

# Lenses for Phantom

Phiroze Dalal

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# Introduction

Lenses form an integral and vital part of any photographic system, and the Phantom ecosystem is no exception. Vision Research does not develop its own lenses, and Phantom cameras are designed to work with as many lens systems as possible.

Being able to choose from a wide array of lenses affords Phantom camera users maximum versatility, and makes Phantom cameras a good fit in many different applications ranging from microscopy to astronomy, and music-videos to machine-vision.

# Glossary of terms

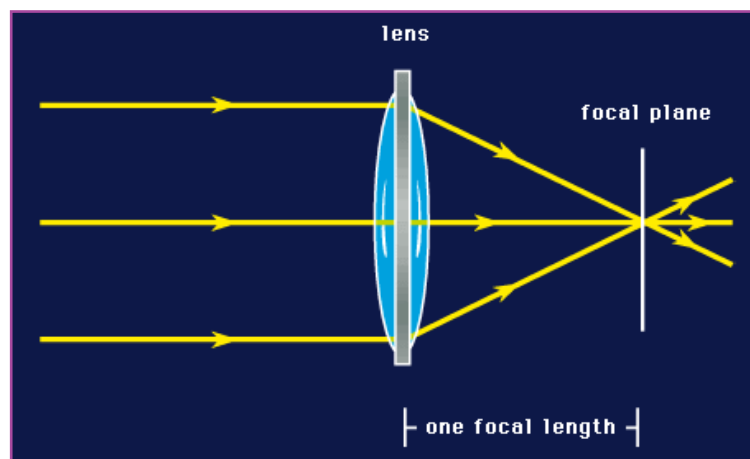
## Lens mount

A lens mount is an interface – mechanical and often also electrical – between a photographic camera body and a lens. It is confined to cameras where the body allows interchangeable lenses, and the optics are not permanently attached to the camera.



## Focal length

The distance between the nodal plane of a lens and the point at which incoming light rays converge.



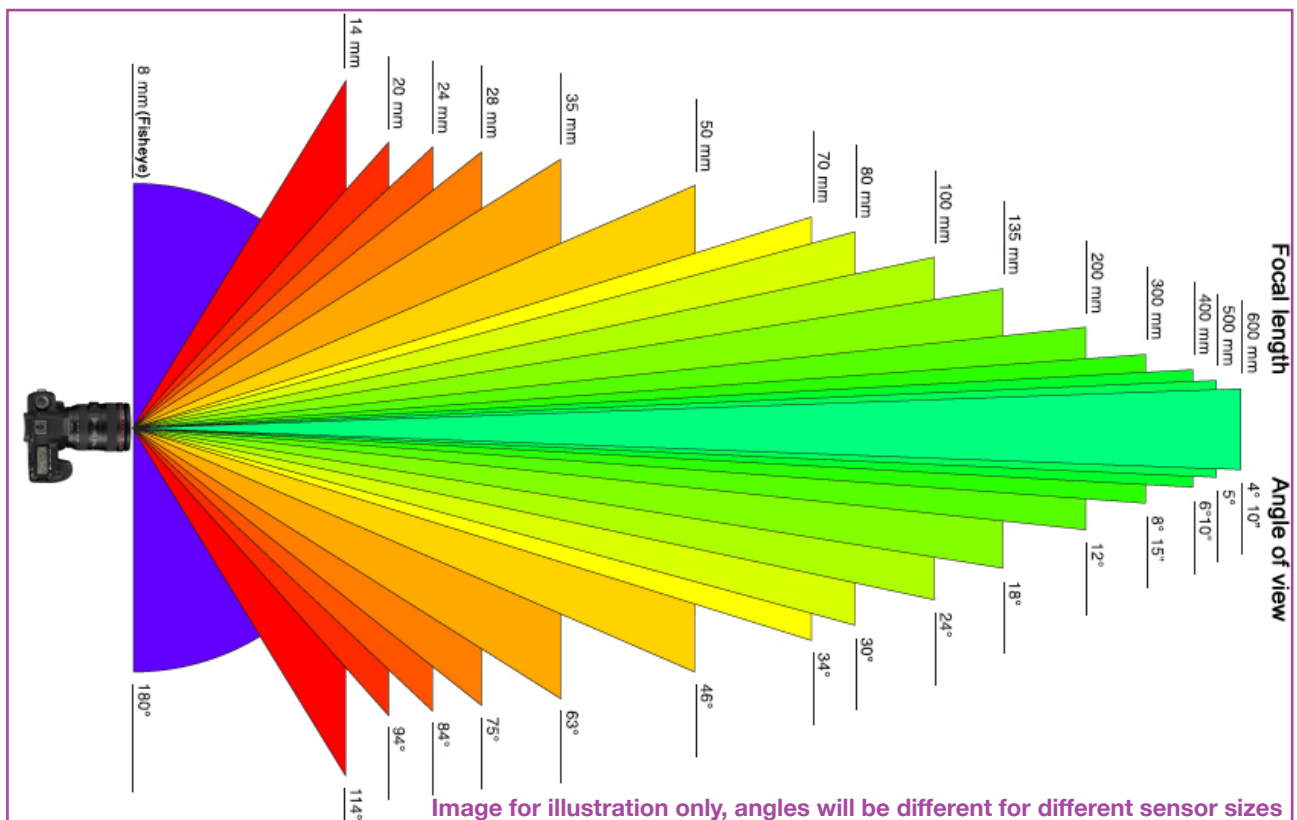
## Aperture / iris / diaphragm / f-stop

Several terms that refer to the same thing. In optics, an aperture is a hole or an opening through which light travels. More specifically, the aperture of an optical system is the opening that determines the amount of light, and cone angle of a bundle of rays that come to a focus in the image plane. The aperture ring in a lens is made up of aperture-blades and has a variable size.



## Field of View (FOV), Angle of View (AOV)

The area (or angle) that is visible through an optical instrument. Relates to focal length and sensor size.



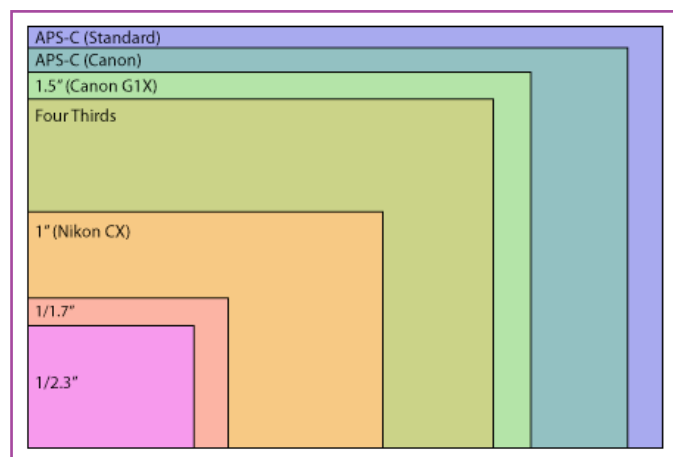
## Depth of Field (DOF)

In optics, particularly as it relates to film and photography, the depth of field (DOF) is the portion of a scene that appears acceptably sharp in the image.



## Sensor size

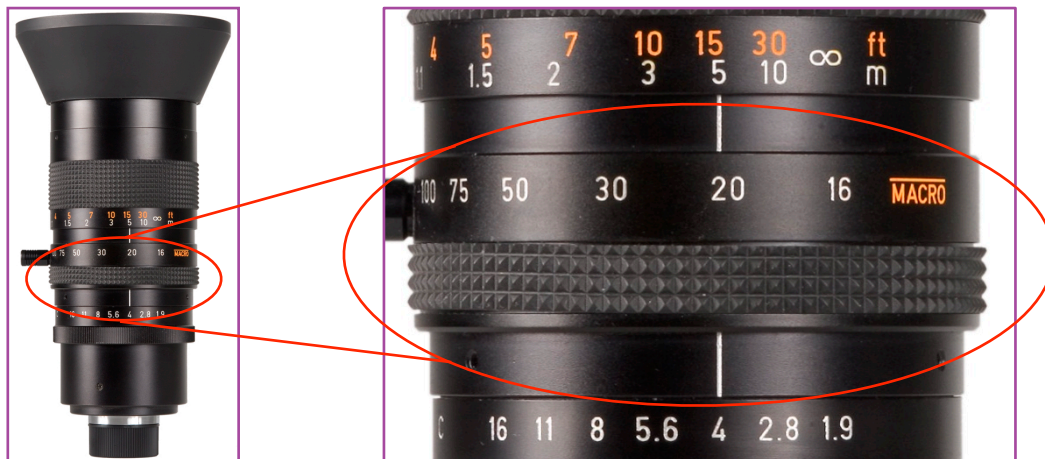
Physical size of the active area of an imaging sensor. Usually expressed as width x height.





## Zoom lens

Any lens that has a variable focal length.



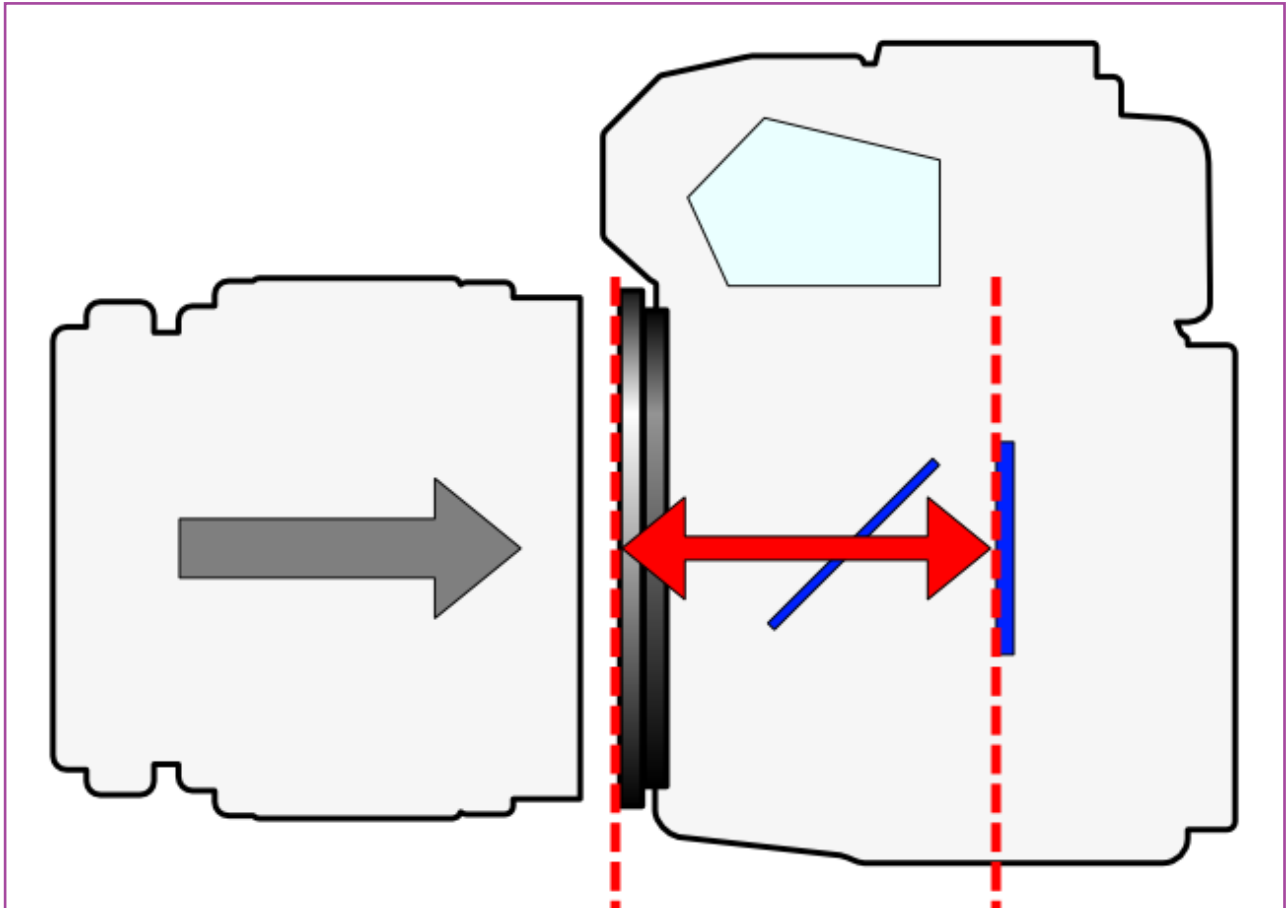
## Prime, or fixed focal length lens

Any lens that has a fixed focal length that can not be changed.



## Flange Focal Distance (FFD)

The distance between the front face (or locking flange) of the lens mount on a camera and the image plane.



# Lens systems by mount type

## **Nikon 'F' mount**

Nikon's 'F' mount is currently the default lens mount on many Phantom cameras and all its competitors. 'F' mount lenses are commonly used in industrial and scientific applications.

## **Canon 'EF' mount**

Canon's 'EF' mount and lens collection is perhaps the most advanced, mature and extensive electronic lens interfacing system in the (stills, small format) photographic world. This system forms the benchmark to which every subsequent electronic interface lens system has been compared.

Phantom cameras remain the only high speed cameras offering deep integration and compatibility with this extensive system of lenses.

## **ARRI 'PL' mount**

ARRI's 'PL' mount has become the industry standards lens mount used on 35 mm. motion-picture cameras. Phantom cameras designed for cinema and production applications are delivered with the 'PL' mount as standard.

## **Sony 'B4' mount**

Sony's 'B4' mount has been widely adopted as the industry standard for high-end video cameras especially those used in (live) broadcast applications. Modern 'B4' lenses are designed around a 2/3" sensor format, but are often used with Phantom cameras in broadcast applications.

## **Cine 'C' mount**

Originally developed for 16 mm. motion-picture (or 'cine') cameras, the 'C' mount has become the standard lens-mount for many industrial and security applications. The 'C' mount has been used on high speed camera systems (including Phantom) with mixed results, but may be attractive when small sensors or low resolutions are in use.

# In-depth system review

## 1 Nikon 'F' mount

### 1.1 History and introduction

The Nikon 'F' mount refers to a bayonet-style lens mounting system first introduced on the Nikon F camera in 1959. Compatible lenses are called 'F' mount lenses and when manufactured by the Nikon Corporation they take the name 'Nikkor' lenses. Though many of the physical attributes (see section 1.2) of the Nikon 'F' mount have remained unchanged since its introduction there are several variants (see section 1.3) with differing levels of compatibility with Nikon cameras.

### 1.2 Physical attributes

<i>Coupling Type:</i>	Bayonet with 3 (unequally sized) flanges, lens twists (counterclockwise) to mount
<i>Flange-focal distance:</i>	46.5 mm.
<i>Aperture mechanisms:</i>	Set via aperture ring or in-camera but always activated mechanically (see section 1.3)
<i>Focusing Mechanisms:</i>	Manual focus and auto-focus (several variants) (see section 1.3)
<i>Zoom Mechanism:</i>	Manual (on zoom lenses)

### 1.3 Variants (F, AI, AI-S, AF, AI-P, AF-I, AF-D, AF-S, AF VR, AF-G, AF DX)

The Nikon 'F' system has evolved significantly especially over the past decade. This list of variants is not exhaustive and some incremental steps have been omitted or only briefly covered based on relevance. Most variants introduced features that allowed better communication between Nikon lenses and camera bodies (first mechanically, then electronically) which allowed for more precise exposure metering.

Phantom cameras were compatible with all manual aperture-ring lenses 'F' mount lenses, but with the introduction of the 'AF-G' series of Nikkor lenses (with no mechanical aperture rings on the body) in 2000 it has become increasingly difficult to find and use Nikkor lenses.

Vision Research will soon introduce a new lens mount for Phantom cameras that can manually activate the aperture in 'AF-G' lenses manually.

### 1.4 Summary

Nikkor lenses have for decades been the default choice for scientific and photographic instrumentation requiring a large range of optics and compatibility over many generations. Over the past decade and with the introduction of the 'AF-G' and subsequently the 'AF DX' series of lenses, Nikon has begun to modernize its lens offerings. Since 'AF-G' series lenses have no aperture rings, VRI (and all manufacturers that uses Nikon 'F' mounts) must create work-around solutions to remain compatible.

## 2 Canon 'EF' mount

### 2.1 History and introduction

Many people believe that Canon was the first company to make an auto-focus camera. In actual fact, Minolta and Nikon had been selling auto-focus cameras for over a year before Canon released its first auto-focus camera.

In March 1987 Canon introduced its first 'EOS' (Electro Optical System) camera and a completely new lens mount that it called 'EF' (Electro Focus). In developing the 'EF' lens mount Canon made the bold decision to maintain no backwards compatibility at all. The 'EF' lens mount was completely new and Canon was widely accused of having abandoned its loyal customers.

It has been over twenty years since the introduction of the 'EF' lens mount and Canon is now acknowledged as having the most mature and advanced auto-focus lens system for SLR cameras. The 'EF' lens mount is a bayonet style mount with only electronic contacts for communication and control between the lens and camera and is arguably one of the main reasons Canon has risen to a leading position in its market.

### 2.2 Physical attributes

<i>Coupling Type:</i>	Bayonet with 3 (unequally sized) flanges, lens twists (clockwise) to mount
<i>Flange-focal distance:</i>	44.0 mm.
<i>Aperture mechanisms:</i>	Set from camera body only, activated by EMD (Electro Magnetic Diaphragm)
<i>Focusing Mechanisms:</i>	Manual focus or auto-focus using focusing-motors integrated into each lens
<i>Zoom Mechanism:</i>	Manual (on zoom lenses)

### 2.3 Variants (EF, EF-S)

All Canon lenses since 1987 have used the 'EF' lens mount. Various technologies have been introduced to Canon's line of 'EF' lenses to increase performance and add features such as 'USM' (UltraSonic Motor), 'IS' (Image Stabilization) and 'DOE' (Diffractive Optical Element), yet all Canon 'EF' lenses use the same physical mount and electronic contacts for communication and most 'EF' lenses are compatible with most 'EOS' cameras. The 'EF' lens mount has no mechanical parts beyond the flanges that hold the lens in place.

In 2003 Canon introduced 'EF-S' lenses which use the same mounting system and electronics as regular "EF" lenses but are designed to produce a smaller image circle for use with low-end 'EOS' digital cameras which have a sensor size that is smaller than 35 mm. film. These lenses only produce an image circle large enough to cover an area of 25.1 x 16.7 mm.

### 2.4 Summary

'EF' lenses are compatible with all modern Phantom cameras when using Vision Research's optionally available Canon 'EF' mounts. Systems to control aperture and focusing distance are embedded in the Phantom camera's control protocol making this a fully integrated and very neat system, with no external accessories or power required.

## 3 ARRI 'PL' mount

### 3.1 History and introduction

The ARRI 'PL' (Positive Lock) mount is the most commonly employed 'open' lens mount system in the cinema industry. The Panavision 'PV' lens mount is popular on Panavision cameras, but Panavision does not license its use to third parties, so it is rarely found on other cameras.

The ARRI 'PL' mount evolved from 'ARRI Bayonet' mount and though it maintains some of the same characteristics (flange-focal distance) it has a larger diameter and is hence not directly compatible with older systems. The ARRI 'PL' mount first appeared around 1980 and has increased in popularity and remains the dominant lens mounting system in the Cinema industry.

### 3.2 Physical attributes

<i>Coupling Type:</i>	Bayonet, 4 symmetric flanges, (with registration notches) – rotating collar on camera.
<i>Flange-focal distance:</i>	52.00 mm.
<i>Aperture mechanisms:</i>	Mechanical iris diaphragm within lens controlled by aperture ring
<i>Focusing Mechanisms:</i>	Manual focus controlled by focus ring
<i>Zoom Mechanism:</i>	Mechanical zoom controlled by zoom ring (on zoom lenses)

### 3.3 Variants (16 mm., 35 mm., 65 mm.)

'PL' mount lenses from various manufacturers are often built with much in common in terms of their design and function. It is important to note that these 'standards' are usually self imposed and not regulatory. While most variants are fully manual systems, they are usually compatible with 'lens-motors' that can be used to control zoom, focus and aperture remotely.

#### 3.3.1 16 mm. 'PL' mount lenses

Designed to cover a 16 mm 'film gate' (also known as the 'Camera Aperture') no bigger than 12.35 x 7.42 mm. these lenses are not a suitable choice for many Phantom cameras.

#### 3.3.2 35 mm. 'PL' mount lenses

These are perhaps the most commonly available 'PL' mount lenses and are the industry standard for 35 mm. film productions. Designed to cover a 'film gate' of up to 24.89 x 18.67 mm these lenses are well suited to use in a digital environment with 'large' sensors. Usually of very high quality these lenses also attract high prices and a great range of focal lengths is available. Most 'PL' mount lenses tend to be prime lenses and zoom lenses are only just beginning to increase in popularity and will continue to do so as lens technology improves.

The Phantom HD Gold, and Phantom Flex cameras are currently delivered with (35 mm.) 'PL' mounts as standard, and 'PL' mounts are available for almost all Phantom camera models.

#### 3.3.3 65 mm. 'PL' mount lenses

Very few sets of these lenses are in existence as currently no 'new' lenses in this format are available. Designed to cover a 'film gate' as large as 52.63 x 37.72 mm. these lenses are always expensive and only a very limited selection is available to rent. The Phantom 65 camera works well with these.

### 3.4 Summary

'PL' mount lenses are popular in the cine industry and will continue to be the dominant lens mount for high end motion-picture production. Various models within the Phantom line already are compatible with this system.

## 4 Sony 'B4' mount

### 4.1 History and introduction

Originally developed by Sony for broadcast video cameras which employ 2/3" sensors (11 mm. diagonal). This mounting system has been widely adopted since the advent of HD (High Definition) video cameras which mostly use 2/3" sensors. Most 'B4' lenses are mounted onto cameras which have 3 image-sensors one each for blue, green and red sensing. These individual sensors are usually separated by a 'prism block' or set of beam splitters and primary colour filters are placed in front of each sensor (blue or green or red).

Phantom cameras are currently not directly compatible with 'B4' mount lenses due to the small image circle they produce, however several commercial adapters exist which enable the attachment of such lenses onto Phantom cameras with 'PL' mounts.

### 4.2 Physical attributes

<i>Coupling Type:</i>	Bayonet, 3 symmetric flanges, (with 1 registration pin) – rotating collar on camera
<i>Flange-focal distance:</i>	48 mm.
<i>Aperture mechanisms:</i>	Mechanical iris diaphragm within lens controlled by aperture ring
<i>Focusing Mechanisms:</i>	Manual focus controlled by focus ring
<i>Zoom Mechanism:</i>	Mechanical zoom controlled by zoom ring (on zoom lenses)

### 4.3 Variants (ENG / EFP, Studio / Field)

Unlike many lens mounting systems 'B4' mount lenses vary greatly in design by their intended field of application. Some of these variants are fully manual systems while others use built in electronics to control focus, aperture and zoom.

#### 4.3.1 ENG / EFP (Electronic News Gathering / Electronic Field Production) lenses

These lenses are designed with ENG / EFP applications in mind and typically include features such as long zoom ranges (compared to still-photographic lenses) and fast apertures. They can vary substantially in size, weight, design and price. These lenses are often intended to be used in conjunction with shoulder mounted cameras or cameras on light-weight tripods and often have accessories to enable assisted or remote zoom, focus and aperture controls.

#### 4.3.2 Studio / Field lenses

These lenses are often very similar in appearance but differ mostly in the range of focal lengths they cover. Studio lenses tend to have a 50x (or shorter) zoom range while Field lenses often have zoom ranges of 70x or 100x. Field lenses also tend to be well suited to harsher outdoor conditions (though they are not 'water proof').

Both Studio and Field lenses are almost always 'Box' lenses and can not be hand-held or shoulder mounted. They usually have a 'sled' that supports the weight of the attached camera and the entire system is mounted atop a 'pedestal' stand or heavy-duty tripod. These lenses almost always require power, and focusing and zoom, focus and aperture controls are always made remotely.

These lenses are routinely used on Phantom cameras in sports and live broadcast productions. There is some interest in using these lenses for outdoor and 'range' type tracking situations because they are readily available and often cheaper than dedicated 'range-telescopes' and offer the added versatility of extremely long zoom ranges and can easily be controlled remotely.

#### 4.4 Summary

'B4' mount lenses are available in a very wide variety of focal lengths and are especially attractive when extremely long focal lengths are required. To use 'B4' mount lenses with Phantom cameras the image they produce needs to be magnified (typically 2x or more) to cover the large sensors in Phantom cameras, and therefore using these lenses on Phantom cameras is accompanied by a 2 stop loss of light.

## 5 Cine 'C' mount

### 5.1 History and introduction

Originally developed for 16 mm. motion picture film, the 'C' mount has been adopted as a common standard for machine-vision and security cameras. Some Phantom camera models currently employ this standard and these are usually very simple lens designs with a completely manual focus and aperture mechanism.

### 5.2 Physical attributes

<i>Coupling Type:</i>	Screw – 1 inch diameter, 32 threads per inch, 3.8 mm. threaded length
<i>Flange-focal distance:</i>	17.52 mm. for 'C' mount, 12.52 mm. for 'CS' mount
<i>Aperture mechanisms:</i>	Mechanical iris diaphragm within lens controlled by aperture ring
<i>Focusing Mechanisms:</i>	Manual focus controlled by focus ring
<i>Zoom Mechanism:</i>	Manual (on zoom lenses)

### 5.3 Variants (1", 2/3", 1/2" – C and CS)

'C' mount lenses are described using an old numbering system based on the diameter of 'Videcon Tubes'. The different numbers indirectly represent the image size that these lenses can cover.

#### 5.3.1 'C' mount 1" (1 – inch)

1 inch 'C' mount lenses produce the biggest image circle and can cover an image area of 12.8 x 9.6 mm. or a diagonal of up to 16 mm., and these are best suited for use with Phantom cameras. Typically 'C' mount lenses do not cover the entire sensor area of most Phantom cameras.



### 5.3.2 'C' mount 2/3" (2/3 – inch)

These lenses have all the same physical attributes of their 1" cousins but produce a smaller image circle only capable of covering an area of 8.8 x 6.6 mm. or a diagonal of 11 mm. and therefore they are not a good choice for use with Phantom cameras.

### 5.3.3 'C' mount 1/2" (1/2 – inch)

These lenses have all the same physical attributes of their 1" cousins but produce a smaller image circle only capable of covering an area of 6.4 x 4.8 mm. or a diagonal of 8 mm. and therefore they are not a good choice for use with Phantom cameras.

### 5.3.4 'CS' mount 1", 2/3" and 1/2" (1 inch, 2/3 inch and 1/2 inch)

'CS' mount lenses are exactly the same as 'C' mount lenses but with a shorter 'flange-focal distance' of only 12.52 mm. Cameras with 'CS' mounts can use 'C' mount lenses with a 5 mm. extension tube attached, but there is no good reason to use 'CS' mount lenses with Phantom cameras.

## 5.4 Summary

'C' mount lenses of the 1" variety may be useful on Phantom cameras thanks to their low cost and usually good quality. 'C' mounts are also found on sever optical instruments ranging from microscopes to telescopes.

## Closing remarks

Lenses have existed since before the advent of photography and film and will continue to exist and play a vital role in the 'imaging-chain' long after today's sensor technologies have been superseded.

Optical technology is more advanced than ever before and Phantom cameras are compatible with most modern lens systems.