 x 285		322 x 205						
1360	1492 x 952			694 x 443				453 x 289		326 x 208						
1380	1514 x 966			705 x 450				460 x 293		331 x 211						
1400	1536 x 981			715 x 456				466 x 298		336 x 215						
1420	1558 x 995			725 x 463				473 x 302		341 x 218						
1440	1580 x 1009			735 x 469				480 x 306		346 x 221						
1460	1602 x 1023			746 x 476				487 x 311		351 x 224						
1480	1624 x 1037			756 x 483				493 x 315		356 x 227						
1500	1646 x 1051			766 x 489				500 x 319		360 x 230						

Standard C-mount Lenses on WVGA VE Series, WD as a function of FOV Chart

FOV (mm)		WD (mm)			
		4mm	8mm	12mm	16mm
		61 x 39 @ 60mm	16 x 10 @ 44mm	11 x 7 @ 47mm	11 x 7 @ 70mm
20 x 15			50	72	101
40 x 30			89	131	183
60 x 45		57	128	191	265
80 x 60		75	167	250	348
100 x 75		94	206	310	430
120 x 90		112	245	369	512
140 x 105		130	283	429	594
160 x 120		148	322	488	676
180 x 135		166	361	548	758
200 x 150		185	400	607	841
220 x 165		203	439	667	923
240 x 180		221	478	726	1005
260 x 195		239	517	786	1087
280 x 210		257	555	845	1169
300 x 225		276	594	905	1251
320 x 240		294	633	964	1334
340 x 255		312	672	1024	1416
360 x 270		330	711	1083	1498
380 x 285		348	750	1143	1580
400 x 300		367	788	1202	1662
420 x 315		385	827	1262	1744
440 x 330		403	866	1322	1827
460 x 345		421	905	1381	1909
480 x 360		439	944	1441	1991
500 x 375		458	983	1500	2073
520 x 390		476	1022	1560	2155
540 x 405		494	1060	1619	2237
560 x 420		512	1099	1679	2320
580 x 435		530	1138	1738	2402
600 x 450		548	1177	1798	2484
620 x 465		567	1216	1857	2566
640 x 480		585	1255	1917	2648
660 x 495		603	1293	1976	2730
680 x 510		621	1332	2036	2813
700 x 525		639	1371	2095	2895
720 x 540		658	1410	2155	2977
740 x 555		676	1449	2214	3059
760 x 570		694	1488	2274	3141
780 x 585		712	1526	2333	3224
800 x 600		730	1565	2393	3306
820 x 615		749	1604	2452	3388
840 x 630		767	1643	2512	3470
860 x 645		785	1682	2572	3552
880 x 660		803	1721	2631	3634
900 x 675		821	1760	2691	3717
920 x 690		840	1798	2750	3799
940 x 705		858	1837	2810	3881
960 x 720		876	1876	2869	3963
980 x 735		894	1915	2929	4045
1000 x 750		912	1954	2988	4127
1020 x 765		931	1993	3048	4210
1040 x 780		949	2031	3107	4292
1060 x 795		967	2070	3167	4374
1080 x 810		985	2109	3226	4456
1100 x 825		1003	2148	3286	4538
1120 x 840		1021	2187	3345	4620
1140 x 855		1040	2226	3405	4703
1160 x 870		1058	2264	3464	4785
1180 x 885		1076	2303	3524	4867
1200 x 900		1094	2342	3583	4949
1220 x 915		1112	2381	3643	5031
1240 x 930		1131	2420	3702	5113
1260 x 945		1149	2459	3762	5196
1280 x 960		1167	2498	3822	5278
1300 x 975		1185	2536	3881	5360
1320 x 990		1203	2575	3941	5442
1340 x 1005		1222	2614	4000	5524
1360 x 1020		1240	2653	4060	5606
1380 x 1035		1258	2692	4119	5689
1400 x 1050		1276	2731	4179	5771
1420 x 1065		1294	2769	4238	5853
1440 x 1080		1313	2808	4298	5935
1460 x 1095		1331	2847	4357	6017
1480 x 1110		1349	2886	4417	6099
1500 x 1125		1367	2925	4476	6182

## Standard C-mount Lens equations for VE Series WVGA

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H = horizontal FOV size, W = working distance



### 4 mm lens

**Banner model:** LCF04 (p/n 68884)

**Marshall Electronics model:** V-4504ML

1/3-inch format, no filter, fixed iris f/2.5

***H(W), mm***

$H = 1.099 \times W - 3$  (minimum W ~ 60mm)

***W(H), mm***

$W = (H + 3)/1.099$  (minimum H ~ 61mm)

NOTE: Banner recommends using a 0.25 mm spacer (LEKS)



### 8 mm lens

**Banner model:** LCF08 (p/n 57298)

**Azure Photonics model:** AZURE-0813F

1/2-inch format, no filter, fixed iris f/1.3

***H(W), mm***

$H = 0.515 \times W - 5.97$  (minimum W ~ 44mm)

***W(H), mm***

$W = (H + 5.97)/0.515$  (minimum H ~ 16mm)



### 12 mm lens

**Banner model:** LCF12 (p/n 57299)

**Marshall Electronics model:** V-4512

1/3-inch format, no filter, fixed iris f/2.0

***H(W), mm***

$H = 0.336 \times W - 4.04$  (minimum W ~ 47mm)

***W(H), mm***

$W = (H + 4.04)/0.336$  (minimum H ~ 11mm)



### 16 mm lens

**Banner model:** LCF16 (p/n 56522)

**Marshall Electronics model:** V-4516

1/3-inch format, no filter, fixed iris f/1.6

***H(W), mm***

$H = 0.243 \times W - 4.6$  (minimum W ~ 70mm)

***W(H), mm***

$W = (H + 4.6)/0.243$  (minimum H ~ 11mm)