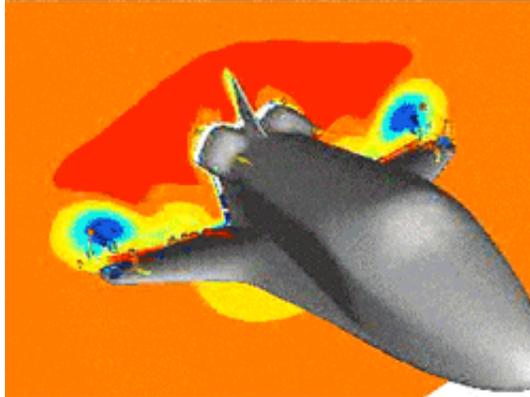


## Animation for Science and Engineering

*Kent Misegades, President, CEI Inc.  
August, 2002*

### Animation's Role in Visualization

Animation brings life to otherwise inanimate objects and greatly enhances one's understanding of geometry, motion and transient phenomena. Pioneered by cartoonists such as Walt Disney in the early part of the 20th century, animation is a mature artistic technique that in recent years has greatly benefited from computer technology. While the use of computers



to create animations for entertainment media has become commonplace through the advent of highly sophisticated software packages, its use in scientific visualization is far less widespread. CEI has long recognized the benefits of computer animation for scientists and engineers and has provided a powerful set of capabilities for the creation and display of animations in its products. The following article describes these features and how they have been implemented in our products, which are briefly described as:

- **EnSight** -- general-purpose visualization software for science and engineering
- **EnSight Gold** -- high-end visualization package for very large data sets and virtual reality
- **EnLiten** -- 3D model and animation viewer
- **EnVideo** -- animation player
- **EnVe** -- animation editor

EnSight and EnSight Gold are used to visualize data and create animations. These can be played in EnSight or recorded to a number of different formats. EnLiten is used to view models as they were rendered and animated in EnSight. EnVideo is a simple animation player. EnVe is used to edit multiple animation sequences into one long movie. (In the following paragraphs, references to EnSight apply also to EnSight Gold, whose capabilities constitute a superset of those in EnSight.)

The following paragraphs are meant to provide you with an introductory

description of the means to create, edit, play and record animations in our products. This is not an exhaustive user guide on animation, and it is recommended that you refer to the extensive descriptions of these capabilities found in the online manuals for each product.

## **Types of Animations and their Creation in EnSight**

The following different types of animations can be created in EnSight:

- **[Streamline Animation](#)**
- **[Plane Sweep Animation](#)**
- **[Isosurface Animation](#)**
- **[Flipbook Animation](#)**
- **[Create Data Animation](#)**
- **[Transient Data Animation](#)**
- **[Linear Load Animation](#)**
- **[Mode Shape Animation](#)**
- **[Keyframe Animation](#)**

Each of these will be described in detail in the following sections. Additional information can also be found in the help documentation for each product.

## Streamline Animation

Any particle trace that has been created in EnSight, i.e. steady streamlines, pathlines from transient flows, massless or massed particles, or traces computed or measured externally and imported into EnSight, can be animated using the options found in the quick interaction area for the streamline feature. Select the particle trace part(s) that are to be animated from the part list and select *Animate* from the quick interaction options. A single pulse will move in the positive time sense from the start to the end of each trace. As the default color of this pulse is identical to the color of the trace, you may find it useful to deactivate the visibility of the trace itself, clicking the visibility icon (eye) found on the left of the EnSight GUI.

There are many options to affect the appearance of the trace animation. These are found in the animation option dialog, labeled *Animate...* in the quick interaction area. Pulse length, speed, color, thickness, max time, and frequency can be modified. A sphere can be displayed on the head of the pulse, the size of which can be constant or scaled according to a local variable; the head would grow, for example, in areas of high temperature or velocity magnitude. If a transient solution is animated using pathlines, it is possible to synchronize the trace animations to a different type of animation, such as a flipbook animation (see below) of moving geometry or a changing variable displayed somewhere in the solution.

The animation options are intuitive and the result of changes will be seen immediately. The best means to understand these options is to experiment with a small number of traces, making adjustments to each option and observing the effects of these changes. Note that while it is possible to animate traces on a per part basis, animation settings are global, i.e. they apply to all traces animated.

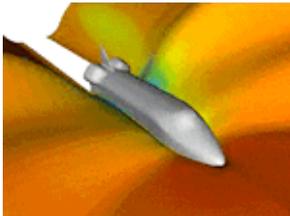
## Plane Sweep Animation

EnSight provides several ways to animate the motion, or sweep, of a plane through model parts. The plane might actually be one of the several types of clip planes that can be created in EnSight's Clip feature: IJK, XYZ, Line, or Plane. (Cylinder, Sphere, Cone, XYZ Box, Revolution Tool and Revolve 1D Part types of Clips cannot currently be animated in EnSight). One might be interested in observing how a variable used to color this plane changes as it sweeps across the model. Another part could be attached to this clip, such as contours of a variable or vector arrows, and one could observe these sweeping across the model.

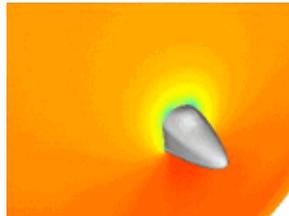
For IJK and XYZ clips, one can quickly sweep in the direction of the coordinate (I/J/K or X/Y/Z) used to create the initial clip by selecting *Interactive Auto* or *Interactive Auto Cycle* for any such clip parts from the options in the *Quick Interaction* area for clips. The parameters *Range Min* and *Max* that appear when using *Interactive Auto* or *Interactive Auto Cycle* limit the extent of the sweeps. The parameter *Auto Delta* defines the granularity of the sweep; decreasing this value results in finer and thus slower sweeps over a range defined by *Min/Max*.

A second, more general type of plane sweep is available in the create data type of flipbook animation, described below.

### Examples:



[IJK plane sweep, Interactive Auto Cycle](#)



[XYZ planesweep, Interactive Cycle](#)

## Isosurface Animation

Similar to plane sweeps described above, isosurfaces can be animated over a range of Min/Max values. The same options to adjust the Min, Max and Delta values, found in the *Quick Interaction* area for isosurfaces, apply to animated isosurfaces as for animated planes.

A second, more general type of isosurface animation is available in the create data type of flipbook animation, described below. Note that if a component of the coordinate vector variable is used as the basis of an isosurface, a constant XYZ clip results, which itself can be animated as an isosurface, equivalent to an XYZ clip plane sweep

## Flipbook Animation

The term flipbook originated in the simple printed animations popular in the early part of the 20th century. One flipped through the pages rapidly to view one or more animated cartoons. EnSight mimics this, loading a series of images into its flipbook memory to be played back rapidly. Flipbooks can be either an object type, where the entire geometry is loaded for each page of the flipbook, or an image type, where only an image pixel representation of the model is loaded. Object flipbooks require more memory, but permit one to modify the orientation and visibility of model parts during the animation. Image flipbooks require less memory, but the model orientation and appearance cannot be altered without reloading the flipbook.

Four different types of flipbooks can be loaded and animated:

- **Create Data Animation** -- create a series of clip planes or isosurfaces
- **Transient Animation** -- loads a series of time steps or time slices from a transient model
- **Linear Load Animation** -- animate model deformation by scaling a displacement vector
- **Mode Shape Animation** - animate the cyclical motion of a model's mode shape

For each of these types of flipbooks described below, a number of options are provided in EnSight to play the loaded pages automatically or manually, stepping through the pages in either direction. One can also modify the speed, direction or extent of the animation by adjusting the parameters found in the *Modify Run* parameters. Changes to the model part representation, other than part visibility and transparency, do not result automatically in changes to the flipbook. These require a new flipbook to be reloaded.

For complex scenes and/or large models, a flipbook, especially one of the object type, can result in a substantial allocation of memory. Therefore it is advisable to delete a flipbook if it is no longer needed. Lower memory usage will result if all model parts that are not to be visible in the flipbook animation are either deleted or their element visual representation is set to *NonVisual* prior to loading the flipbook.

## Create Data Animation

A create data flipbook does just that: For each page, a new clip plane or isosurface is created. For clip planes, one first must create a clip plane using the IJK, XYZ, Line or Plane options. The resulting clip is made interactive and positioned at the starting location of the desired motion in the flipbook. Switching now to the flipbook *Quick Interaction* parameters, a *Create Data* load type is selected, *Start* is selected, and the *Number of Flipbook Pages to Create* is set to the desired number of pages, or total number of clips to create between the start and stop positions. The plane is now moved to its final position by adjusting the appropriate parameters or tools, depending on how the plane was originally created. *Stop* is then selected for the flipbook, and the two limits have now been set. *Selecting Load* generates the intermediate positions of the clip plane/line. Note that for planes defined using the plane or line tool, the transformation, or motion of the clip, is interpolated linearly between the Start and Stop positions. With the flipbook loaded, the animation can now be played per the instructions in the previous paragraphs dealing with flipbook animations in general.

A similar approach is followed if an isosurface animation is to be loaded in the flipbook. Create the first isosurface and set the interactivity to *Manual*, select *Start* and *Number of Flipbook Pages to Create* in the flipbook parameters as before, adjust the isosurface to the final value, then select *Stop* and *Load* in the flipbook parameters.

One might wonder why clips and isosurfaces can be animated through both their respective *Quick Interaction* parameters as well as by a *Create Data* flipbook animation. While isosurfaces and clips can indeed be quickly animated using the Min/Max/Delta parameters as described above, the flipbook also provides a means to animate clipped lines defined using the line tool and clip planes defined using the plane tool, allowing more arbitrary motion during plane sweeps. The flipbook animator also permits image flipbook animations (resulting in lower memory requirements) and a means to record animations, not available in the clip and isosurface animators.

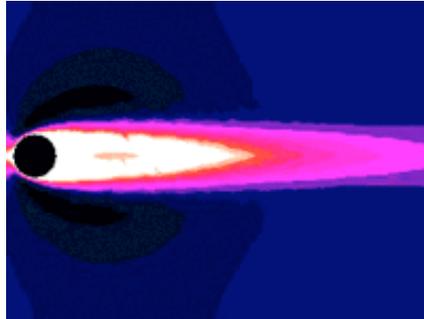
## Transient Data Animation

The most common type of flipbook is a Load Type Transient animation. One simply creates a desired visual (background, part visibility, coloring, newly created parts, annotation, plots -- the sum of all graphical entities as they appear in the graphics window) and loads the flipbook. Control is provided for the range of time steps or solution time (*Adjust Beg/End Time...*) as well as for the step increment or time slice (*Increment Time by*) to be taken when loading the flipbook. If particle paths (time accurate) have already been computed, these can also be animated and are by default synchronized to the loaded flipbook when it is played.

### Examples:



[Animation of car part deformation, ABAQUS](#)



[Animation of transient velocity field, N3S](#)

## Linear Load Animation

Static structural analyses result typically in a displacement vector and one or more scalar, vector or tensor variables representing the state of the model upon application of a given load. The nature of a static analysis permits one to scale the load and the resulting displacement linearly from unloaded to the fully loaded state. A linear load animation depicts the transition from these two states. Before loading a linear load flipbook, apply the displacement vector variable to the appropriate model parts, and color these by an appropriate variable if desired. The flipbook will scale the displacement vector from zero to the value of the vector, and vary the color from its lowest level to the color palette chosen for the variable by which the parts are colored.

### Examples:



### [Linear load animation of ANSYS cantilever beam](#)

## Mode Shape Animation

Structural analysis software can be used to predict the vibrational modes for an excited structure, also referred to as an Eigenvalue or mode shape solution. Such computations result in a displacement vector for each vibrational mode, or input load frequency. By animating the motion of a model from the positive to the negative extremes of this displacement, it is possible to gain an understanding of the relative importance of each vibrational mode. Before loading a mode shape flipbook, apply the displacement vector variable to the appropriate model parts. The flipbook will automatically scale the displacement vector from its negative to its positive extreme.

## Keyframe Animation

Keyframe animations depict model details and results. By saving a series of key frames, or model positions, then interpolating between these positions, it is possible to create smooth fly-arounds, fly-throughs or even part explosions for a given model. One begins by choosing the initial desired position of the model and saving this position, or keyframe, by selecting the save button in the *Quick Interaction* area for keyframe animations. The model is then moved to the next desired position, a new keyframe is saved, and so forth. When the keyframe is run, the model will move smoothly from one keyframe to the next.

Selecting the option *Animate Transparency Change* will include changes in part transparency between keyframes, allowing parts to fade in or out during playback of the animation. Selecting the option *Use Interactive Iso/Clip* will record the value of an interactive isosurface or the position of an interactive clip (IJK, XYZ, Plane, Line type of clips) along with the model part position at each keyframe. Saving a series of different clip positions at each keyframe allows complex motions of plane sweeps, such as along the axis of a manifold or any other curved model part.

The parameters found in the *Set Speed/Actions...* dialog allow one to vary the speed of motion between any two keyframes; by default, 20 subframes are created between any two keyframes. Increasing the number of sub-frames between keyframe pairs results in slower motion between them. (A rule-of-thumb in creating any animation is that 30 frames equal approximately one second of animation.) The *Set Speed/Actions...* dialog also contains an option to execute a series of commands at the start of a new keyframe. This can be used to vary annotation and part visibility, for example, or to turn other types of animations on or off. The *Hold* option in this dialog can be used to hold the animation at a given keyframe for a given number of frames prior to progressing to the next frame. Holds are useful to permit the viewer to understand what he/she is looking at before motion begins.

The *Keyframe Animator* senses changes made in EnSight's *Frame Mode*. By attaching certain parts to new local frames, one can move these parts relative to one another during a keyframe animation, resulting in so-called part explosions. These can be very useful to initially depict the entire model, then remove exterior parts to reveal inner details.

Keyframe animations can become quite lengthy and are typically created only to be saved to one of the digital video formats supported by EnSight (see "Playing and Recording Animations in EnSight"). While creating keyframe animations, you will typically want to play and modify these in EnSight several times prior to saving. Since a fully rendered model can result in lengthy playback times on even the fastest computers, it is recommended to create the keyframe animation with only the most essential parts visible, and these should be rendered in the feature angle form of element visual representation. This will result in much faster playback speeds. Once you are satisfied with the animation, render the model as you wish to see it in the final form, make the

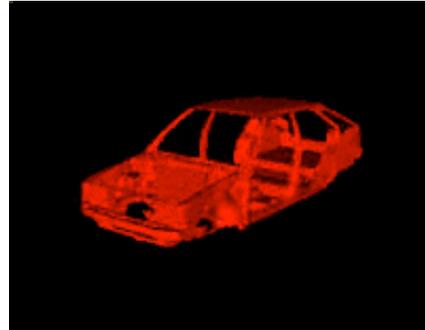
selections to record to a file, and run the animation.

The creation of a good, professional-quality keyframe animation requires some practice and the observance of proven techniques. A description of these is too lengthy for the purpose of this article and will be addressed in further articles from CEI.

**Examples:**



[Zoom up with transparency changes](#)

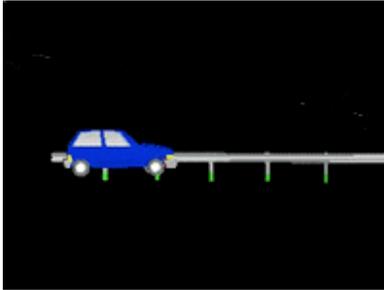


[Part Explosion](#)

## Combining Two or more Types of Animations

All of the various forms of animations described in this article can be viewed and recorded in EnSight simultaneously. A typical example would be to first create a flipbook animation of a transient phenomena, such as a vehicle impact simulation, and combine this with a keyframe animation showing the vehicle motion and deformation from various viewpoints. The examples below show how two or more types of animations can be combined in EnSight.

### Examples:



[Vehicle impact flipbook and keyframe animation - 869 KB](#)



[Particle trace and plane sweep animation - .99 MB](#)

## Playing and Recording Animations in EnSight

A brief description on how one plays the various types of animation has been provided above. In all instances, controls are provided to vary the speed of playback. For animated streamlines, playback controls are found in the *Animate...* dialog for streamlines. For clip plane and isosurface animation, one varies the playback speed by changing the *Auto Delta* parameter that determines how fine or coarse EnSight creates the clips/isosurfaces between the defined Range Min/Max extremes.

For all four types of flipbook animations, options to control playback speed and direction are found in the *Modify Run...* dialog in the *Quick Interaction* area for flipbook animations. As described earlier, the speed of keyframe animation playback is determined by the number of subframes between keyframe pairs. Note that in all instances, the actual speed of playback cannot be explicitly specified by the user, but instead is a function of model size and other aspects of the animation as well as the performance of the computer.

Animations can be recorded to files only from within the flipbook animation and keyframe animation *Quick Interaction* areas. Once you are satisfied with the animations when run from within EnSight, they can be saved out either one frame at a time to any of EnSight's supported image formats, or the entire animation can be saved to a single video format file. In either case, choose first the *Record...* button to select the desired format (*Set Format...*) and enter the desired file name prefix. Next, define the size of the image file(s) using the *Record...* (*Save Window Type*) option for flipbooks or the *Viewing Window...* options for keyframe animations. The actual recording of a flipbook animation takes place when the *Record* button is selected. The actual recording of a keyframe animation takes place when the *Run* button is selected.

Three different video formats are available in EnSight: uncompressed AVI, MPEG and EVO. For the best compromise between animation quality and file size, CEI recommends use of the EVO format, which can be viewed in CEI's free .evo viewer, EnVideo. See more about EnVideo below.

EVO files use either JPEG or RLE (run length encoding) compression. Whereas JPEG compression generally results in smaller files, RLE compressed animation files will exhibit better image quality. Currently, EVO files can be played only in CEI's EnVideo player (see below). EVO files are generally larger than compressed AVI and MPEG files, but have superior image quality. They can be played on any hardware platform for which a version of EnVideo exists.

AVI files created in EnSight are uncompressed, resulting in large file sizes. These can be compressed, however, to a small fraction of their original size (typically under 10%) using the program *avi\_compress*, which is found in the unsupported directory of every EnSight installation. Note: *avi\_compress* will execute only on a PC under the Windows operating system. See the README file in this same directory for details.

MPEG files created in EnSight are compressed according to default parameters chosen to result in a balance between file size and image quality. These parameters can be modified by editing the file *tmp\_mpeg.param* found in your *.ensight7* configuration directory, which is automatically created by EnSight in your home directory upon your initial use of EnSight.

The following table compares file sizes for several animations saved at a window size of 320 x 240 in EnSight to three different formats:

<b>Animation</b>	<b>EVO (JPEG)</b>	<b>EVO (RLE)</b>	<b>AVI (uncom.)</b>	<b>AVI (comp.)</b>	<b>MPEG</b>
Flipbook CFD	9,622KB	17,216KB	54,005KB	3,859KB	1,016KB
Flipbook CAD	6,381KB	15,303KB	36,604KB	2,026KB	689KB

Keyframe	3,506KB	4,748KB	46,204KB	1,720KB	870KB
CSM					

## Playing Animations in EnVideo

EnVideo is an animation player developed by CEI to play .evo format video animations. It is a simple but powerful program, requiring no training and little documentation. Versions of EnVideo are available free of charge from CEI's web site for any hardware platform for which EnSight is also available. At the time of this writing, EnVideo accepts only .evo format files. EnSight, EnSight Gold and EnLiten (see below) can all generate such files. An API is also available free of charge from CEI's web site for the purpose of generating .evo format files in any application.

Buttons to control animation direction, speed, frame stepping, graphics window size, and to toggle to stereo mode are provided in EnVideo. (Note that in order to display an .evo animation in stereo, it must have been recorded in stereo to begin with.) You can append .evo files, resulting in a longer animation made up of two or more individual .evo files. Appending can be selected in the command line options or through the *File > Append Movie...* option.

By default, EnVideo streams images from disc to the graphics window. For small-sized animations, this results in fast playback on most systems. For animations meant to be shown on large displays, such as projected screen systems requiring a saved window size of greater than 640 x 480, the .evo file size can become large and the playback speed might be too slow. For these situations, EnVideo provides an option to first cache the animation to memory prior to playing. The resulting playback speed is much greater, but EnVideo could require a very large cache memory. Should you wish to take advantage of the caching capability, start EnVideo with the "-cache" command line option. The size of the required cache memory is (image pixel width) x (image pixel height) x (3 bytes) x (number of frames in the animation). For stereo animations, the memory requirement will be double this figure. (Note that the cache option is not currently available for the Windows version of EnVideo)

Any frame of an animation in EnVideo may be printed using *File > Print...*

## Viewing Models and Animations in EnLiten

Whereas EnVideo provides an excellent means to play animations created in EnSight and EnSight Gold (or EnLiten, see below), EnLiten provides the user with full control over the original 3D model, including animations. EnLiten is a simple but powerful program, requiring no training and little documentation. Inspired by the defunct VRML 3D geometry standard (EnSight and EnSight Gold still support an option to export VRML-2 format files), EnLiten relies on .els scenario files created in EnSight. *File > Save > Scenario...*, a scenario file with the default file type of .els, contains the geometry of all model parts selected in the EnSight parts list at the time of saving the file. If keyframe, flipbook or particle trace animations have been created in EnSight, the user can select which of these will also be saved into the scenario file. One can also save certain model views and notes into the scenario file. For more information on saving scenario files, see *How To Save Scenario* in the EnSight online *How To Manual (Help > How To Manual...)*

Once the .els file exists, it can be loaded into EnLiten either by entering it in the command line during execution, or by starting EnLiten by entering the file name in *File > Open EnLiten scenario...* The model can be rotated/translated/zoomed in the graphics window, and any saved animations can be played. Options exist in EnLiten to display the model in full screen or stereo mode. Views saved into the scenario file can be selected. Notes saved in the scenario file can be reviewed and appended in the *Scenario Note Viewer/Composer*. A particular view of the model can be saved to any one of a number of image formats using *File > Save Image...* Animations playing in EnLiten can be saved to EVO, AVI or MPEG files using *File > Save Animation...*

EnLiten Gold, which can be purchased from CEI, includes all of EnLiten's features as well as EnSight Gold's advanced rendering capabilities for virtual reality environments. Contact CEI or one of its authorized [distributors](#) for pricing information.

## Editing Animations in EnVe

EnVe is a simple, command-driven program to edit animations saved in CEI's EVO format. It can be used to paste together multiple animation segments into a complete movie, processing commands interactively or from command files.

Currently, EnVe performs the following operations:

- specify an output movie
- append a movie or a subset of a movie
- copy the last frame
- query a movie file

### **The Future of Animation at CEI**

Animation remains one of the most effective means to display complex geometry and physical phenomena resulting from numerical simulations. CEI's products provide a complete suite of tools to create, play, record and view animations of many different types. Current animation development work at CEI focuses on the following:

- improvements to EnSight's keyframe animator
- reduction of EnLiten scenario file size
- addition of EnSight-like controls to EnVideo and EnLiten

These improvements will be incorporated into future releases of our products.

For further details regarding the animation capabilities of CEI's products, please refer to the online *How To Manual* and *User Manual*.