Advanced Animation in ArcScene™

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Introduction

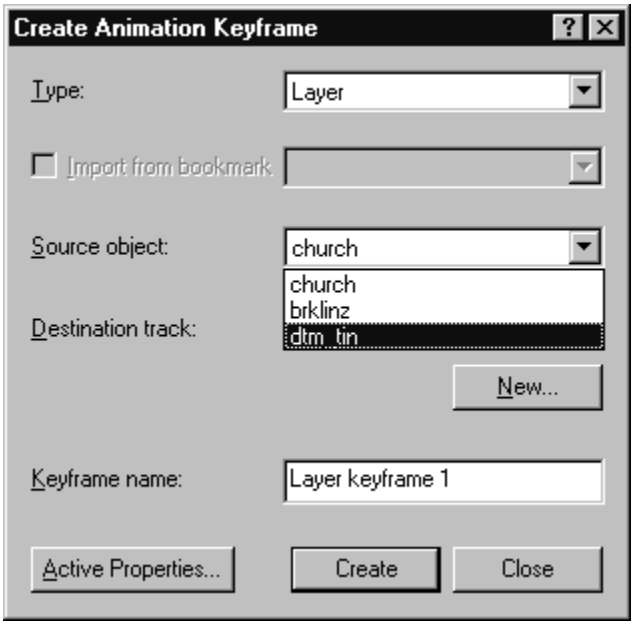
This document provides hints and examples for ArcScene™ software users to develop advanced animations, making use of functionality that is accessible from the graphical user interface but is not described extensively in the basic documentation. This document applies only to ArcScene 8.2 and later versions.

The animation functionality of ArcScene allows you to create complex, dynamic effects in three-dimensional scenes, going much farther than a simple flyby or layer group sequence. To achieve these elaborated effects, multiple tracks can be combined with different active properties and timing parameters to control one or more objects. A special case of this combination technique is the composition of layer transformations.

Track Binding

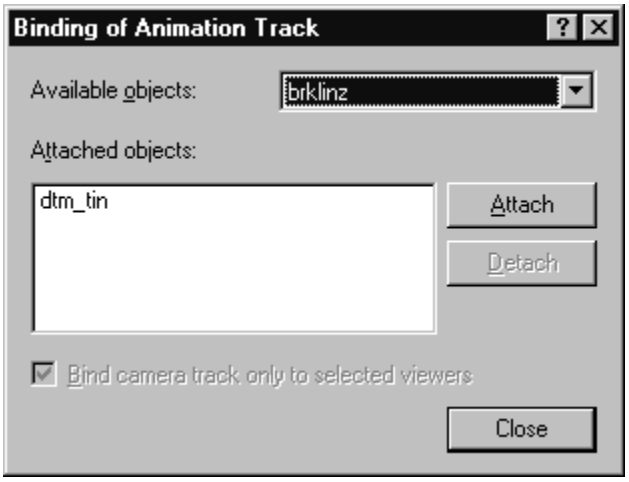
Each animation track controls the state of one or more objects to which the track is bound or attached. When the ArcScene tools are used to create animation tracks, the tools decide which objects the track is bound to. For instance, when you use the Create Animation Keyframe dialog box, you select a unique source object (Figure 1). If you create a new track (by clicking on the New button), it will be attached to this source object.

Figure 1
Selection of an Object in the Create Animation Keyframe Dialog Box



You can change the list of objects attached to a track. To do this, select the track in the Tracks view of the Animation Manager and click on the Binding button. The Binding dialog box will pop up, showing the list of attached objects (Figure 2). You can remove or add objects to the list. For example, if you have created a layer track to change the transparency of a certain layer but you later change your mind and want it to be applied to a second layer instead, you can remove (detach) the first layer from the binding list and add the second one. Or you can have both in the list, so the two layers will change their transparencies simultaneously.

Figure 2
Changing the Binding of a Track



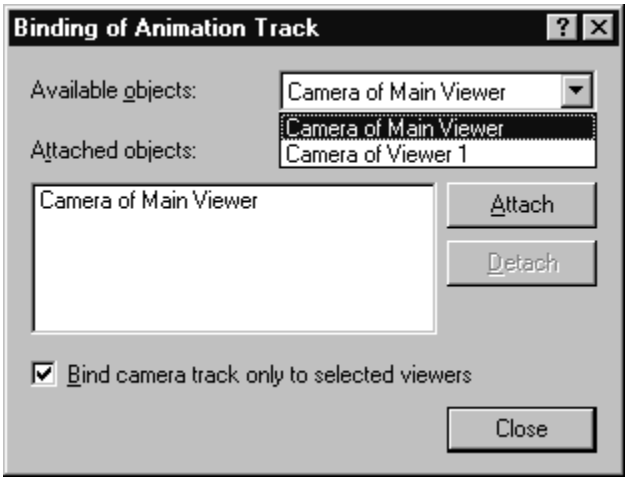
Multiple tracks can be attached to the same object, and they can all be enabled simultaneously. In general, the track that is first in the list will dominate and override the effect of the other ones on the object. However, you will see later how sometimes you can make all the tracks work together to achieve a combined effect.

Camera tracks have an additional property that can be used to bind the track to any viewer of the scene automatically, so if you remove or add viewers, you do not need to change the binding each time. For instance, the camera tracks created by the Capture View, Record, or Import from Path tools are automatically bound to all viewers, so they can be played in any of them. In the Binding dialog box (Figure 3), the option "Bind camera track only to selected viewers" is enabled, unselected, for those tracks.

However, in some situations you may want to bind a camera track only to specific viewers. For example, you may want to play different camera tracks in different viewers. For example, you have two camera tracks, A and B, and you would like to play A in the main viewer, while B plays in a secondary viewer. First, you must make sure that there is actually a secondary viewer open. Then you can select track A, open the Binding dialog box, enable the check box to bind it only to a selected viewer, and make sure that the main viewer is the only one in the list of attached objects. For track B, you also enable the check box. In this case you use Detach to remove the main viewer from the list of

attached objects, then select the secondary viewer from the list of available objects and click the Attach button.

Figure 3
Binding a Camera Track to Selected Viewers



Once you have bound each track to a different viewer, you have two options: you can play both simultaneously, or you can play them alternatively. To play them at the same time, make sure the "Play in all Viewers" option is selected in the Animation Controls dialog box, and click on the Play button. To play alternatively, uncheck "Play in all Viewers," click on the main or the secondary viewer, and click on the Play button.

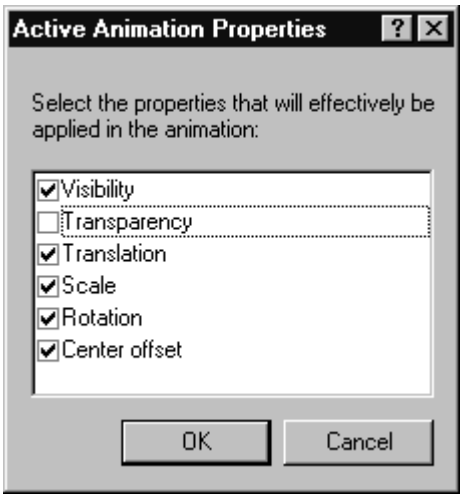
Active Properties

Each animation track can control the number of properties of a certain object type. For example, a camera track is able to control the projection type, target, azimuth, inclination, roll, view distance, view angle, and ortho extent of the camera of an ArcScene viewer simultaneously. The keyframes of each animation track store values for all these properties; therefore, when you open the Keyframes tab in the Animation Manager, you can see the names of the properties in the table header and their actual values.

You can also see the list of properties that each track controls by selecting it in the Tracks tab of the Animation Manager and clicking Properties (Figure 4). This dialog box not only lists the properties but also shows which are active in the track and allows you to enable or disable them by using the check boxes.

What is the effect of disabling some of the track properties? When the track is played during the animation, the disabled properties will not change their values in the object that is attached to the track. For instance, if you disable the transparency property of a layer track, the layer transparency will not change during the animation. The layer will keep whatever transparency value it had before.

Figure 4
Active Properties Dialog Box (for a layer track)



There are two reasons why it can be useful to disable track properties. First, you may want to change those properties interactively instead of controlling them from the animation. For instance, if you import a camera flyby from a path, you can select the imported track and disable the Azimuth and Inclination properties. This will allow you to rotate the view interactively while the camera target moves during the animation.

A second reason to disable some properties is the use of simultaneous tracks to control different parameters of the same object. For example, when you use the Move Layer along Path command, a layer track is created that only has the Translation and Rotation properties enabled by default. You can then create a second track attached to the same layer to control a different parameter such as transparency. In this second track you would disable all the other properties. Both tracks can now play simultaneously without conflict.

You can also disable properties at individual keyframes. To do so, click Active Properties on the Create Animation Keyframe dialog box or Properties in the Keyframes page of the Animation Manager. Keyframe properties can be disabled to allow interactive control or combine the effect of tracks in certain parts of the animation and also to turn off the effect of individual keyframes without actually removing them from the track. When a keyframe property is disabled, a special string ("—") will appear in the keyframes table instead of a regular value.

In some cases the keyframe properties may have been automatically disabled by the animation framework. For example, when camera keyframes are created, the properties that do not correspond to their projection type are disabled. If the keyframe was captured with a perspective projection, the ortho extent property is disabled. In the same way, all the other camera parameters are disabled when the captured keyframe used orthographic projection.

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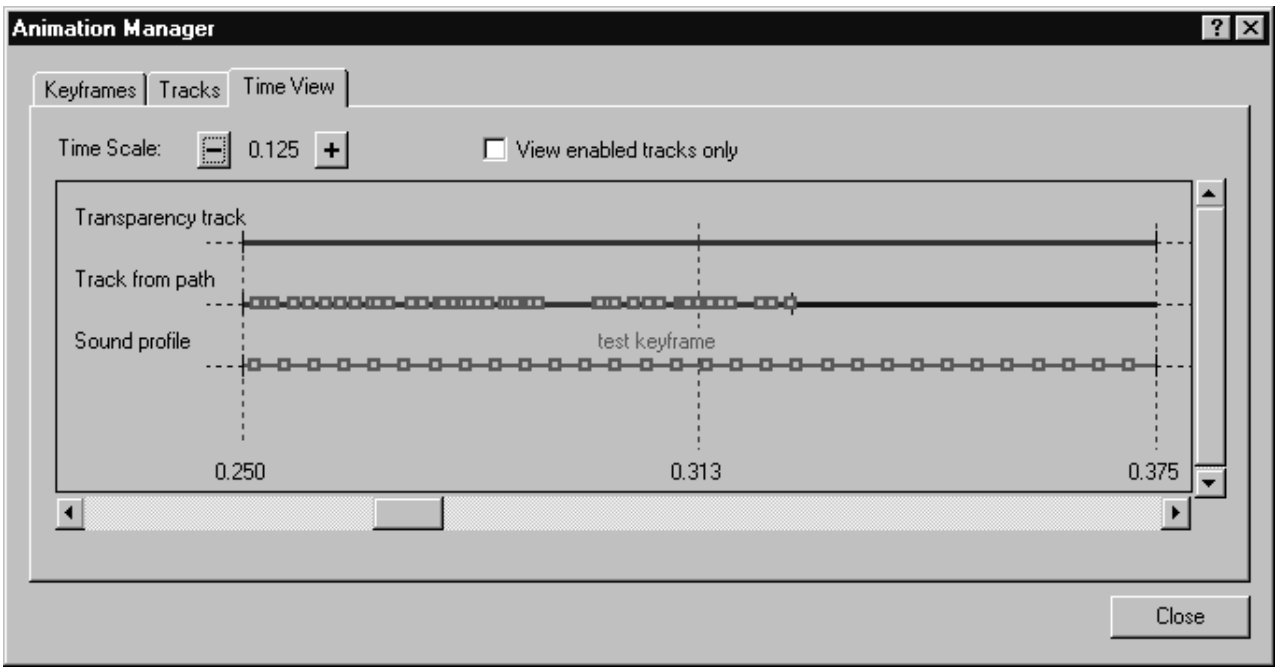
Working with Time

The Time View of the Animation Manager (Figure 5) offers a representation of how the tracks and keyframes are arranged along the animation time, normalized from 0.0 to 1.0, and can be used to interactively change this arrangement.

Figure 5
Tracks and Keyframes in the Time View



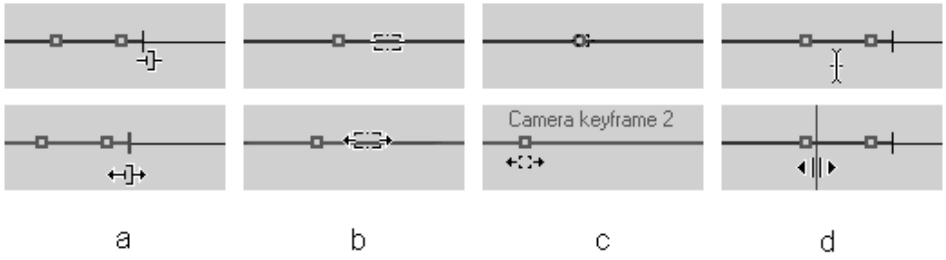
By default, animation tracks span along the entire animation: Their Begin Time is 0.0, and their End Time is 1.0. These values can be changed in the Tracks view or modified interactively by dragging the edges of the track in the Time View. To do this, position the cursor a bit above or below the edge point until it changes its shape into an opening or closing bracket (Figure 6a). Then click and drag along the time axis. In the lower left part of the view, you will see the changing time value in red.

By changing the beginning and ending times of the tracks, you can create effects that happen in different parts of the animation. For instance, if you have two camera tracks, one with some captured views and another with recorded navigation, you can make the first one to control the viewer camera from 0.0 to 0.5 and the second one from 0.5 to 1.0. The result is that when the animation is played, the camera will follow the captured views during the first half of the animation and the navigation during the second half.

If the duration of a track is shorter than the total animation, the track can also be moved along the time line. To do this, position the cursor on the track line or its continuation, avoiding the keyframe squares (Figure 6b). The cursor will change its shape into a wide rectangle. Then click and drag along the time axis.

Keyframes have a time stamp that also ranges from 0.0 to 1.0. However, this value refers to the time within the track, not to the total animation interval. If you change the beginning or ending time of the track, the time stamps of its keyframes will not change. The Time View can be used to edit the time stamp of a keyframe and the order of the keyframes in the track. To do this, position the cursor on the green keyframe marker (its shape changes into a small square; see Figure 6c), click, and drag. The changing value of the time stamp will be shown in red in the lower left part of the view.

Figure 6
Editing Operations in the Time View



Notice that you can change the time scale and use the horizontal scroll bar in the Time View to zoom in and have more precision in your changes. You can also preview the animation using the Time View by clicking and dragging the cursor in the areas between tracks where the cursor changes into a skinny vertical shape (Figure 6d).

Each animation track has an option that controls whether the time stamps of its keyframes are distributed evenly or not when a new keyframe is added. This option is exposed as a check box in the Keyframes tab of the Animation Manager (Figure 7), and it is active by default. When the option is active and you add a new keyframe to the track (for example, by using the Create keyframe command), all the time stamps are redistributed to be equally spaced in time. You can also force this rearrangement by clicking Reset Times.

When the "Distribute time stamps evenly" option is not active in a track, new keyframes will be assigned a fixed time stamp of 1.0, thus positioning them at the end of the track. In this case if you click Reset Times, the time stamps of the keyframes are redistributed between 0.0 and 1.0 but they keep their proportional separation. If the first keyframe was already at 0.0 and the last one was at 1.0, there will be no change.

This mode can be useful when you need to add keyframes at the end or beginning of an existing track that already contains keyframes with time stamps that are not equally spaced. For example, you have created a layer track with 30 keyframes, and you have carefully set specific time stamps for each of them from 0.0 to 1.0. Now you realize you would like to add one more keyframe that represents a later state of the layer. You need to add it to the track, but you do not want to edit the other 30 time stamps to accommodate the new keyframe.

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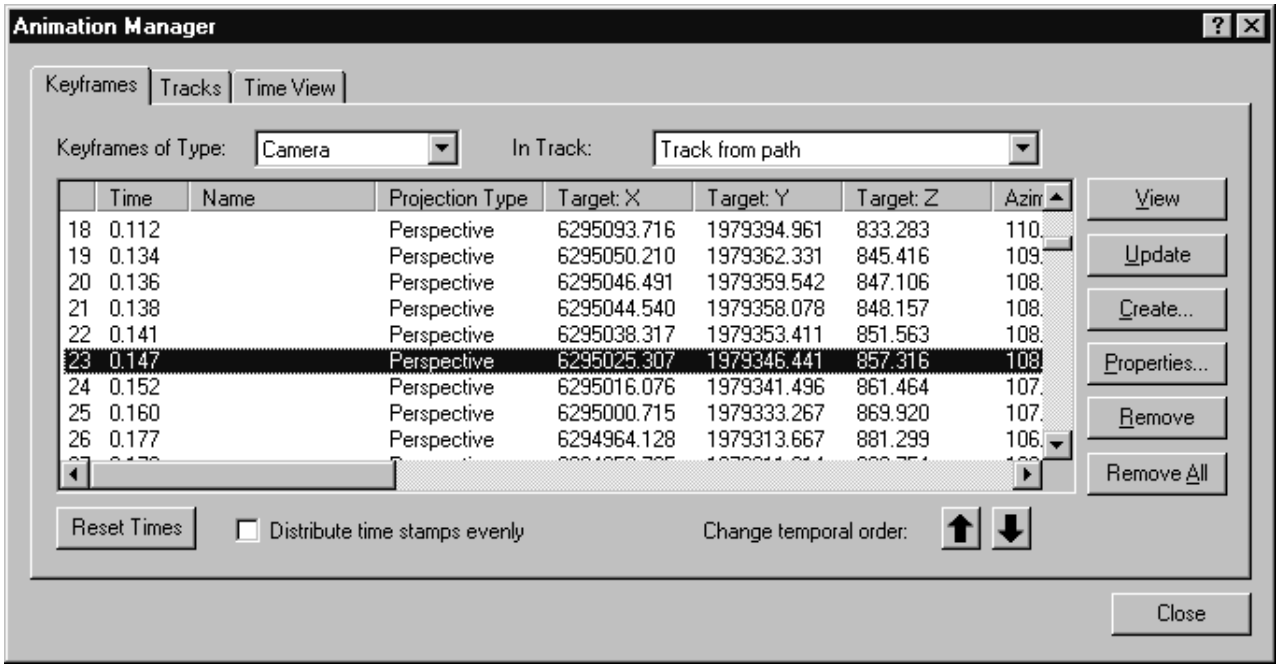
Figure 7
Distributing the Time Stamps in the Keyframes Tab



The way to proceed is to (a) disable the "Distribute time stamps evenly" option of the track; (b) create the new keyframe, which will get a time stamp of 1.0; (c) change its time stamp to be higher than 1.0, depending on how much later you want it to occur in the animation; and (d) click Reset Times. The new keyframe will now be at 1.0, and all the others will have been redistributed according to their proportional separation. Steps (c) and (d) can be repeated until you are satisfied with the animation effect.

Looping Tracks

The Animation Controls dialog box provides an option to loop the animation when it is played. However, this repetition affects the entire set of tracks, so it is not useful when you want to repeat only a certain effect within the animation. For instance, you want to create a video in which you see the oscillating rotation of a radar while flying. The radar oscillation is a repetitive movement that must last for the entire animation, while the camera flight does not repeat.

The solution is to create a layer track that describes a single oscillation of the radar and then enable the Loop property of this track. To do this, choose No in the Loop property column in the Tracks tab of the Animation Manager. To repeat the oscillation n times during the animation, the beginning and/or ending times of the track must be changed so that its duration is 1/n. This technique can be used to create several simultaneous oscillations that repeat at different speeds. In addition, looping tracks is compatible with looping the entire animation when playing.

When the loop option is enabled for a track, it is drawn in the Time View tab with a thick blue line that spans from 0.0 to 1.0, meaning that the track is now active along the whole animation.

Understanding Layer Transformations

One compelling effect in an animation is the movement of objects through the scene. The moving layers can represent dynamic objects such as planes or vehicles, data that needs to be separated for a clearer analysis, or the evolution in time of some geographic feature. The animation framework allows you to create very complex transformations, but to do so it is important to understand how they work.

A single layer track or keyframe has the following transformation properties: translation (T*x*, T*y*, T*z*), scale (S*x*, S*y*, S*z*), rotation (R*x*, R*y*, R*z*), and center offset (C*x*, C*y*, C*z*). The rotation angles correspond to the classic Euler angles: R*x* means rotation around the *x* axis (roll or yaw angle), R*y* is the rotation around the *y* axis (inclination or pitch angle), and R*z* is the rotation around the *z* axis (azimuth or heading angle).

These transformations are applied in a certain order. First, the object is translated, so if it was originally located in *(x, y, z)* now it will be located in (x + Tx, y + Ty, z + Tz). After the object is moved, the scaling is applied to change each of its dimensions. If the object originally extended Δx in the *x* axis, Δy in the *y* axis, and Δz in the *z* axis, now it will extend Sx. Δx, Sy. Δy, and Sz. Δz. Then the object is rotated around the three axes, also in a very specific sequence. First, the Roll (R*x*) rotation is applied, then the Inclination (R*y*), and finally the Azimuth (R*z*) rotation.

These transformations happen in a coordinate system that is attached to the object, so when the object rotates, the *x*, *y*, *z* axes rotate with it, and so forth. The default values for the transformation parameters (zero for translations and rotations, and one for scales) make each of the former operations have no effect unless you change the default.

With the default center offset (0.0, 0.0, 0.0), the scale and rotation operations are performed using the center of the layer bounding-box as a fixed point. You can change the value of this offset to make the layer scale or rotate with respect to a different location.

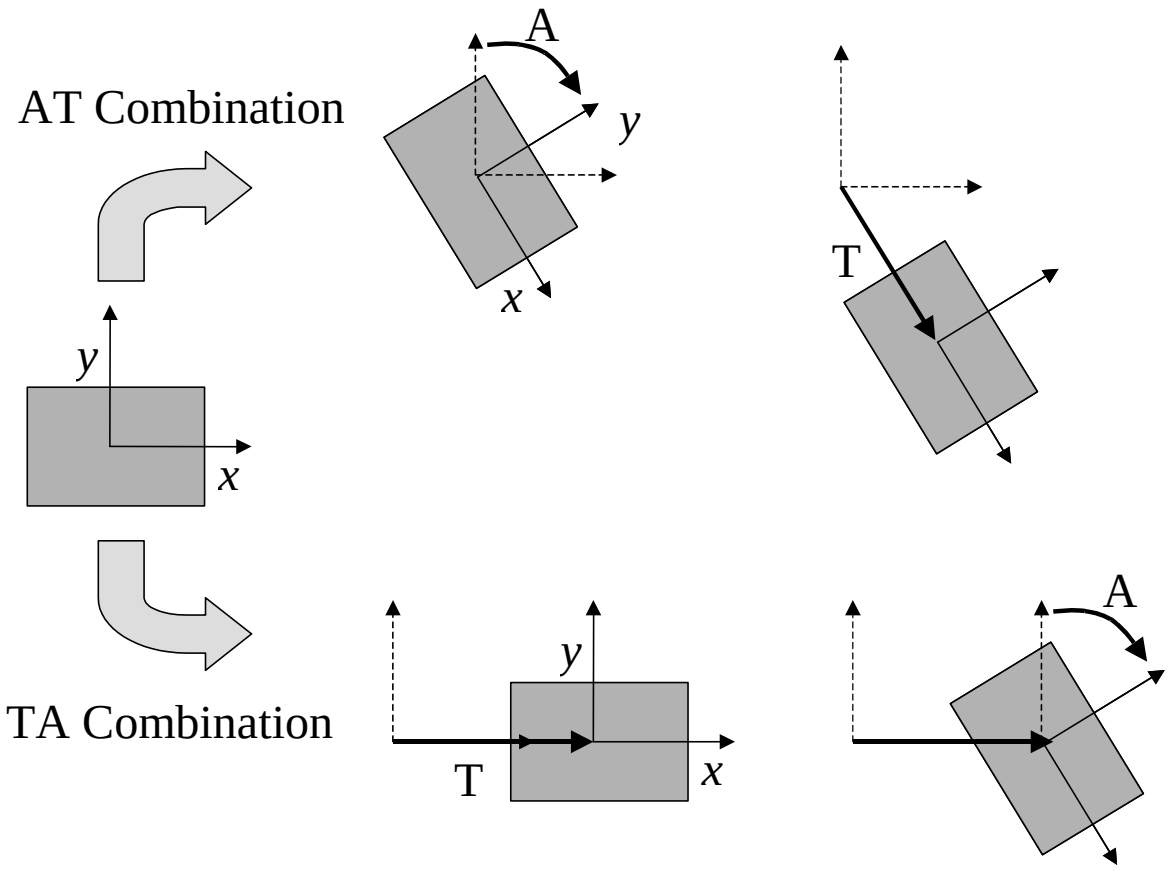
This sequence of transformations, Translation->Scale->Roll->Inclination->Azimuth (TSRIA), is enough to move a layer along a path with the proper orientation. The translation moves the object to different points located on the line, while the rotations turn it to be oriented with the path and possibly have a roll angle while it moves.

However, sometimes you may need to perform more transformations or apply them in a different order. Consider the case of an object O rotating around another object P, for example, the Earth around the sun. For simplicity assume that both O and P are initially in the center of the coordinate system (0, 0, 0). How can you make O rotate around P by using the layer transformations? One solution would be to calculate all the positions of O along the orbit and use them as translation values. But for a circular orbit, there is a simpler solution that can be used to illustrate the composition of transformations.

Consider what happens if you first rotate O by an angle A around the *z* axis and then translate it a fixed distance along the *x* axis (Azimuth->Translation = AT). If you perform a transformation in this order for variable values of A, the effect is to make O follow an orbit with a constant radius. This happens because when you rotate O, its *x* axis rotates too. So when you later translate O along that axis, it will move to a location that depends on the rotation angle A.

The transformation sequence AT cannot be generated from a single TSRIA transformation, since in the latter the Translation happens before the Azimuth rotation. Figure 8 compares the effects of AT and TA. The solution is to compose or accumulate two TSRIA transformations. In the first one only a variable Azimuth (tsriA) is used, and from the second only a constant Translation (Tsria) is used, so that AT = tsriA + Tsria. But, how can you create this composite transformation by using layer tracks?

Figure 8
Comparison of AT and TA Transformations



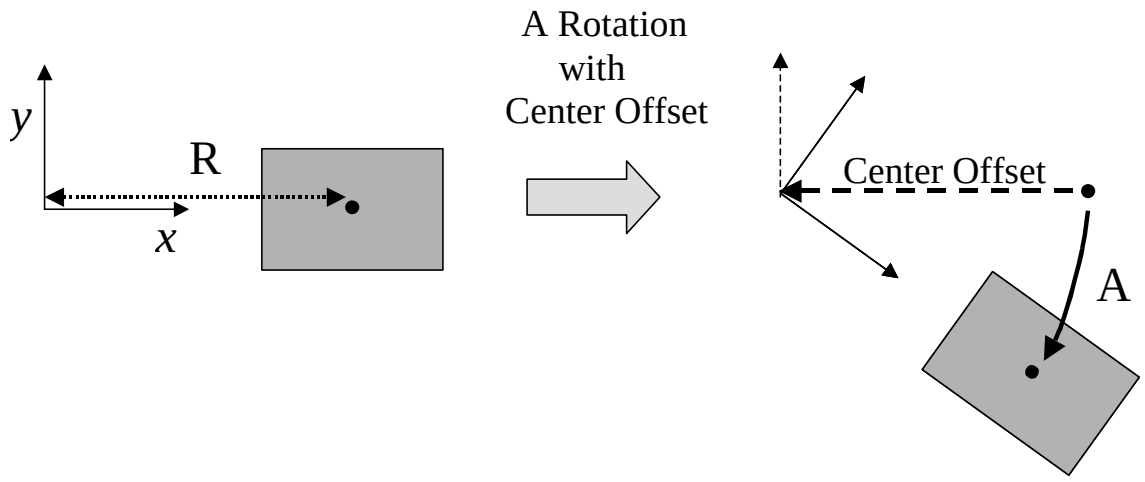
When a layer is attached to multiple tracks, their transformations are combined instead of overwriting one another. This means you can make O orbit by attaching two layer tracks to it. Because of the way transformations are calculated internally, the tracks must be sorted in reverse order: The first transformation with the variable Azimuth will be the

second track in the list, and the one with the constant Translation will be the first one. This order can be changed by using the arrow buttons in the Tracks tab.

To complete the orbiting effect, you can add another azimuth change A' that makes O rotate around itself (spin) in addition to the rotation around P. The total transformation sequence would be now ATA'. This combined transformation can still be represented with only two tracks in this way: tsriA + TsriA'.

During this discussion it was assumed that the object O was positioned at the origin. Now imagine that P is at the origin but O is located a distance R along the positive *x* axis (Figure 9). In this case you can make O orbit around P by creating a single track with a variable azimuth angle and a center offset of (-R, 0, 0).

Figure 9
Orbiting by Using the Center Offset



Putting the Pieces Together

Different techniques have been presented that you can use to more precisely control your animation effects. Normally you would start an animation project by using the Animation Toolbar commands to create basic tracks that you can use as the building blocks of a complex animation. Each track can be enhanced with additional keyframes and by adjusting their binding and active properties. The time edition guarantees that all the pieces work precisely in a coherent structure.

Furthermore, the exposure of animation classes in ArcObjects™ allows developers to create and modify tracks and keyframes using their own routines and tools. The out-of-the-box animation types can also be extended with custom types that control other ArcGIS™ or external objects.