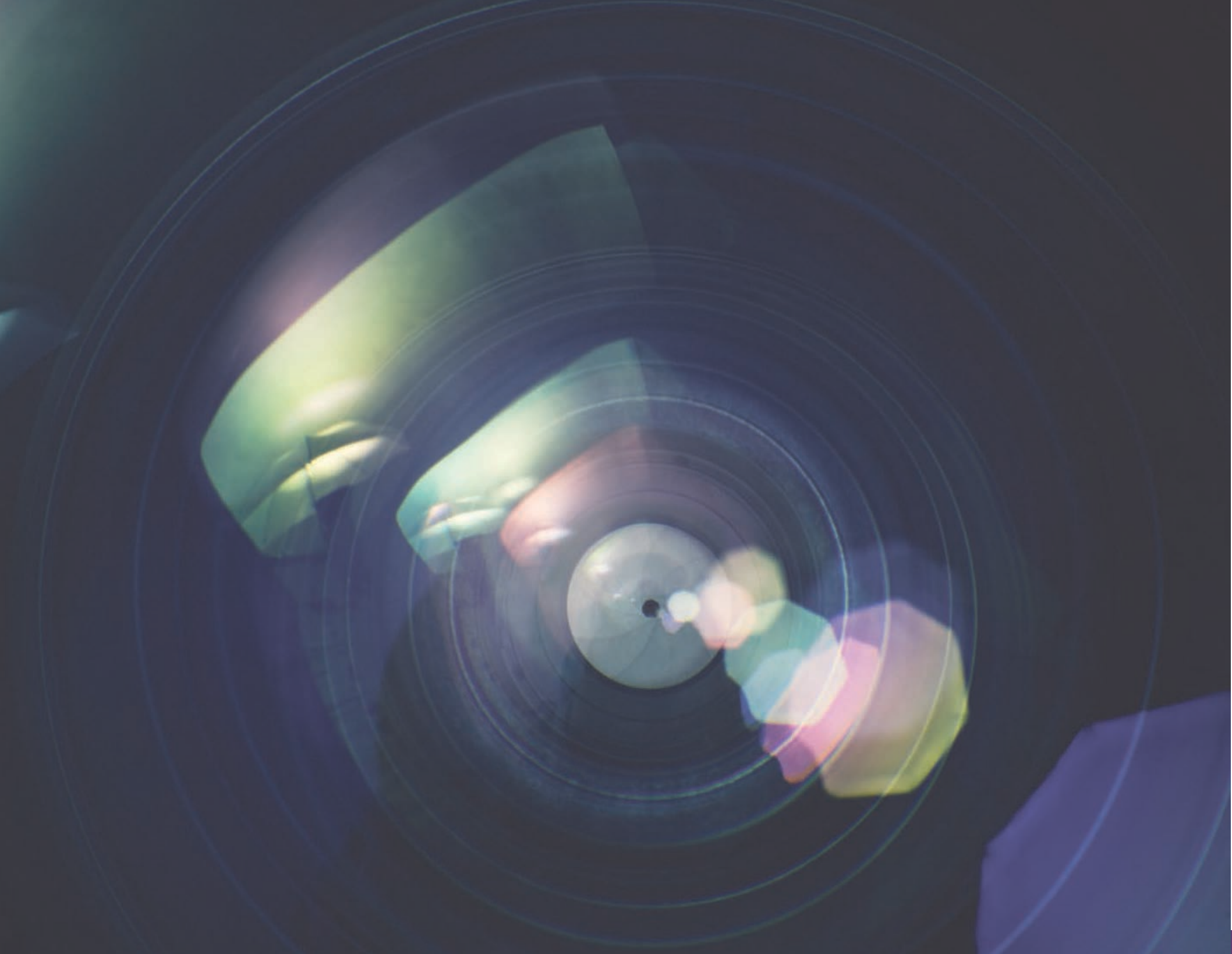




PROJECTION OPTICS

› FROM HD TO 4K AND BEYOND





High Performance Projection Lenses

Navitar projection lenses offer versatility, flexibility and unbeatable performance. Our complete line of fisheye and conversion lenses are used in a range of environments from small mobile planetariums to high impact entertainment attractions and museum exhibits.

We work closely with leading projector manufacturers, producers of dome theater equipment, top simulation companies, providers of high resolution, full motion immersive environments and display systems, and the world's foremost creators, designers, and builders of themed attractions.

Navitar has developed off the shelf, and custom optics for single, dual, and multi-projector applications that require 2K, 4K, or 8K system resolutions.

Partnering with Navitar

Navitar's ultimate goal is to deliver unsurpassed, personalized optical solutions in a timely, cost-effective manner. Whether you choose a standard lens or require a custom optical design, we will work with you from project inception to completion, ensuring all your questions are addressed and your expectations are exceeded.



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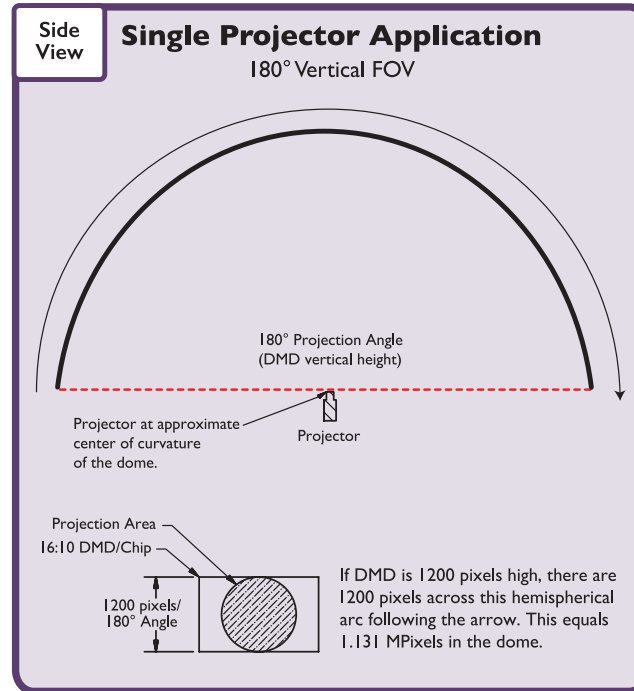
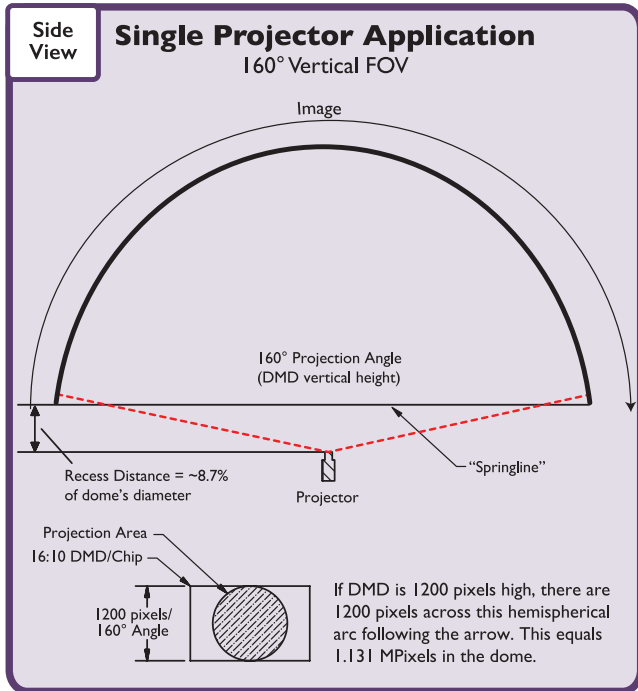
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Icon Guide:



Look for these icons to quickly determine the projection view angle of the lens

Navitar Lens & Projector Application Diagrams

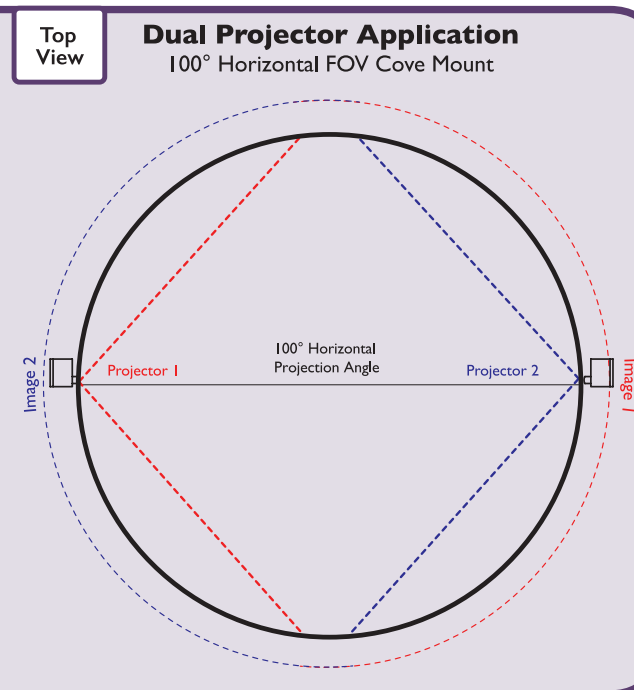
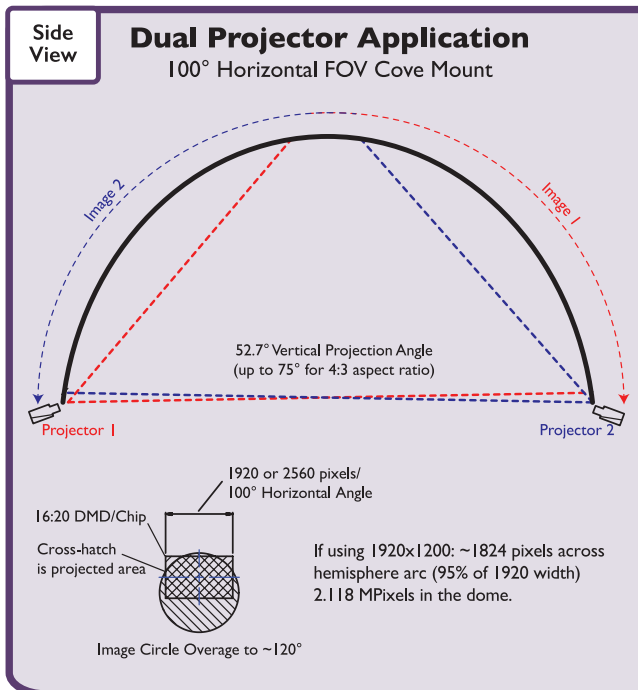


Navitar projection lenses offer precise resolution, accurate color registration, and consistent quality from center to edge.

Our fisheye lenses have a very large depth of focus, allowing them to maintain sharpness in a variety of settings.

Navitar off the shelf and custom projection lenses have helped customers:

- Decrease the number of projectors used to cover a dome surface
- Create seamless display overlaps
- Achieve superb center-to-edge image resolution
- Maximize impact with high-quality images and brightness



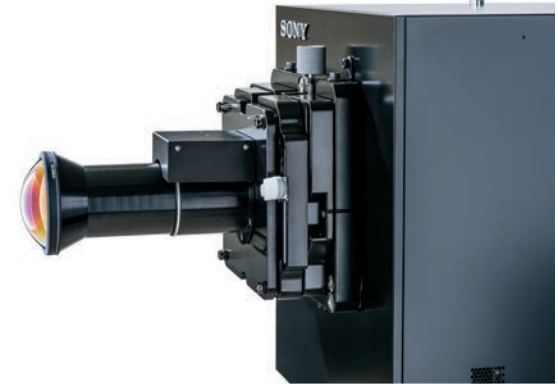
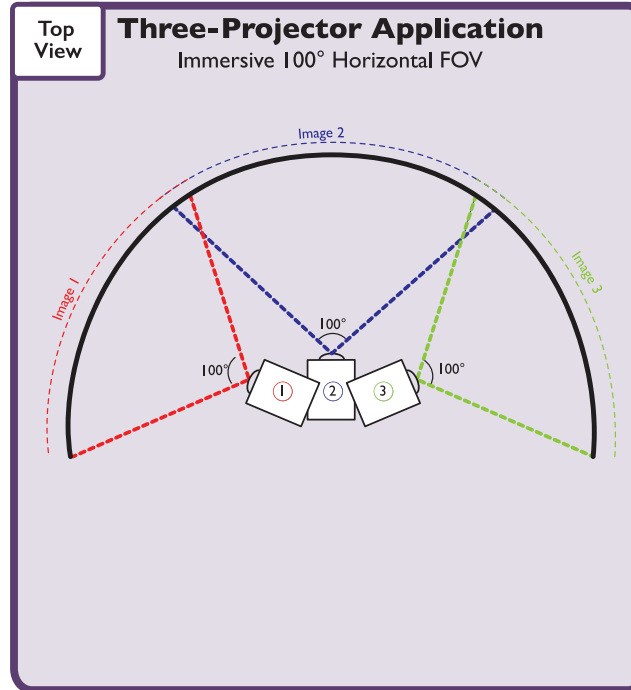
Navitar lenses output crisp images and the true color brightness of the projector.

Projector Application Diagrams

Our ultra wide-angle HemiStar lenses are used in cove and pit mount planetarium applications, single or multi-channel simulation configurations, full dome setups, and complex, dynamic amusement ride systems.

Whatever your application, Navitar has a solution. Design capabilities include:

- Relay and non-relay designs
- Rectilinear and fisheye design forms
- Fisheye lenses with F-theta distortion
- Uniform pixel mapping at image edge
- Unique chip sets and color off-sets
- Panel size variations in light engines
- Custom internal masking requirements
- Tolerance and sensitivity analyses



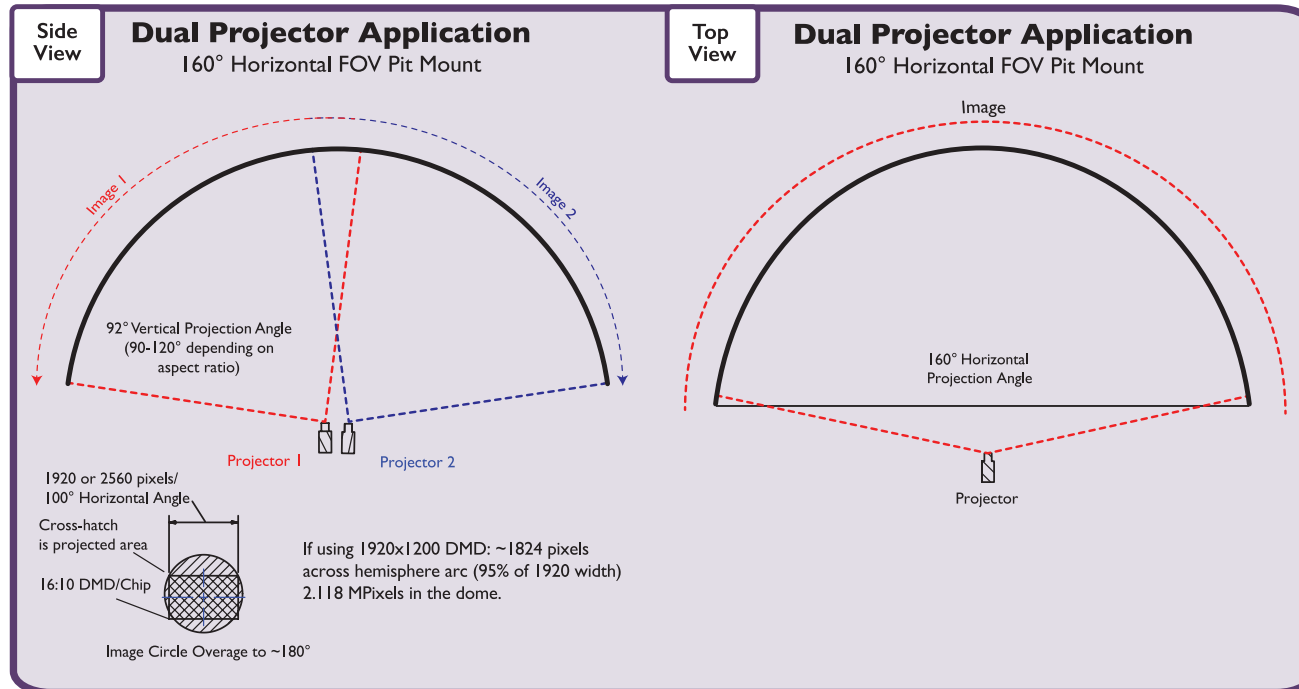
4K-S-0.90 Lens in Sony SRX-T615 Projector



HT49 Lens in Christie DS+10K-M Projector



HM4K-178 Lens in Christie D4K2560 Projector



Custom Projection Lens Design

Perfect Resolution by Design

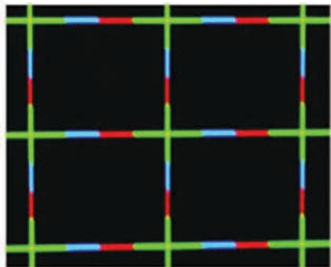
The lens designers at Navitar understand the exact design requirements for 1080p, 2K and 4K projection lenses. The secret to a near-diffraction limited lens design is in part from the lens designer working closely with the projector manufacturer to overcome subtle projector nuances when designing lenses. For example, in most cases the RGB panels within the light engine are tuned for factory lenses. This must be considered when designing replacement lenses.

Tight Color Registration - All the Way to the Corners

Navitar understands the need for perfect color registration all the way to the four corners of your projected image. We can design an apochromatic lens ensuring the 3 colors (red, green and blue) come together at a common focus spot. For high end applications, lateral color shift can have devastating effects on an end user. For example, in training simulators, a slight offset in the red channel can make a single pixel of information be the wrong color – causing a pilot looking for landing lights in the distance to make an incorrect decision.

Below is a recent example of a high end 1:1 ratio wide angle 1080p resolution lens showing excellent color registration all the way to the four corners. These are actual photos of the center and top right corner from the projected image. The required specifications for lateral color shift for this customer was less than 1/2 a pixel at the edge of the field. We met and exceeded that requirement.

Center of Projected 1080p Image



Right Corner of Projected 1080p Image

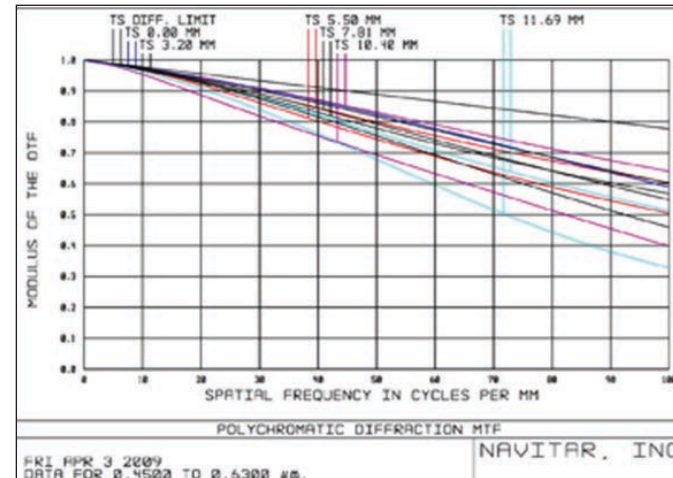


Low Distortion: Less than 2/10 of 1%

Most simulator packages require multiple images to be stitched together to create a panoramic view. Although small amounts of pincushion and barrel distortion can be tolerated on a consumer projector, industrial applications like simulation require near-perfect distortion.

Resolution in Terms of Modulation Transfer Function (MTF)

The MTF of a lens is the true report card of the resolution of a lens design. During the specification development stage, Navitar lens designers work closely with the customer to establish the required resolution based upon the pixel size of the projector sensor.



MTF graph of the 1080p 1:1 lens

Typically, two acceptance standards will be established; one for the image center and one for the image corners since some falloff is normal at the edge of the field. For example, the design requirements for a 1080p projector with 7 micron pixel size is above 50% center @ 70 linepairs (lp)/ millimeters (mm), and 30% corners @ 70 lp/mm. Regardless of the criteria, Navitar lens designers will work with the customer to ensure they understand the resolution requirements necessary for their application.

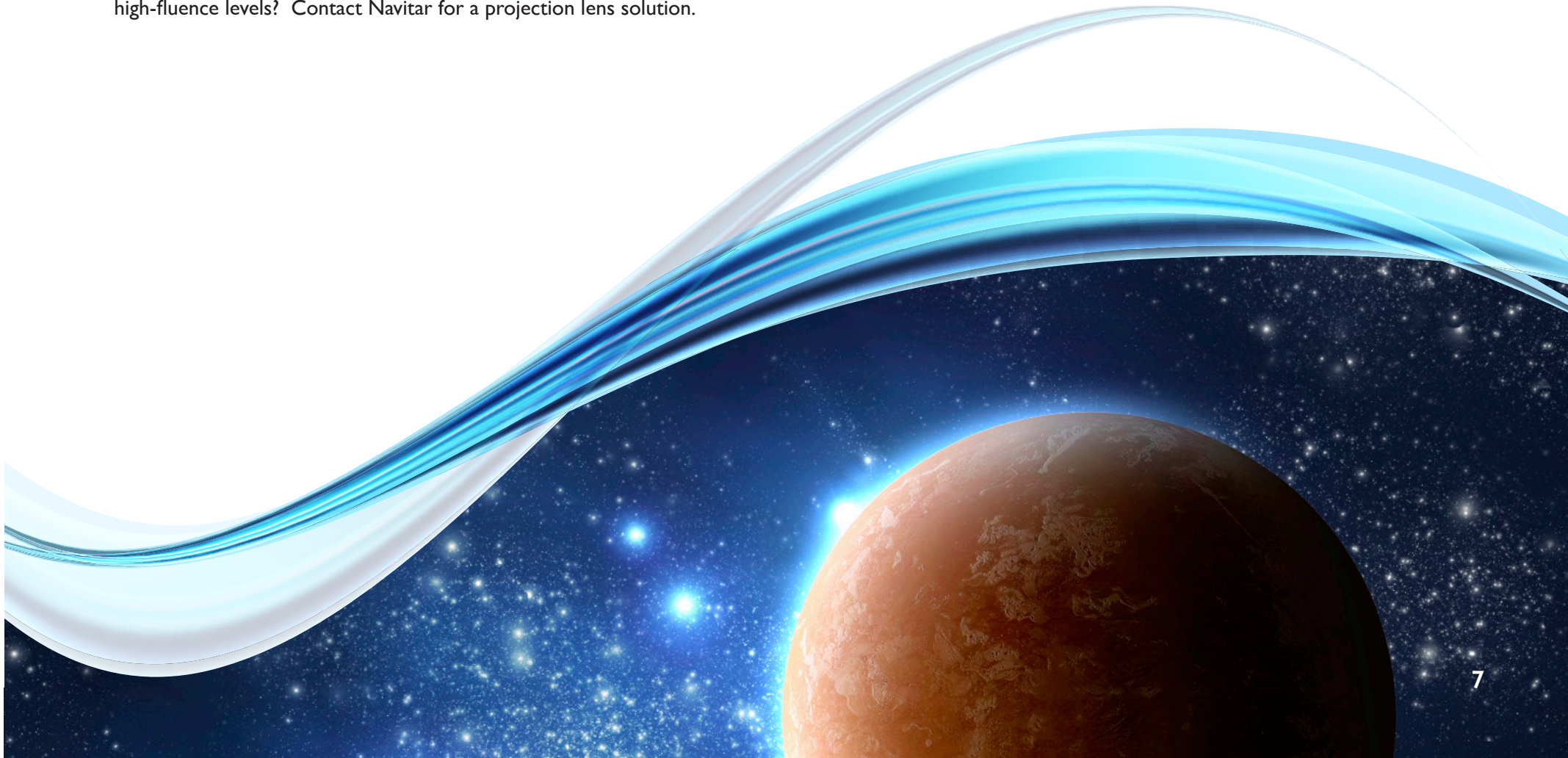
High Contrast and High Fluence Projection Lens Design

Through extensive internal development efforts, acquisition, and partnerships with projector manufacturers and customers in the premier digital cinema market, Navitar has gained expertise in high contrast/ high lumen (fluence) projection lens design.

Navitar has developed lenses that work with traditional Xenon based light engines up to 40K ANSI lumens as well 6P platforms up to 60K ANSI lumens. We have over 500 lenses installed on 1.38" DLP platforms for digital cinema applications which see 35K ANSI lumens on a daily basis.

Our designs are engineered for peak power and continual thermal cycles through on/off routines. Navitar lenses currently achieve contrast ratios in excess of 400:1.

Have an application that requires zero installation down time and excellent performance at high lamp output or high-fluence levels? Contact Navitar for a projection lens solution.



HemiStar® Fisheye Lenses

Navitar has designed and produced world-class projection lenses since 1978. Today, we offer an innovative series of HemiStar lenses ideal for small, medium and large planetariums, as well as simulation and immersive projection. Our fisheye projection lenses have an almost infinite depth of focus, allowing them to maintain sharpness in a variety of settings.

2K SOLUTIONS

HS30	HS48	HT49
HS41	HS68	HM74
HS45	HMI17	HM79

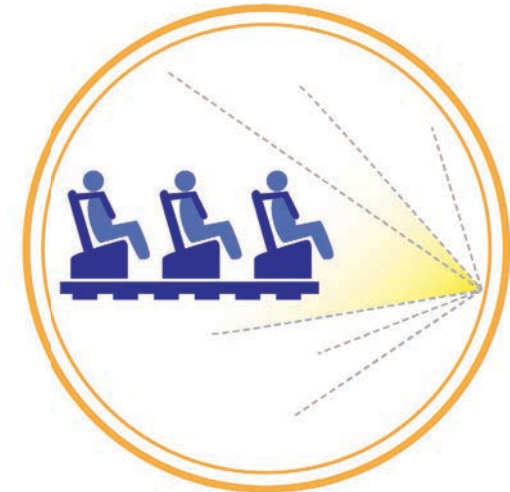
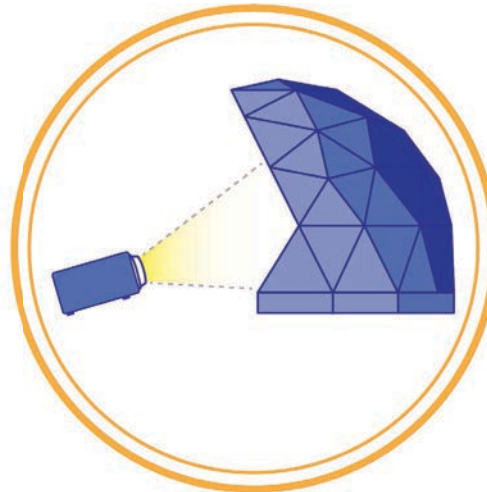
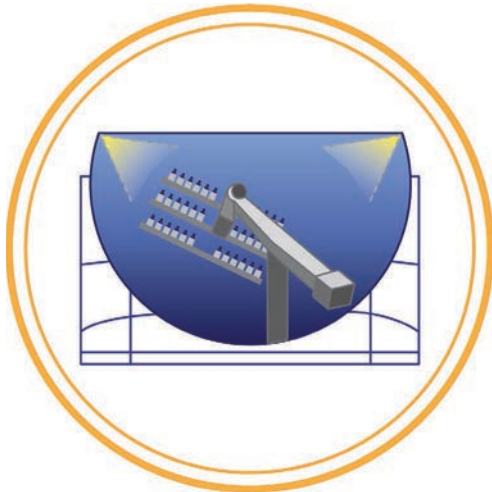
4K SOLUTIONS

HM4K-96	HMR197
HM4K-168	HSRZ-55
HM4K-178	3.5X Conv.
HMR113	0.65:1

8K SOLUTIONS

HM4K-168	HMR197
HM4K-178	4K-S-0.90

IMMERSIVE ENVIRONMENTS • COMMAND & CONTROL • AUTOMOTIVE DESIGN • EDUCATION • TUNNEL RIDES
PLANETARIUMS • PRAISE & WORSHIP • SIMULATION • MUSEUMS • THEME PARKS & ATTRACTIONS • FLYING THEATERS



HemiStar® Lens Offerings

2K and Less Projectors	
Panel Size	Resolution
0.67" 1-chip DLP WUXGA	1920 x 1200
0.67" 3-chip DLP WUXGA	1920 x 1200
0.90" 1-chip DLP WQXGA	2560 x 1600
0.94" 1-chip DLP SXGA+	1400 x 1050
0.94" 3-chip DLP SXGA+	1400 x 1050
0.94" 1-chip DLP 1080HD	1920 x 1080
0.94" 3-chip DLP 1080HD	1920 x 1080
0.96" 1-chip DLP WUXGA	1920 x 1200
0.96" 3-chip DLP WUXGA	1290 x 1200
1.3" 3-chip LCD	1024 x 768
1.4-3.5:1 T.R. 1-chip & 3LCD w/ prime	any

4K Projectors	
Manufacturer & Panel Size	Resolution
Sony 0.74" 4K LCoS	4096 x 2160
JVC 1.27" 4K LCoS	4096 x 2400
Barco/Christie/DP 1.38" DLP 4K	4096 x 2160
Sony 1.48 4K LCoS	4096 x 2160
Sony 1.55 4K LCoS	4096 x 2160

Lenses for Single Projector Applications	
Inflatable Domes Small-Mid Planetariums and Spheres	
Single Pit Mount	
180° Vertical	160° Vertical
HS30	
HS41	HS45
HS48	
HT49	
	HS45
HS45	HS48
	HT49
HS68	

Single Pit Mount	
180° Vertical	160° Vertical
	HS4K-62*
HSRZ-55	HSRZ-55
	HSR-70*

Lenses for Dual Projector Applications	
Small-Large Planetariums Simulators and Amusement	
Pit Mount	Cove Mount
160° Horizontal	100° Horizontal
HM55*/HC-3.5X	HM87*/HC-3.5X
HM74	HM117
HM74	HM117
	HMT-110*
HM79	HM124*
	HMT-119
HM79	HM124*
	HMT-119
HC-3.5X	HC-3.5X

Pit Mount	Cove Mount
160° Horizontal	100° Horizontal
	HM4K-96
HMR-105*	HM4K-168
HMR-113	HM4K-178
	HM4K-185*
HMR-131*	HMR-197

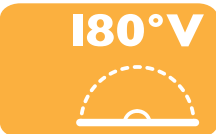
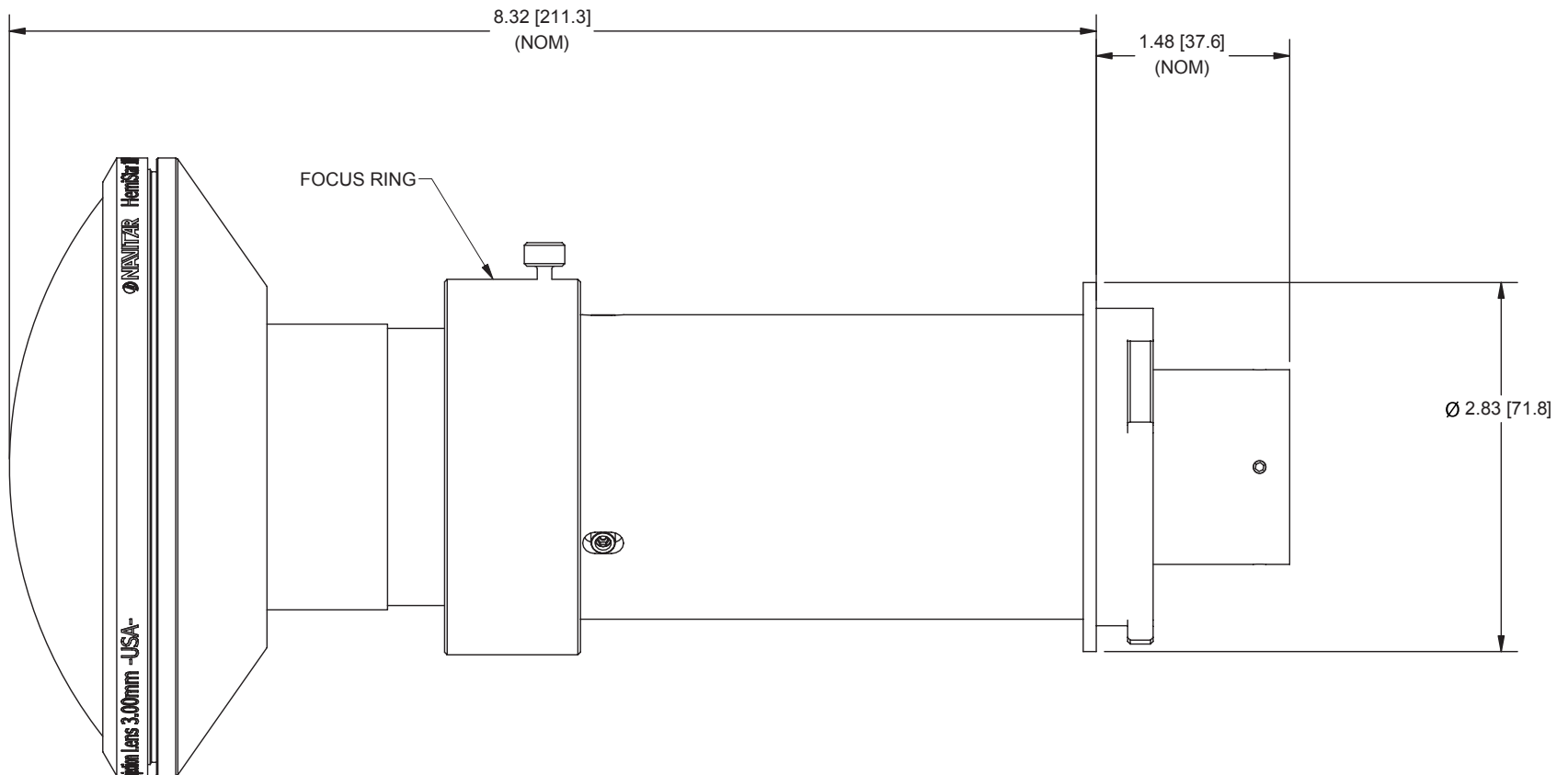
Lenses for Multiple Projector Applications	
Planetariums, Dome Theaters and Amusement Dark Rides	
Pit Mount	Cove Mount
105° Horizontal	58° Horizontal
HM87*/HC-3.5X	
	2K3-D-0.90
HM117	
HM117	
HMT-110*	
HM117	
HMT-119	
HM117	
HMT-119	
HC-3.5X	

Pit Mount	Cove Mount
105° Horizontal	58° Horizontal
HM4K-96	4K-SS-0.90*/ 4K-SS-0.65
HM4K-168	
HM4K-178	
HM4K-185*	4K-S-0.90
HMR-197	

*These lenses are planned. Please call for details.

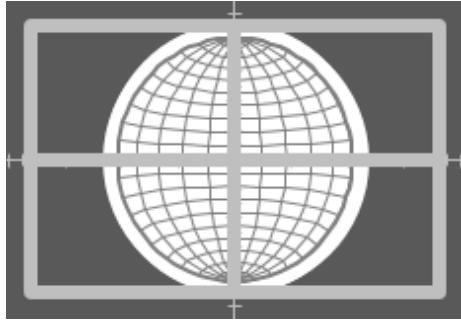
HemiStar HS30

Projection Angle Chart																
Display Type		Resolution			Panel Size (mm)			# Pixels Projected				Projection Angles (°)		Shift		
Dome Lens		H	V	Pixel Pitch (μm)	H	V	Diag.	H	V	@ 180°	Mpixel Count	H	V	H +/-%	V +/-%	V Angle +/-°
Original Panel 0.67" WUXGA		1920	1200	7.56	14.515	9.072	17.117	1200	1200	1176	1.13	184.7	184.7	0%	0%	0.0
Alternate Panels	0.76" 3LCD WUXGA	1920	1200	8.5	16.320	10.200	19.245	1067	1067	1046	0.89	184.7	184.7	0%	0%	0.0
	0.74" 3LCD 1080p	1920	1080	8.5	16.320	9.180	18.725	1067	1067	1046	0.89	184.7	184.7	0%	0%	0.0
	0.69" XGA	1024	768	13.68	14.008	10.506	17.510	663	663	650	0.35	184.7	184.7	0%	0%	0.0
	0.66" HD1080	1920	1080	7.56	14.515	8.165	16.654	1200	1080	1176	0.92	184.7	163.3	0%	6%	10.7
	0.65" WXGA	1280	800	10.8	13.824	8.640	16.302	840	800	823	0.50	184.7	174.3	0%	2%	5.2



Panel Usage

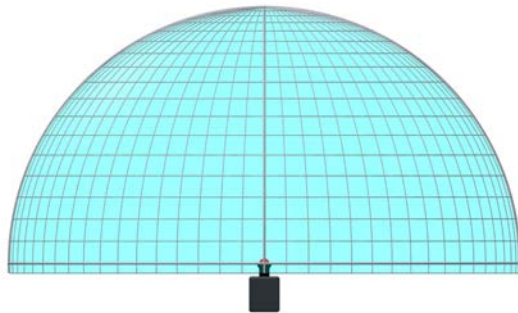
Active Image on Projector Panel



The illustration shows the active pixels used to project a hemisphere. A full hemisphere is projected as a circle of (active) pixels. This is a single channel example of the HS30 projecting a 0.67" WUXGA panel.

On-Screen Projection

Active Image on Screen



The illustration shows the projected image against a 5° azimuth-elevation grid. The projector is positioned at dome center and uniformly casts a hemispherical beam to the screen.

Lens Specifications

Focal Length	3.00mm	MTF Center	66% @ 66 lp/mm
Image Circle	9.072mm	MTF Edge	60% @ 66 lp/mm
Max Half-Angle	92°	Lateral Color R-G	< 4µm
F/#	F/2.5	Lateral Color B-G	< 2µm
Focus Range	600mm – Inf.	F-Theta Distortion	-6.0% Max
Transmittance	81-89%	Relative Illum.	>95%
Back Focus	Suitable for small format single-chip DLP and 3LCD.		

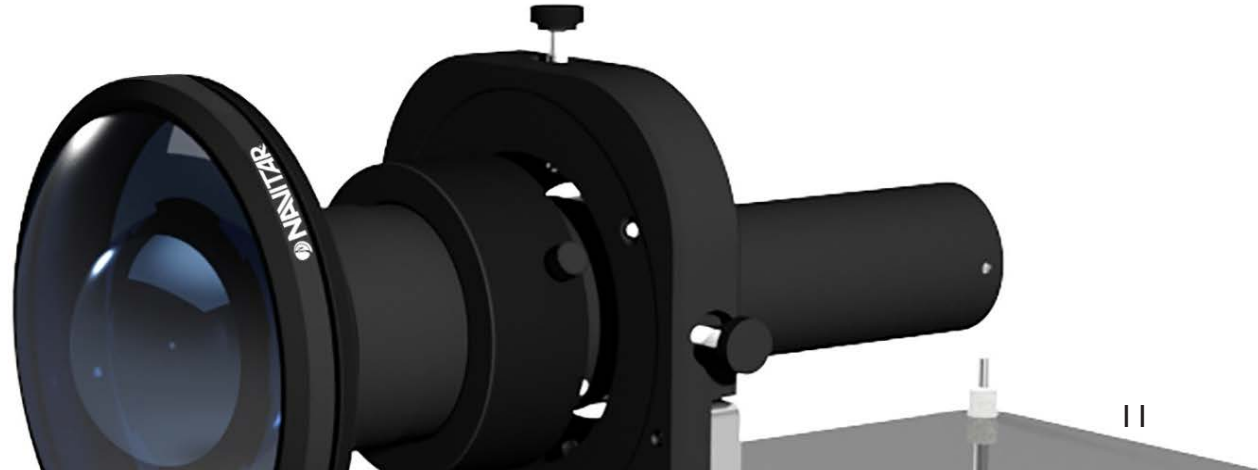
HS30 - Model Numbers

Navitar Part #*	Projector	Resolution	Brightness ⁺
I-24106**	Optoma EH503	1080p	5,200
I-24106**	Optoma EH505	WUXGA	5,000
I-24106**	Optoma W505	WXGA	5,200
I-24106**	Optoma X605	XGA	6,000
I-24106**	Vivitek D5380	WUXGA	5,000
I-19985	Optoma EH7700	WUXGA	7,000
I-22450	Panasonic PT-DZ870/780	WUXGA	8,500
I-22450	Panasonic PT-DX820	XGA	7,000
I-22450	Panasonic PT-DW830	WXGA	8,500
I-22450	Panasonic PT-RZ660/670/770/970	WUXGA	6,500
I-22450	Panasonic PT-RW930/730/630	WXGA	6,500
I-22450	Panasonic PT-DX100/820	XGA	10,000

* Part numbers vary depending on projector manufacturer and model

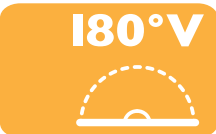
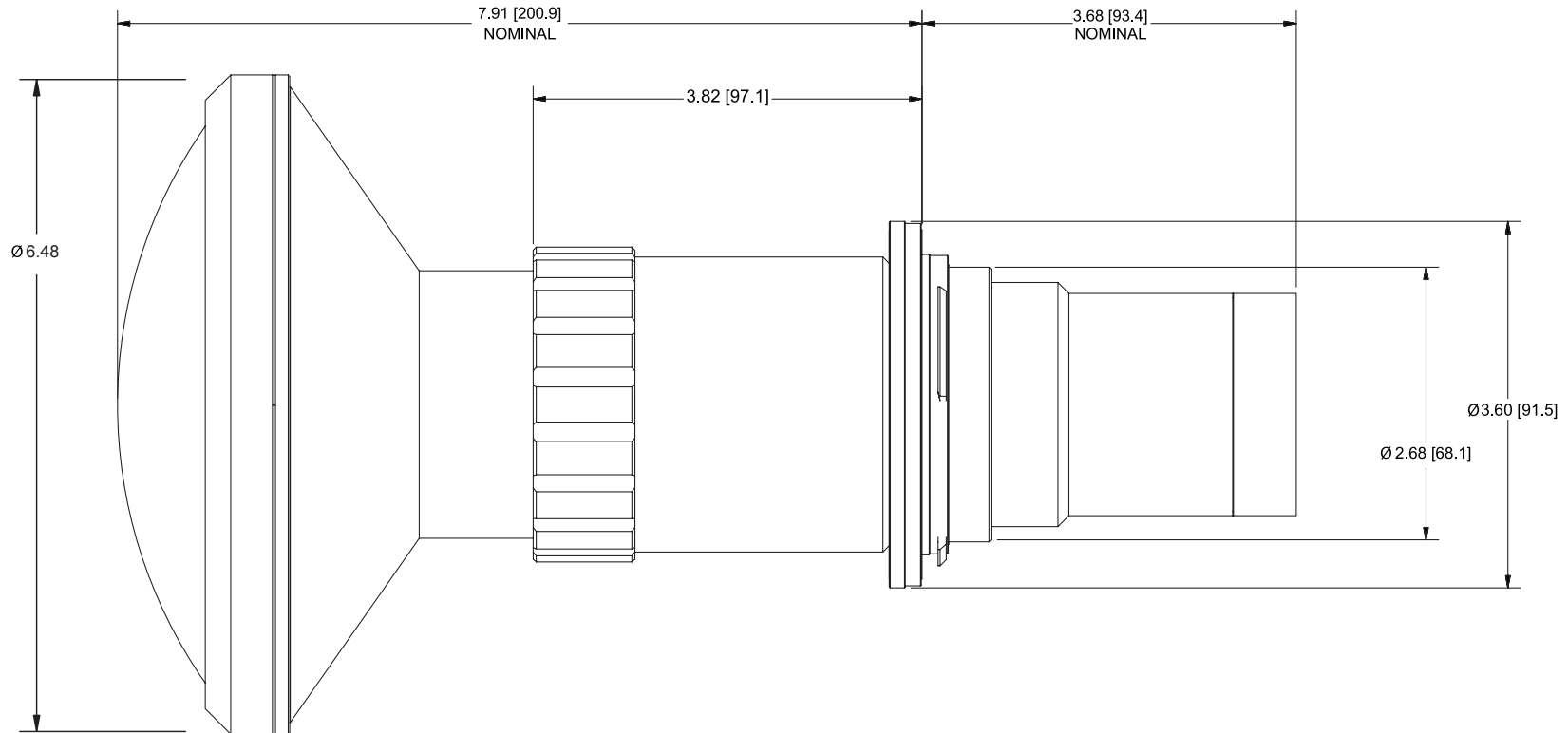
+ Projector brightness is stated for reference only, it is not representative a maximum lens brightness rating.

**I-24106 includes the projector mounting plate. The drawing can be found on www.navitar.com.



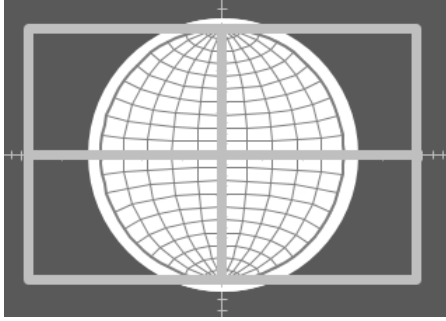
HemiStar HS4 I

Projection Angle Chart																
Display Type		Resolution			Panel Size (mm)			# Pixels Projected				Projection Angles (°)		Shift		
Dome Lens		H	V	Pixel Pitch (μm)	H	V	Diag.	H	V	@ 180°	Mpixel Count	H	V	H +/-%	V +/-%	V Angle +/-°
Original Panel 0.90" WQXGA		2560	1600	7.56	19.354	12.096	22.823	1714	1600	1609	2.01	195.2	179.1	0%	4%	8.1
Alternate Panels	0.96" WUXGA	1920	1200	10.8	20.736	12.960	24.453	1200	1200	1126	1.13	195.2	195.2	0%	0%	0.0
	0.94" HD1080	1920	1080	10.8	20.736	11.664	23.791	1200	1080	1126	0.92	195.2	171.7	0%	6%	11.8
	0.94" SXGA+	1400	1050	13.68	19.152	14.364	23.940	947	947	889	0.70	195.2	195.2	0%	0%	0.0
Partial Dome	0.76" 3LCD WUXGA	1920	1200	8.5	16.320	10.200	19.245	1525	1200	1431	1.13	195.2	148.1	0%	14%	23.6
	0.74" 3LCD 1080p	1920	1080	8.5	16.320	9.180	18.725	1525	1080	1431	0.92	195.2	132.7	0%	21%	31.3
	0.67" WUXGA	1920	1200	7.56	14.515	9.072	17.117	1714	1200	1609	1.13	195.2	131.1	0%	21%	32.1
	0.66" HD1080	1920	1080	7.56	14.515	8.165	16.654	1714	1080	1609	0.92	195.2	117.7	0%	29%	38.8
	0.61" 3LCD 1080p	1920	1080	7.03	13.498	7.592	15.486	1844	1080	1730	0.92	195.2	109.3	0%	35%	43.0



Panel Usage

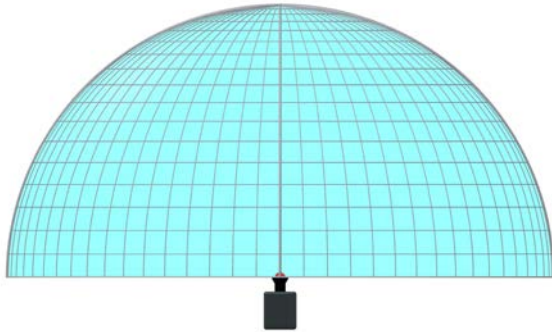
Active Image on Projector Panel



The illustration shows the active pixels used to project a hemisphere. A full hemisphere is projected as a circle of (active) pixels. The grid shows optimal brightness and resolution uniformity is achieved by distributing pixels evenly onto the dome.

On-Screen Projection

Active Image on Screen



The illustration shows the projected image against a 5° azimuth-elevation grid. The projector is positioned at dome center and uniformly casts a hemispherical beam to the screen.

Lens Specifications

Focal Length	4.08mm	MTF Center	65% @ 66 lp/mm
Image Circle	12.96mm	MTF Edge	35% @ 66 lp/mm
Max Half-Angle	97.6°	Lateral Color R-G	< 5µm
F/#	F/3	Lateral Color B-G	< 2µm
Focus Range	800mm – Inf.	F-Theta Distortion	-5.7% Max
Transmittance	>71%	Relative Illum.	>95%
Back Focus	Suitable for 0.95” single-chip DLP and 3LCD.		

HS4 I - Model Numbers

Navitar Part #*	Projector	Resolution	Brightness ⁺
I-22388	DP mVision	1080p, WUXGA	1,000
I-22027	Barco F32	SXGA+, 1080p, WUXGA	8,000
I-22027	Barco F35	1080p, WUXGA, WQXGA	7,500
I-22027	DP dVision 35	1080p, WUXGA, WQXGA	7,500
TBD	Barco F90	WQXGA, WUXGA, 4K UHD	11,800
TBD	Norxe PI	WQXGA	4,000
I-26667	Christie D13WU-HS	1080p, WUXGA	13,000

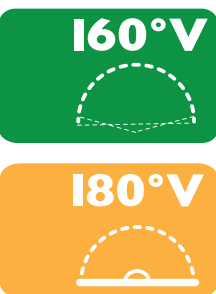
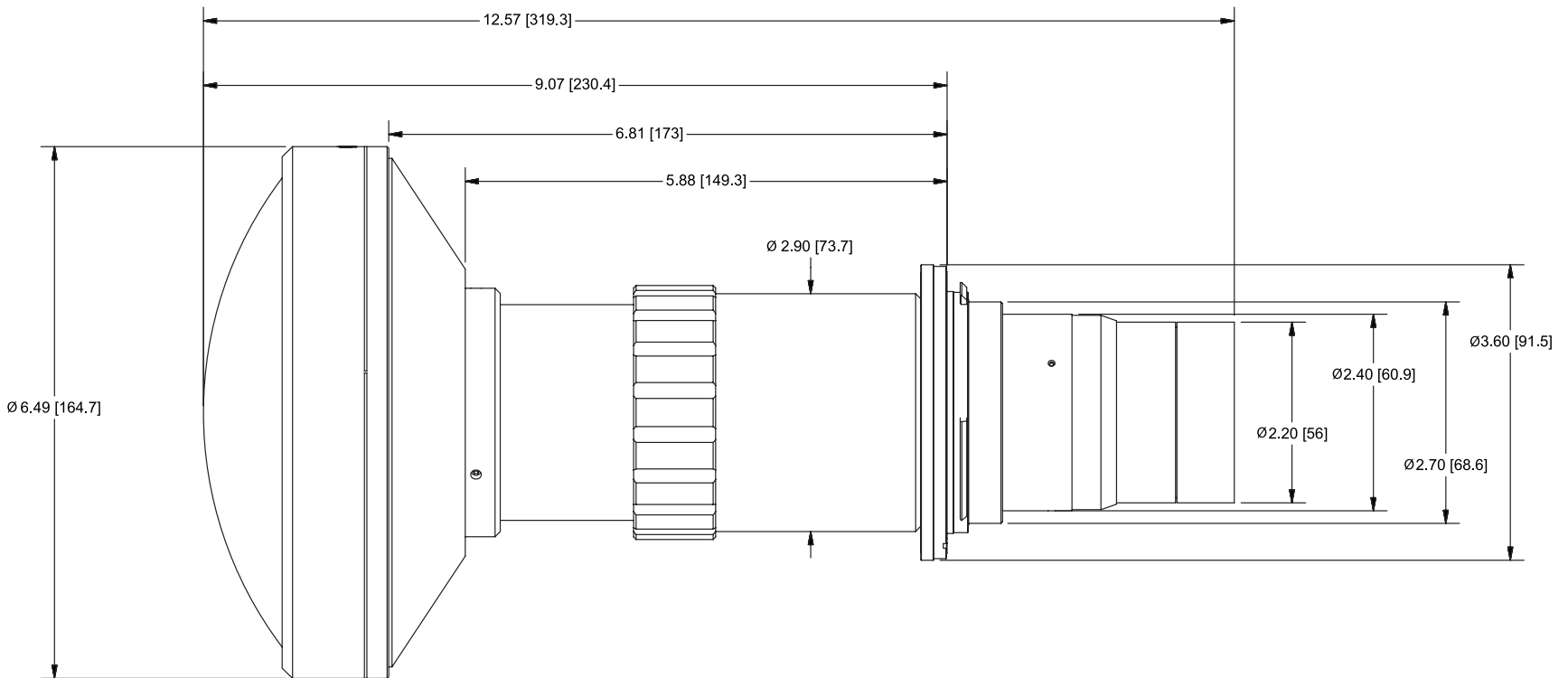
* Part numbers vary depending on projector manufacturer and model

+ Projector brightness is stated for reference only, it is not representative a maximum lens brightness rating.



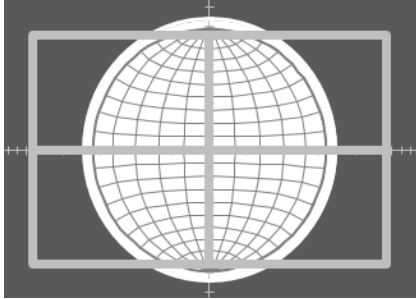
HemiStar HS45

Projection Angle Chart																
Display Type		Resolution			Panel Size (mm)			# Pixels Projected				Projection Angles (°)		Shift		
Dome Lens		H	V	Pixel Pitch (µm)	H	V	Diag.	H	V	@ 180°	Mpixel Count	H	V	H +/-%	V +/-%	V Angle +/-°
Original Panel 0.90" WQXGA		2560	1600	7.56	19.354	12.096	22.823	1831	1600	1781	2.01	185.8	160.2	0%	7%	12.9
Alternate Panels	0.96" WUXGA	1920	1200	10.8	20.736	12.960	24.453	1281	1200	1247	1.13	185.8	172.8	0%	3%	6.6
	0.94" HD1080	1920	1080	10.8	20.736	11.664	23.791	1281	1080	1247	0.92	185.8	154.0	0%	9%	16.0
	0.94" SXGA+	1400	1050	13.68	19.152	14.364	23.940	1012	1012	984	0.80	185.8	185.8	0%	0%	0.1
Partial Dome	0.76" 3LCD WUXGA	1920	1200	8.5	16.320	10.200	19.245	1628	1200	1584	1.13	185.8	133.5	0%	18%	26.3
	0.74" 3LCD 1080p	1920	1080	8.5	16.320	9.180	18.725	1628	1080	1584	0.92	185.8	119.5	0%	25%	33.3
	0.67" WUXGA	1920	1200	7.56	14.515	9.072	17.117	1831	1200	1781	1.13	185.8	118.0	0%	26%	34.0
	0.66" HD1080	1920	1080	7.56	14.515	8.165	16.654	1831	1080	1781	0.92	185.8	105.8	0%	35%	40.1
	0.61" 3LCD 1080p	1920	1080	7.03	13.498	7.592	15.486	1920	1080	1915	0.92	180.7	98.1	1%	41%	43.9



Panel Usage

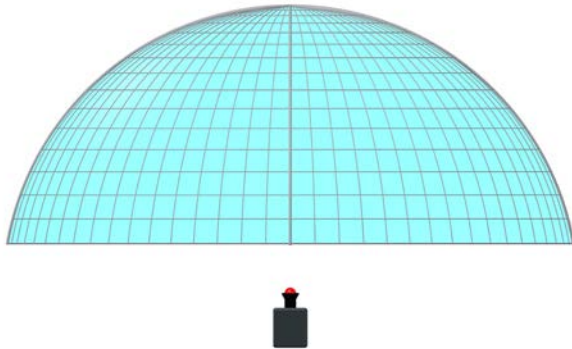
Active Image on Projector Panel



The illustration shows the active pixels used to project a hemisphere. A full hemisphere is projected as a circle of (active) pixels. The grid shows optimal brightness and resolution uniformity is achieved by distributing pixels evenly onto the dome.

On-Screen Projection

Active Image on Screen



The illustration shows the projected image against a 5° azimuth-elevation grid. The projector is positioned at dome center and uniformly casts a hemispherical beam to the screen.

Lens Specifications

Focal Length	4.5mm	MTF Center	70% @ 66 lp/mm
Image Circle	13.84mm	MTF Edge	40% @ 66 lp/mm
Max Half-Angle	93°	Lateral Color R-G	< 3.4µm
F/#	F/2.5	Lateral Color B-G	< 3.6µm
Focus Range	800mm – Inf.	F-Theta Distortion	-5% Max
Transmittance	80%	Relative Illum.	95%
Back Focus	Suitable for 0.95" single-chip DLP and 3LCD.		

HS45 - Model Numbers

Navitar Part #*	Projector	Resolution	Brightness ⁺
I-22882	Barco F32	SXGA+, 1080p, WUXGA	8,000
I-22882	Barco F35	1080p, WUXGA, WQXGA	7,500
I-22882	DP dVision 35	1080p, WUXGA, WQXGA	7,500
TBD	Barco F90	WUXGA, WQXGA, 4K UHD	11,800
TBD	Norxe PI	WQXGA	4,000
I-26668	Christie D13WU-HS	1080p, WUXGA	13,000

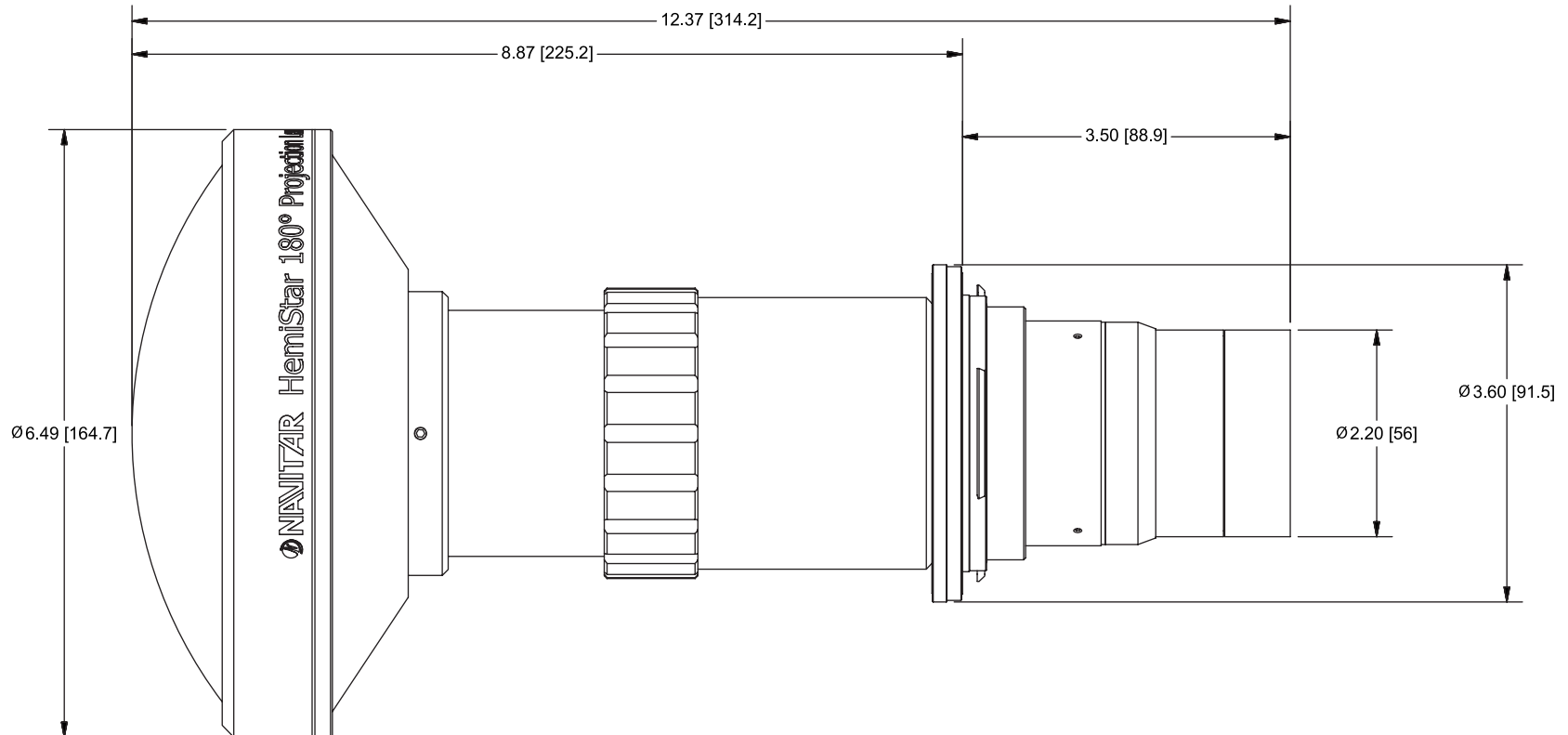
* Part numbers vary depending on projector manufacturer and model

+ Projector brightness is stated for reference only, it is not representative a maximum lens brightness rating.



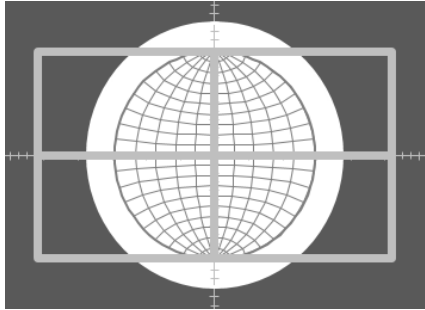
HemiStar HS48

Projection Angle Chart																
Display Type		Resolution			Panel Size (mm)			# Pixels Projected				Projection Angles (°)		Shift		
Dome Lens		H	V	Pixel Pitch (µm)	H	V	Diag.	H	V	@ 180°	Mpixel Count	H	V	H +/-%	V +/-%	V Angle +/-°
Original Panels	0.96" WUXGA	1920	1200	10.8	20.736	12.960	24.453	1377	1200	1338	1.13	185.9	160.2	0%	7%	12.9
	0.94" SXGA+	1400	1050	13.68	19.152	14.364	23.940	1087	1050	1056	0.87	185.9	179.0	0%	2%	3.5
Alternate Panels	0.94" HD1080	1920	1080	10.8	20.736	11.664	23.791	1377	1080	1338	0.92	185.9	143.2	0%	14%	21.4
	0.90" WQXGA	1920	1600	7.56	19.354	12.096	22.823	1967	1600	1911	2.01	185.9	148.8	0%	11%	18.6
Partial Dome	0.76" 3LCD WUXGA	1920	1200	8.5	16.320	10.200	19.245	1749	1200	1700	1.13	185.9	124.4	0%	23%	30.8
	0.74" 3LCD 1080p	1920	1080	8.5	16.320	9.180	18.725	1749	1080	1700	0.92	185.9	111.5	0%	31%	37.3
	0.67" WUXGA	1920	1200	7.56	14.515	9.072	17.117	1920	1200	1911	1.13	181.0	110.1	1%	32%	37.9
	0.66" HD1080	1920	1080	7.56	14.515	8.165	16.654	1920	1080	1911	0.92	181.0	98.8	1%	41%	43.6
	0.61" 3LCD 1080p	1920	1080	7.03	13.498	7.592	15.486	1920	1080	2056	0.92	167.3	98.1	5%	48%	47.1



Panel Usage

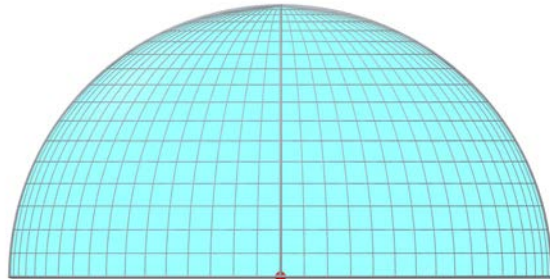
Active Image on Projector Panel



The illustration shows the active pixels used to project a hemisphere. A full hemisphere is projected as a circle of (active) pixels. This is a single channel example of the HS48 projecting a 0.90" WQXGA panel.

On-Screen Projection

Active Image on Screen



The illustration shows the projected image against a 5° azimuth-elevation grid. The projector is positioned at dome center and uniformly casts a hemispherical beam to the screen.

Lens Specifications

Focal Length	4.8mm	MTF Center	72% @ 66 lp/mm
Image Circle	14.868mm	MTF Edge	45% @ 66 lp/mm
Max Half-Angle	93°	Lateral Color R-G	< 3.6µm
F/#	F/2.5	Lateral Color B-G	< 4.4µm
Focus Range	800mm – Inf.	F-Theta Distortion	-4% Max
Transmittance	80%	Relative Illum.	95%
Back Focus	Suitable for 0.95" single-chip DLP and 3LCD.		

HS48 - Model Numbers

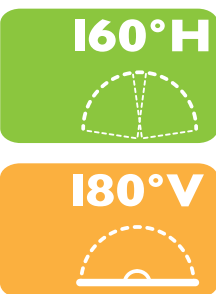
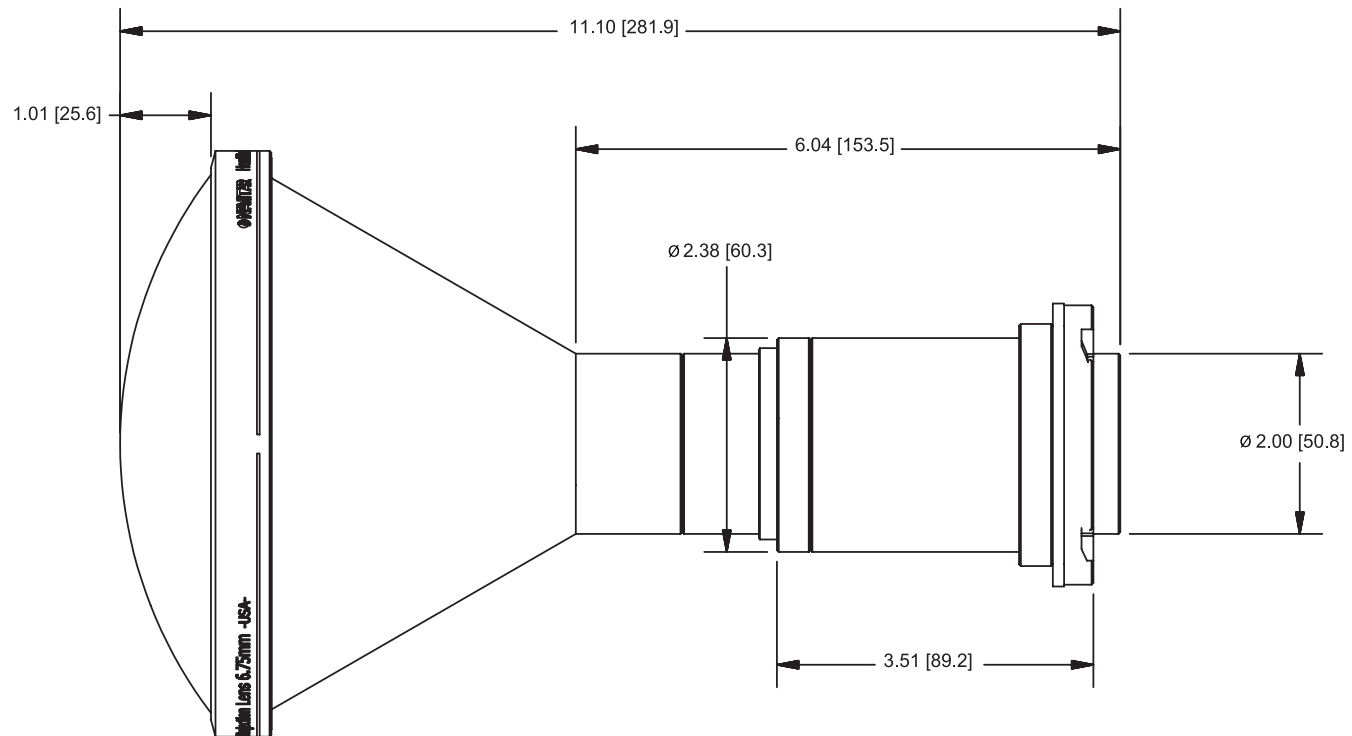
Navitar Part #*	Projector	Resolution	Brightness ⁺
I-2288I	Barco F32	SXGA+, 1080p, WUXGA	8,000
I-2288I	Barco F35	1080p, WUXGA, WQXGA	7,500
I-2288I	DP dVision 35	1080p, WUXGA, WQXGA	7,500
TBD	Barco F90	WUXGA, WQXGA, 4K UHD	11,800
TBD	Norxe PI	WQXGA	4,000
I-26669	Christie DI3WU-HS	1080p, WUXGA	11,000

* Part numbers vary depending on projector manufacturer and model
 + Projector brightness is stated for reference only, it is not representative a maximum lens brightness rating.



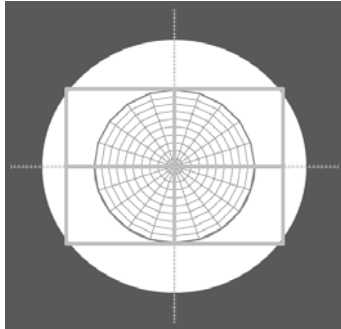
HemiStar HS68

Projection Angle Chart																	
Display Type		Resolution			Panel Size (mm)			# Pixels Projected				Projection Angles (°)			Shift		
Dome Lens		H	V	Pixel Pitch (μm)	H	V	Diag.	H	V	@180°	Mpixel Count	H	V	TR Equiv.	H +/-%	V +/-%	V Angle +/-°
Original Panel 1.3" XGA		1024	768	25.8	26.419	19.814	33.024	771	768	771	0.46	180.0	179.0	—	0%	0%	0.0
Partial Domes	1.2" 1080p	1920	1080	13.8	26.496	14.904	30.400	1442	1080	1442	0.92	180.0	130.2	—	0%	17%	24.9
	0.96" WUXGA	1920	1200	10.8	20.736	12.960	24.453	1843	1200	1843	1.13	180.0	112.7	—	0%	27%	33.6
	0.95" LCD WUXGA	1920	1200	10.65	20.448	12.780	24.113	1869	1200	1869	1.13	180.0	111.1	—	0%	28%	34.4
	0.94" HDI080	1920	1080	10.8	20.736	11.664	23.791	1843	1080	1843	0.92	180.0	101.3	—	0%	35%	39.4
	0.94" SXGA+	1400	1050	13.68	19.152	14.364	23.940	1400	1050	1455	0.87	171.7	125.3	—	2%	19%	27.4
	0.90" WQXGA	2560	1600	7.56	19.354	12.096	22.823	2560	1600	2633	2.01	173.9	105.1	—	1%	32%	37.5
	0.76" WUXGA	1920	1200	8.5	16.320	10.200	19.245	1920	1200	—	1.13	143.3	88.4	0.166	11%	48%	45.8
	0.67" WUXGA	1920	1200	7.56	14.515	9.072	17.117	1920	1200	—	1.13	126.6	78.6	0.251	19%	60%	50.7
0.66" HDI080	1920	1080	7.56	14.515	8.165	16.654	1920	1080	—	0.92	126.6	70.7	0.251	19%	72%	54.7	



Panel Usage

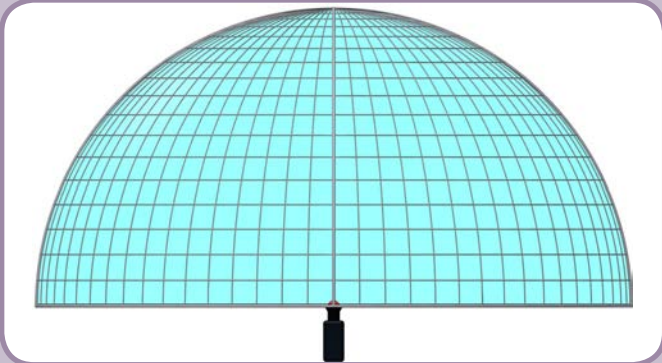
Active Image on Projector Panel



The illustration shows the active pixels used to project a hemisphere. A full hemisphere is projected as a circle of (active) pixels. This is a single channel example of the HS68 projecting a 1.3" XGA panel.

On-Screen Projection

Active Image on Screen



The illustration shows the projected image against a 5° azimuth-elevation grid. The projector is positioned at dome center and uniformly casts a hemispherical beam to the screen.

Lens Specifications

Focal Length	6.75mm	MTF Center	55% @ 46 lp/mm
Image Circle	19.882mm	MTF Edge	20% @ 46 lp/mm
Max Half-Angle	90°	Lateral Color R-G	< 7µm
F/#	F/3	Lateral Color B-G	< 9µm
Focus Range	800mm – Inf.	F-Theta Distortion	-5.7% Max
Transmittance	>82%	Relative Illum.	95%
Back Focus	Suitable for 0.95" single-chip DLP and 3LCD.		

HS68 - Model Numbers

Navitar Part #*	Projector	Resolution	Brightness ⁺
I-19306	Barco F32	SXGA+, 1080p, WUXGA	8,000
I-19306	Barco F35	1080p, WUXGA, WQXGA	7,500
I-19306	DP dVision 35	1080p, WUXGA, WQXGA	7,500
TBD	Barco F90	WUXGA, WQXGA, 4K UHD	11,800
I-19004	Christie LX700/650	XGA	7,000
I-19004	Eiki LC X85	XGA	7,000

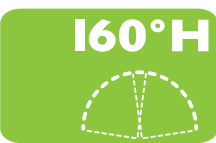
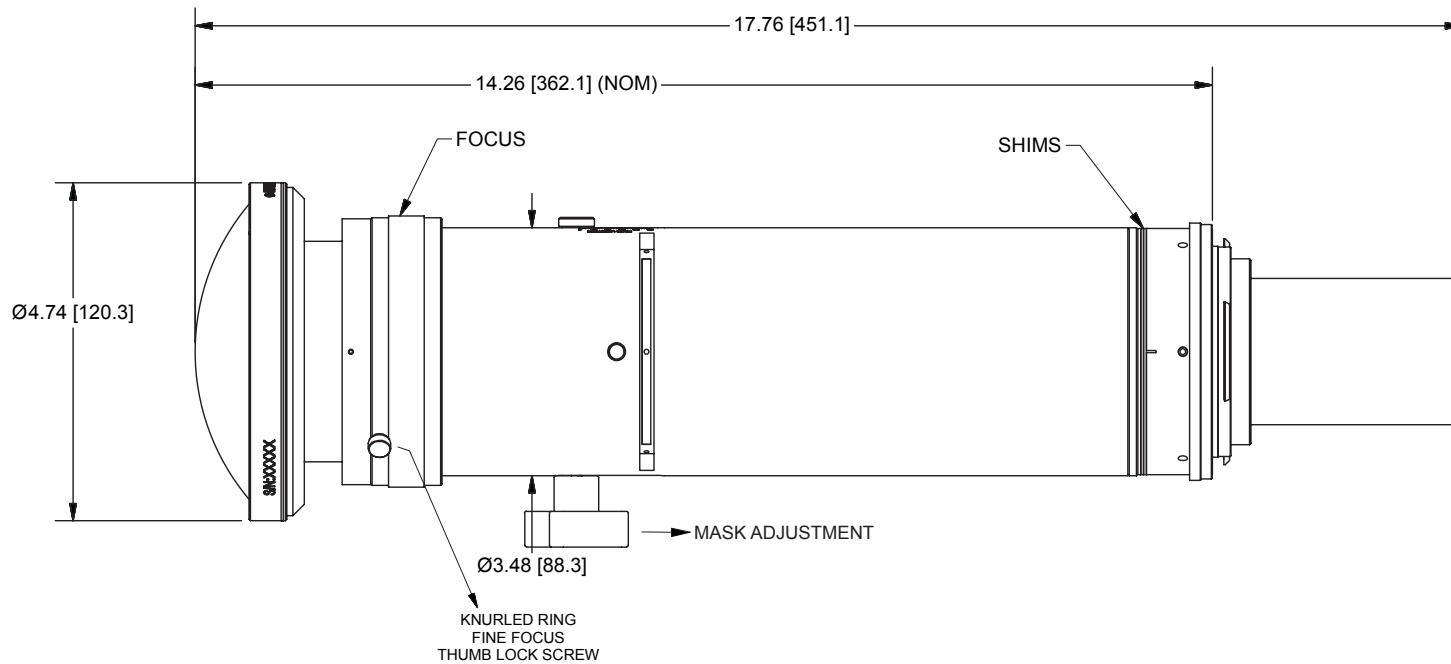
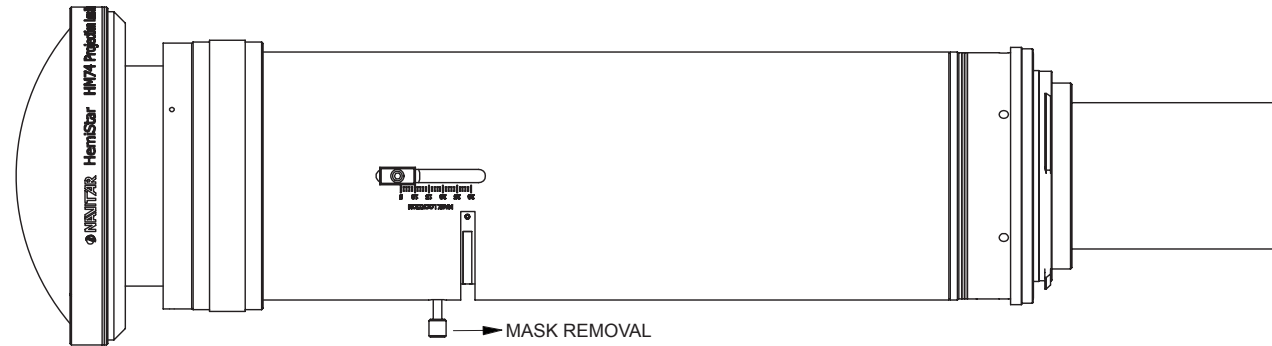
* Part numbers vary depending on projector manufacturer and model

+ Projector brightness is stated for reference only, it is not representative a maximum lens brightness rating.



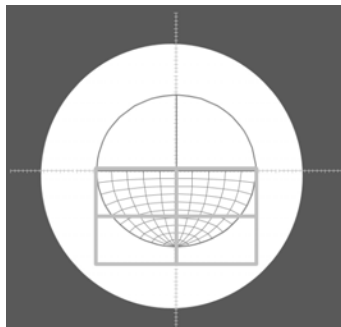
HemiStar HM74

Projection Angle Chart														
Display Type	Resolution			Panel Size (mm)			# Pixels Projected			Projection Angles (°) *			Shift	
Dome Lens	H	V	Pixel Pitch (µm)	H	V	Diag.	H	V	Mpixel Count	H	V	Diag.	V +/-%	V Angle +/-°
Original Panel 0.90" WQXGA DLP	2560	1600	7.56	19.354	12.096	22.823	2560	1600	4.10	160.1	95.1	180.0	37%	41.9



Panel Usage

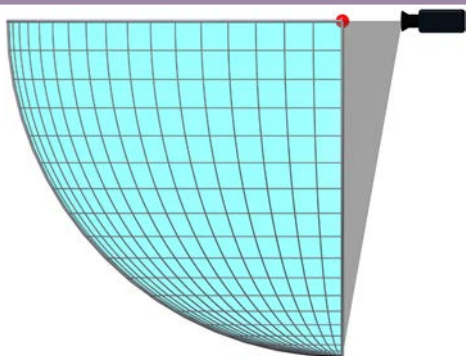
Active Image on Projector Panel



The illustration shows the active pixels used to project a hemisphere. A full hemisphere is projected as a circle of (active) pixels. This is a single channel example of the HM74 projecting a 0.90" WQXGA panel.

On-Screen Projection

Active Image on Screen



The illustration shows the projected image against a 5° azimuth-elevation grid. The projector is positioned at dome center and uniformly casts a hemispherical beam to the screen.

Lens Specifications

Focal Length	7.4mm	MTF Center	62% @ 66 lp/mm
Image Circle	24.453mm	MTF Edge	40% @ 66 lp/mm
Max Half-Angle	90°	Lateral Color R-G	< 4µm
F/#	F/2.5	Lateral Color B-G	< 4µm
Focus Range	1m – Inf.	F-Theta Distortion	-10% Max
Transmittance	82%	Relative Illum.	>93%
Back Focus	single-chip DLP or 3LCD		

HM74 - Model Numbers

Navitar Part #*	Projector	Resolution	Brightness ⁺
I-25372	Barco F35	1080p, WUXGA, WQXGA	7,500
I-25372	DP dVision 53	1080p, WUXGA, WQXGA	7,500
TBD	Barco F70	WUXGA, WQXGA, 4K UHD	11,800
TBD	Barco F90	WUXGA, WQXGA, 4K UHD	11,800
TBD	Norxe PI	WQXGA	4,000
I-26670	Christie DI3WU-HS	1080p, WUXGA	13,000

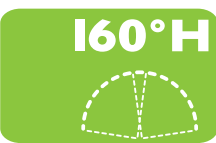
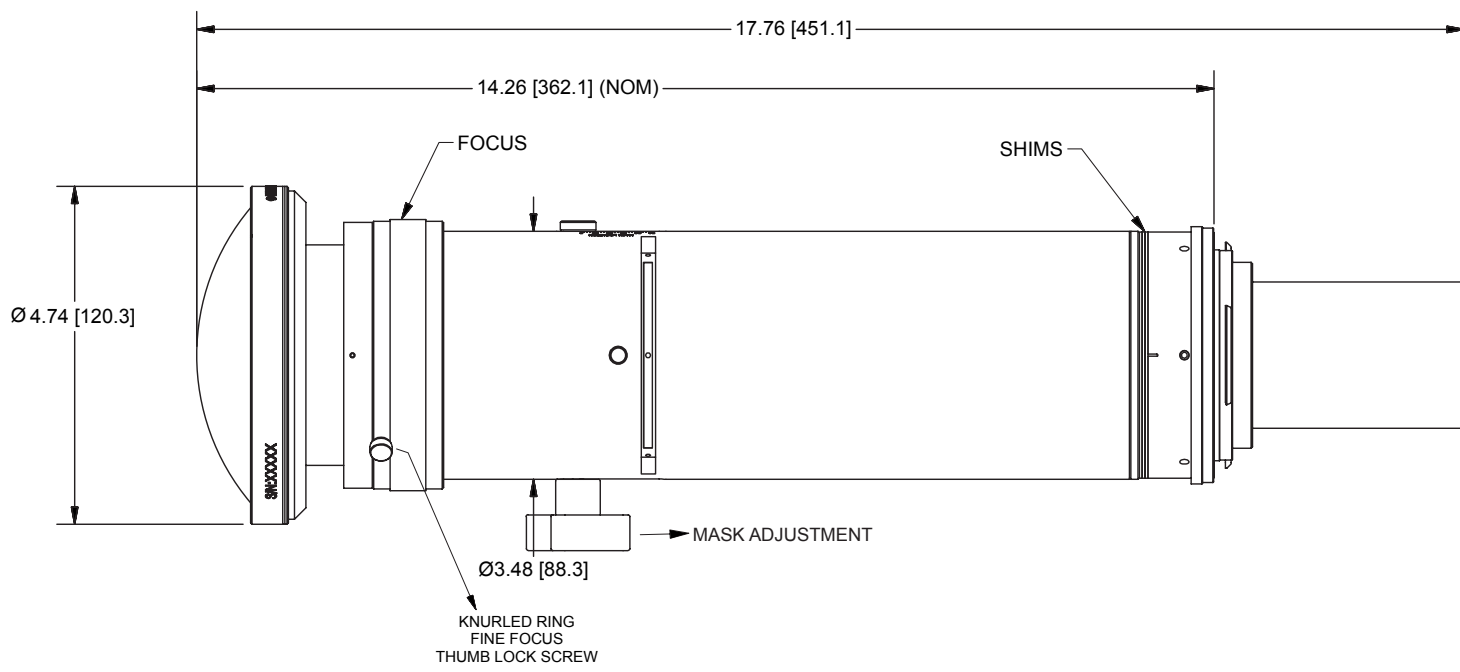
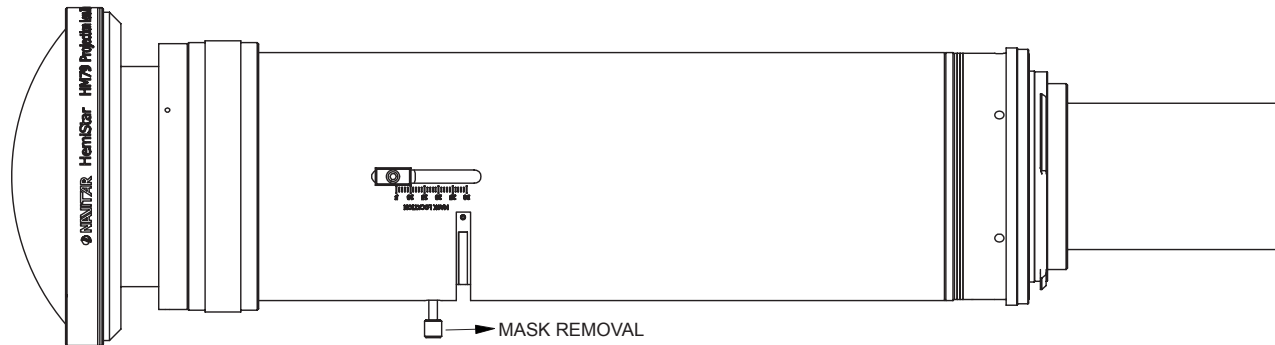
* Part numbers vary depending on projector manufacturer and model

+ Projector brightness is stated for reference only, it is not representative a maximum lens brightness rating.



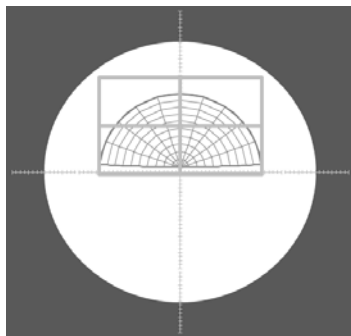
HemiStar HM79

Projection Angle Chart															
Display Type		Resolution			Panel Size (mm)			# Pixels Projected			Projection Angles (°) *			Shift	
Dome Lens		H	V	Pixel Pitch (µm)	H	V	Diag.	H	V	Mpixel Count	H	V	Diag.	V +/-%	V Angle +/-°
Original Panel	0.96" WUXGA DLP	1920	1200	10.8	20.736	12.960	24.453	1920	1200	2.30	160.1	95.1	180.0	37%	41.9



Panel Usage

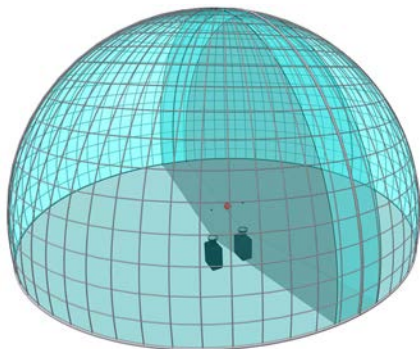
Active Image on Projector Panel



The illustration shows the active pixels used to project a hemisphere. A full hemisphere is projected as a circle of (active) pixels. This is a dual channel example of the HM79 projecting two 0.96" WUXGA panels.

On-Screen Projection

Active Image on Screen



The illustration shows the projected image against a 5° azimuth-elevation grid. The projector is positioned at dome center and uniformly casts a hemispherical beam to the screen.

Lens Specifications

Focal Length	7.9mm	MTF Center	68% @ 66 lp/mm
Image Circle	22.823mm	MTF Edge	50% @ 66 lp/mm
Max Half-Angle	90°	Lateral Color R-G	< 4µm
F/#	F/2.5	Lateral Color B-G	< 4µm
Focus Range	1m – Inf.	F-Theta Distortion	-9.5% Max
Transmittance	82%	Relative Illum.	>80%
Back Focus	single-chip DLP or 3LCD		

HM79 - Model Numbers

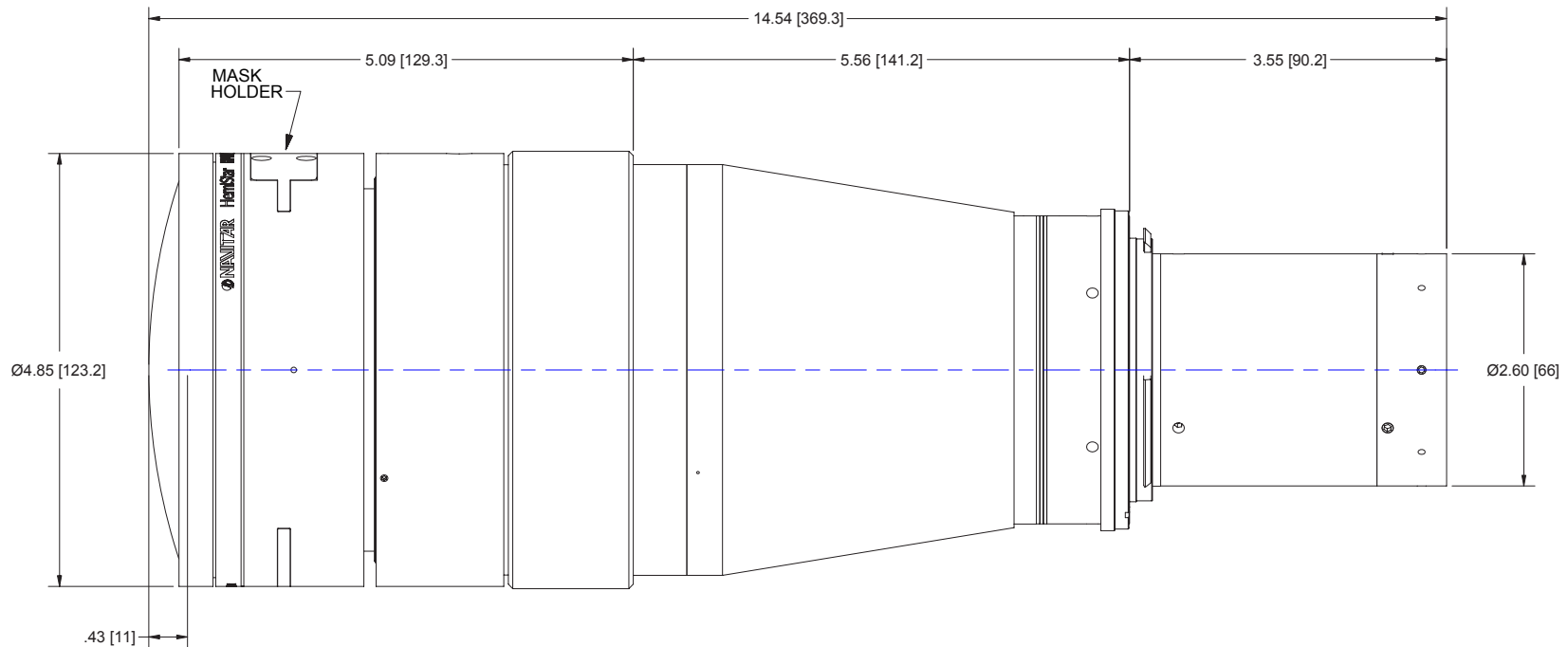
Navitar Part #*	Projector	Resolution	Brightness+
I-25371	Barco F35	1080p, WUXGA, WQXGA	7,500
I-25371	DP dVision 35	1080p, WUXGA / WQXGA	7,500
TBD	Barco F70	WUXGA, WQXGA, 4K UHD	11,800
TBD	Barco F90	WUXGA, WQXGA, 4K UHD	11,800
I-26671	Christie D13WU-HS	1080p, WUXGA	13,000

* Part numbers vary depending on projector manufacturer and model
 + Projector brightness is stated for reference only, it is not representative a maximum lens brightness rating.



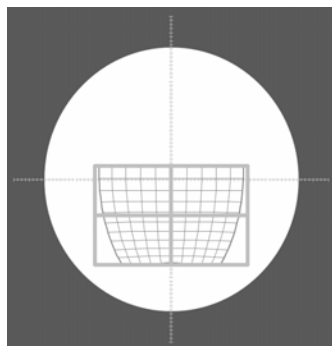
HemiStar HMI 17

Projection Angle Chart																	
Display Type		Resolution			Panel Size (mm)			# Pixels Projected			Projection Angles (°)				Shift		
Dome Lens		H	V	Pixel Pitch (µm)	H	V	Diag.	H	V	Mpixel Count	H	V	Diag.	TR Equiv.	H +/-%	V +/-%	V Angle +/-°
Original Panel 0.90" WQXGA		2560	1600	7.56	19.354	12.096	22.823	2560	1600	4.10	99.9	60.4	120.4	0.42	5%	12%	7.5
Alternate Panels	0.96" WUXGA	1920	1200	10.8	20.736	12.960	24.453	1920	1200	2.30	108.0	64.9	130.5	0.36	0%	0%	0.0
	0.94" HD1080	1920	1080	10.8	20.736	11.664	23.791	1920	1080	2.07	108.0	58.2	126.4	0.36	2%	6%	3.4
	0.94" SXGA+	1400	1050	13.68	19.152	14.364	23.940	1400	1050	1.47	98.8	72.4	127.3	0.43	2%	3%	2.3
Wide Angle Fisheye	0.76" WUXGA	1920	1200	8.5	16.320	10.200	19.245	1920	1200	2.30	83.0	50.7	99.3	0.57	18%	39%	21.4
	0.67" WUXGA	1920	1200	7.56	14.515	9.072	17.117	1920	1200	2.30	73.2	44.9	87.3	0.67	28%	58%	28.4
	0.66" HD1080	1920	1080	7.56	14.515	8.165	16.654	1920	1080	2.07	73.2	40.4	84.8	0.67	29%	71%	30.7



Panel Usage

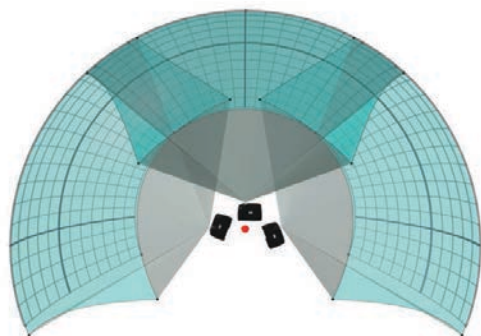
Active Image on Projector Panel



The illustration shows the active pixels used to project a hemisphere. A full hemisphere is projected as a circle of (active) pixels. This multi-channel example shows 3 WQXGA panels (0.90") with shifted HMI 17 lenses.

On-Screen Projection

Active Image on Screen



The layout allows projection forward from the screen center. The steep projection to the base of the screen reduces cockpit shadowing & maximizes downwards FOV from the pilot eyepoint in flight simulation.

Lens Specifications

Focal Length	11.70mm	MTF Center	85% @ 66 lp/mm
Image Circle	24.454mm	MTF Edge	59% @ 66 lp/mm
Max Half-Angle	65.3°	Lateral Color R-G	< 3µm
F/#	F/2.5	Lateral Color B-G	< 2µm
Focus Range	800mm – Inf.	F-Theta Distortion	-9.0% Max
Transmittance	75%	Relative Illum.	>88%
Back Focus	Suitable for 0.95" single-chip DLP and 3LCD.		

HMI 17 - Model Numbers

Navitar Part #*	Projector	Resolution	Brightness ⁺
I-23150	Barco F32	SXGA+, 1080p, WUXGA	8,000
I-23150	Barco F35	1080p, WUXGA, WQXGA	7,500
I-23150	DP dVision 35	1080p, WUXGA, WQXGA	7,500
I-25208	Barco F50	1080p, WUXGA, WQXGA	5,500
I-25208	DP iVision 50	1080p, WUXGA, WQXGA	5,600
TBD	Barco F70	WUXGA, WQXGA, 4K UHD	11,800
TBD	Barco F90	WUXGA, WQXGA, 4K UHD	11,800
TBD	Norxe PI	WQXGA	4,000
I-26666	Christie D13WU-HS	1080p, WUXGA	13,000
I-25723	Christie Mirage WQ-L	WQXGA	800
I-25723	Christie Mirage WU-L	WUXGA	600

* Part numbers vary depending on projector manufacturer and model

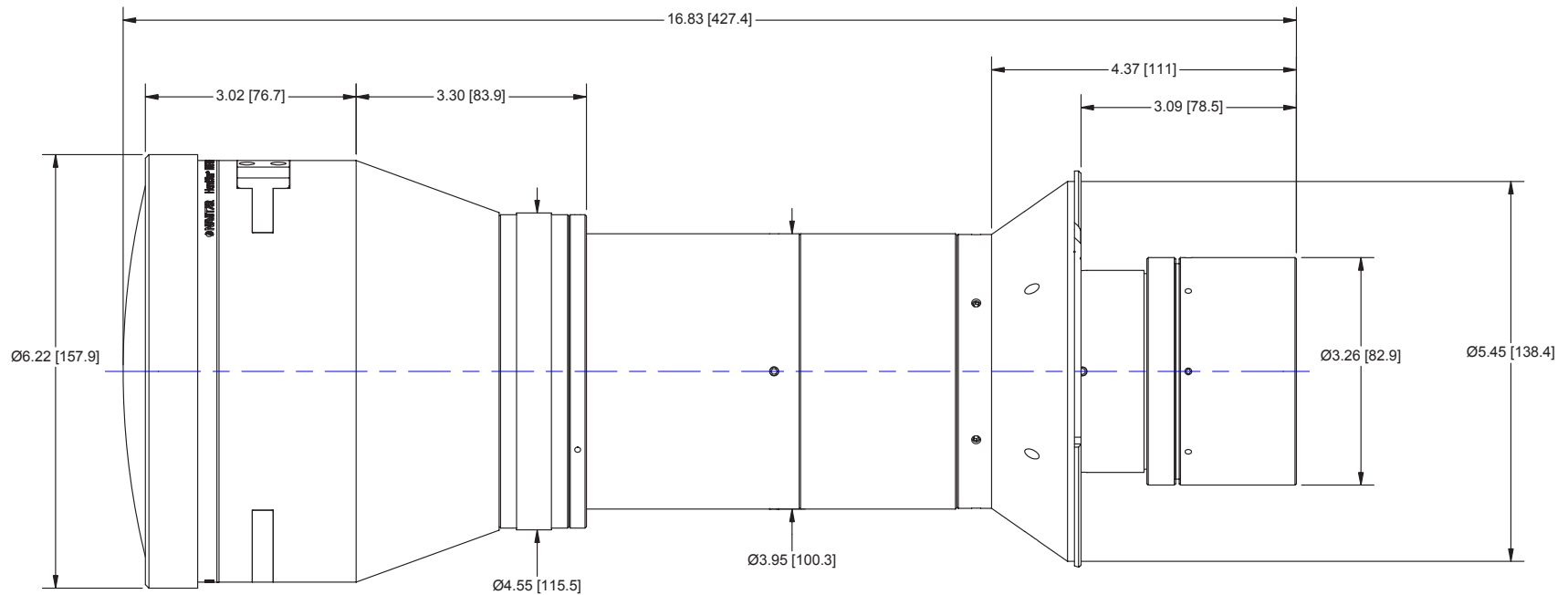
+ Projector brightness is stated for reference only, it is not representative a maximum lens brightness rating.



HemiStar HMT-119

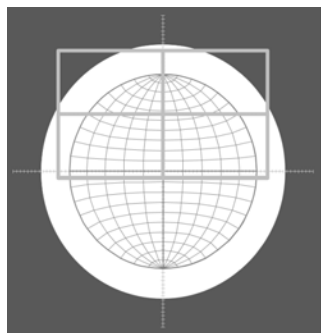
Projection Angle Chart

Display Type		Resolution			Panel Size (mm)			# Pixels Projected			Projection Angles (°)				Shift		
		H	V	Pixel Pitch (µm)	H	V	Diag.	H	V	Mpixel Count	H	V	Diag.	TR Equiv.	H +/-%	V +/-%	V Angle +/-°
Original Panels	0.96" WUXGA	1920	1200	10.80	20.736	12.960	24.453	1920	1200	2.30	105.0	63.7	126.5	0.38	13%	50%	36.2
	0.94" SXGA+	1400	1050	13.68	19.152	14.364	23.940	1400	1050	1.47	96.2	70.8	123.5	0.45	18%	41%	32.6
Alternate Panels	0.85" WXGA	1366	768	13.68	18.687	10.506	21.438	1366	768	1.05	93.7	51.3	108.9	0.47	20%	74%	42.4
	0.94" HD1080	1920	1080	10.8	20.736	11.664	23.791	1920	1080	2.07	105.0	57.1	122.6	0.38	13%	61%	39.5
	0.67" WUXGA	1920	1200	7.56	14.515	9.072	17.117	1920	1200	2.30	71.6	44.1	85.2	0.69	40%	93%	46.0



Panel Usage

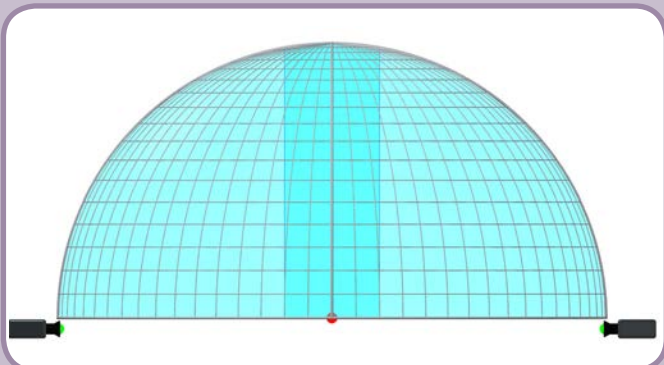
Active Image on Projector Panel



The illustration shows the active pixels used to project a hemisphere. A full hemisphere is projected as a circle of (active) pixels. This is a dual channel example of the HMT-119 projecting a 3-chip 4K 1.38" DLP panel with blend allowance.

On-Screen Projection

Active Image on Screen



The illustration shows the projected image against a 5° azimuth-elevation grid. The projectors are positioned at dome edges and uniformly cast a hemispherical beam to the screen.

Lens Specifications

Focal Length	11.88mm	MTF Center	90% @ 66 lp/mm
Image Circle	26.0mm	MTF Edge	41% @ 66 lp/mm
Max Half-Angle	68°	Lateral Color R-G	< 3.75µm
F/#	F/2.5	Lateral Color B-G	< 3.75µm
Focus Range	4m – Inf.	F-Theta Distortion	-8.5% Max
Transmittance	75%	Relative Illum.	>97%
Back Focus	90.528mm Air Equivalent, suitable for 3 chip WUXGA DLP		

HMT-119 Model Numbers

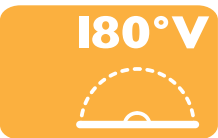
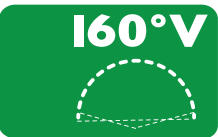
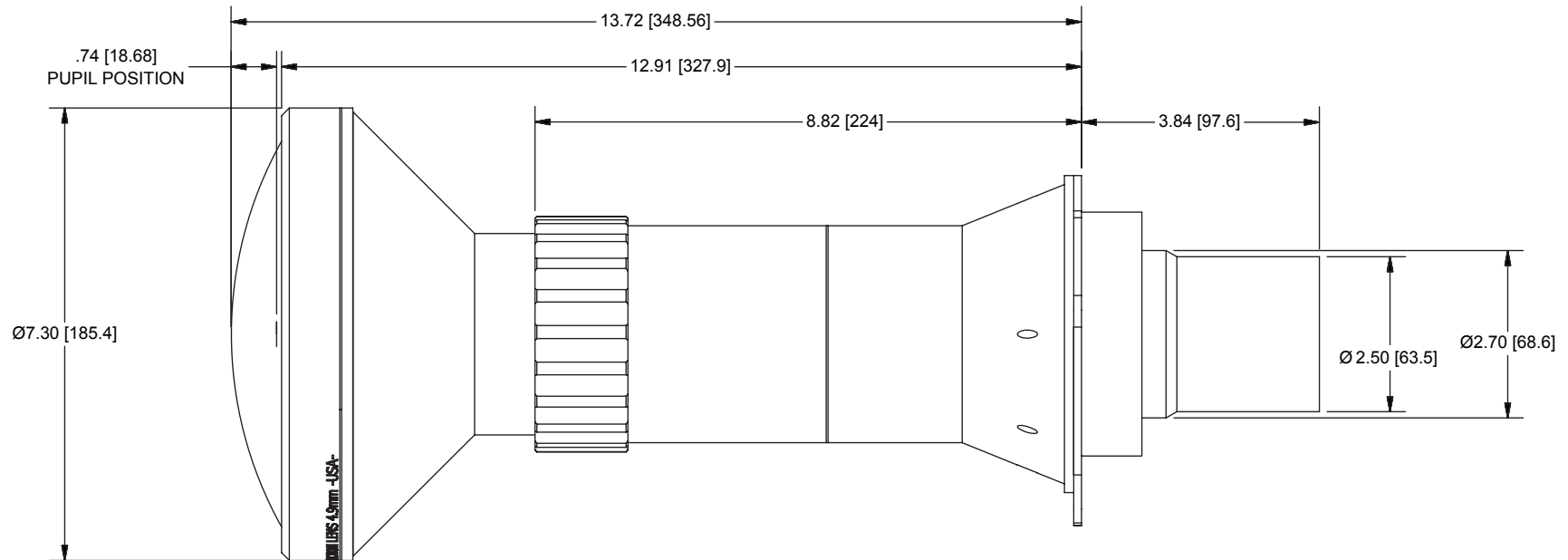
Navitar Part #*	Projector	Resolution	Brightness ⁺
I-25743	Christie Mirage	S+22K-J	20,000
I-25743	Christie WU 14KM	SXGA+, WUXGA	14,000
I-25743	Christie HDI4K-M	1080p	13,500
I-25743	Christie Mirage WU20K-J	WUXGA	18,000
I-25745	Panasonic PT-RZ12	WUXGA	12,000
I-25745	Panasonic PT-DW17K2E	WXGA	17,000
I-25745	Panasonic PT-DZ13K	WUXGA	12,000
I-25745	Panasonic PT-DZ21K2E	WUXGA	20,000
I-25745	Panasonic PT-DZ16KU	1080p	16,000
I-25744	DPTITAN	1080p, WUXGA	20,000
I-25742	Barco HDF-W26	WUXGA	26,000

* Part numbers vary depending on projector manufacturer and model.
⁺ Projector brightness is stated for reference only, it does not represent the maximum lens brightness rating.
 Call a Navitar representative to discuss brightness greater than 15,000. Standard warranty does not apply.



HemiStar HT49

Projection Angle Chart																
Display Type		Resolution			Panel Size (mm)			# Pixels Projected				Projection Angles (°)		Shift		
Dome Lens		H	V	Pixel Pitch (µm)	H	V	Diag.	H	V	@ 180°	Mpixel Count	H	V	H +/-%	V +/-%	V Angle +/-°
Original Panels	0.96" WUXGA	1920	1200	10.8	20.736	12.960	24.453	1352	1200	1322	1.13	185.9	160.0	0%	6%	13.0
	0.94" SXGA+	1400	1050	13.68	19.152	14.364	23.940	1068	1050	1044	0.87	185.9	181.8	0%	1%	2.1
Alternate Panels	0.94" HD1080	1920	1080	10.8	20.736	11.664	23.791	1352	1080	1322	0.92	185.9	142.1	0%	13%	22.0
	0.90" WQXGA	2560	1600	7.3	18.688	11.680	22.038	2001	1600	1956	2.01	185.9	142.3	0%	16%	25%
	0.85" WXGA	1366	768	13.68	18.687	10.506	21.438	1068	768	1044	0.46	185.9	127.0	0%	20%	29.5



Panel Usage

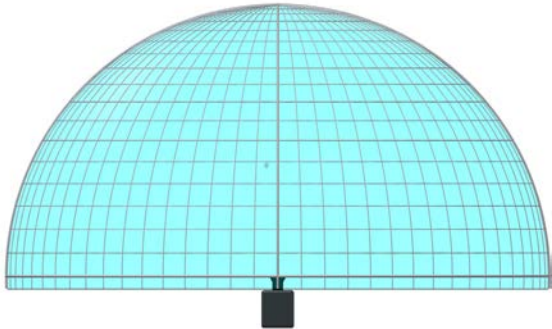
Active Image on Projector Panel



The illustration shows the active pixels used to project a hemisphere. A full hemisphere is projected as a circle of (active) pixels. This is a single channel example of the HT49 projecting a 0.96” WUXGA panel.

On-Screen Projection

Active Image on Screen



The illustration shows the projected image against a 5° azimuth-elevation grid. The projector is positioned at dome center and uniformly casts a hemispherical beam to the screen.

Lens Specifications

Focal Length	4.87mm	MTF Center	73% @ 46 lp/mm
Image Circle	14.606mm	MTF Edge	40% @ 46 lp/mm
Max Half-Angle	93°	Lateral Color R-G	< 5.5µm
F/#	F/3	Lateral Color B-G	< 2.5µm
Focus Range	1m – Inf.	F-Theta Distortion	-8% Max
Transmittance	69%	Relative Illum.	89%
Back Focus	Suitable for 3-chip DLP		

HT49 - Model Numbers

Compatible with most 0.94” & 0.96” 3-Chip DLP® projectors*

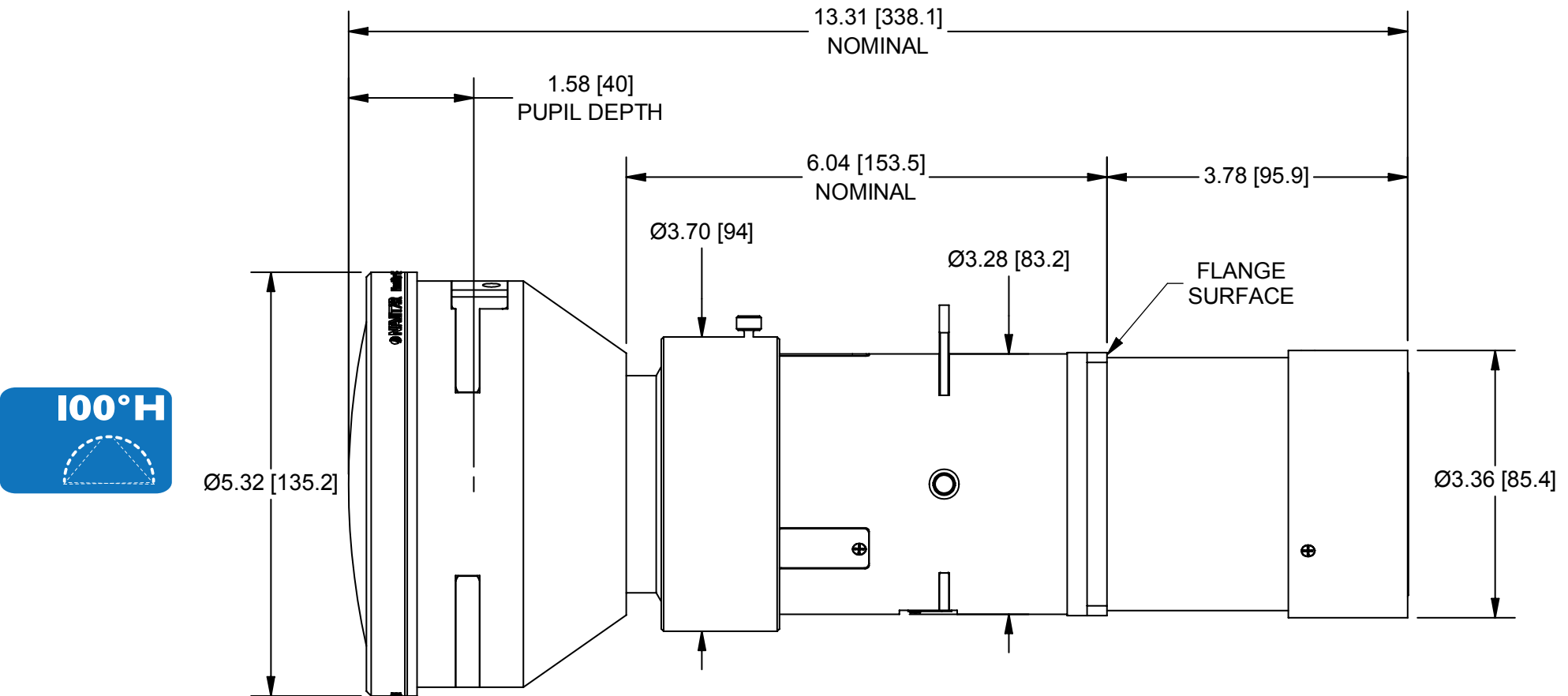
Navitar Part #*	Projector	Resolution	Brightness ⁺
I-22653	Christie Mirage	S+22K-J	20,000
I-22653	Christie WU 14KM	SXGA+, WUXGA	14,000
I-22653	Christie HD14K-M	1080p	13,500
I-22653	Christie Mirage WU20K-J	WUXGA	18,000
I-23058	Panasonic PT-RZ12	WUXGA	12,000
I-23058	Panasonic PT-DW17K2E	WXGA	17,000
I-23058	Panasonic PT-DZ13K	WUXGA	12,000
I-23058	Panasonic PT-DZ21K2E	WUXGA	20,000
I-23058	Panasonic PT-DZ16KU	1080p	16,000

* Part numbers vary depending on projector manufacturer and model
 + Projector brightness is stated for reference only, it is not representative a maximum lens brightness rating.



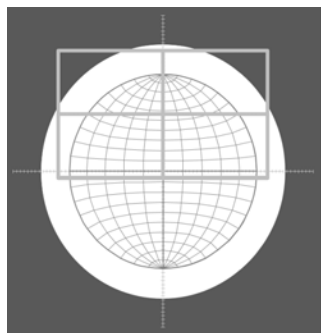
HemiStar HM4K-96

Projection Angle Chart																
Display Type	Resolution			Panel Size (mm)			# Pixels Projected			Projection Angles (°)				Shift		
Dome Lens	H	V	Pixel Pitch (μm)	H	V	Diag.	H	V	Mpixel Count	H	V	Diag.	TR Equiv.	H +/-	V +/-	V Angle +/-°
Sony 0.74" 4K GTZ Series	4096	2160	4.05	16.859	8.748	18.754	4096	2160	8.85	105.1	53.0	120.9	0.38	8%	61%	36.5



Panel Usage

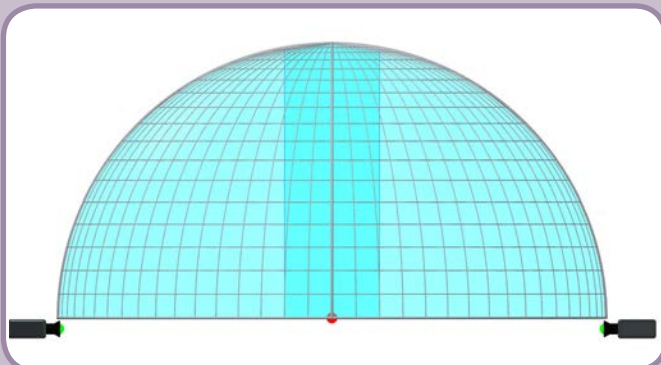
Active Image on Projector Panel



The illustration shows the active pixels used to project a hemisphere. A full hemisphere is projected as a circle of (active) pixels. This is a dual channel example of the HM4K-96 projecting a 0.74 4K chip panel with blend allowance.

On-Screen Projection

Active Image on Screen



The illustration shows the projected image against a 5° azimuth-elevation grid. The projectors are positioned at dome edges and uniformly cast a hemispherical beam to the screen.

Lens Specifications

Focal Length	9.6mm	MTF Center	65% @ 125 lp/mm
Image Circle	19.4mm	MTF Edge	63% @ 125 lp/mm
Max Half-Angle	62.96°	Lateral Color R-G	< 0.7µm
F/#	F/2.4	Lateral Color B-G	< 1.0µm
Focus Range	2m – Inf.	F-Theta Distortion	8.1% Max
Back Focus	77.76mm		

HM4K-96 Model Numbers

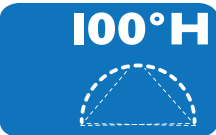
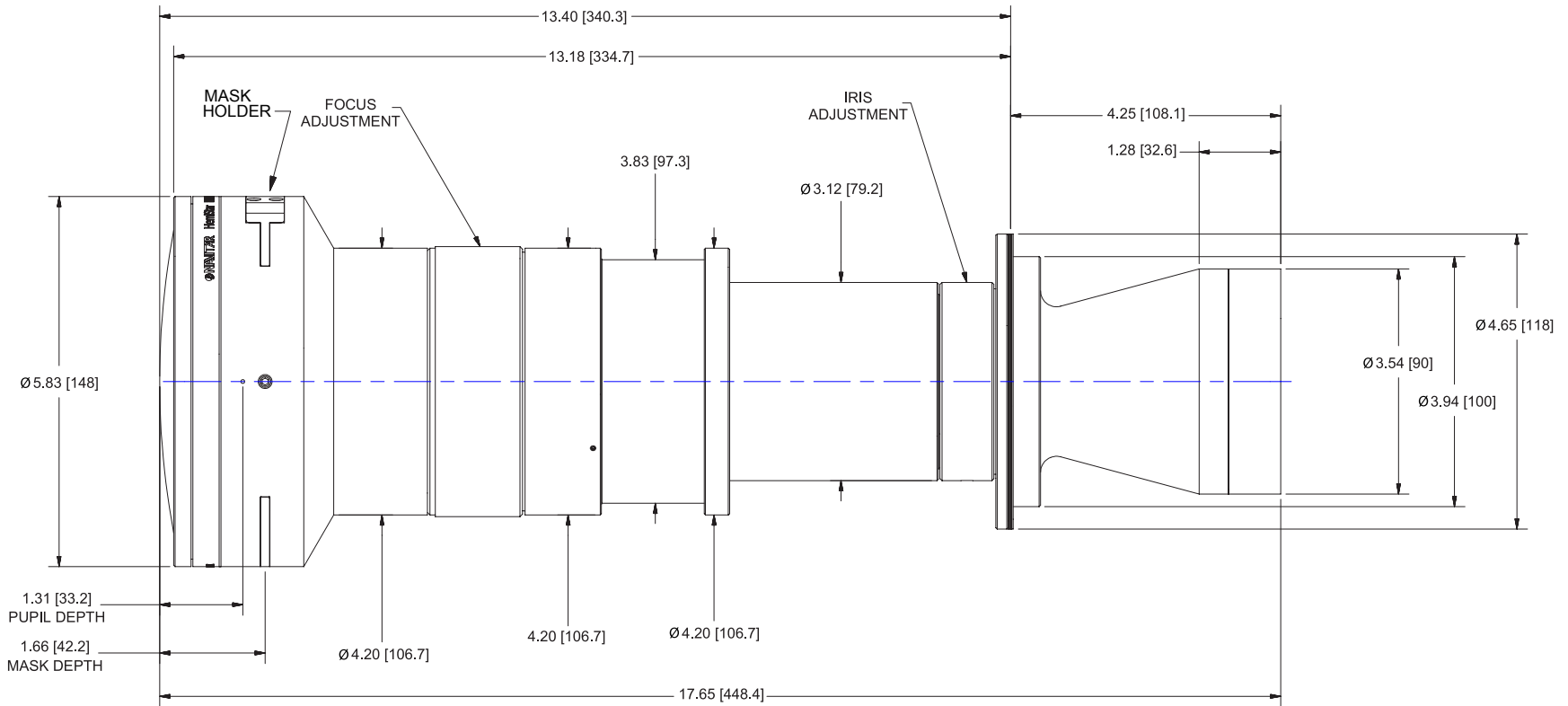
Navitar Part #*	Projector	Resolution	Brightness ⁺
I-26906	Sony VPL-GTZ270	4K SXR	2,000/5,000
I-26906	Sony VPL-GTZ280	4K SXR	2,000/5,000

* Part numbers vary depending on projector manufacturer and model
 + Projector brightness is stated for reference only, it is not representative a maximum lens brightness rating.



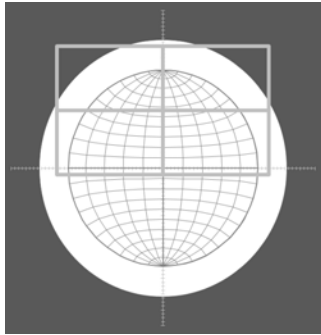
HemiStar HM4K-I68

Projection Angle Chart																
Display Type	Resolution			Panel Size (mm)			# Pixels Projected			Projection Angles (°)				Shift		
Dome Lens	H	V	Pixel Pitch (μm)	H	V	Diag.	H	V	Mpixel Count	H	V	Diag.	TR Equiv.	H +/-%	V +/-%	V Angle +/-°
Original Panel 1.38" JVC LCoS	4096	2400	6.8	27.853	16.320	32.282	4096	2400	9.83	102.9	57.0	123.1	0.40	8%	49%	33.1



Panel Usage

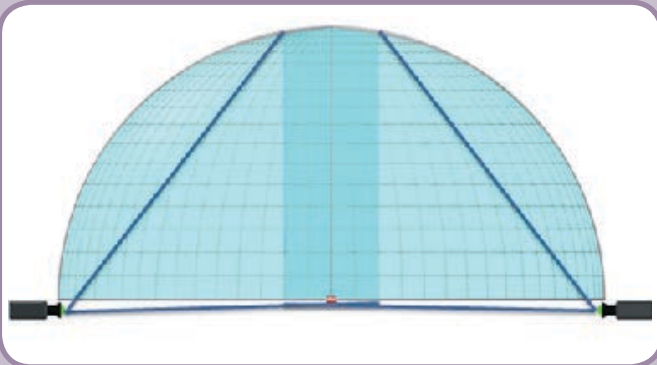
Active Image on Projector Panel



The illustration shows the active pixels used to project a hemisphere. A full hemisphere is projected as a circle of (active) pixels. This dual channel examples shows the HM4K-168 projecting a 3-chip 4K 1.38" D-ILA panel with blend allowance.

On-Screen Projection

Active Image on Screen



The illustration shows the projected image against a 5° azimuth-elevation grid. The projectors are positioned at dome edges and uniformly cast a hemispherical beam to the screen.

Lens Specifications

Focal Length	16.81mm	MTF Center	71% @ 73 lp/mm
Image Circle	32.3mm	MTF Edge	35% @ 73 lp/mm
Max Half-Angle	61.6°	Lateral Color R-G	<3µm
F/#	F/3.2	Lateral Color B-G	<4µm
Focus Range	2m – Inf.	F-Theta Distortion	< -11.9% Max
Transmittance	73-86%	Relative Illum.	>87%
Back Focus	JVC 4K LCoS compatible		

HM4K-168 Model Numbers

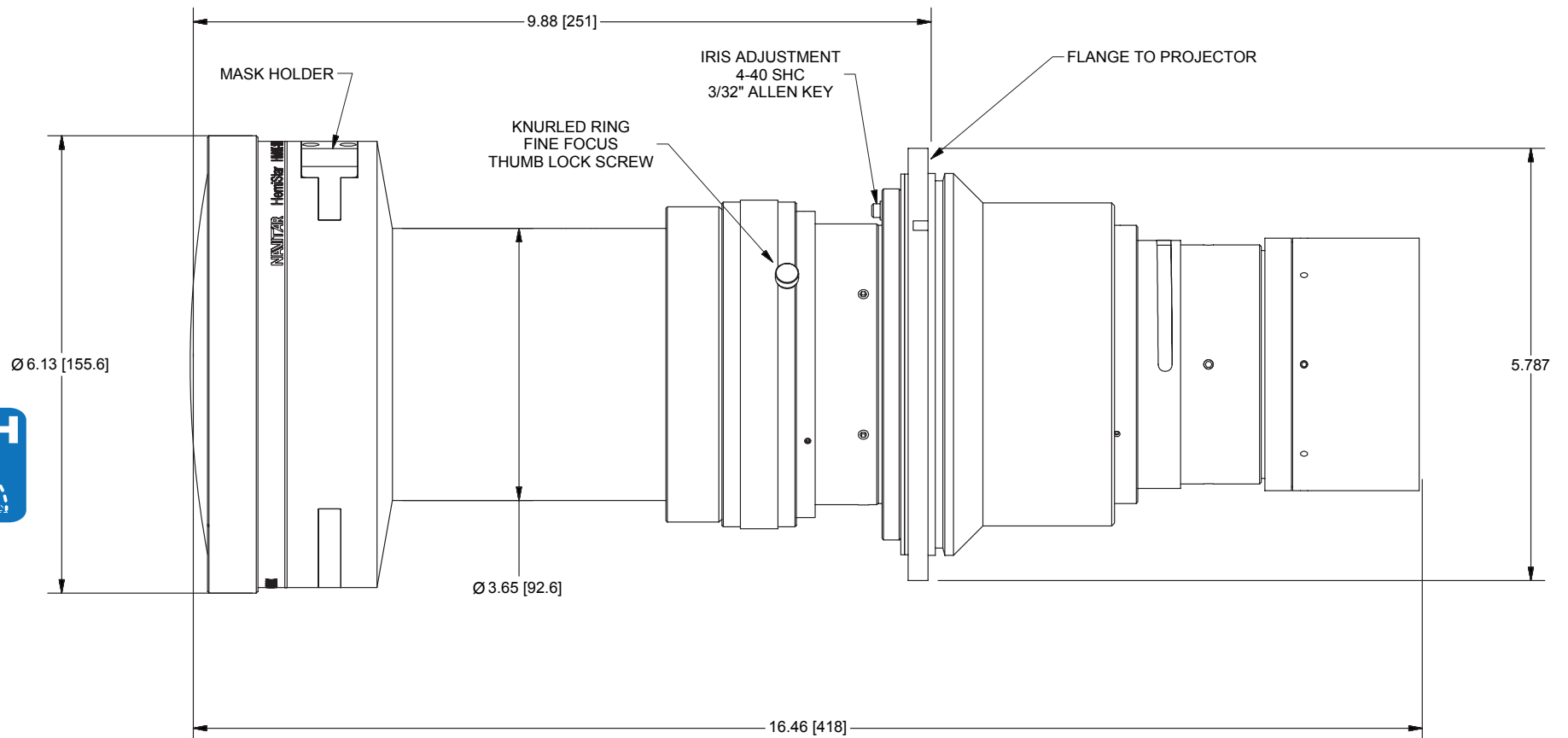
Navitar Part #*	Projector	Resolution	Brightness ⁺
I-23280	JVC DLA-SH7NLG	4K UHD	5,000
I-23280	JVC DLA-SH4KNLG	4K UHD	3,000

* Part numbers vary depending on projector manufacturer and model
 + Projector brightness is stated for reference only, it is not representative a maximum lens brightness rating.



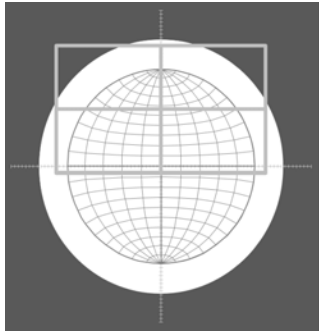
HemiStar HM4K-I78

Projection Angle Chart																	
Display Type		Number of Pixels			Panel Size (mm)			# Pixels Projected			Projection Angles (°)				Shift		
Dome Lens		H	V	Pixel Pitch (µm)	H	V	Diag.	H	V	Mpixel Count	H	V	Diag.	TR Equiv.	H +/-%	V +/-%	V Angle +/-°
Original Panel	1.38" 4K DLP	4096	2160	7.56	30.966	16.330	35.008	4096	2160	8.85	105.1	53.1	120.9	0.38	9%	62%	37.0
Alternate Panel	1.25" 2048 x 1080	2048	1080	13.68	28.017	14.774	31.674	2048	1080	2.21	94.0	48.0	107.8	0.47	15%	74%	39.6



Panel Usage

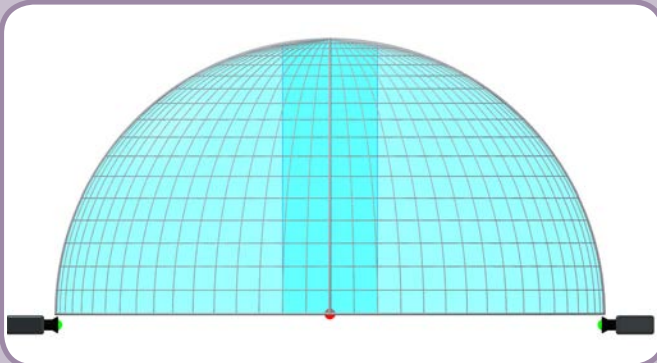
Active Image on Projector Panel



The illustration shows the active pixels used to project a hemisphere. A full hemisphere is projected as a circle of (active) pixels. This is a dual channel example of the HM4K-178 projecting a 3-chip 4K 1.38" DLP panel with blend allowance.

On-Screen Projection

Active Image on Screen



The illustration shows the projected image against a 5° azimuth-elevation grid. The projectors are positioned at dome edges and uniformly cast a hemispherical beam to the screen.

Lens Specifications

Focal Length	17.82 mm	MTF Center	75% @ 66 lp/mm
Image Circle	36.5mm	MTF Edge	55% @ 66 lp/mm
Max Half-Angle	63.5°	Lateral Color R-G	< 2.5µm
F/#	F/2.5	Lateral Color B-G	< 2.5µm
Focus Range	4m – Inf.	F-Theta Distortion	-8% Max
Transmittance	77-87%	Relative Illum.	>89%
Back Focus	TI 4K DLP		

HM4K-178 Model Numbers

Navitar Part #*	Projector**	Resolution	Brightness ⁺
I-25210	Barco DP4K-32B	4K UHD	33,000
I-25210	Barco HDQ-4K35	4K UHD	35,000
I-25211	Christie D4K3560	4K UHD	35,000
I-25211	Christie Roadie HD+35K	4K UHD	35,000
I-25932	Christie Boxer 4K30	4K UHD	30,000
I-25212	DP INSIGHT 4K QUAD	4K UHD	17,500
I-25212	DP INSIGHT LASER 4K	4K UHD	12,000

* Part numbers vary depending on projector manufacturer and model.

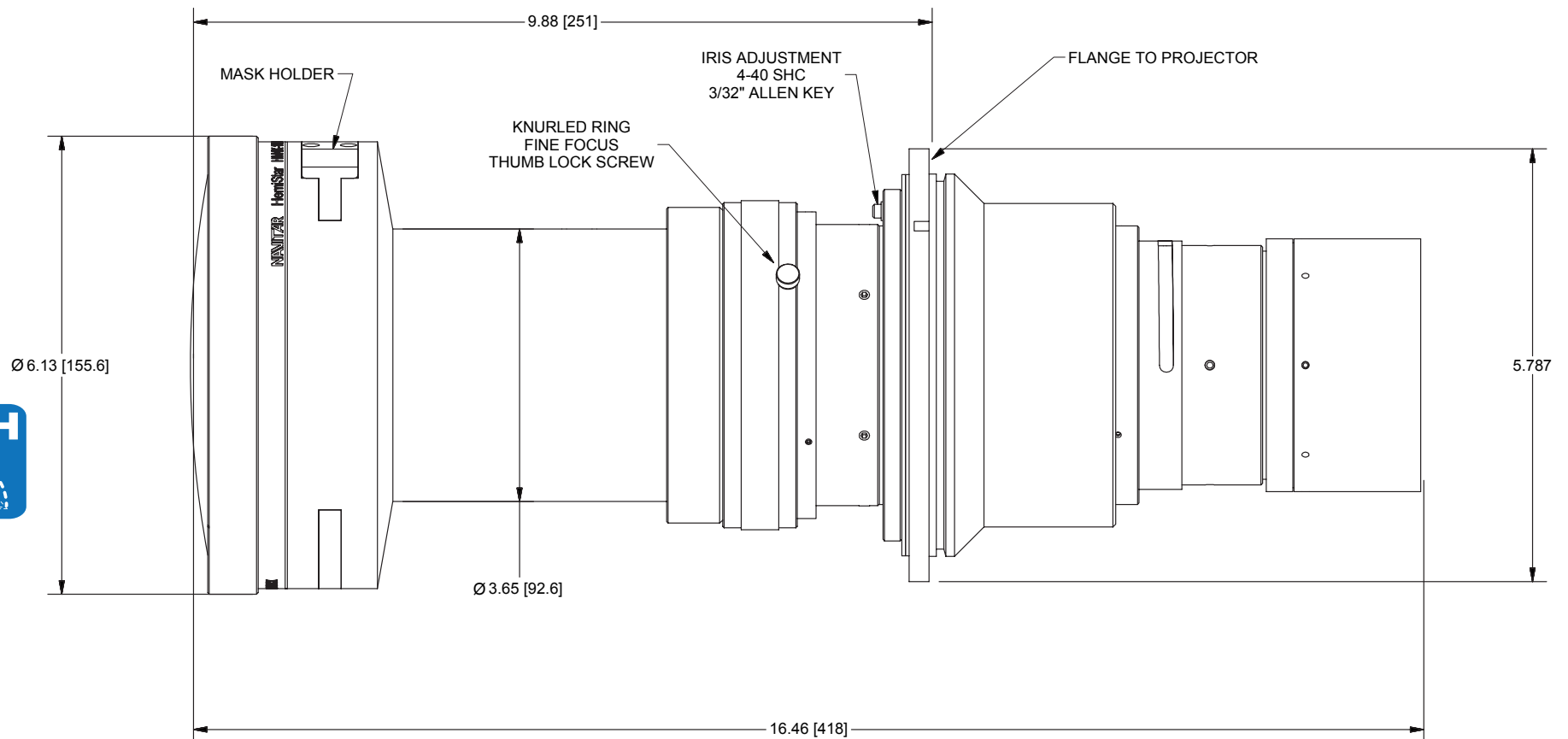
**Call a Navitar representative to discuss brightness greater than 20,000. Standard warranty does not apply. For applications beyond the warranty limit, Navitar recommends the HL lens version

+ Projector brightness is stated for reference only, it is not representative a maximum lens brightness rating.



HemiStar HM4K-I78 - High Lumen

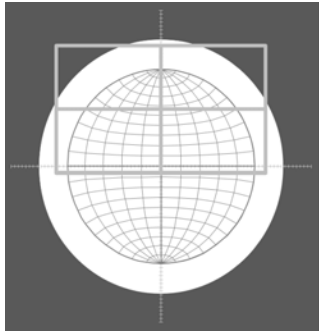
Projection Angle Chart																	
Display Type		Number of Pixels			Panel Size (mm)			# Pixels Projected			Projection Angles (°)				Shift		
Dome Lens		H	V	Pixel Pitch (µm)	H	V	Diag.	H	V	Mpixel Count	H	V	Diag.	TR Equiv.	H +/-%	V +/-%	V Angle +/-°
Original Panel	1.38" 4K DLP	4096	2160	7.56	30.966	16.330	35.008	4096	2160	8.85	105.1	53.1	120.9	0.38	9%	62%	42.8
Alternate Panel	1.25" 2048 x 1080	2048	1080	13.68	28.017	14.774	31.674	2048	1080	2.21	94.0	48.0	107.8	0.47	15%	74%	45.4



HM4K-178 - High Lumen

Panel Usage

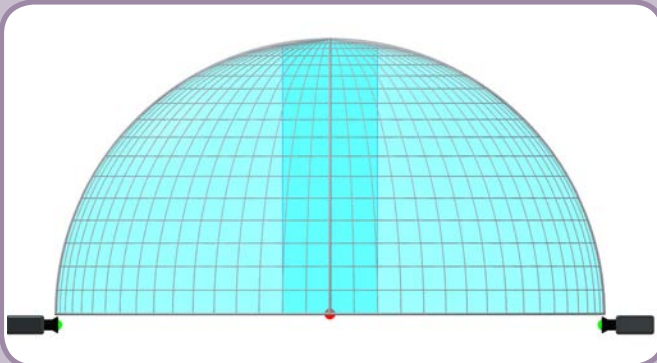
Active Image on Projector Panel



The illustration shows the active pixels used to project a hemisphere. A full hemisphere is projected as a circle of (active) pixels. This is a dual channel example of the HM4K-178 projecting a 3-chip 4K 1.38" DLP panel with blend allowance.

On-Screen Projection

Active Image on Screen



The illustration shows the projected image against a 5° azimuth-elevation grid. The projectors are positioned at dome edges and uniformly cast a hemispherical beam to the screen.

Lens Specifications

Focal Length	17.85 mm	MTF Center	80% @ 66 lp/mm
Image Circle	36.5mm	MTF Edge	52% @ 66 lp/mm
Max Half-Angle	69.4°	Lateral Color R-G	< 3.2µm
F/#	F/2.5	Lateral Color B-G	< 3.2µm
Focus Range	4m – Inf.	F-Theta Distortion	-7.2% Max
Transmittance	65%	Relative Illum.	>97%
Back Focus	TI 4K DLP		

HM4K-178 HL Model Numbers

Navitar Part #*	Projector**	Resolution	Brightness ⁺
I-27080	Barco DP4K-32B	4K UHD	33,000
I-27080	Barco HDQ-4K35	4K UHD	35,000
I-27081	Christie D4K3560	4K UHD	35,000
I-27081	Christie Roadie HD+35K	4K UHD	35,000
I-27083	Christie Boxer 4K30	4K UHD	30,000
I-27082	DP INSIGHT 4K QUAD	4K UHD	17,500
I-27082	DP INSIGHT LASER 4K	4K UHD	12,000

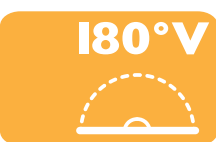
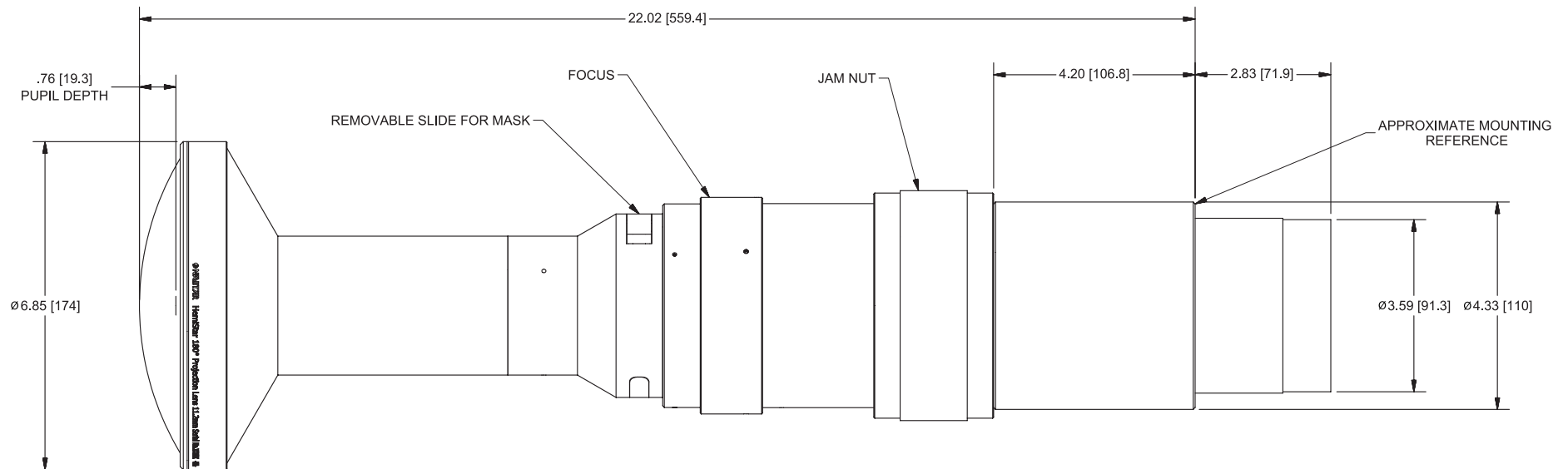
* Part numbers vary depending on projector manufacturer and model

+ Projector brightness is stated for reference only, it is not representative a maximum lens brightness rating.



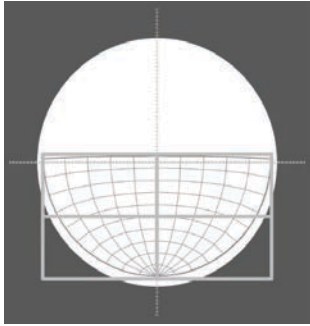
HemiStar HMRI I3

Projection Angle Chart																	
Display Type	Resolution			Panel Size (mm)			# Pixels Projected			Projection Angles (°)				Shift			
	H	V	Pixel Pitch (µm)	H	V	Diag.	H	V	Mpixel Count	H	V	Diag.	TR Equiv.	H +/-%	V +/-%	V Angle +/-°	
1.38" 4K DLP 3-Chip	4096	2160	7.56	30.966	16.330	35.008	4096	2160	8.8	170.6	84.4	180.0	0.04	2	+25 /-49%	+23 /-47.3	
1.25" 2K DLP 3-Chip	2048	1080	13.68	28.017	14.774	31.674	2048	1080	2.2	151.7	76.2	175.2	0.13	7	+30 /-59%	+25 /-51.4	



Panel Usage

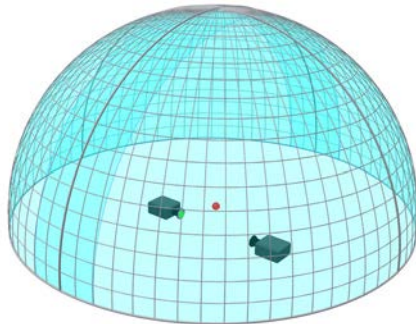
Active Image on Projector Panel



The illustration shows the active pixels used to project a hemisphere. A full hemisphere is projected as a circle of (active) pixels. This is a dual channel example of the HMRI 13 projecting a 3-chip 4K 1.38" DLP panel with blend allowance.

On-Screen Projection

Active Image on Screen



The layout allows wide projection of content with a 3-chip 4K DLP device for multi-viewer attractions.

Lens Specifications

Focal Length	11.27mm	MTF Center	60% @ 66lp/mm
Image Circle	32.24mm	MTF Edge	53% @ 66lp/mm
Max Half-Angle	90°	Lateral Color R-G	<1/4 pixel with 7.56 um pixel
F/#	F/2.5	Lateral Color B-G	<1/2 pixel with 7.56 um pixel
Focus Range	3m – Inf.	F-Theta Distortion	< -9.0% Max
Transmittance	73%	Relative Illum.	82%
Back Focus	TI 4K DLP		

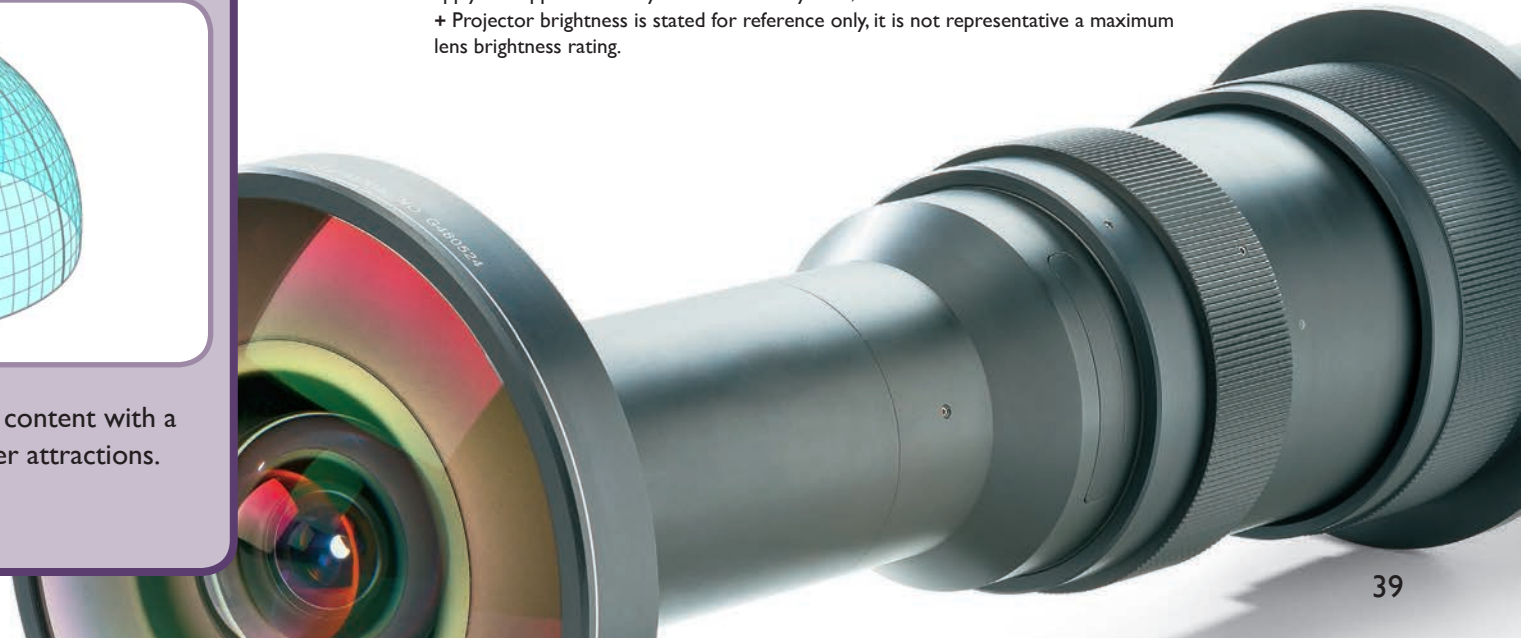
HMR-113 Model Numbers

Navitar Part #*	Projector**	Resolution	Brightness ⁺
I-24226	Barco DP4K-32B	4K UHD	33,000
I-24226	Barco HDQ-4K35	4K UHD	35,000
I-23439	Christie D4K3560	4K UHD	35,000
I-23439	Christie Roadie HD+35K	4K UHD	35,000
I-25934	Christie Boxer 4K30	4K UHD	30,000
I-25081	DP INSIGHT 4K QUAD	4K UHD	17,500
I-25081	DP INSIGHT LASER 4K	4K UHD	12,000

* Part numbers vary depending on projector manufacturer and model.

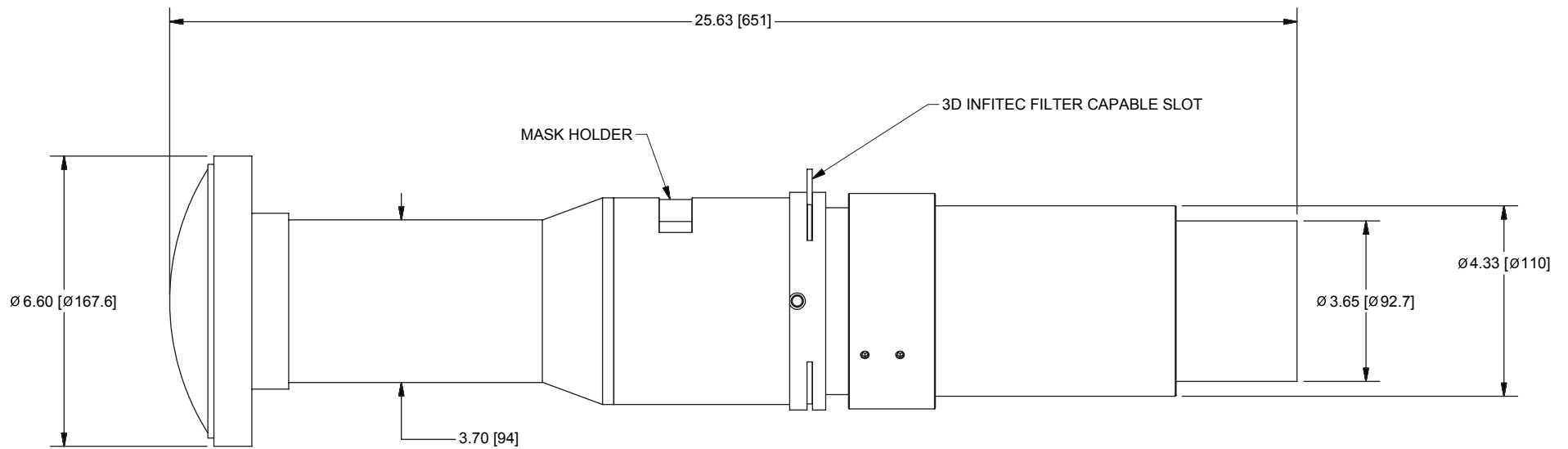
**Call a Navitar representative to discuss brightness greater than 20,000. Standard warranty does not apply. For applications beyond the warranty limit, Navitar recommends the HL lens version

+ Projector brightness is stated for reference only, it is not representative a maximum lens brightness rating.



HemiStar HMRI I3 - High Lumen

Projection Angle Chart																	
Display Type	Resolution			Panel Size (mm)			# Pixels Projected			Projection Angles (°)				Shift			
	H	V	Pixel Pitch (µm)	H	V	Diag.	H	V	Mpixel Count	H	V	Diag.	TR Equiv.	H +/-%	V +/-%	V Angle +/-°	
1.38" 4K DLP 3-Chip	4096	2160	7.56	30.966	16.330	35.008	4096	2160	8.8	170.0	84.4	180.0	0.04	2	49%	47.3	
1.25" 2K DLP 3-Chip	2048	1080	13.68	28.017	14.774	31.674	2048	1080	2.2	151.7	76.2	175.2	0.13	7	59%	51.4	



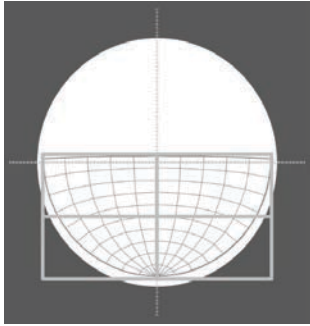
180°V



HMRI 13 - High Lumen

Panel Usage

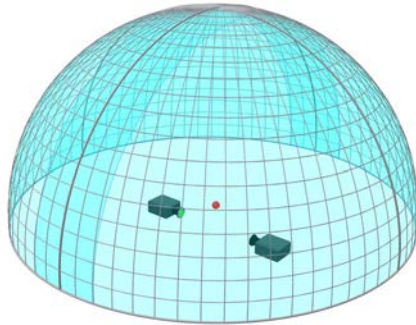
Active Image on Projector Panel



The illustration shows the active pixels used to project a hemisphere. A full hemisphere is projected as a circle of (active) pixels. This is a dual channel example of the HMRI 13 projecting a 3-chip 4K 1.38" DLP panel with blend allowance.

On-Screen Projection

Active Image on Screen



The layout allows wide projection of content with a 3-chip 4K DLP device for multi-viewer attractions.

Lens Specifications

Focal Length	11.27mm	MTF Center	55% @ 66lp/mm
Image Circle	32.24mm	MTF Edge	55% @ 66lp/mm
Max Half-Angle	90°	Lateral Color R-G	< 1/2 pixel with 7.56 um pixel
F/#	F/2.5	Lateral Color B-G	< 1/2 pixel with 7.56 um pixel
Focus Range	3m – Inf.	F-Theta Distortion	< -9.0% Max
Transmittance	73%	Relative Illum.	95%
Back Focus	TI 4K DLP		

HMR-113 HL Model Numbers

Navitar Part #*	Projector	Resolution	Brightness ⁺
I-27076	Barco DP4K-32B	4K UHD	33,000
I-27076	Barco HDQ-4K35	4K UHD	35,000
I-27077	Christie D4K3560	4K UHD	35,000
I-27077	Christie Roadie HD+35K	4K UHD	35,000
I-27079	Christie Boxer 4K30	4K UHD	30,000
I-27078	DP INSIGHT 4K QUAD	4K UHD	17,500
I-27078	DP INSIGHT LASER 4K	4K UHD	12,000

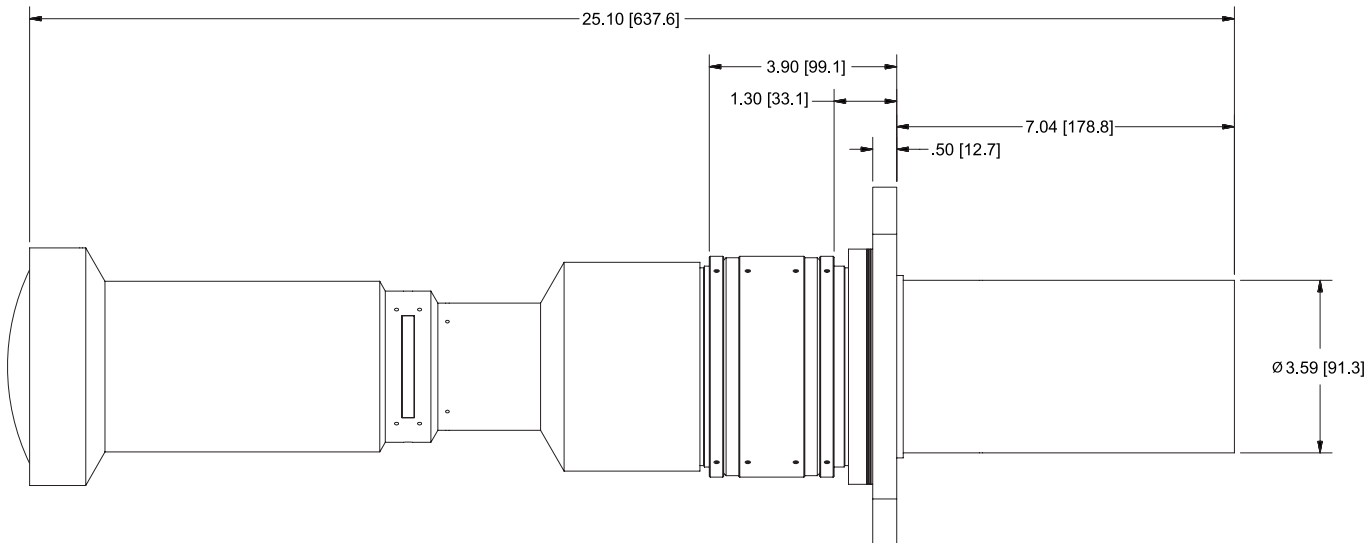
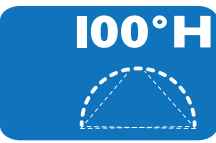
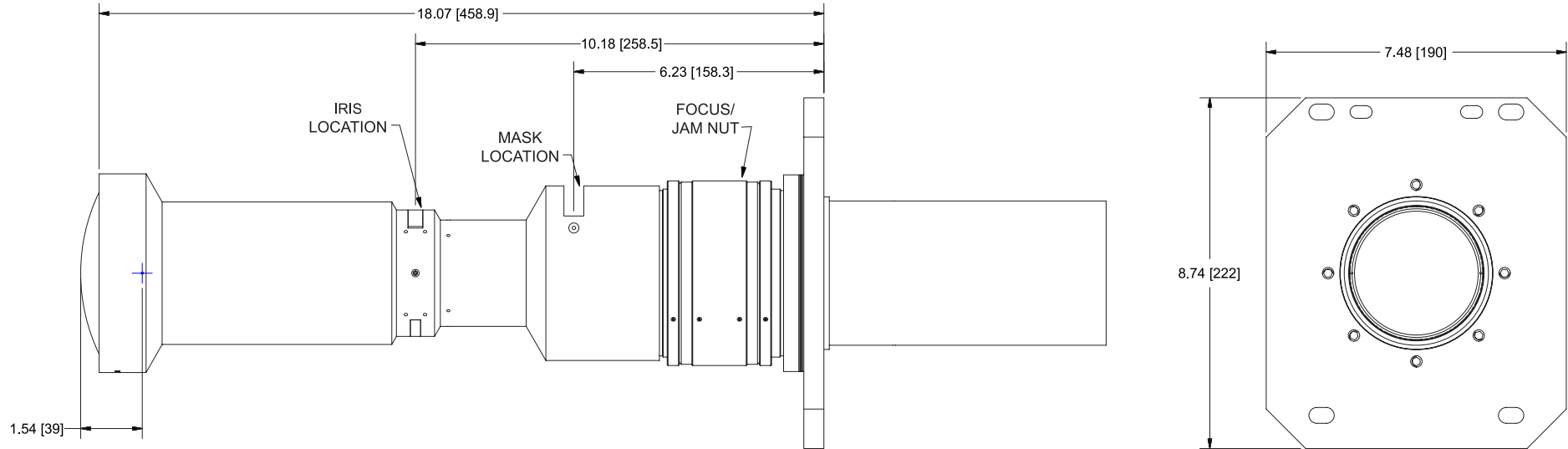
* Part numbers vary depending on projector manufacturer and model

+ Projector brightness is stated for reference only, it is not representative a maximum lens brightness rating.



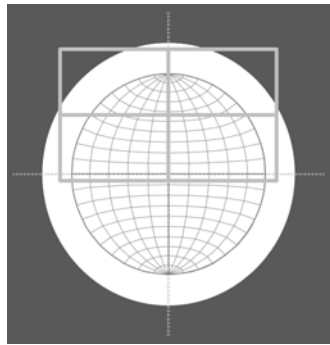
HemiStar HMRI97

Projection Angle Chart																	
Display Type		Resolution			Panel Size (mm)			# Pixels Projected			Projection Angles (°) *				Shift		
Dome Lens		H	V	Pixel Pitch (μm)	H	V	Diag.	H	V	Mpixel Count	H	V	Diag.	TR Equiv.	H +/-%	V +/-%	V Angle +/-°
Original Panel	1.55" 4K LCoS	4096	2160	8.5	34.824	18.365	39.370	4096	2160	8.85	102.2	53.6	116.0	0.40	9%	61%	33.2



Panel Usage

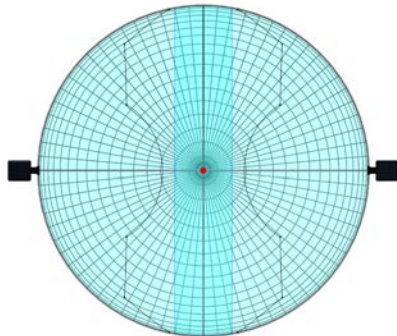
Active Image on Projector Panel



The illustration shows the active pixels used to project a hemisphere. A full hemisphere is projected as a circle of (active) pixels. This is a dual channel example of the HMRI97 projecting a 1.55" Sony 4K SXRD panel with blend allowance.

On-Screen Projection

Active Image on Screen



The illustration shows the projected image against a 5° azimuth-elevation grid. The projectors are positioned at dome edges and uniformly cast a hemispherical beam to the screen.

Lens Specifications

Focal Length	19.66 mm	MTF Center	70% @ 60 lp/mm
Image Circle	40.75mm	MTF Edge	65% @ 60 lp/mm
Max Half-Angle	60°	Lateral Color R-G	< 1.5µm
F/#	F/3.2	Lateral Color B-G	< 0.6µm
Focus Range	4m – Inf.	F-Theta Distortion	-1.2% Max
Transmittance	65%	Relative Illum.	>90%
Back Focus	SONY 4K SXRD		

HMRI97 Model Numbers

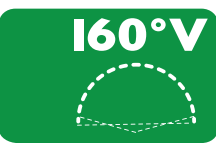
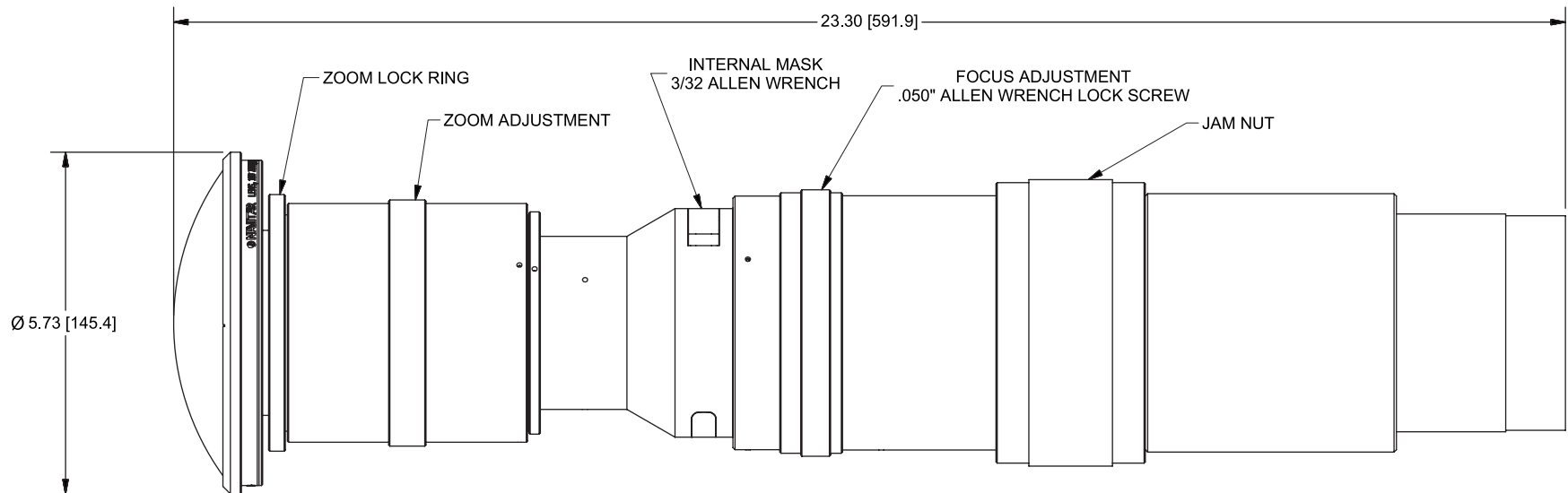
Navitar Part #	Projector	Resolution	Brightness ⁺
I-21911	SONY SRX-T423	4K SXRD	30,000

* Part numbers vary depending on projector manufacturer and model

+ Projector brightness is stated for reference only, it is not representative a maximum lens brightness rating.

HemiStar HSRZ-55 Zoom

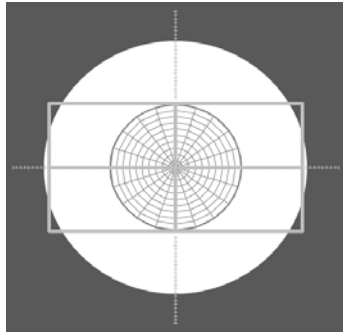
Projection Angle Chart															
Display Type		Resolution			Panel Size (mm)			# Pixels Projected			Projection Angles (°)		Shift		
Dome Lens		H	V	Pixel Pitch (µm)	H	V	Diag.	H	V	Mpixel Count	H	V	H +/-%	V +/-%	V Angle +/-°
Original Panel TI 4K 1.38" DLP - 6.5mm		4096	2160	7.56	30.966	16.330	35.008	2585	2160	4.84	184.7	150.3	0%	10%	17.3
Original Panel TI 4K 1.38" DLP - 5.9mm		4096	2160	7.56	30.966	16.330	35.008	2436	2160	4.45	189.5	165.0	0%	6%	12.5
Original Panel TI 4K 1.38" DLP - 5.5mm		4096	2160	7.56	30.966	16.330	35.008	2266	2160	3.98	189.6	179.4	0%	2%	5.3
Alternate Panels	1.25" 2K - 6.5mm	2048	1080	13.68	28.017	14.774	31.674	1429	1080	1.38	184.7	134.6	0%	16%	25.2
	1.25" 2K - 5.9mm	2048	1080	13.68	28.017	14.774	31.674	1346	1080	1.28	189.5	147.5	0%	12%	21.2
	1.25" 2K - 5.5mm	2048	1080	13.68	28.017	14.774	31.674	1252	1080	1.16	189.6	160.3	0%	8%	14.9



HSRZ-55 Zoom

Panel Usage

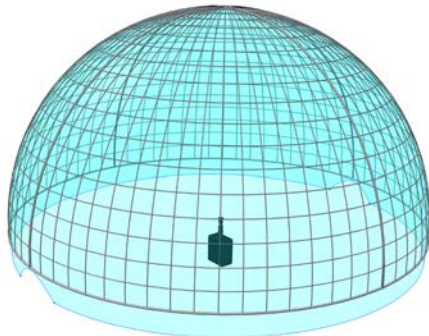
Active Image on Projector Panel



The illustration shows the active pixels used to project a hemisphere. A full hemisphere is projected as a circle of (active) pixels. This is a single channel example of the HSRZ-55 projecting a 3-Chip 4K DLP panel with focal length of 5.51mm.

On-Screen Projection

Active Image on Screen



The illustration shows the HSRZ-55 projecting a 3-Chip 4K DLP from dome center to illustrate its zoom range.

Lens Specifications

Focal Length	5.5-6.5mm	MTF Center	70% @ 66lp/mm
Image Circle	19.542mm	MTF Edge	50% @ 66lp/mm
Max Half-Angle	92.5°	Lateral Color R-G	<=4 um
F/#	F/2.5	Lateral Color B-G	<=3 um
Focus Range	1m – Inf.	F-Theta Distortion	< -6.5% Max
Transmittance	72%	Relative Illum.	84-86%
Back Focus	TI 4K DLP Compatible		

HSRZ-55 Zoom Model Numbers

Navitar Part #*	Projector**	Resolution	Brightness ⁺
I-25254	Barco DP4K-32B	4K UHD	33,000
I-25254	Barco HDQ-4K35	4K UHD	35,000
I-25255	Christie DP4K3560	4K UHD	35,000
I-25255	Christie Roadie HD+35K	4K UHD	35,000
I-25933	Christie Boxer 4K30	4K UHD	30,000
I-25256	DP INSIGHT 4K QUAD	4K UHD	17,500
I-25256	DP INSIGHT LASER 4K	4K UHD	12,000

* Part numbers vary depending on projector manufacturer and mode

** Call a Navitar representative to discuss brightness greater than 20,000. Standard warranty does not apply.

+ Projector brightness is stated for reference only, it is not representative a maximum lens brightness rating.

NOTE:

For single projector pit mount domes, vertical angle should be considered as full angle for both vertical and horizontal.

Example: 6.5mm is 150.3°H x 150.3°V, not 184.7°H x 150.3°V

As this is a zoom, all angles between 150 - 180° are achievable.



0.65:1 Throw Ratio 4K Wide Angle Accessory Lens

Designed for Sony VPL-GTZ280/270 4K SXRD

Projector/Lens Applications

- Simulation
- Training
- Visualization
- Retail
- Museums
- Theme Parks
- Planetarium

SONY VPL-GTZ280 4K Projector

- 4K SXRD resolution
- Laser phosphor light source
- Native resolution: 4096 x 2160
- Ideally suited for simulation
- IR compatible for night vision simulation



Sony VPL-GTZ280/270

Lens Specifications

Focal Length	10.7mm	On Axis MTF	60% @ 125lp/mm
Throw Ratio	0.65:1	Full Field MTF	45% @ 125lp/mm
Focus Adjustment	Manual	Vertical Lens Shift	+/- 15%
Zoom Adjustment	Fixed	Horizontal Lens Shift	+/- 5%
F/#	F/2.8	Transmittance @ 460-630nm	>80%
Focus Range	~2m – Inf.	Transmittance @ 780nm	50%

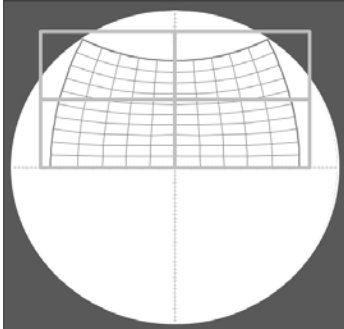
0.65:1 Model Numbers

Projector	Resolution
Sony VPL-GTZ280	4096 x 2160

4K-S-0.90 Sony Wide Angle Lens

Panel Usage

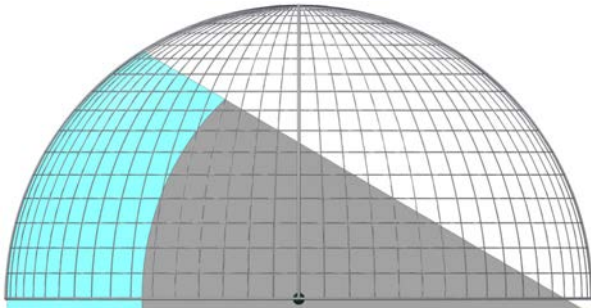
Active Image on Projector Panel



The illustration shows the active pixels used to project a hemisphere. A full hemisphere is projected as a circle of (active) pixels. This image is a side view showing the dome channel.

On-Screen Projection

Active Image on Screen



The illustration shows the projected image against a 5° azimuth-elevation grid. The projector is positioned at dome center and uniformly casts a hemispherical beam to the screen.

Projection Angle Chart

	Resolution			Panel Size (mm)			Projection Angles (°)			Throw Ratio	Shift	
	H	V	Pixel Pitch (µm)	H	V	Diag.	H	V	Diag.		H +/-%	V +/-%
Original Panel 1.48" 4K LCoS	4096	2160	8	32.768	17.280	37.045	58.4	32.7	64.6	0.89:1	15%	15%

Lens Specifications

Focal Length	29.5mm	MTF Center	85% @ 60lp/mm
Image Circle	39.73mm	MTF Edge	52% @ 60lp/mm
Max Half-Angle	34.18°	Lateral Color R-G	<=4 µm
F/#	F/2.5	Lateral Color B-G	<=4 µm
Focus Range	2m – Inf.	TV Distortion	0.46%
Transmittance	79-89%	Relative Illum.	>74%

4K-S-0.90 Model Numbers

Navitar Part #	Projector	Resolution	Brightness ⁺
I-24014	Sony SRX-T615	4K SXRD	17,000
I-24014	Sony SRX-R515P	4K SXRD	15,000

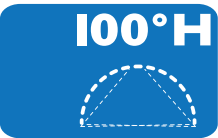
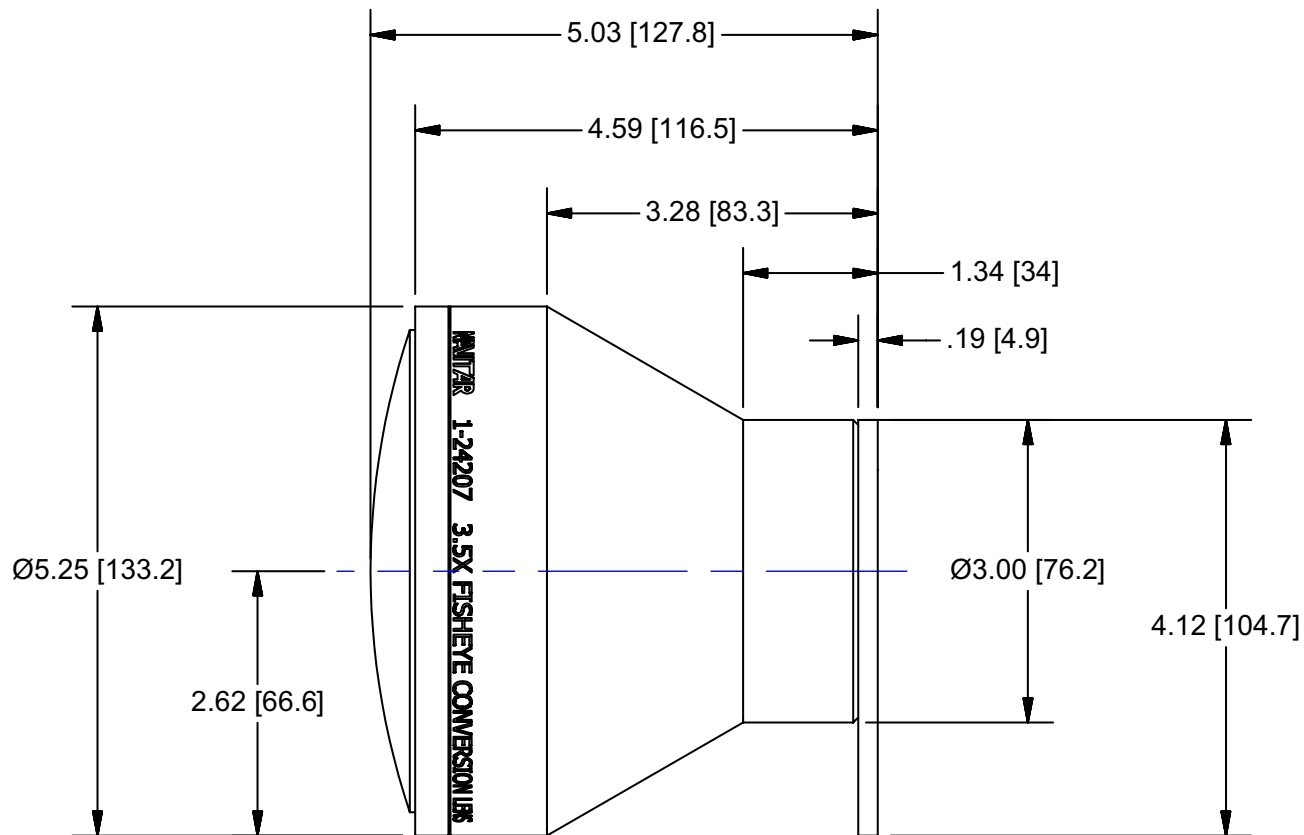
+ Projector brightness is stated for reference only, it does not represent the maximum lens brightness rating.



3.5X Fisheye Conversion Lens

Examples of Projectors and Projection Angles*					
Navitar Part # 1-24207			Prime Lens	With Conversion Lens	
Projector	Panel	Aspect Ratio	Throw Ratio	Short Throw Angles H x V (°)	Long Throw Angles H x V (°)
JVC DLA X55R/ X75R/ X95R	0.70" D-ILA x3	16:9 HD	1.38 - 2.79:1	172.3 x 84.3	73.4 x 40.6
Panasonic PR RZ370 /RZ470	0.66" DLP	16:9 HD	1.46 - 2.94:1	155.6 x 79.2	71.3 x 39.3
Canon WUX450	0.70" LCOS x3	16:10	1.39 - 2.51:1	169.8 x 94.1	82.2 x 50.8
Sony VPL VW600ES/ VPL VW1100ES	0.70" SXRD x3	17:9	1.38 - 2.38:1	172.3 x 78.6	87.2 x 45.0
NEC PE401H	0.66" DLP	16:9 HD	1.60 - 2.72:1	137.3 x 71.9	75.4 x 41.8
Epson PL Pro Cinema 6030UB	0.70" 3LCD	16:9 HD	1.34 - 2.87:1	184.0 x 87.1	71.3 x 39.3

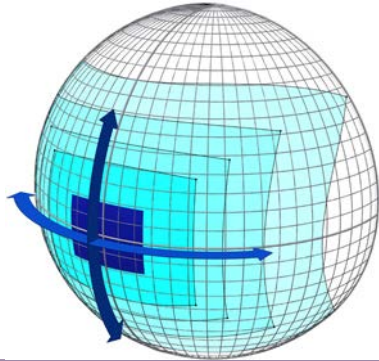
*This lens is designed to work with 0.70" panel projectors with prime zooms that have a focal length of 19-40mm. Lens may work with other panel sizes and other focal length prime lenses. Will require user testing.



3.5X Fisheye Conversion Lens

On-Screen Projection

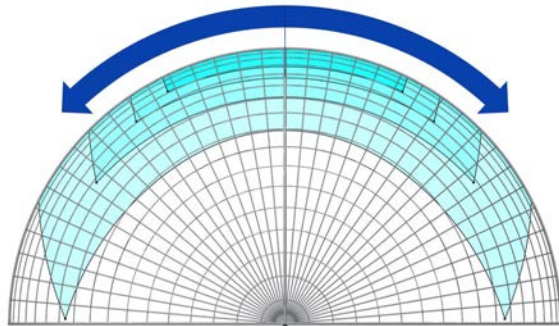
Active Image on Projector Panel



A prime lens, which alone projects a image size shown by the small dark blue rectangle, is fitted with the 3.5X conversion lens to provide a magnified image, as shown by the light blue shaded areas.

The magnified image is capable of focusing onto a curved screen. The illustration shows the range of converted angular sizes for a 4:3 image and a selection of prime lens throw ratios.

At the widest range a 1.3:1 prime lens can produce a 199°H x 125°V image (4:3 aspect ratio) with the 3.5X conversion lens.

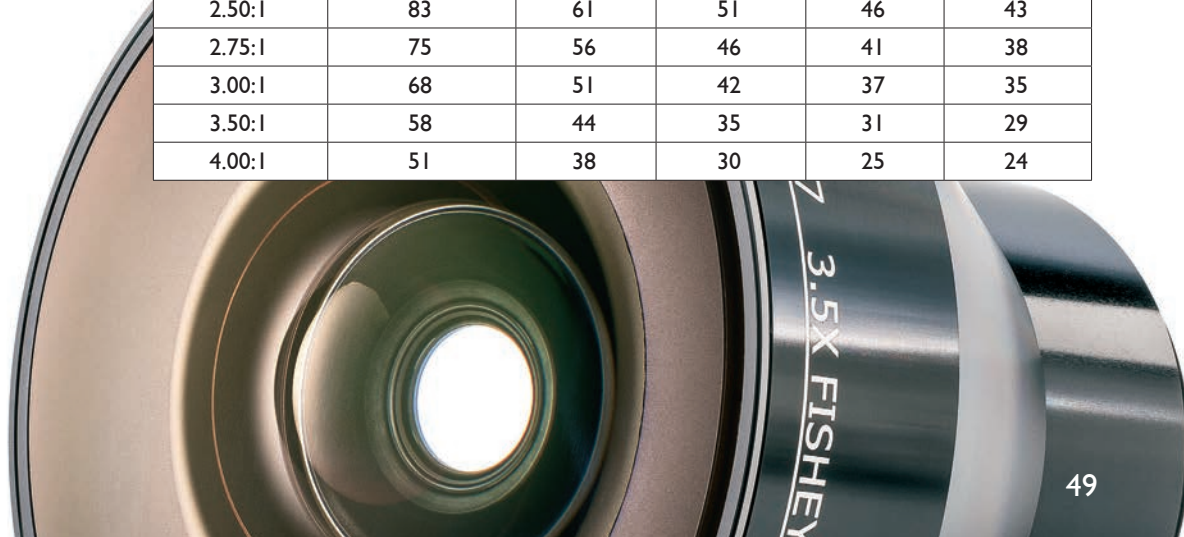


Lens Specifications

Image Circle	40mm	MTF Center	55% @ 73lp/mm
Max FOV	200°	MTF Edge	10% @ 50lp/mm
F/#	F/2.5	F-Theta Distortion	< -23% Max
Focus Range	1500mm – Inf.	Relative Illum.	80.5% Horizontal Field 89.6% Trans. related 65.9% Dist. related
Transmittance	89.8% Axis		

Throw Ratio to Projected Angle Conversion Chart

Original Prime Lens Throw	New Projected Angle (°) H	4:3 Angle (°) V	16:10 Angle (°) V	16:9 Angle (°) V	2K/4K 17:9 Angle (°) V
1.30:1	199	125	102	90	84
1.35:1	180	120	97	86	80
1.40:1	167	115	93	83	77
1.44:1	160	112	91	81	75
1.50:1	149	107	86	77	72
1.60:1	137	99	80	72	67
1.70:1	128	92	75	68	63
1.80:1	120	87	71	64	60
1.90:1	113	82	67	60	57
2.00:1	106	77	64	57	54
2.10:1	101	73	61	55	51
2.25:1	93	68	57	51	48
2.50:1	83	61	51	46	43
2.75:1	75	56	46	41	38
3.00:1	68	51	42	37	35
3.50:1	58	44	35	31	29
4.00:1	51	38	30	25	24



ScreenStar Conversion Lenses

Navitar ScreenStar wide-angle and long-throw conversion lenses sit in front of a projector's standard lens to increase or decrease picture size or throw distance. These lenses decrease costs by reducing the number of projectors needed for installations, and allowing users to select consumer off-the-shelf projectors.

Available Lenses

	Part #	Description	Image Conversion	Mount Part #
Standard	SSW065	0.65X Wide-angle converter	50% Larger	I-17262
	SSW08	0.8X Wide-angle converter	25% Larger	I-17263
	SST120	1.20X Telephoto converter	17% Smaller	I-17263
	SST150	1.50X Telephoto converter	33% Smaller	I-17262
	SST300*	3.00X Telephoto converter	67% Smaller	-----
Mini	SSC065	0.65X Mini wide-angle converter	50% Larger	I-17264
HD	HDSSW08	0.8X HD Wide-angle converter	25% Larger	I-17262
	HDSSW065	0.65X HD Wide-angle converter	50% Larger	I-17262

* Stabilizing leg and table mount are not available for this model



Ceiling Mounted Projector with HDSSW065 & Mount
Image courtesy of Digital Home Creations

Applications Include:

RENTAL & STAGING • HOME THEATERS
PLANETARIUMS • EDUCATION • MUSEUMS

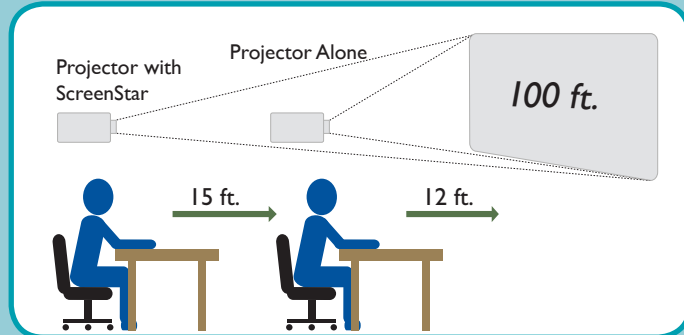
ScreenStar Conversion Lenses

No matter what image size or throw distance you require, Navitar has a solution.

Smaller Image

Telephoto Conversion Lens

Same image size, longer throw distance.



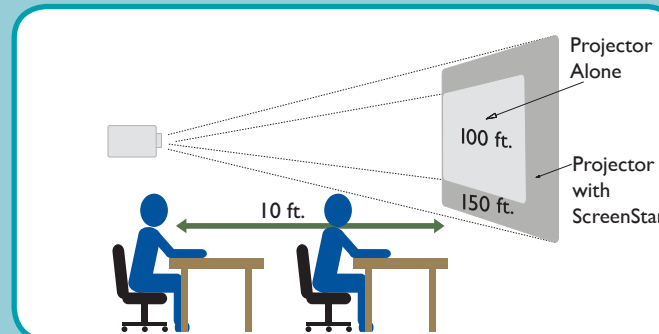
Telephoto conversion lenses allow you to:

- Place projector farther from screen
- Maintain the same image width, or reduce picture size while projecting from the same distance

Shorter Throw Distance

Wide-Angle Conversion Lens

Larger image, same throw distance.



Wide-angle conversion lenses allow you to:

- Increase image size from the same projection distance
- Keep the same size image while moving projector closer to the screen

Mounting Options

A **stabilizing leg** is included with all ScreenStar models with the exception of the SST300. The leg allows for secure placement of the lens in front of the prime lens of the projector.

Table mounts for ScreenStar lenses allow for placement of the lens in front of projector and height and tilt adjustment of the lens (for all models except the SST300).



Stabilizing leg attaches to back of lens. Pre-drilled holes for hard mounting.

Ceiling mount adapters for

ScreenStar lenses are available directly from Chief Manufacturing (part #NAV1 and NAV2) and Premier Mounts (part #PP-NVT).

For high-volume OEM orders, Navitar's engineering team can design a custom mount if required. Please contact us to discuss your needs.



Table mounts allow for lens height and tilt adjustment.

NuView Replacement Lenses

Navitar's **NuView lenses** replace the projector's existing prime lens to produce **bright, sharp images**. We offer a **wide selection** of off-the-shelf and custom lenses suited to numerous applications, screen sizes and projection distances.

Part #	Focal Length		Distance-to-Width Ratio by Panel Size						
	(mm)	(inches)	0.7 DLP	0.8 LCD	0.95 DLP	1.2 LCD (1080P)	1.22 LCD (WXGA)	1.64 LCD (1080P)	1.8 LCD
Long Throw									
MCZ275	50-70	2.0-2.75	3.5-4.9:1	3.0-4.3:1	–	–	–	–	–
MCZ500	70-125	2.75-5.0	4.9-8.8:1	4.3-7.7:1	–	2.9-5.1:1	–	–	–
MCZ125	70-125	2.75-5.0	–	–	–	–	2.6-4.6:1	1.9-3.39:1	1.9-3.4:1
MCZ087	132-220	5.2-8.7	9.3-15.4:1	8.1-13.5:1	–	5.4-9.0:1	–	–	–
MCZ900	150-230	6.0-9.0	10.7-16.1:1	9.2-14.1:1	–	6.1-9.4:1	–	–	–
MCZ151	184-314	7.2-12.4	–	–	–	–	6.8-11.6:1	5.0-8.4:1	5.0-8.6:1
Wide Angle									
MCL1625	16	0.63	1.2:1	1.0:1	0.8:1	0.7:1	–	–	–
MCL2125	21	0.83	1.5:1	1.3:1	1.1:1	0.9:1	–	–	–

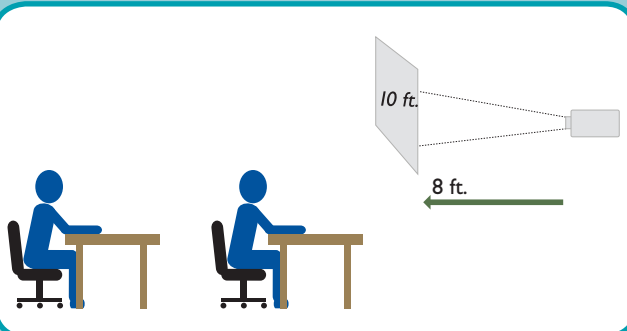
Applications Include:

CORPORATE • EDUCATION
PRAISE & WORSHIP • MUSEUMS

Larger Image

Wide-Angle Lens

Rear projection example.



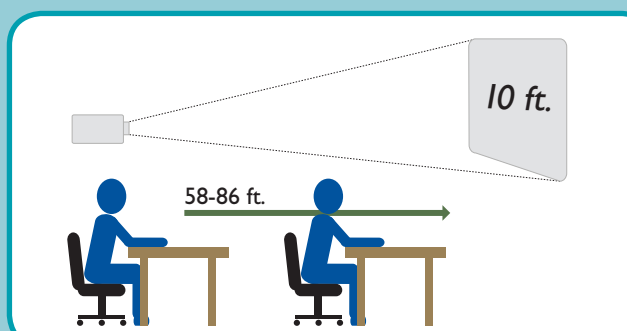
Wide-angle fixed focal length lenses allow you to:

- Use the projector closer to the screen.
- Produce a larger image at your present working distance.
- Shorten present working distance and increase image back to the original size.

Longer Throw Distance

Long Throw Lens

Front projection example.



Long-throw zoom lenses allow you to:

- Increase the working distance and place projector farther away from the screen.
- Choose a variety of projection distances and image sizes by rotating the lens.



NuView Replacement Lenses

NuView Projection Chart

Navitar's long-throw zoom (MCZ) and fixed focal length (MCL) replacement lenses are listed below with focal lengths (mm and inches) and distance-to-width ratios for compatible projector panel sizes.

Full Navitar part numbers include a three-digit projector-specific prefix. Please visit navitar.com or contact your sales representative for a complete list of available lenses.

Part #	Focal Length		Distance-to-Width Ratio by Panel Size							
	(mm)	(inches)	0.7 DLP	0.8 LCD	0.95 DLP	1.2 LCD (1080P)	1.22 LCD (WXGA)	1.3 LCD	1.64 LCD (1080P)	1.8 LCD
Long Throw										
MCZ275	50-70	2.0-2.75	3.5-4.9:1	3.0-4.3:1	–	–	–	–	–	–
MCZ500	70-125	2.75-5.0	4.9-8.8:1	4.3-7.7:1	–	2.9-5.1:1	–	2.7-4.8:1	–	–
MCZ125	70-125	2.75-5.0	–	–	–	–	2.6-4.6:1	–	1.9-3.39:1	1.9-3.4:1
MCZ729	115-203	4.5-7.99	–	–	5.96-10.5:1	–	–	–	–	–
MCZ537	117-199	4.6-7.8	–	–	–	–	4.3-7.4:1	–	3.1-5.4:1	3.2-5.4:1
MCZ087	132-220	5.2-8.7	9.3-15.4:1	8.1-13.5:1	–	5.4-9.0:1	–	5.0-8.3:1	–	–
MCZ900	150-230	6.0-9.0	10.7-16.1:1	9.2-14.1:1	–	6.1-9.4:1	–	5.8-8.6:1	–	–
MCZ151	184-314	7.2-12.4	–	–	–	–	6.8-11.6:1	–	5.0-8.4:1	5.0-8.6:1
MCZ123	187-312	7.4-12.3	–	–	–	7.7-12.8:1	–	7.1-11.8:1	–	–
Wide Angle										
MCL1625	16	0.63	1.2:1	1.0:1	0.8:1	0.7:1	–	–	–	–
MCL2125	21	0.83	1.5:1	1.3:1	1.1:1	0.9:1	–	0.8:1	–	–
MCL1028	25.4	1.0	1.8:1	9.0:1	1.3:1	1.0:1	–	0.9:1	–	–
MCL012	30	1.2	2.1:1	9.0:1	1.5:1	1.2:1	–	1.2:1	–	–





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