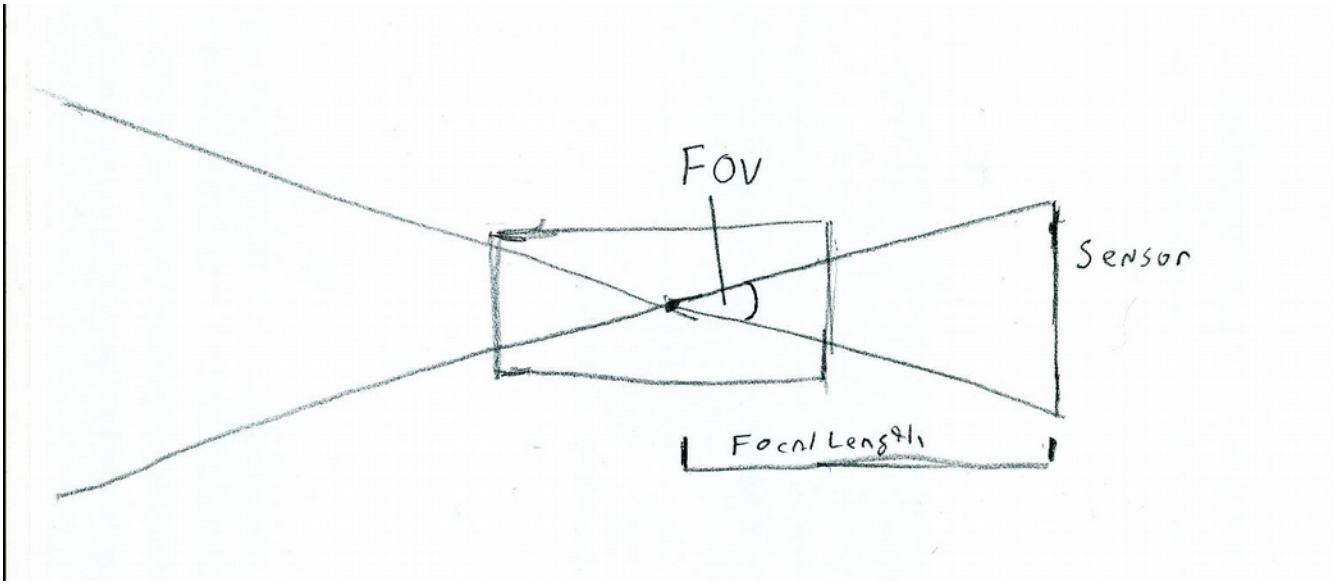
How was it created?

by Malcolm McElvaney

I took this photo at Fort Davis, TX on 06/23/2021 at 1:10pm but what hidden secrets does that original source file contain. If this image had been made from a film negative all the decisions and gear used would be lost unless noted down and archived carefully. While one can compare film versus digital photography in multiple way it is one key advantage of digital that I'm covering here as those decisions and gear used, at least partially, are recorded in the image file created as Exif data. This (Ex)changeable (i)mage (f)ile format contains the settings used to create the image and are often valued by photographers to find clues how an admired photo might have been created. Beyond being a sneak peek into a part of the file being shown here there is something to be learned here as terms are defined and illustrations are used to interconnect key concepts. Photography can be taught multiple ways so perhaps learning to read a data file is just as

applicable.

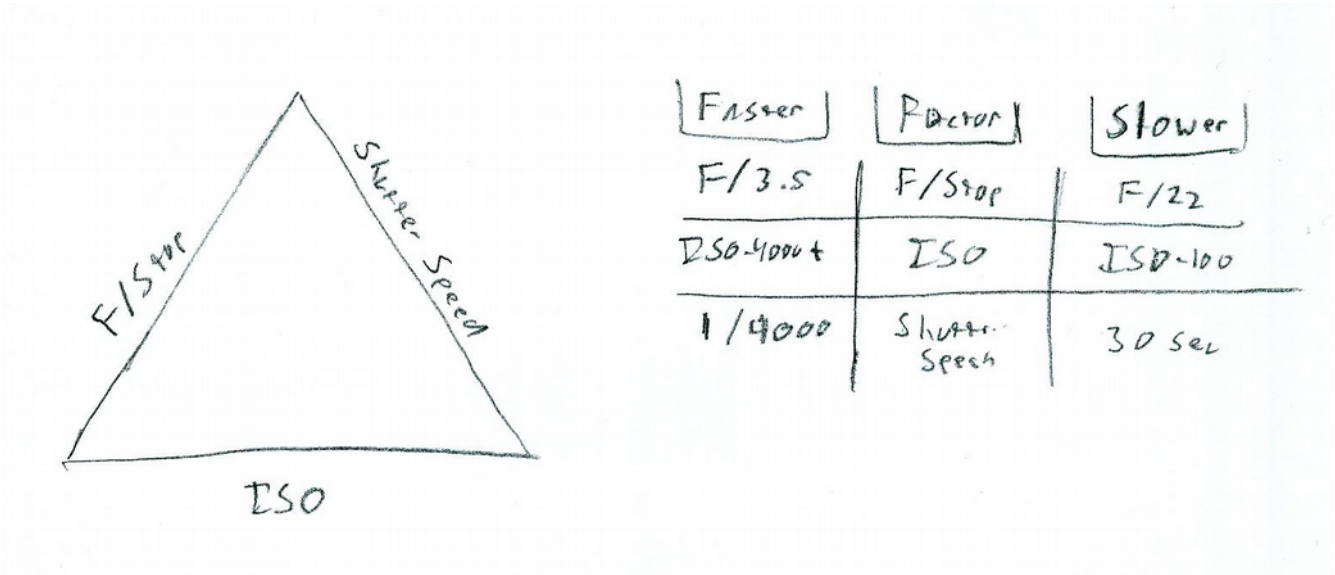
FocalLength - 21.00 mm



focal length - distance in millimeters between the center of a lens and the camera sensor
field of view - part of the world visible through the camera defined in terms of angle of view

A camera captures the light coming from the world you see and are trying to capture with it. It travels through the lens and is projected onto the sensor to be recorded altering it as only the tool being used does; while, it may not replicate how we see the world it is a filter we use to compose it. Light itself is the common element that we our attempting to control and compose with. The focal length in conjunction with the sensor size helps determine the field of view captured but the image we are viewing as a result of it allows us to see it differently than we would normally. The camera doesn't see like us either so it is an even exchange.

ExposureTime - 1/250 seconds
FNumber - 9.00
ExposureProgram - Manual control
ISOSpeedRatings - 100
Recommended Exposure Index – 100



shutter speed - length of time a camera sensor is exposed to light when taking a photo
f/stop – set of standardized opening sizes to allow more or less light into the camera and to the sensor
aperture - opening through which light passes through the lens to enter the camera
ISO - International Organization for Standardization, represents the sensor's sensitivity to the light
bracketing - general technique of taking several shots of the same subject using different camera settings

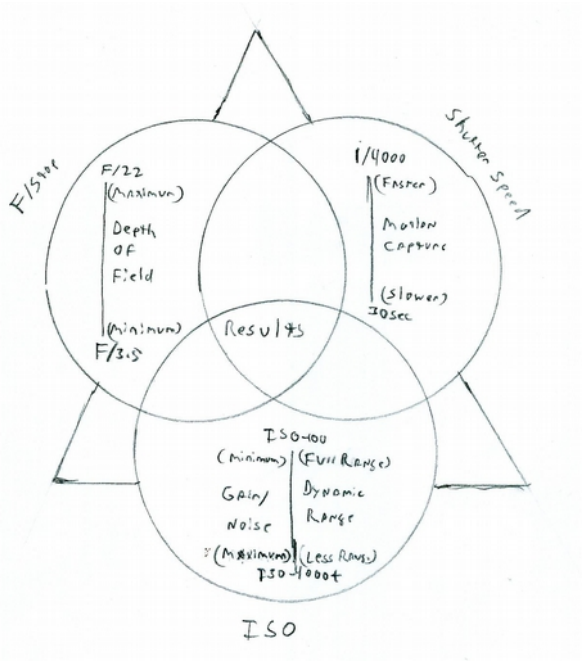
One the easiest ways to visualize how the shutter speed, f/stop, and ISO work together to control the exposure is the exposure triangle; however, there are differences between the exif data and the terms I defined so I will try to clear it up. Fnumber and F/stop are the same but both represent a ratio of the aperture and focal length. It can get confusing as various camera manufactures use different parts but the aperture will be set for the focal length being used so the desired ratio is achieved. The result is f/9 or fnumber=9.00 will allow the same level of light into any camera. ISO is also an interesting case study as the organization set standards for many things and not just cameras but the specific standard to look at would be ISO 12232.

The three factors that control the light levels being recorded are unique in how they are notated and the scales may seem reversed but they do alter the exposure times to be slower or faster. The same light level can be achieved with multiple combinations

depending on the desired result.

At the simplest level it is a mathematical model that mains goal is to keep a balance between two of factors and leave the other one alone. A practical example would be increasing the the f/stop making it necessary to increase the amount of light for the the exposure. The translation is a higher f/stop darken the image so the shutter speed is increased to compensate and bring the overall light captured to a net gain of zero. The way it is usually stated is double one factor and halve another.

A more advanced photography technique called bracketing that you may one day use takes only one factor, usually the shutter speed, to take multiple images of the same scene. Based on your initial exposure setting a neutral image is captured along with a number of images that are overexposed and underexposed using the doubling and halving concept. The reasons for doing this maybe to capture more dynamic range, I will cover it later, or increase your chances of a correct exposure.



dynamic range - range of luminance of an image between its highest and lowest light intensities, usually pure white and pure black
gain – amplification of the signal to full strength
depth of field - distance between the nearest and the farthest objects that are in acceptably sharp focus in an image

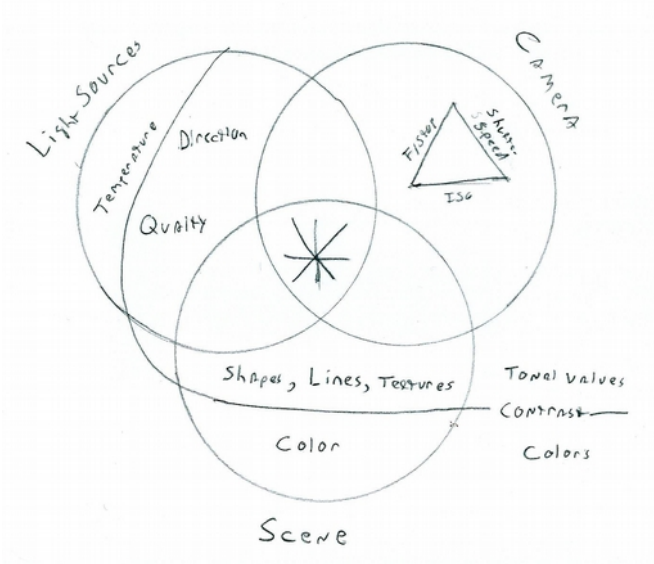
Just as each factor has an unique notation and numbering scheme they also influence the visual appearance of the final image. Having the ability to choose a different combination of factor for the same exposure also allow you to fine tune the image artistically. The slightly enhanced exposure triangle shows a ranges of scales and effects

each factor contributes.

F/stop controls how much light enters into your camera and that opening size will alter the overall depth of field (how much is in focus). There is more to it than I can explain here but f/3.5 will have a shallow, out of focus background; while f/22 will have your foreground and background both in focus. Shutter speed is primarily how fast motion is captured but if this is your main concern then you may have to compromise on another factor. The final factor is ISO and I do explain it later on but the higher the ISO the more noise you will see and the amount of light in terms of dynamic range will be reduced.

Composition of your image is going to be based on visually what appeals to you as much as the "rules" you learn to break later but conditions within the scene will make some setting necessary but you do have some creative control even then.

White Balance – Auto



white balance - adjustment done to an image in order to compensate for the temperature of the light illuminating the scene
Kelvin - absolute thermodynamic unit used to measure temperature color

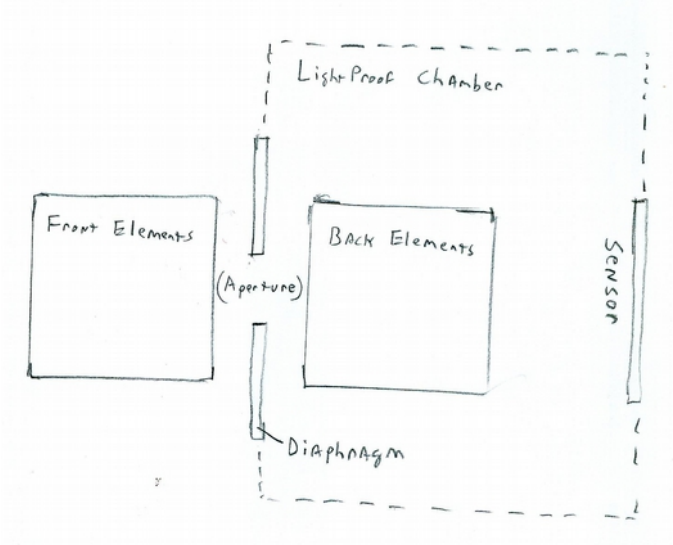
I rarely alter this setting from auto but should I choose to I can select from other presets for artificial lighting to any number on the kelvin range from 2500k to 9900k but I am highlighting this particular entry for a reason. If we get to focused on the gear we use I think we forget about the most important piece of photography gear, us, and no matter how smart the camera gets we point it at the subject to capture. The temperature of the light in the scene is something we also appreciate and take into account.

The vinn diagram takes the light sources, the scene, and the camera and considers them as a whole. Limitations will always exist but how can the best possible results be

achieved given what is available. This is a departure from the camera basics but composition is important too.

The light sources in the scene will have a direction and quality about them but also have their own temperature color that influence everything. The sunrise, high noon, or even a sunset will alter how or if we shoot pictures because the shifting light plays with the perceived colors. The scene itself isn't fixed but depending on your point of view at the time is full of shapes, lines, and textures to capture your eye to compose with. Normally color is something we take for granted but what if you are doing black and white photography? The source of contrast in that scene maybe from the color or tonal values so depending on which one the focus of the image shifts. I ran through the diagram rather quickly but everything does relate to each other. The camera portion is just one-third of this diagram so remember to look around and enjoy photography while mastering your tools.

Make - SONY
Model - ILCE-6000
Lens Info - 18.00 55.00 3.50 5.60
Lens Model - E 18-55mm F3.5-5.6 OSS



diaphragm - mechanical device inside a camera lens that controls the aperture
shutter – device covering the sensor to control when it is being exposed
ccd – (charged coupled device) type of digital sensor
cmos – (complementary metal-oxide-semiconductor) type of digital sensor
geometrical optics - branch of optics that deals with those phenomena of reflection and refraction
refractive index - determines how much the path of light is bent, or refracted, when entering a material
refraction - the change in direction of a wave passing from one medium to another

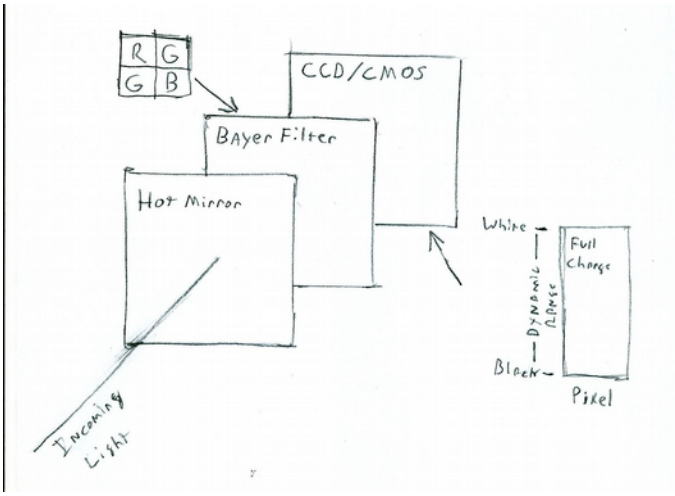
caused by its change in speed
diffraction - phenomena that occur when a wave encounters an obstacle or opening

The basic components of a camera as illustrated comes in many forms and sizes from the cell phone you are likely familiar with to the original large format 8 x 10 inch view camera. Film is not as universal as it once was but digital sensors, unlike film, do have size constraints placing some limits on digital cameras. Regardless of the medium recording the image the lightproof chamber is critical so only the projected light is captured. The lens is composed of optical elements designed to work with the aperture so aberrations can be corrected for to produce the images we take for granted. Lenses like the cameras they are attached to are designed to solve a problem and work the placement of the optical elements and aperture to fit that solution. The shutter (not pictured) controls the actual exposure of the sensor which in digital usually will a CCD or CMOS type device.

While it is not absolutely needed to know this to do photography I want to briefly introduce you to how the light is redirected through the lens. The math behind it is called geometrical optics and with this knowledge the shapes and densities of those elements can be calculated for the results needed. How about the science behind the lens components? The aperture is an opening letting light through but it is diffraction that creates the level of detail brought into focus. I have yet to wrap my mind around this myself but you might be interested in trying to figure it out. The optical elements are shaped to redirect light but it also the refractive index or density of the material used to bend the light that is key. Rabbit holes can very educational.

BrightnessValue - 9.91
ExposureBiasValue - 0.00
MaxApertureValue - F 4.00
MeteringMode - Spot
LightSource - Auto
Flash - Flash not fired, compulsory flash mode
FlashPixVersion - 0100
ColorSpace - sRGB
ExifImageWidth - 6000
ExifImageHeight - 4000
InteroperabilityOffset - 38166
FileSource - DSC - Digital still camera
SceneType - A directly photographed image
CustomRendered - Normal process
ExposureMode - Auto bracket
SceneCaptureType - Standard
Contrast - Normal
Saturation - Normal
Sharpness - Normal
High ISO NoiseReduction - Normal

Creative Style - Standard
Dynamic Range Optimizer - Off
Image Stabilization - Off
Color Mode - Standard
Quality – Fine



hot mirror - filter designed to pass visible light while blocking infrared and ultraviolet light with a sharp cutoff at either end
bayer filter - color filter array (CFA) for arranging RGB color filters on a square grid of photosensors

The long list of controls and there status are a glimpse of the settings you can control to produce the final files created. This stage of the image creation is handled by the processor and what was read off of the sensor (ccd or cmos) but some interesting behind the scenes aspects are worth noting.

Where is the color you see coming from? A CCD can only record the build up of electrons resulting from the light hitting each pixel on that chip. All of these individual pixels combine to form the image yet are essentially black and white. Built on top of the sensor are two filters that play an important part. The light initially passes through a hot mirror so only visible light we can see is recorded and then goes through a bayer pattern with a combination of red, green, and blue filters in a repeating pattern before that light hits the actual sensor. Interpolation is used to combine the information and create that full color image.

If you only have one sensor where do all the ISO's come from? In the case of my camera it has one native ISO, ISO-100, where the full dynamic range is used. Dynamic range is more limited for the camera but can be considered the darkest detail you can see to the brightest detail you can see all at once. For the camera it will be the darkest detail you can capture to the brightest detail you can capture within one image. The trade off for this full range of capture is a longer exposure time needed; however, as you go to

progressively higher ISO numbers the processor is reading the sensors data sooner to decrease the exposure time needed. Gain or amplification is then applied to create a brighter image and this where the noise is introduced. The pattern I found was ISO-200 was sampled one stop lower, ISO-400 was sampled two stops lower, etc hopefully this helps clear it up.

The need to use a higher ISO may be unavoidable yet the reduced dynamic range is an issue given the contrast between the shadows and highlights so a technique called bracketing can be used. The overexposed version has enhanced details in the shadows and the underexposed version has enhanced details in the highlights to be combined in post-processing. Another term it will be found as is HDR (high dynamic range).

I'm a photographer who likes to explore drawing, painting, comics, and video game development even though I don't actually attempt those particular art forms but I do get inspiration for my photography from them. It was my aim to hopefully introduce you to photography from another perspective and mind set but before I reveal the full Exif data "as is" here are some of the resources I found useful in my research so far.

- What is ISO? Understanding ISO for Beginners - Photography Life ISO - A better picture: International Standard gives photography a new exposure
- Micro Lens Making Patents Make Largan Shinning Star – WAVES (techpolicyviews.com)
- Smartphone Imaging Constraints - Understanding Camera Optics & Smartphone Camera Trends, A Presentation by Brian Klug (anandtech.com)
- A Guide to Types of Lens Aberrations in Photography (expertphotography.com)
- Lens Rentals | Blog - Lens Genealogy part 1
- Lens Rentals | Blog – From Petzval's Sum to Abbe's Number
- (1) Geometric Optics 2 - YouTube
- What Is Lens Diffraction? (photographylife.com)

Filename - DSC06673.JPG
ImageDescription -
Make - SONY
Model - ILCE-6000
Orientation - Right top
XResolution - 350
YResolution - 350
ResolutionUnit - Inch
Software - ILCE-6000 v3.20
DateTime - 2021:06:23 13:10:50
YCbCrPositioning - Co-Sited

ExifOffset - 364
ExposureTime - 1/250 seconds
FNumber - 9.00
ExposureProgram - Manual control
ISOSpeedRatings - 100
Recommended Exposure Index - 100
ExifVersion - 0230
DateTimeOriginal - 2021:06:23 13:10:50
DateTimeDigitized - 2021:06:23 13:10:50
ComponentsConfiguration - YCbCr
CompressedBitsPerPixel - 3 (bits/pixel)
BrightnessValue - 9.91
ExposureBiasValue - 0.00
MaxApertureValue - F 4.00
MeteringMode - Spot
LightSource - Auto
Flash - Flash not fired, compulsory flash mode
FocalLength - 21.00 mm
UserComment -
FlashPixVersion - 0100
ColorSpace - sRGB
ExifImageWidth - 6000
ExifImageHeight - 4000
InteroperabilityOffset - 38166
FileSource - DSC - Digital still camera
SceneType - A directly photographed image
CustomRendered - Normal process
ExposureMode - Auto bracket
White Balance - Auto
DigitalZoomRatio - 1.00 x
FocalLengthIn35mmFilm - 31 mm
SceneCaptureType - Standard
Contrast - Normal
Saturation - Normal
Sharpness - Normal
Lens Info - 18.00 55.00 3.50 5.60
Lens Model - E 18-55mm F3.5-5.6 OSS

Maker Note (Vendor): -
High ISO NoiseReduction - Normal
Creative Style - Standard
Dynamic Range Optimizer - Off
Image Stabilization - Off
Color Mode - Standard
Quality - Fine
Sony Model ID - ILCE-6000
Lens Type - -1

Thumbnail: -

Compression - 6 (JPG)
ImageDescription -
Make - SONY
Model - ILCE-6000
Orientation - Right top
XResolution - 72
YResolution - 72
ResolutionUnit - Inch
Software - ILCE-6000 v3.20
DateTime - 2021:06:23 13:10:50
JpegIFOffset - 38458
JpegIFByteCount - 7951
YCbCrPositioning - Co-Sited