

# An Introduction to Building 3D Crime Scene Models Using SketchUp

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## ABSTRACT

Crime scene investigators generally have two options when they need to create a three-dimensional (3D) model of a crime scene: enlist the services of an expert 3D modeller who specializes in graphic modelling or learn one of the full-fledged modelling tools to create the model themselves. Many modelling tools have a very steep learning curve, so the time required to invest in learning a tool to get even a simple result is often prohibitive. In this article, we introduce SketchUp (version 8) as a relatively easy-to-use tool for modelling crime scenes in 3D, give an example of how the software can be applied, and provide resources for further information.

**Keywords:** Crime scene sketching, 3D visualization, software modelling, crime scene models, SketchUp, Trimble, crime scene reconstruction, forensic science

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## Introduction

Computer graphics have been used to enhance the visualization of shapes and structures across a wide variety of disciplines since the 1970s, when the capability to produce computerized 3D models was first developed [1]. Shortly after this technological advancement, professionals in the field of forensics began to utilize computer modelling techniques to demonstrate eye-witness accounts and forensic findings during testimony in court [2-4]. However, until recently, using computer programs to model in 3D has generally been a complex undertaking, usually requiring an expert in

modelling or computer aided design (CAD) to produce a meaningful 3D model. As a result, investigators have been limited in terms of which scenes they can model in 3D because of the time-consuming and expensive nature of the modelling process.

Fortunately, over the last few years, as investigators have become more comfortable interacting with computers and graphics software has become easier to use, new options have become available to the average investigator. One tool in particular—SketchUp (version 8)—has really flattened the learning curve and made basic 3D modelling available



to any investigator willing to spend a little time learning the software.

## Crime Scene Graphics

Crime scene graphics are visual designs intended to illustrate details observed at a physical location. Such graphics communicate spatial relationships to those who did not attend the scene and provide an effective way to document a scene for subsequent analysis and presentation. They include basic, hand-drawn illustrations (commonly called rough sketches), intricate, detailed drawings (known as final sketches or diagrams), and interactive, realistic replicas (referred to as 3D models in this article).

Typical scene sketches and models present a two-dimensional (2D), top-down representation of the scene [5]. While 2D sketches and models are useful for presenting the spatial information collected at scenes, 3D models can be more effective at communicating such information.

With SketchUp, the authors propose that investigators who have no professional graphics training can produce realistic 3D crime scene models without altering the way they process the scene and they can even create to-scale 3D models if sufficient measurements are available.

## SketchUp's Background

What is SketchUp, and why is it of interest to crime scene investigators? SketchUp is a 3D modelling tool originally developed by @Last Software in 2000, and acquired by Google in 2006 to provide a tool for building 3D models for their Earth and Map projects. In June 2012, the rights to SketchUp were purchased by Trimble (<http://www.trimble.com/>). SketchUp is available for both Mac OS X and Windows. Users may download a free version of SketchUp or purchase the Pro version at <http://sketchup.google.com/download/>.

While there are many very impressive 3D modelling tools currently on the market, a novice modeller with access to the internet will find the free version of SketchUp easy to obtain and easy to learn. This means that an investigator can learn to create these models themselves instead of relying on someone who

may not have even attended the scene. The cost, ease-of-use, and availability of thousands of models in the Warehouse database make SketchUp a great option for investigators who need to produce 3D models of crime scenes.

## Basic SketchUp Concepts

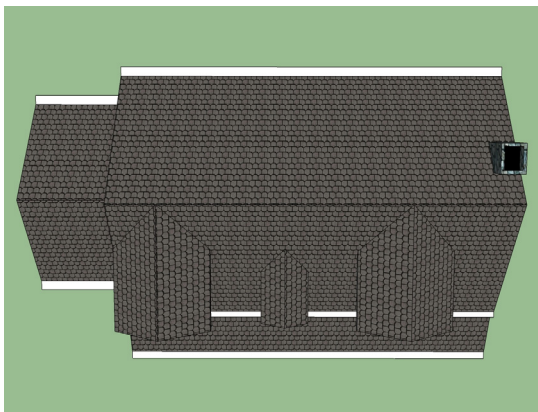
Before jumping into an example of how to build a 3D model, it is important to understand some of the basic concepts used in SketchUp. When SketchUp is started, the user is presented with a window allowing the selection of a drawing *template* for the project. Templates do not change the way SketchUp works; they simply provide a way to set the default scale, style, and color for new projects. Any of these settings may still be changed after the project is created. SketchUp provides several built-in templates for both imperial and metric units, and the user can create and save personalized templates for future use.

When the user creates a new project, they are presented a window displaying three axes, which represent the x, y, and z axes of the Cartesian coordinate system. SketchUp uses three colors to represent the different axes: red, green, and blue. The blue line represents up and down and the other two make up the ground plane for the model. Each of the axes have a solid line on one side of the origin and a dotted line on the other to help with orientation. These axes act as guidelines and are used to indicate direction and rotation, to line up objects, and to provide a visual cue when moving the virtual camera around the scene.

## The Model and the Camera

A SketchUp *model* is simply the virtual 3D world the modeller is creating (the crime scene) which will contain objects such as furniture, walls, victims, evidence markers, etc. The *camera* moves about this scene, allowing the user to view objects from any angle. SketchUp provides tools to pan, zoom, and move about the scene (these tools are described below). SketchUp also provides seven standard views that are helpful in positioning the camera at specific locations relative to the scene's axes and for focusing the camera position on the center of the scene. These views, accessed



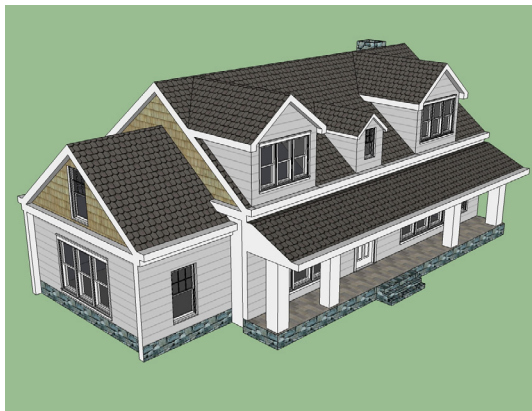
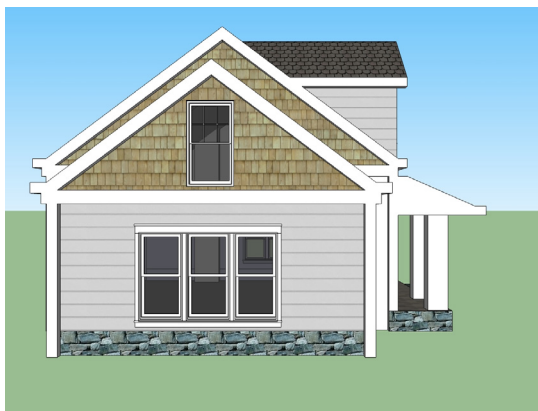


◀ Figure 1 (top left): Top view

Figure 2 (top right): Front view

Figure 3 (bottom left): Side view

Figure 4 (bottom right): Iso view



using the Camera->Standard Views menu, are Top (Figure 1), Front (Figure 2), Back, Left, Right (Figure 3), Bottom, and Iso (Figure 4).

Another important aspect to viewing the scene is choosing the camera projection. There are three different camera projections available: Parallel Projection (Figure 5), Perspective (Figure 6), and Two-Point Perspective. The default camera setting is Perspective, which makes items closer to the viewer appear larger than objects further away. This is a visual

technique that makes your scene appear 3D even though it is seen on a 2D computer screen. Consider a picture straight down some railroad tracks. The tracks appear to meet at a point in the distance which is called the vanishing point. With a Parallel Projection, however, the apparent depth in the model is removed. This is especially useful when the modeller would like to produce a traditional, top-down, 2D sketch of the scene. Two-Point Perspective uses two vanishing points instead of one and is not really



◀ Figure 5 (left): Parallel Projection

Figure 6 (right): Perspective

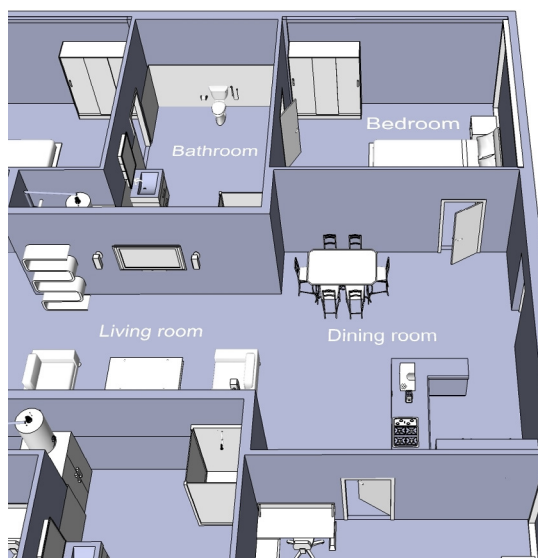


Figure 7 (top left): Shaded with Textures style

Figure 8 (top right): Shaded style

Figure 9 (bottom left): Monochrome style

Figure 10 (bottom right): X-ray style



useful for crime scene models, so it will not be discussed here.

The user may also add custom fixed camera positions by using the Scene Manager window, accessed using the Window>Scenes menu item. The plus icon in the upper left corner of the window will create a tab at the top of the viewing window, called “Scene 1.” Clicking on this tab will always return the camera to this saved position. The user can keep moving the camera to a new position, and repeating the “add scene” operation until the user has the desired number of camera positions saved. Established scenes may be renamed, rearranged, revised, or deleted under the scene manager window. Selected scenes may be exported as 2D images, 3D models, or animated “fly-through” videos (see the Advanced Topics section).

## Styles

One of the ways to change the look of the model is to change the style that affects the edges and surfaces (faces) of the scene. The options in the View>Face Styles menu allow the user to quickly change the visual style of the model to include textures (Shaded With Textures, Figure 7) or just show the surfaces as colors (Shaded, Figure 8). Two other very useful styles are the Monochrome style (Figure 9), which removes colors, and the X-ray style (Figure 10), which makes the entire model transparent. The authors have found this a useful tool when creating visually busy scenes in that it can simplify the appearance of the model and make different viewing options available to the modeller for presentations.



## Layers

A key feature of SketchUp is the ability to organize models into layers, which is a concept many readers may be familiar with if they have worked with Photoshop. Items in the scene may be assigned to different layers created by the modeller and then the visibility of these layers may be turned on and off. This is an extremely valuable tool for the modeller if they need to temporarily hide an object or objects from view, either for editing purposes, or because the modeller needs to draw attention to other items in the scene. Grouping objects into logical layers as the model is being built can save a lot of time when putting together presentations or trying to demonstrate something using the model. The user might put all the furniture in one layer, for example, so it may be easily hidden to show only the floor plan.

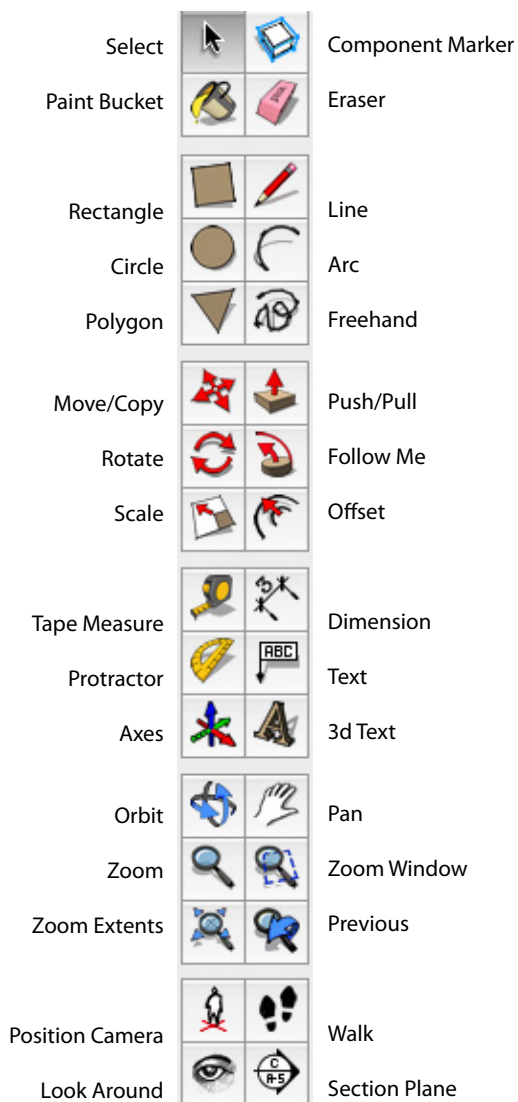
## Essential SketchUp Tools

SketchUp provides many tools to manipulate, view, and work with your model. This article is not going to examine all of them, but will introduce the most basic tools used to create, modify, and view the edges and faces of a model. SketchUp provides several tools palettes that may be shown by selecting them in the View menu. Though most are for special tasks, the Large Tool Set palette (Figure 11) (accessed by selecting it from the View>Tool Palettes menu) contains all of the basic tools needed for the example presented in this article. When a basic tool is selected, the status indicator at the bottom of the window provides instructions for how to operate it. The question mark icon next to the status indicator will open the Instructor window, which is a helpful guide investigators can use to familiarize themselves with each of the tools' basic and advanced operations. The authors also strongly encourage new users to take advantage of free tutorials posted on the SketchUp website (<http://www.sketchup.com/intl/en/training>).

The Line, Arc, and Freehand tools allow the modeller to draw 2D lines. The Line tool is used to draw a line simply by clicking the starting point of the line, clicking the endpoint of the line, and then optionally typing in a

length (seen in the Measurements box located in the bottom right corner of the window) followed by the return key, which will adjust the line to the length specified. With the Arc tool, the user clicks the start point of the arc and the end point, and then, as with the line tool, may optionally type in a number that indicates the bulge of the arc. The Freehand tool lets the user draw arbitrary shapes, which is converted into a series of lines by SketchUp.

Often the user wants to draw circles, rectangles, or other regular, multi-sided 2D shapes. SketchUp provides a way to quickly draw these primitives using the Rectangle, Circle, and Polygon tools. To use the Rectangle tool, the user clicks the location of the first corner of the rectangle, then clicks the opposite corner when the rectangle is the correct size. As with the previous tools, the dimensions may be entered while the tool is active to set the



◀ Figure 11: Large Tool Set palette



dimensions. The Circle tool works the same way, allowing the modeller to specify the radius of the circle. Finally, after selecting the Polygon tool, the user first specifies how many sides in the shape—3 for a triangle, 5 for a pentagon, etc.—by typing the number followed by the return key, clicks the location of the center of the shape, and finally drags the mouse to the desired radius. As with all the other tools, the radius may be specified by typing the radius followed by the return key.

So far all of these tools allow the modeller to draw 2D shapes on a specified plane. How is this translated into 3D? When a 2D shape's edges are closed (there are no gaps) SketchUp shades the surface of the shape to indicate that it is a face that may now be manipulated. The Push/Pull tool lets the user click on any face and push it or pull it using the mouse to transform a 2D shape into a 3D shape. For this tool, typing a number will adjust the size of the shape, allowing the user to make cylinders and boxes with specific dimensions.

The Offset tool, which the authors find especially useful in building walls within rooms and buildings, will copy selected coplanar lines, and reposition those lines at a uniform distance from the originals. To use the Offset tool, the user clicks on a flat face, and then clicks inside or outside of the original surface to create a new border defined by the edges of the original face. As with the other tools, the user can enter a dimension to set it to a specific distance away from the original edges.

The Move and Rotate tools move and rotate 2D and 3D figures about the model's three axes. In order to look at the other side of the objects in the scene, the modeller needs to move the camera. The simplest way to do this is using the Orbit and Pan tools. With the Orbit tool selected, clicking and dragging the scene will rotate the scene as if it were a globe. The Pan tool picks up and moves the camera without rotating the scene.

The Scale tool may be used to re-size and stretch figures relative to the overall dimensions of the model, while the Dimension tool will allow the modeller to display the to-scale length, width, and/or height of an object with a length precision of 1/64 inch or 0.039687

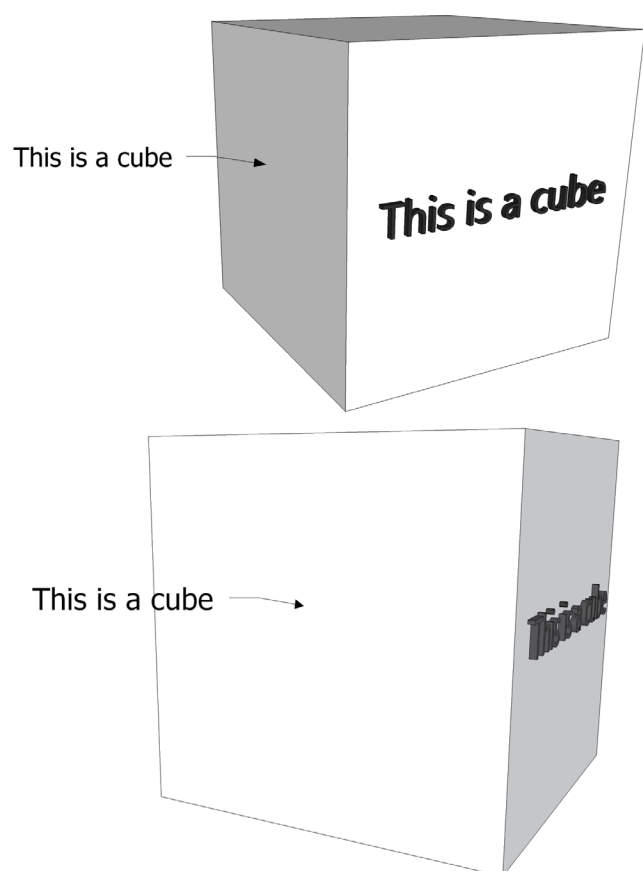
cm. The format of the model's dimensions (imperial vs. metric) depends on the default measurement setting of the template originally selected when SketchUp was first launched, but it may be manually adjusted by the user at any point after the start of the project.

The Tape Measure and Protractor tools let the modeller measure established distances and angles, and place guidelines at fixed distances and angles. These guidelines are particularly important in that they help a user place objects at specific locations within the model. To use the Tape Measure tool, the user clicks on any edge or endpoint, moves the cursor away from that point, and clicks again. The Protractor tool is used in the same manner, except the user clicks on the vertex of an angle, and then two locations to identify the legs of the angle being measured. The Measurements box in the bottom-right of the window will show the length or angle between the starting and ending points specified by the user. The user can type in a new length if he or she would like to resize the entire model. The "Control" key will toggle the guide line feature and instruct SketchUp to create a guide line at the ending point of the measurement. The user can then type in a new length or angle for the accurate placement of the guide line—a feature that is particularly useful during the construction of to-scale models.

The Text and 3D Text tools may be used to label objects or particular points of interest in the scene. The Text tool creates 2D text boxes within the model that may be placed at stationary locations within the viewport, or attached to objects within the scene by leader and a point or arrow. Text created using this tool shifts as the model is rotated in order to stay oriented towards the camera. In contrast, the 3D Text tool produces 2D text tags and 3D text objects that remain in place as the model is rotated (Figure 12). The user may edit the size, color, and font style of text created by either tool.

The Paint Bucket tool allows the user to select and apply any solid color or material stored in the SketchUp materials library. These materials are abundant and include images of different types of wood, metal, textiles, and





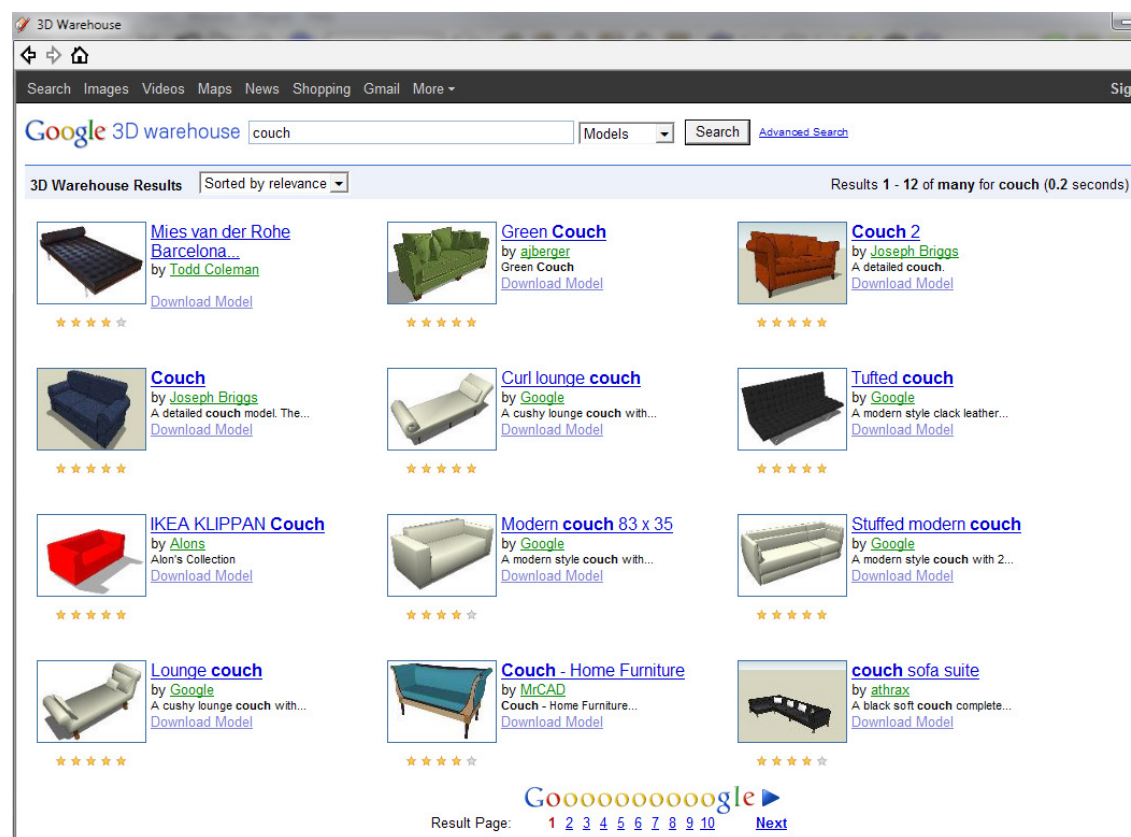
◀ Figure 12: 2D and 3D Text. Note that the 3D text remains on the surface whereas the 2D text rotates to face the camera.

## The 3D Warehouse

The SketchUp 3D Warehouse is one of the best benefits of using SketchUp for crime scene sketching. The 3D Warehouse is a free, online database containing thousands of models that have been uploaded by SketchUp users since 2006. SketchUp users may access the database through the online site (<http://sketchup.com/3dwarehouse/>) or through the SketchUp program under File>Warehouse>Get Models. Then it is simply a matter of doing a keyword search for an object the modeller would like to import into their sketch. For example, a search for the word *couch* will return thousands of models of couches, loveseats, and chairs that a modeller can download (Figure 13).

The sophistication of the objects within the 3D Warehouse vary quite a bit, so a modeller may have to spend several minutes hunting for the right object for their model. Once objects have been imported into the scene, they may be resized and edited as needed. The 3D Warehouse is constantly being updated with new models from the SketchUp community, so it is always a good first stop if a modeller needs to add something to their crime scene. Adding models to the 3D Warehouse is also

vegetation. Users may edit any of the pre-loaded materials or upload new images to add color and texture to an object in their model.



◀ Figure 13: Screenshot of search results within Warehouse.





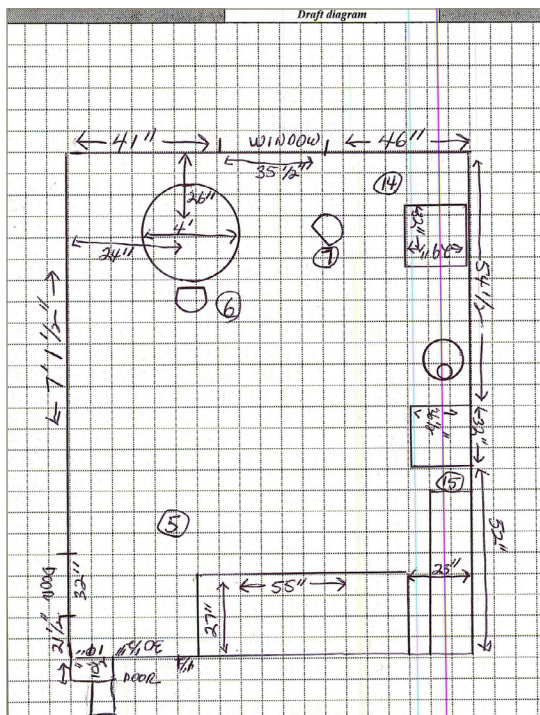
Figure 14: View from the kitchen door into the kitchen.



Figure 15: View of the dining room through to the kitchen.







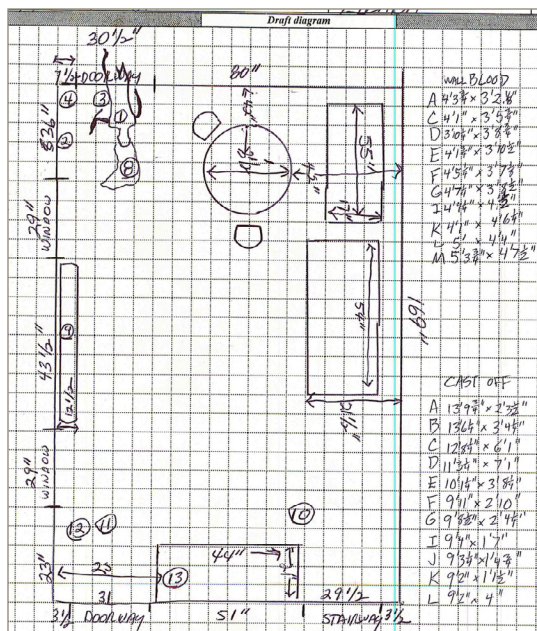
possible. If an investigator creates a model of something from a crime scene which might be useful to others, it is simple to add it to the 3D Warehouse for other investigators and SketchUp users.

## Scene Example

To present an example of how one might build a 3D model from a 2D sketch of a crime scene, the authors have chosen a small two-room scene from a homicide in Reading, Pennsylvania, USA (Figures 14 and 15). Two males entered a residence armed with a hammer and a baseball bat and struck the victim approximately 23 times about the head and body. The assault started in the kitchen and ended in the dining room, with the victim ending up in the doorway between the two rooms. Detectives subsequently sketched the scene by hand and documented the scene with a laser measuring tool and a tape measure using the baseline method.

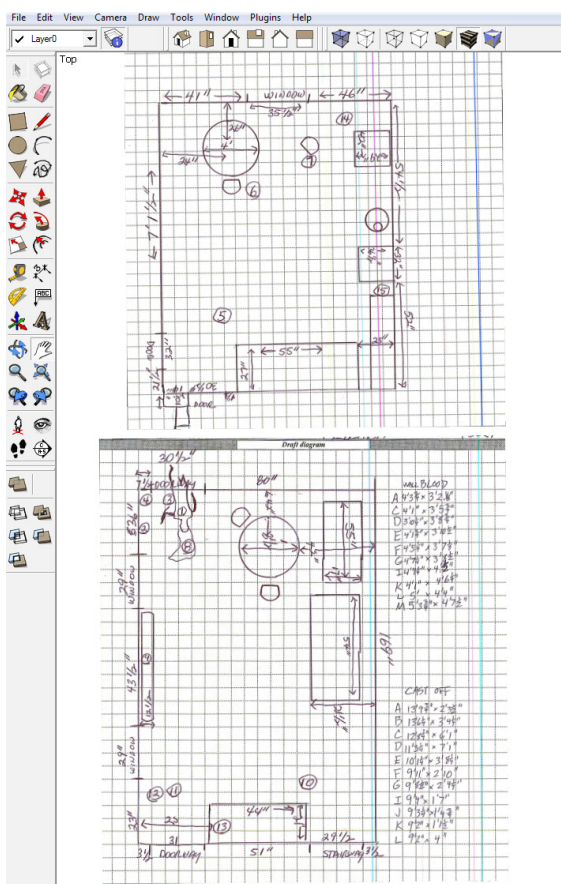
Two hand-drawn sketches from the crime scene (Figure 16) were used to build the 3D model in SketchUp. Measurements of window openings, doorways, evidence locations, body measurements, and some of the furniture were recorded on separate sheets and are not presented here.

Before outlining the steps that were taken



◀ Figure 16: Hand-drawn sketches of the kitchen (left) and dining room (right).

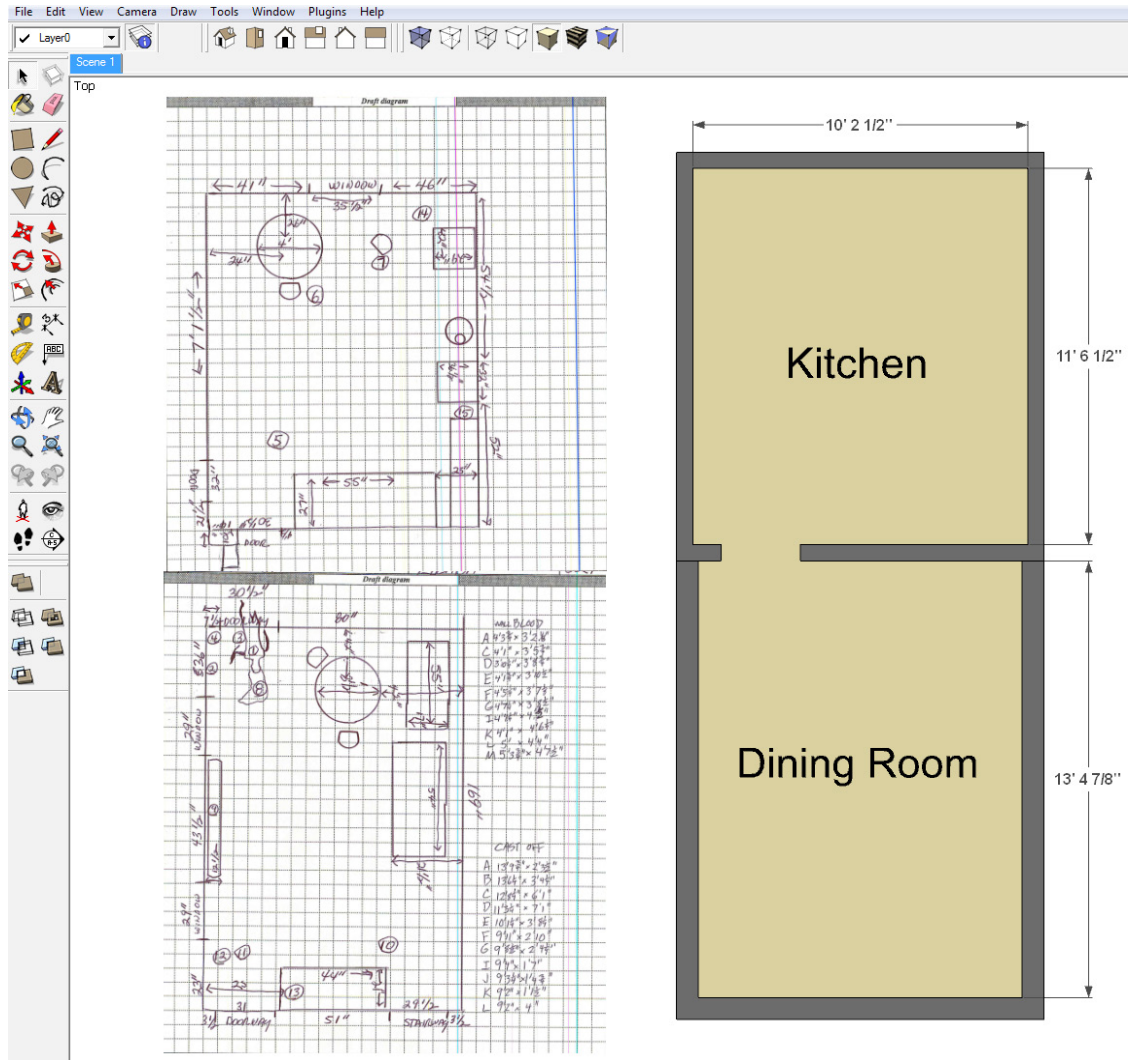
to build the 3D model of the crime scene, it is important to note that the steps and methods presented for this example are just one way of building a 3D crime scene model using SketchUp. There are many other tricks and techniques that may work better for a given modeller, so users are encouraged to experiment to find a workflow that suits them.



◀ Figure 17: Importing the 2D hand-drawn sketches into SketchUp.



Figure 18: Using the Rectangle, Offset, Eraser, and Dimension tools.



## Importing The Rough Sketches

A new project was created by opening SketchUp and choosing the Plan View - Feet and Inches template. Next, scanned copies of the hand-drawn sketches were imported and placed in the x-y plane (the top-down view) as a reference while building the model (Figure 17). This provides a reference so the user does not have to switch between programs to look at the sketch, and permits a side-by-side visual comparison as the user is modelling.

## Room Outline

An outline of the rooms was created corresponding to the measurements from the sketch. Using the Rectangle tool, the floor was added with the specified dimensions. The Offset tool was then used to add thickness to the walls and the Eraser tool used to create the doorway. Finally, the Dimension tool was used to add the dimensions of each room to the model (Figure 18).

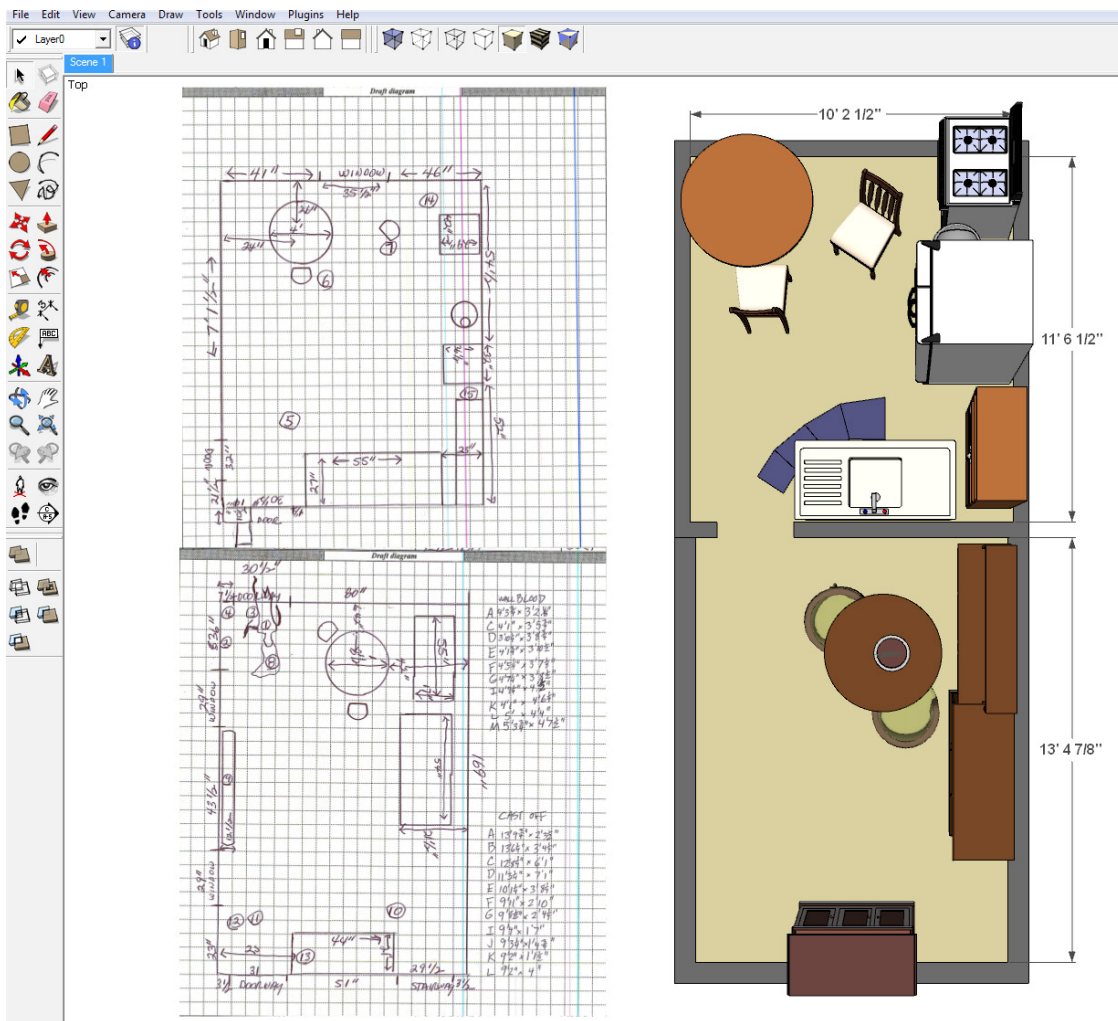
## Adding Furniture

For each piece of furniture in the room, a search was conducted using the 3D Warehouse to find furniture that closely matched the actual furniture in the crime scene photos. Any furniture that was not found online was modelled separately and then imported into the scene. The size and colors of the objects were adjusted to match the dimensions and colors of the physical objects and the objects were placed in the correct location based on the measurements from the crime scene (Figure 19).

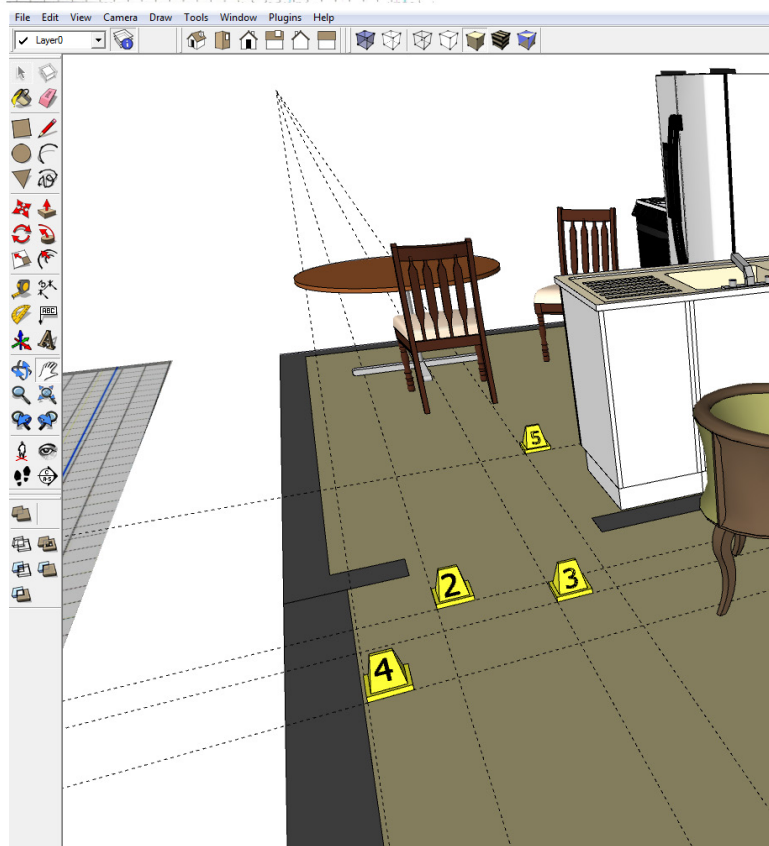
## Markers & Guidelines

Guidelines are instrumental for placing objects at known locations in the scene. For each evidence location, the Guideline tool was used to measure and mark the location within the scene and then a model of an evidence marker model was positioned accordingly (Figure 20).





◀ Figure 19: Top-view of scene after furniture is added.



◀ Figure 20: Using the Guideline tool to position evidence markers.





Figure 21: Adjusting the control points to pose a *muryoung* model.

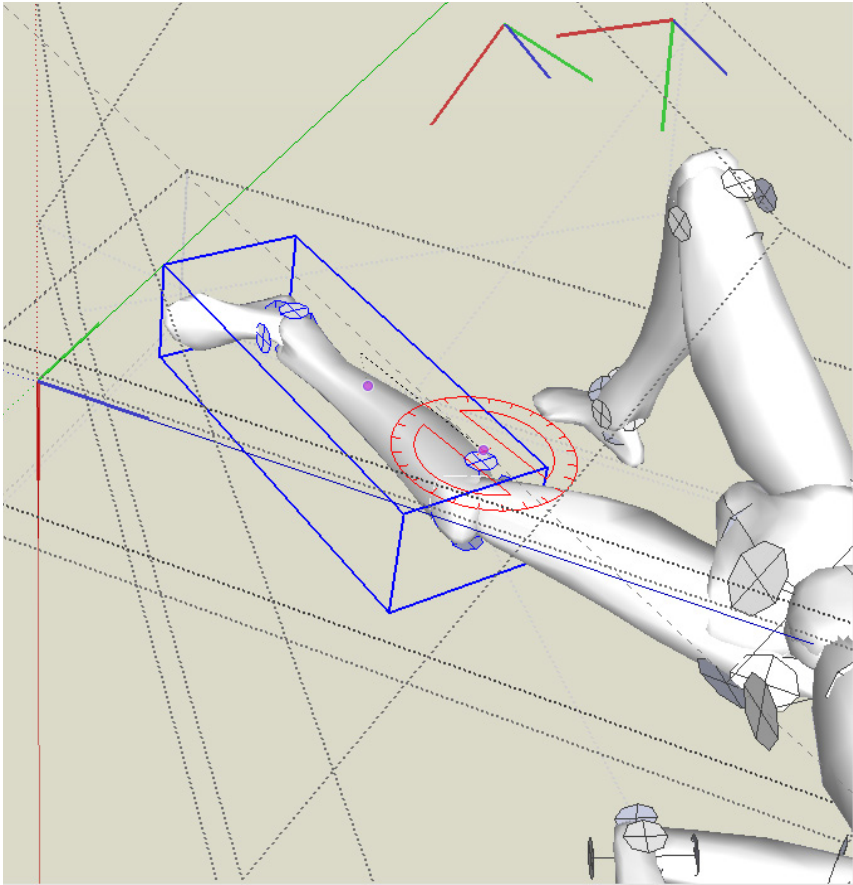
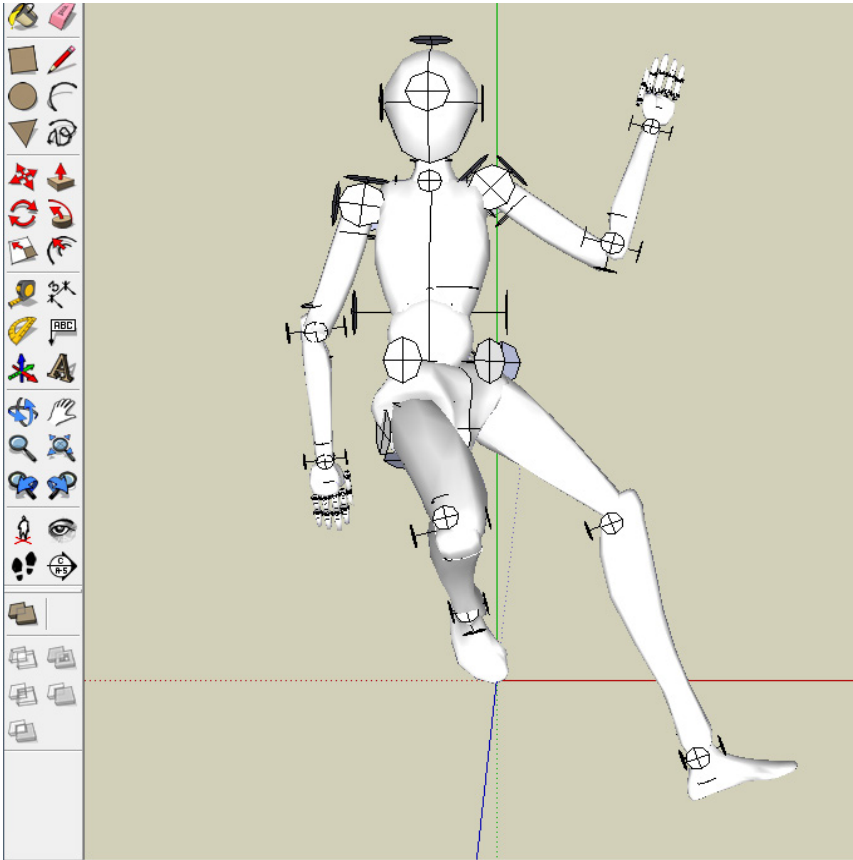
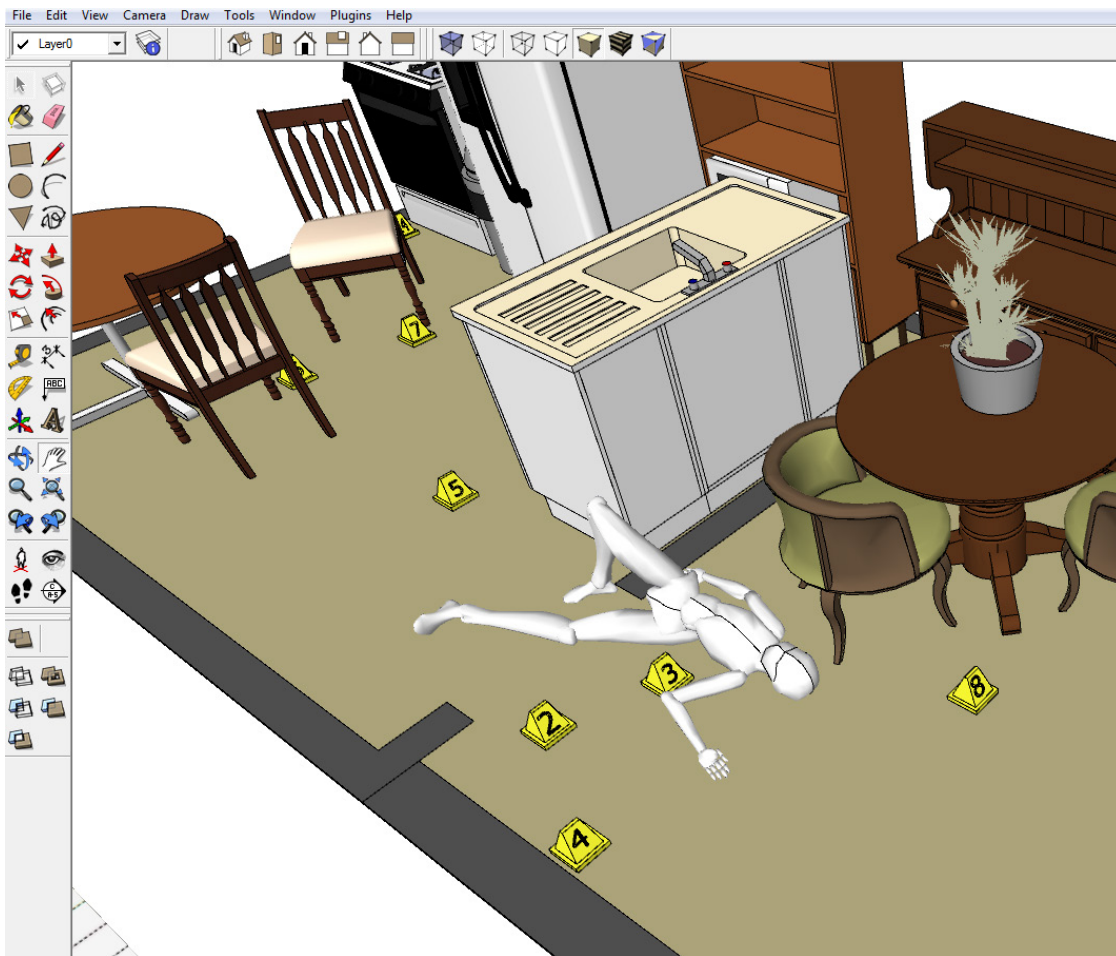


Figure 22: Final pose of the *muryoung* model before importing into the crime scene.





◀ Figure 23: Body imported and placed in the crime scene model (note that the control points layer has been hidden).

Keeping in mind that the investigator probably does not want the evidence markers visible all the time, the markers were created on a separate layer within the model, which allows the user to hide them using the Layers window.

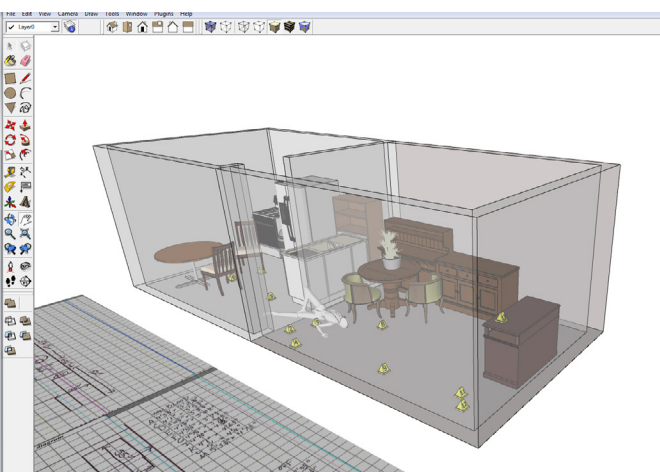
## The Body

Placing a body or bodies in a 3D model can be challenging. One method is to use other software, such as SmithMirco's Poser (<http://poser.smithmicro.com>), to build the model

and then to import it into the SketchUp crime scene. For this example, however, the authors used the Muryoung\_Standard\_Pose posable body found in the 3D Warehouse (search for "muryoung") and reference photos from the scene to create a model of a body in the correct pose. The *muryoung* model was built in such a way that control points on the body may be used to pose it in the correct orientation and then these control points, which are on a separate layer, may be hidden in the final presentation (Figures 21 through 23). Some modellers prefer to work with models like this in a separate SketchUp file and then import them into their main crime scene model, as the authors have done here. Using separate files may also be useful if there are multiple people collaborating on creating one crime scene model.

## The Walls

Now that all the objects were placed within the scene, the next step was to use the Offset, Push/Pull, and Eraser tools to create the walls of the dining room and kitchen. Some modellers



◀ Figure 24: Adding walls to the model.



Figure 25: Adding detail to ►  
the model.

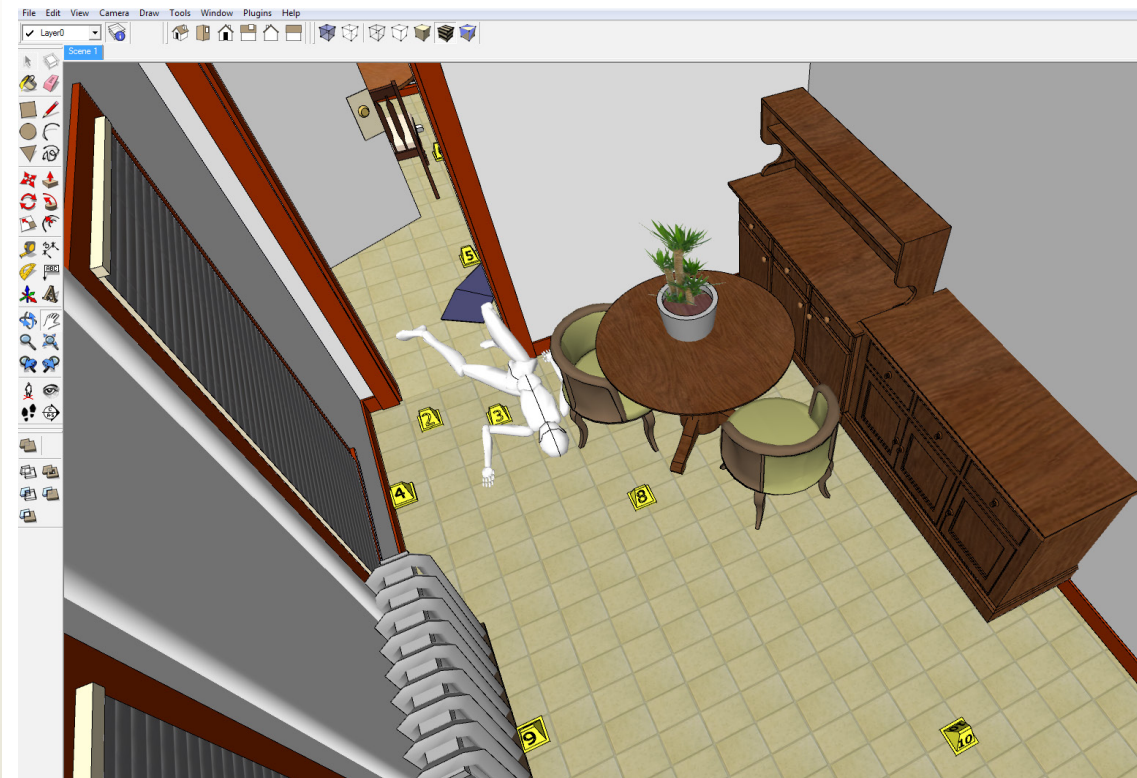


Figure 26: Top view, with- ►  
out perspective.

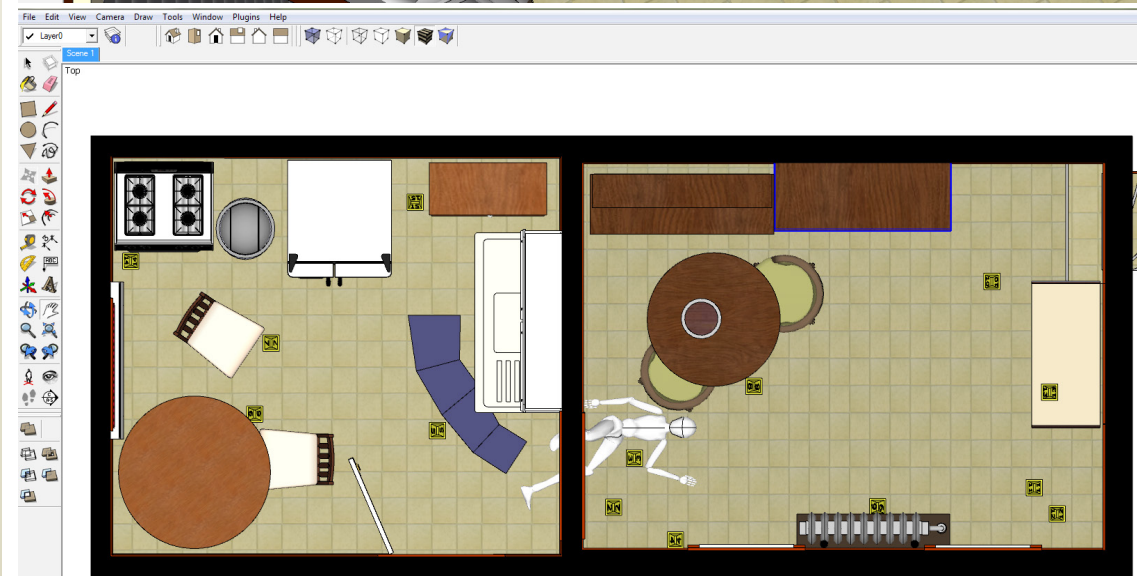
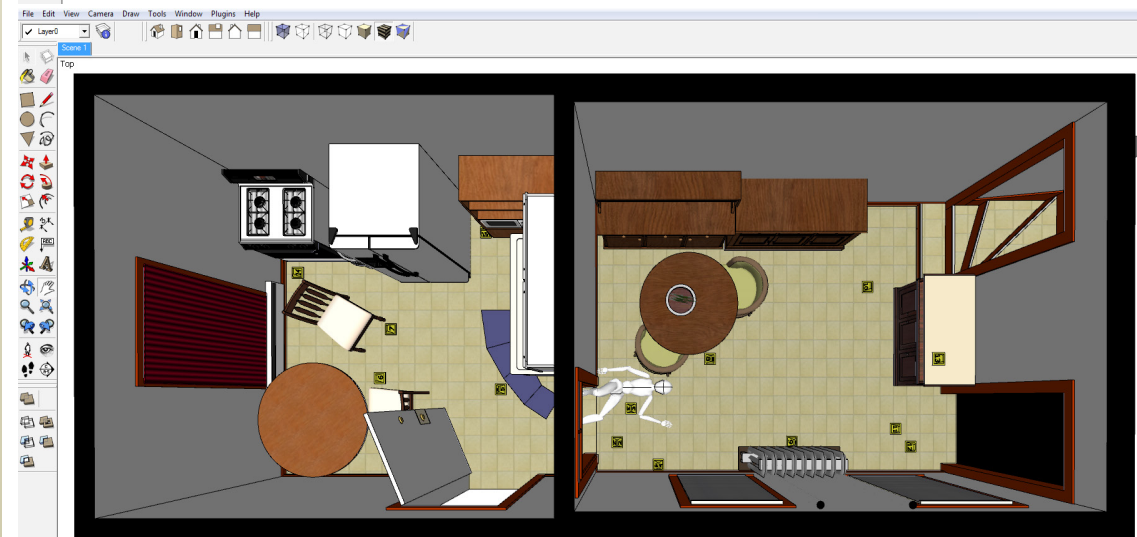


Figure 27: Top view, with ►  
perspective.







prefer to do this step at the beginning when they build the outline of the room and then hide the walls using layers, but in this instance the modeller added them towards the end of construction (Figure 24).

## Adding Detail

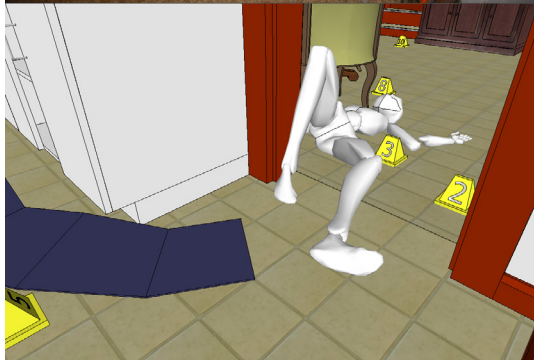
At this point, the main part of the model was complete, so the final step was to add some extra detail. For this example, the windows and doors were added and textures added to the floor, furniture, and other surfaces (Figure 25).

## Different Views

Once the investigator has completed their model, there are many options for viewing it and displaying it to others. As discussed earlier, there are several built-in camera views that the user can select from the Camera>Standard Views menu. One of the most useful is obviously the top-down, or birds-eye, view. The camera projection may also be chosen in the Camera menu to show something like an architectural floor plan without perspective (Figure 26) or a 3D perspective view (Figure 27).

## Final Results

The final model can now be compared directly with photos from the crime scene by moving the camera around the scene using the Orbit,



Pan, and Zoom tools. These camera locations may be saved using the Scene Manager, described earlier, so they can be accessed with a simple click when the investigator needs to present their model and may also be used for simple animated walkthroughs of the scene (see the Advanced Topics section).

Any view of the scene may be exported as a 2D image, like a snapshot from the virtual camera, using the File>Export>2D Graphic menu item. SketchUp will save these images



◀ Figure 28 (top left): Photograph of kitchen.

Figure 29 (bottom left): View within SketchUp model corresponding with view captured in photograph displayed as Figure 28.

Figure 30 (top right): Photograph of body.

Figure 31 (bottom right): View within SketchUp model corresponding with view captured in photograph displayed as Figure 30.

◀ Figure 32: Photograph of body.

Figure 33: View within SketchUp model corresponding with view captured in photograph displayed as Figure 32.



in JPEG, PNG, or TIFF format. For each of the reference photos, the camera was placed in approximately the same location and the images exported from SketchUp (Figures 28 through 33).

## Advanced Topics

This article has introduced some of the basic concepts, tools, and functionality available in SketchUp. There are several other, more advanced, capabilities that have not been covered but may be of interest to users after they become familiar the basic capabilities of SketchUp.

## Photography

As discussed in the introduction, the level of realism of a model can vary dramatically. With photography, the type and number of photos may depend on whether the investigator is planning to build a more sketch-like 3D model or whether they aim to build a to-scale realistic rendering of the scene. If the investigator is intending to build a more realistic model, then representative texture photos of walls, floors, furniture, and other objects in the scene should be shot so they may be used within SketchUp to texture the models.

Regardless of the level of realism planned, it is always helpful to have numerous reference photos of the scene from different angles and positions. These will be instrumental in positioning objects, setting colors, and choosing models from the 3D warehouse to represent furniture and other objects in the scene. If a model of a specific object is not available in the 3D Warehouse, then the investigator may have to create their own, so, in addition to the measurements, reference photos are essential. If there are bodies to be documented and placed in the model, then photos will be crucial for posing the body model in SketchUp; thus it is highly advisable to take many photos from different angles.

## Scene Animation

Using the Scene Manager discussed earlier, the user can add several camera positions throughout the scene. To see the animation,

the user right-clicks a scene tab and selects Play Animation. SketchUp will cycle through all saved camera views, starting from the scene tab that was selected. The time it takes the camera to transition from scene to scene may be edited under the Animation section of the Model Info window located under Window>Model Info. When the user is satisfied with the movement of the camera from the first scene to the last scene, they can export the animation as an Audio Video Interleaved (.avi) file. This file may be opened with an audio/video player like Windows Media Player or QuickTime. This animation might be used to virtually “walk” someone through a crime scene.

## Extending SketchUp

Plug-ins, optional software add-ons that allow users to automate tasks and add capabilities to SketchUp, can either be written using a programmer’s interface and a language like C++ or using a scripting language called Ruby. Plug-ins are available for both SketchUp and SketchUp Pro and are a great way to add features to SketchUp that are not included as part of the basic software.

A good example—one that may be useful for crime scene presentations—is the free Advanced Camera Tools plug-in created for SketchUp Pro (<http://sketchup.com/intl/en/download/plug-ins.html#advcam>). This provides more refined control of the camera, allowing adjustment of focal length and other physical camera settings, that can help the user create views of their 3D model that more closely resemble a physical photo for comparison.

While plug-ins are not required to complete a high-quality crime scene model, users are encouraged to explore the sites listed in the Supplemental Materials section below, as they will find useful plug-ins like 3D Grid and Toggle Units. CubicPanoOut is an especially interesting plug-in that works in conjunction with a panoramic image converter like Garden Gnome Software’s Pano2VR (<http://gardengnomesoftware.com/pano2vr.php>) to create virtual 3D panoramic tours of the SketchUp model.

There are many other plug-ins that are available for a fee, which help more advanced



users of SketchUp create photorealistic renderings of a SketchUp model. Twilight Render (<http://twilightrender.com/>) and LightUp for SketchUp (<http://www.light-up.co.uk/>) are two examples of rendering plug-ins that give the modeller precise control over lighting and shadows, which can help when presenting 3D models of crime scenes.

## Using SketchUp With Other Tools

SketchUp provides capabilities that allow the user to import models created in other software or export their crime scene model for use in another program. Some types of model might be easier to create in other software such as 3ds Max (<http://autodesk.com/3ds-max>) or Blender (<http://blender.org>), or they might be generated by other software such as FORident Software's HemoSpat, a bloodstain pattern analysis application (<http://hemospat.com>). These may be saved in one of several file formats, imported into SketchUp, and placed in the user's crime scene model. Similarly, using SketchUp may be an intermediate step in a user's process and the models may be exported to a variety of formats for import into other programs.

## SketchUp vs. SketchUp Pro

While the free version of SketchUp is a powerful tool, there are several features in SketchUp Pro that give users more flexibility when creating 3D crime scene models and can make the process easier. Some of the features include capabilities to extend SketchUp, for example plug-ins and additional file formats for importing and exporting data and some add completely new capabilities like the report generation and integration with the LayOut application.

## Import and Export

The free version of SketchUp supports importing of 3ds Max (.3ds) files, COLLADA (.dae) files, Earth (.kmz), and digital elevation model (.dem) files. For 3D models, SketchUp will export to COLLADA or Earth formats. COLLADA is an emerging standard used to share 3D information between applications. One drawback, however, is that COLLADA

support varies greatly between applications and sometimes materials, textures, or animations applied to a model in one application get lost in the translation.

SketchUp Pro adds support for importing and exporting a wider range of 2D and 3D file formats such as AutoCAD (.dxf and .dwg), Autodesk FBX Technology (.fbx), and others that are already standard in the CAD and modelling industry.

## Attribute Report

SketchUp Pro has a report generator that can be invaluable for demonstrating accuracy of models in court. The report generator creates an attribute report that lists each component in the model, along with its x-y-z location and dimensions. To make this report useful, it is good practice to group and make components of objects and to save them on separate layers while creating the model. The report may be saved as an HTML file, suitable for a web browser or a comma-separated values (CSV) file that may be viewed in spreadsheet software such as Microsoft Excel or LibreOffice Calc. To make the CSV report easier to read, columns may be re-labelled to better describe what they represent. For example, the report displays "LenX" (length in X axis), "LenY" (length in Y axis), and "LenZ" (length in Z axis). Once imported into the spreadsheet software, these titles may be renamed to something more user-friendly (e.g. "Length", "Width", and "Height"). Providing this computer-generated report along with the sketch measurements demonstrates that the model is based on real world measurements.

## LayOut

LayOut (<http://sketchup.com/intl/en/product/layout.html>) is an application that comes with SketchUp Pro that takes 3D models and turns them into high-definition 2D images. LayOut is useful when creating slideshows of a 3D model, fly-through animations, or simply to display a 2D drawing of a crime scene model. While the free version of SketchUp allows printing of models, the resolution is limited to screen resolution that limits the ability to mount large scale models. LayOut removes this limitation





Figure 34: The Schade Body ► posed for the example crime scene.

and allows printing high quality vector or raster images of a 3D model. LayOut is fully integrated with SketchUp Pro, so any changes made to the model in SketchUp will be reflected automatically in the LayOut presentation.

## Resources

There are numerous resources available, not only to learn to use SketchUp, but also to provide models for thousands of objects the modeller can add to their crime scene model. Trimble has a web page devoted to SketchUp resources which is a good place to start (<http://sketchup.com/intl/en/community/resources.html>).

## Tutorials

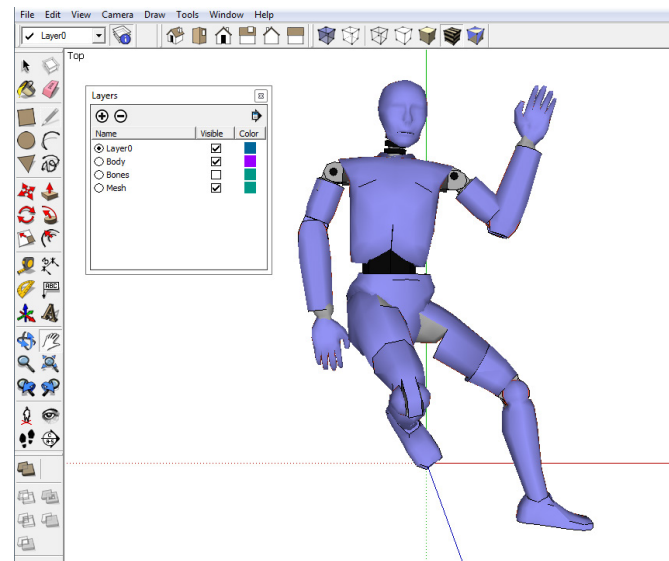
New users should probably start with Trimble's online video tutorials. These cover a wide range of topics from an introduction to basic concepts to advanced topics, such as using photo matching to create models (<http://sketchup.com/training/videos.html>). Many SketchUp users have also uploaded their own tutorials onto video forums like YouTube. New users are encouraged to explore these free services when first learning how to use SketchUp.

## Models

As mentioned in the section above, the SketchUp 3D Warehouse provides tens of thousands, if not hundreds of thousands, of pre-built models. This is a goldmine for an investigator trying to quickly model a room in a house (<http://sketchup.com/3dwarehouse/>).

SketchUp also imports other model formats, so if a user finds the exact model they are looking for they can likely import it and use it in their scene. There are many websites that offer free-to-use models that may be suitable for a user's crime scene model.

Although they were not used in the example for this article, one of the authors has built two new body models—one male, one female—that offer a lot of control of the joints to help position bodies in a scene (Figure 34). These models may be found in the 3D Warehouse by searching for "Det Schade".



## Plug-ins

As mentioned in the Advanced Topics section above, plug-ins provide a great way to extend the capabilities of SketchUp. Trimble provides a range of free and commercial plug-ins (<http://sketchup.com/intl/en/download/plugin-ins.html>) and some third-parties also develop and sell plug-ins. This web page also has links to several other websites that provide plug-ins.

Two other good sources for plug-ins are Smustard (<http://smustard.com>) and the Ruby Library Depot (<http://rhin.crai.archi.fr/rld/index.php>).

Looking at examples of plug-ins written in Ruby might be useful for any users wanting to create their own custom plug-ins. Trimble provides some sample Ruby scripts available to get users started (<http://sketchup.com/intl/en/download/rubyscripts.html>).

## Conclusion

Creating 3D crime scene models has typically been expensive and time-consuming. SketchUp, while not specifically designed for crime scene work, is a tool that provides crime scene investigators a relatively simple and cheap alternative to create their own 3D models. This article presented the basic tools and concepts necessary for working with SketchUp and provided an end-to-end example, taking a 2D crime scene sketch and creating a 3D model. The authors hope that this introduction gives investigators an idea of what is possible with SketchUp and enough information and

resources so that they can start working with SketchUp to produce their own 3D crime scene models.

## Acknowledgements

The authors would like to acknowledge the SketchUp development team for creating such a great tool. In addition, there are many modellers who choose to provide their work for free through the 3D Warehouse. The authors would like to acknowledge the creators of the models from the 3D Warehouse that were used in this article: Benji\_02, Christopher Clepoint, Elfpainter, GE Appliances, Highlander, Joseph Briggs, KARE Design/Sketchup, Kostyan Novikoff, Medallion Cabinetry, Woodsmith, and the SketchUp Team. The authors would also like to thank the Berks County District Attorney's Office for giving permission for the use of the crime scene photographs used in this article.

## Supplemental Material

The following files are included in the supplemental material:

- Example Scene.skp—the complete SketchUp model for the crime scene example used in this article.
- Muryoung body–Posed.skp—the SketchUp file for the *muryoung* body model posed for

the example crime scene in this article.

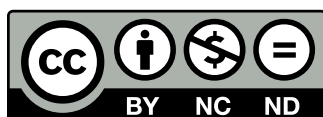
- Schade body–Posed.skp—the SketchUp file for the new male body model, mentioned in the Resources section, posed for the example crime scene in this article.

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## Suggested Reading

Chopra A. Google SketchUp 8 for Dummies. Hoboken (NJ): Wiley Publishing, Inc.; 2011.



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