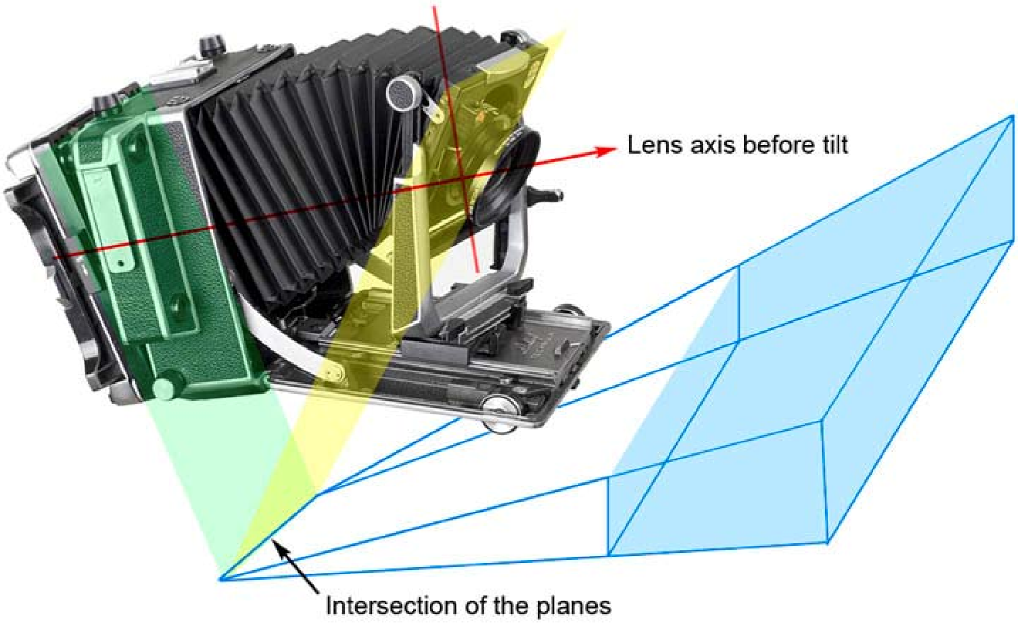
Focusing the Tilt-Shift lens

an article by David Summerhayes ©

Introduction – With normal 35mm camera lenses, the axis of the lens is mounted in a fixed position at right angles to the film plane. The lens can move forward and backward creating a plane of sharp focus in front of it. A slice of focused space if you like, that also moves forward and backward, but always parallel to the film plane.

Tilt shift lenses are designed to emulate the camera movements found on larger monorail and technical field cameras. These cameras, with their fine mechanical controls, have the ability to move this slice of space to the left and right, up and down and most importantly tilt and swing it away from the perpendicular. For example, by tilting the lens forward by the right distance, a photographer is able to adjust the plane of focus to run along the ground, giving a vastly increased apparent depth of field, even with the lens wide open!

This is the classic illustration of the Scheimpflug rule in action. Theodor Scheimpflug (1865-1911) stated that; 'when the extended lines from the lens plane, the object plane and the film plane intersect at the same point, the entire subject plane is in focus.' I won't go into a detailed explanation, as much has already been written on the subject, but I hope the diagram below illustrates the concept. For my simple focusing technique, knowing how far the object plane lies in relation to the lens axis is very important.

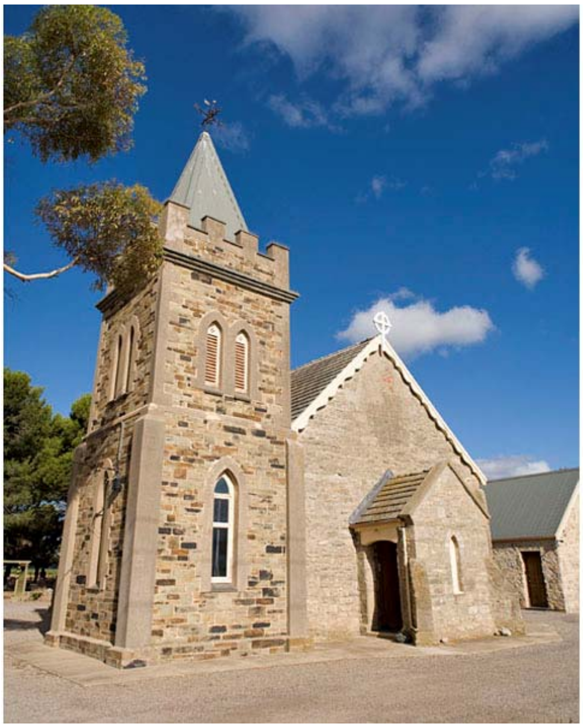


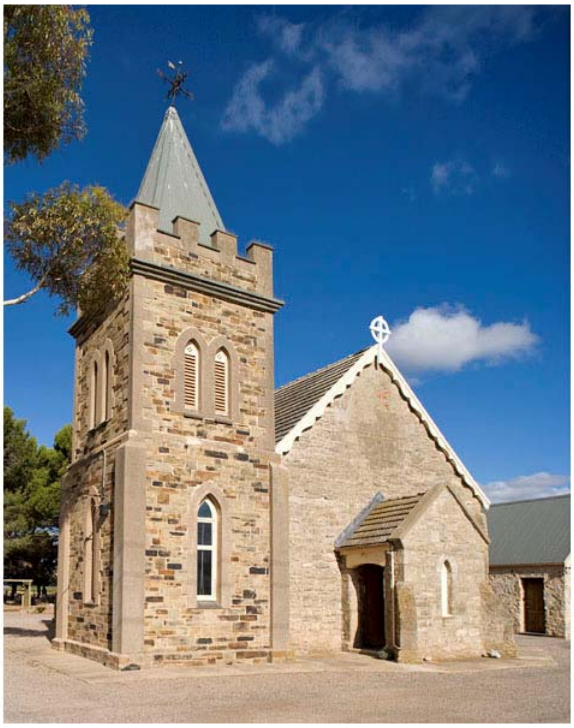
This is my old Linhof Technika showing its extreme range of movements
and a very simplified diagram of the Scheimpflug rule in action.

Green is the film plane, Yellow is the lens plane and Blue is the object plane which is actually wedge shaped, extending out from the intersection, varying in size with aperture and lens focal length selected.

The most important distance we need to know or measure is the distance parallel from the lens axis to the intersection of the plane on which the main subject lies. The nearer the object plane is to the camera, the more accurate the measurement should be.
When using 35mm formats on many occasions even a good guess will suffice as being out by 10cm or so over a metre will only mean an error of a fraction of a degree of tilt – just about impossible to set on these lenses or to see the difference in practical use.
Also, sometimes the intersecting point occurs behind a wall, tree or even underground.
So being able to estimate the correct distance is a valuable skill to have.

Shifting Shift lenses can move sideways and up and down to control perspective and key-stoning (converging verticals). They can also be rotated to facilitate vertical and horizontal shooting but as well as this and very importantly, they can be set to shift at angles of 30° and 60° to the horizontal. Shifting at one of these angles is the same as using a shift combined with a rising front movement on a view camera.
For those new to camera movements; my opinion is to never correct converging verticals into perfect parallels. It is the best way to make a building look as if it will fall on top of you and one of my long-time pet hates in architectural photography. I almost always leave a little convergence. After all, it is a normal visual phenomenon!





These before and after pics were taken hand held, to show ease of use, with a 24mm shift lens. The shot on the right was given 5 degrees of shift at an angle of 30 degrees from the vertical, upward and slightly to the right, to bring the right hand side of the building closer and to give the turrets on the tower less emphasis. Notice I have kept a slight convergence as you look upward to keep a more natural or expected look.

An added bonus to being able to shift the lens, in digital photography, is the advantage of being able to produce images left and right of the fixed camera position to be later stitched seamlessly into a panorama. By increasing the file size, this technique can dramatically extend the apparent resolution normally possible with a camera. As this article is about focusing, I won't dwell on this only to say it is very handy to have one of these lenses.

This panorama was made by stitching together three 12mega pixel shots taken with a 45mm shift lens.

Tilting As stated before, tilting the lens off axis moves the plane of focus in relation to the sensor plane (film plane). But it can be so much more. Again, used in conjunction with rotation, the plane of focus can be made to run in practically any direction away from the viewer. For example, along the top of a picket fence running off into the distance. Add an extension tube, and tilting the lens opens up a whole new world of possibilities with macro photography. For example, looking along the surface of a leaf from close up foreground to wider view background without worrying about diffraction from stopping down to *f*22. The very same technique can be used to limit depth of field to a narrow view such as setting the focus across the petals of a flower.

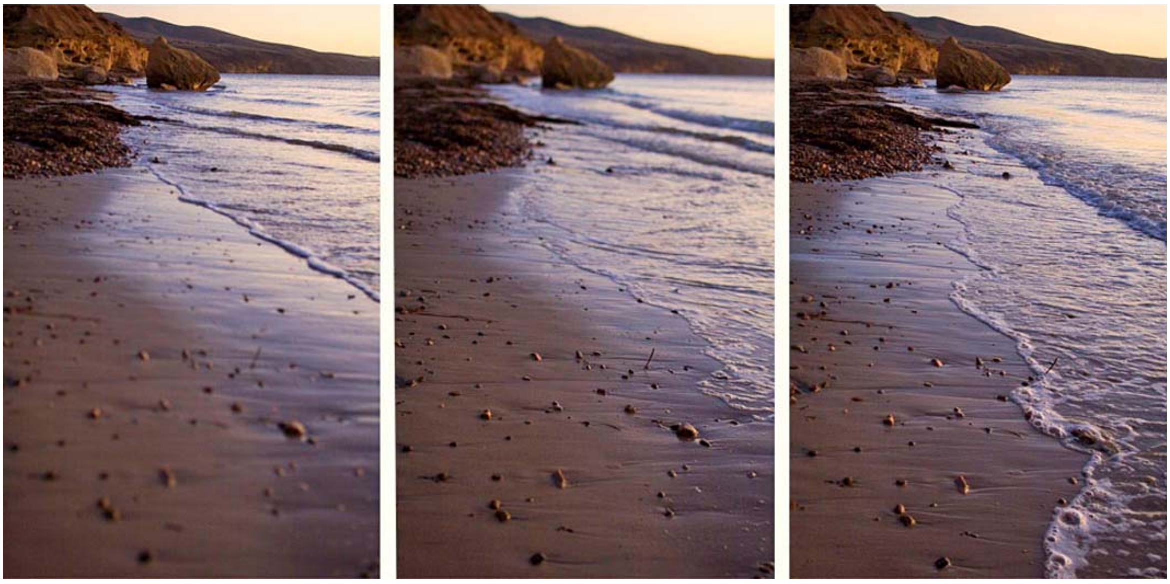
This is a simple example of using lens tilt with a 45mm lens. For this demonstration all shots were taken hand held, under low lighting conditions with the lens at the maximum aperture *f*2.8. Left and middle are focused for the distance then foreground. The shot on the right was also made at *f*2.8 with 4 degrees of tilt.

Focusing On large format cameras when shifting the lens off axis, focusing is easier as the image can be closely inspected with a 10x loupe on the ground glass screen – not so with 35mm cameras and this has always been the frustration of using these lenses.
The book says; with the camera on a tripod, focus on the most distant point. Then, tilt the lens until the nearest object comes into focus. Readjust the angle if necessary, check that the far point is still in focus and adjust the angle again if necessary – difficult in low light situations and I think it is at this point a lot of photographers give up and just look for *f*22. But don't despair as there is a simple way of working out the correct angle almost as soon as the composition is realized.

The Maths you don't have to know There is a simple formula that describes how to work out the correct angle of lens tilt to get a given object plane in focus.
The angle of tilt is simply the inverse sine (arcsine) of the focal length of the lens divided by the distance from the object plane to the principal point (axis) of the lens.
You should try it sometime but you don't have to. I did sit down one cold, rainy evening and after doing lots of research, made a set of tables for the 3 most common focal length T/S lenses 24mm 45mm and 90mm. These lenses all have 8° of shift so the table basically has 8 conclusions, although I did add a few half points for good measure. The increments on these lenses are very small and setting a fraction of a degree accurately is practically impossible. Granted sometimes the angles need tweaking in real situations but usually only by a nudge or so, especially where the lens principal point to subject plane estimates, are a bit out. The most common mistake I have seen is over estimating the amount of tilt needed. Just throwing in 5 degrees of tilt for a starting point to get a Scheimpflug effect on a normal landscape is usually way too much as the sample below may illustrate.

In Practice In the field there is no need to carry tape measures and calculators in your pack although a ruler is handy when using this technique for macro. With lenses of 24mm and 45mm focal length, the longest measurement of consequence is only 2.5 metres and 5 metres when using 90mm lenses.

With a good understanding of the principles and using the tables provided below, the distance to the focus plane can be estimated to good enough accuracy. I usually have this distance worked out and the correct angle set on the lens before it goes on the tripod. In fact this works so well a tripod is often not necessary. For example, if I am standing (my eye level is 1.7m) and using a 45mm lens, the focus plane being the ground from my feet to infinity, I will need a shift of 1.5 degrees to get everything focused using the optimum aperture I choose. If I decide I don't like that composition and decide to crouch down, my eye level is now just over a metre, so I would set an angle of 2 degrees for the same effect. Once the angle has been determined you can focus on any point along the plane - usually the most important or contrasty point.



Again, for demonstration, all shots were taken hand held, under low lighting conditions with the lens at the maximum aperture *f*2.8. Left and middle are focused for the background then foreground. The shot on the right was also made at *f*2.8 but with 2 degrees of tilt. I was crouching down so estimated the distance from the camera to the ground to be a little over a metre – hence 2 degrees. Once the tilt was calculated I just focused on the contrasty pebbles and everything came together.

In skilled hands, using these lens movements open up boundless more possibilities for scope and creativity than I can show here. In many cases similar effects can be achieved by stopping the lens down or combining two shots in Photoshop.

Extremely 'bending' photos in Photoshop to correct perspective can be a very destructive process to apply to a 'fine print' file and should be used with extreme discretion.

For me, knowing I am using the sweet spot of the lens stopped down to the best aperture without fear of diffraction is invaluable. Also, I really feel that I am practicing the craft of photography and thinking more about the subject when using these lenses - letting go of the habit of using auto functions – a feeling I miss since selling my Linhof 4x5 outfit.

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A final word about the Canon TS-E 24mm tilt shift lens

I have read in many reviews from owners of these lenses complaining about the edges not being sharp at wide apertures. This is true and although not desirable it is necessary and can be quite simply explained. This lens is <u>not</u> of a flat field design! A good example of a flat field designed lens could be an enlarger lens or macro lens. These lenses are designed to focus on a flat field plane where the focus holds true as well at the centre of the field as it is at the edges. Many wide angle lenses are corrected for this but then again they do not have to operate at such extremes as the tilt/shift designs.

Imagine if you will the difference in distance from the camera to the centre of the focus plane verses the distance from the camera to the edge of the focus plane. When using a 24mm lens with its 84° angle of view, if the centre of the field is 3.5 metres away from the camera, the edges of the field will be 5 metres away. At 18 metres the edges of the field will be 25 metres away and so on. When using this lens at the widest aperture and at moderate distances, the focus plane could be imagined as radiating out from the camera rather than a flat plane as previously described. The moral of the story is to always stop down to get the most out of this lens design and retain corner sharpness.

It is necessary for the lens not to be a flat field design to accommodate ‘shift’.
Imagine what would happen to your focus when you shifted left or right if the edges of the lens focused further away than the centre! When shifted the centre focus would jump forward, magnification would change ever so slightly making stitching difficult.

What people are actually seeing when they focus on lens charts or a flat field object is not so much ‘soft focus’ as in lens aberration but more just plain ‘out of focus’. Perhaps if the lens chart was curved to be equidistant from the lens the result would be different.

It should be carefully noted that for the same reasons, the edges of the frame may appear out of focus when this very wide angle lens is tilted, even when the correct angle of tilt has been calculated. Here it might be wise to think of the ‘flat’ plane of focus as being slightly bow shaped. Once the angle of tilt has been calculated I would suggest not focusing right in the centre of the lens but instead to find an object about a third of the way into the composition to average out this annoying quality of the lens design. Again it is always best to close down a few stops to achieve the best results.

It may be true that Canon could design a faster wide angle shift lens but the focusing problems would become even more noticeable and the extra lens elements needed to correct problems would make the lens much more expensive. The laws of physics as well as economics still dictate lens performance. Especially as we approach the limits of sensor miniaturization. Improvements will always come with time. The current Canon series of TS lenses were designed way back in 1991 when film was king and digital cameras were just becoming a reality.

Addendum Just released, the Canon TS-E 24mm f/3.5 L II and the TS-E 17mm f/4 L
As yet I haven’t had the chance to try these but my friend Bryan has done a brilliant job thoroughly testing them. See more of his reviews on The-Digital-Picture.com
As predicted, these lenses are more expensive but they are built to very high standards to accommodate the new 21 megapixel cameras.

Feel free to print out and laminate the tables below. Practice makes perfect - enjoy!

The distances in these tables have been rounded off to
facilitate practical field use
I have made them wallet size as I find this the best place to keep them
but they can be easily enlarged to suit personal needs
they work for full frame and APS sized DSLRs as well as medium format

To use, simply measure or estimate the perpendicular distance from the lens
to the plane of focus then read off and apply the corresponding degree of tilt required

Tilt/shift 17mm lens	
Degree of tilt	Focus Plane
0.5 °	1.94 m
1 °	97 cm
1.5 °	65 cm
2 °	49 cm
2.5 °	39 cm
3 °	32 cm
4 °	24 cm
5 °	195 mm
6 °	162 mm
7 °	139 mm
8 °	122 mm
www.davidsummerhayes.com	

Tilt/shift 24mm lens	
Degree of tilt	Focus Plane
1 °	1.3m
1.5 °	900mm
2 °	690mm
2.5 °	550mm
3 °	460mm
3.5 °	390mm
4 °	345mm
5 °	275mm
6 °	230mm
7 °	197mm
8 °	172mm
www.davidsummerhayes.com	

Tilt/shift 45mm lens	
Degree of tilt	Focus Plane
1 °	2.6m
1.5 °	1.7m
2 °	1.3m
2.5 °	1m
3 °	860mm
3.5 °	740mm
4 °	645mm
5 °	520mm
6 °	430mm
7 °	370mm
8 °	320mm
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Tilt/shift 90mm lens	
Degree of tilt	Focus Plane
1 °	5.2m
1.5 °	3.5m
2 °	2.6m
2.5 °	2m
3 °	1.7m
3.5 °	1.4m
4 °	1.3m
5 °	1m
6 °	860mm
7 °	740mm
8 °	645mm
www.davidsummerhayes.com	

Can’t find your lens here?
send an e-mail to me at davesum@chariot.net.au
and I will tailor make a table for you.
Please let me know where you are from and what camera you are using

Feet and inches for my friends in the United States

The distances in these tables have been rounded off to
facilitate practical field use
I have made them wallet size as I find this the best place to keep them
but they can be easily enlarged to suit personal needs
they work for full frame and APS sized DSLRs as well as medium format

To use, simply measure or estimate the perpendicular distance from the lens
to the plane of focus then read off and apply the corresponding degree of tilt required

Tilt/shift 17mm lens	
Degree of tilt	Focus Plane
0.5 °	6′ 5″
1 °	3′ 3″
1.5 °	2′ 2″
2 °	1′ 8″
2.5 °	1′ 4″
3 °	1′ 1″
4 °	9 ½″
5 °	7 ⅞″
6 °	6 ½″
7 °	5 ½″
8 °	4 ⅞″
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Tilt/shift 24mm lens	
Degree of tilt	Focus Plane
1 °	4′ 3″
1.5 °	3′
2 °	2′ 3″
2.5 °	1′ 10″
3 °	1′ 6″
3.5 °	1′ 3″
4 °	1′ 1″
5 °	11″
6 °	9″
7 °	8″
8 °	7″
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Tilt/shift 45mm lens	
Degree of tilt	Focus Plane
1 °	8′ 6″
1.5 °	5′ 7″
2 °	4′ 3″
2.5 °	3′ 3″
3 °	2′ 10″
3.5 °	2′ 5″
4 °	2′ 1″
5 °	1′ 8″
6 °	1′ 5″
7 °	1′ 2″
8 °	12″
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Tilt/shift 90mm lens	
Degree of tilt	Focus Plane
1 °	17′
1.5 °	11′ 6″
2 °	8′ 6″
2.5 °	6′ 6″
3 °	5′ 7″
3.5 °	4′ 7″
4 °	4′ 3″
5 °	3′ 3″
6 °	2′ 10″
7 °	2′ 5″
8 °	2′ 1″
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send an e-mail to me at davesum@chariot.net.au
and I will tailor make a table for you.
Please let me know where you are from and what camera you are using