Full Throttle STEM™ at Eldora Speedway: Virtual RC Car

Challenge Problem and Resources

Developed by:

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Gaming Research Integration for Learning Laboratory™ (GRILL™)
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TABLE OF CONTENTS

1. CHALLENGE PROBLEM: VIRTUAL RC CAR

Utilize a commercial off-the-shelf (COTS) computer based racing game to create, import and implement a virtual RC Car that will be the player's vehicle in a virtual racing game.

1.1. THE TOOLS

Use tools such as X-Motor Racing (COTS game), SketchUp, Blender, 3ds Max® and perhaps some computer scripting or coding.

1.2. THE CHALLENGE

Solutions to this problem are likely to have students creating a 3D model of an RC Sprint car in SketchUp, importing the car into X-Motor Racing, applying all physics properties, and virtually racing the car in the X-Motor Racing game.

Figure 1: Remotely controlled car

2. TUTORIALS

Wright Scholars, in collaboration with educators and the GRILL™ team, created the tutorials described below as possible solutions to solve the challenge problem. At the time of creation these were working tutorials; however, with software updates and changes in technology, additional steps may be required. Teachers are encouraged to communicate any issues, problems, or suggested changes to these tutorials to ensure the dissemination of helpful materials to support challenge problem implementation.

2.1. VIRTUAL RC CAR

X-Motor Racing features the ability to import vehicle models from other racing games as well as vehicles created in 3D modeling software, like SketchUp. This tutorial provides instructions to import a vehicle model, created in SketchUp, into X-Motor Racing. This tutorial will not include how to use SketchUp or XMR Editor to create or edit models. Previous experience with this software, as well as general familiarity with vehicles, may be beneficial. Recommended software includes X-Motor Racing, XMR Editor, SketchUp, Blender, Paint.NET, and VTFEdit.

This tutorial includes the following topics:
- Setting up Folders (Section 2.1.1)
- Tips for Creating a Model in Sketchup (Section 2.1.2)
- Exporting a Model from Sketchup to XMR Editor (Section 2.1.3)
- Navigating in XMR (Section 2.1.4)
- Adding Textures to the Car (Section 2.1.5)
- Physics Properties (Section 2.1.6)
- Adding Wheel Markers to the car (Section 2.1.7)
- Adding Vertex IDs (Section 2.1.8)
- Exporting the Vehicle (Section 2.1.9)
- Importing Car Model to X-Motor Racing (Section 2.1.10)
- Adjusting the Physics In-Game (Section 2.1.11)
- Troubleshooting (Section 2.1.12)

2.1.1. SETTING UP FOLDERS

After installing all of the necessary software, you need to create a number of folders for organization.

To create folders:

1. Create a main folder and name this folder the same name as the car. This entire folder will be placed into the program files of XMR to enable the vehicle to be played in-game.
2. Create a subfolder called Textures. This folder will house the .tga files that you create for textures used on the vehicle.
3. (Optional) Create a folder for SketchUp and Blender exported models. Do not place this folder inside the main folder.

### 2.1.2. TIPS FOR CREATING A MODEL IN SKETCHUP

- A functional car in XMR requires the following elements: four wheels, suspension, brakes, and a cockpit with steering wheel. Not having a cockpit will limit the camera options in-game.
- Scale the model so that the front end is approximately 5 inches in width in SketchUp. This is the scale for an average car. Scale other vehicles, such as an RC-Car or monster truck, appropriately.
- Creating a model composed of too many polygons (max. 60,000) could cause problems. Once you export the model to XMR editor, you can check the polygon count. If there are too many polygons, you can modify unnecessary curved or spherical parts.
- Explode the model completely by right clicking and selecting Explode. This will combine faces into components.

2.1.3. EXPORTING A MODEL FROM SKETCHUP TO XMR EDITOR

After you successfully create a car model, you need to import it into the XMR editor to edit it further before it can be driven.

1. Export the model as a COLLADA file by selecting the entire model, and then selecting File→Export→3D Model.
2. Export as a .dae file in the folder created in the Setting up Folders Section 2.1.1.
3. Open Blender and import the COLLADA file by selecting File→ Import. If the model does not load correctly, you may need to delete unnecessary details or explode the model in SketchUp.
4. Select File→Export to export the file from Blender.
5. Save the file as a .3DS file in the models folder to import it into XMR editor.
6. Select File→ Open to open the .3DS file in XMR Editor.
7. Search for .3DS models (the default is .wld). It will appear as though you did not import anything because the car lacks textures.
8. Use the selection tool (blue arrow) to select the car and view the wire frame.
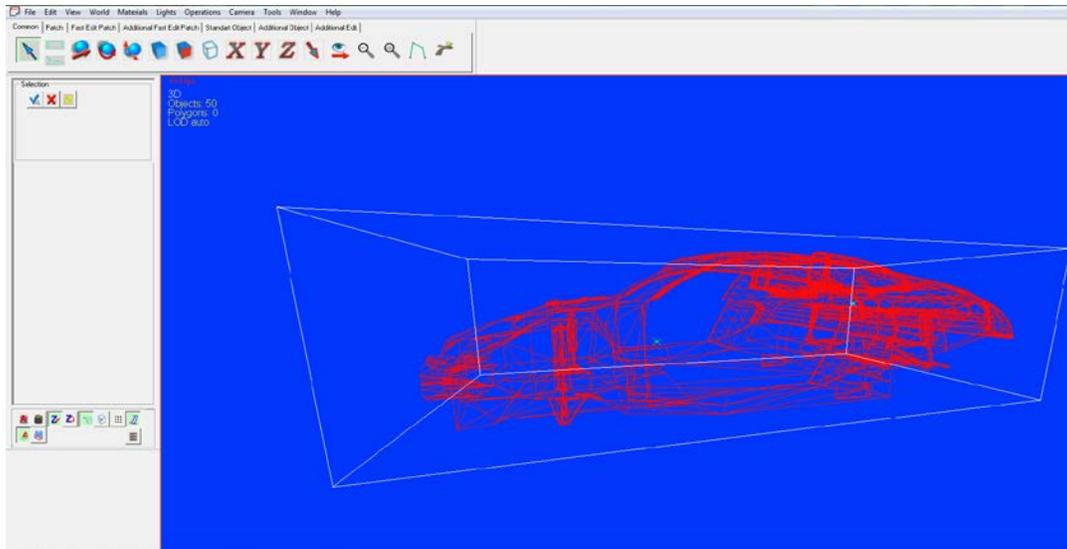
2.1.4. NAVIGATING IN XMR

XMR uses a different key configuration than most 3D editing programs to navigate 3D space and interact with the world. Use the number pad on the keyboard to navigate in XMR Editor. The arrow keys replicate the 8, 4, 6, and 2 keys.

7: Move up	8: Move forward	9: Tip up
4: Turn left	5: Nothing	6: Turn right
1: Move down	2: Move back	3: Tip down

- The icons in the toolbar help navigate within XMR Editor and allow the selection of objects, faces, and vertices.
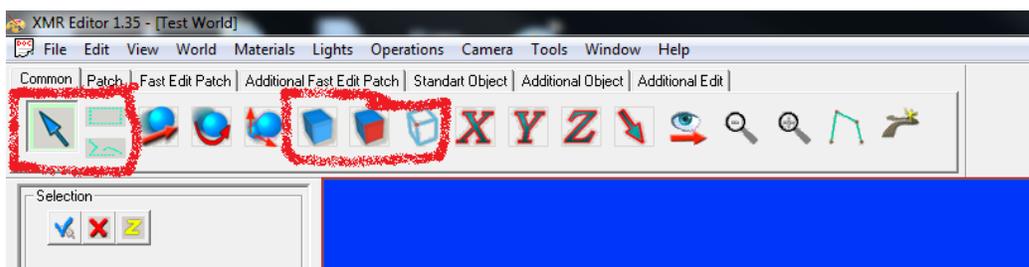

- You can hide and unhide selected objects using the Hide and Unhide functions in the *Edit* menu. This is useful when accessing and modifying internal parts (e.g. suspension) to apply textures and physics.
- You can select multiple objects using the Ctrl key

## 2.1.5. ADDING TEXTURES TO THE CAR

Textures for the car can be an image that already exists or one created in an image editing software such as Paint.NET, GIMP, or Photoshop.

**To create a new car texture:**

1. Open Paint.Net.
2. Select File→ New (or Ctrl + N) to create a new project. The pixel width and height must be equal to a power of two (2n: 2, 4, 8, 16, 32, 64, 128, etc.).
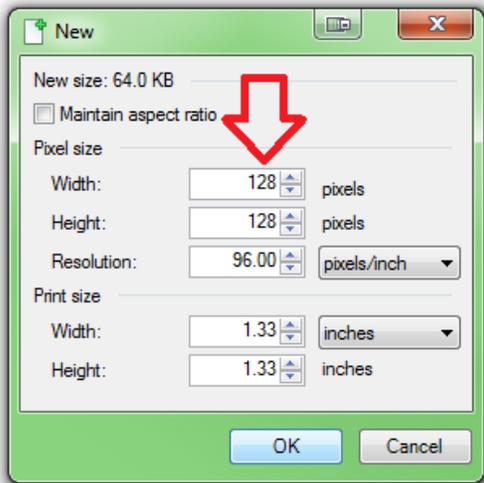

3. Choose a color using the Colors window and select the paint bucket tool in the Tools window.
4. Click on the canvas to give the square color.
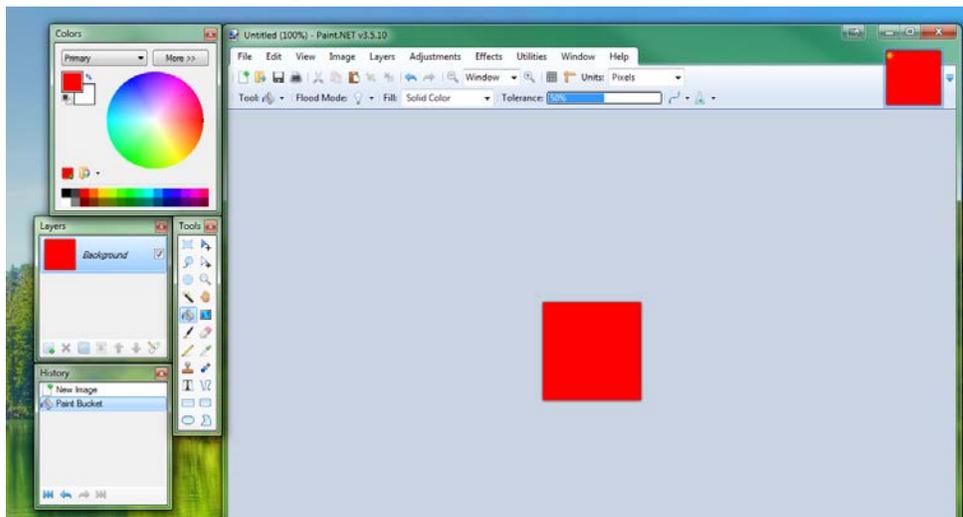
5. Save the image as a .tga file by selecting File→ Save As. Other file types are acceptable; however, the conversion will be easier if the file type is .tga.
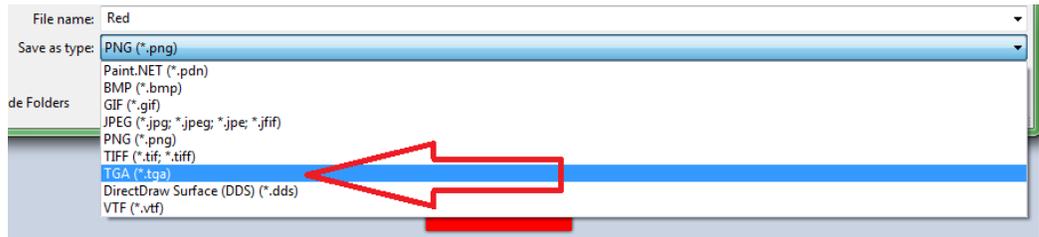
6. Open VTFEdit and import the saved image by selecting File→ Import.
7. Export the file to the Textures folder by selecting File→ Export as a .tga file. This can replace the original Paint.NET .tga file. **Note**: This step seems redundant but is necessary to open the .tga file in XMR Editor.
8. In XMR Editor, right click anywhere on the car model and select Texture Manager from the pop-up menu.
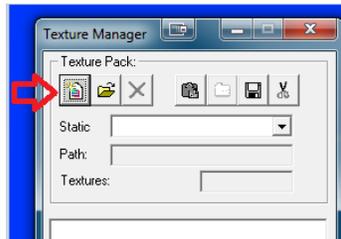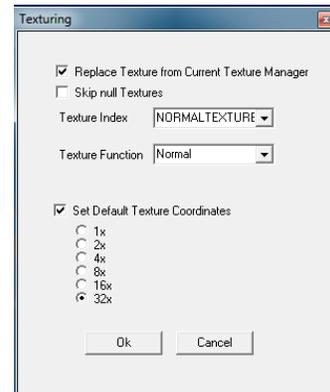

9. Create a new texture pack by selecting the button at the top, left of the Texture Manager window.
10. Name this file and place it in the main folder.
11. Add textures to this pack by clicking on the clipboard icon in the Texture Manager window and selecting the .tga file that you added to the Textures folder. If there are multiple textures, add all of them to the Texture Pack.
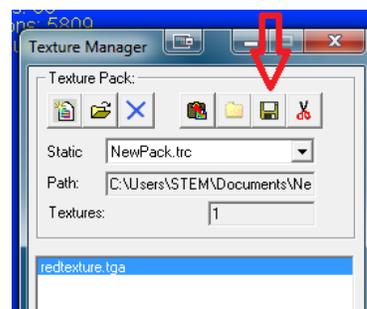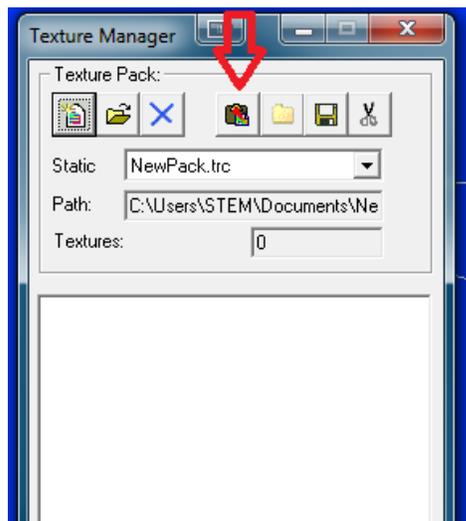
12. Click the save (disk) icon to save the texture pack.

To apply texture to the car:
1. Select the texture in the Texture Manager window, then select the portion of the model to texture.
2. Right click and select Texturing.
3. Uncheck Skip Null Textures, set the Texture Index to NORMAL_TEXTURE_INDEX and the Texture Function to Normal.
4. Check the Set Default Coordinates Box, and change the value to 32x.
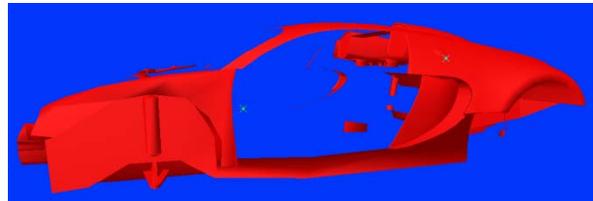5. Select Ok.
   Note: Do not texture windows yet. The texture will probably look like a solid color with no shading.
6. Select Lights→UpdateNormals→All. This step will make the textures look more realistic with shading.
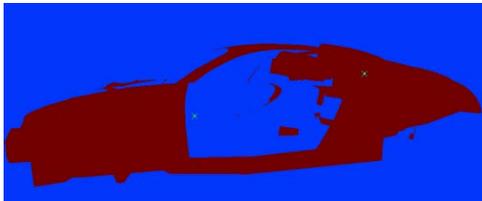
Before   After

2.1.5.1. CHANGING TEXTURE MATERIAL (OPTIONAL)

The car can look more realistic by changing the texture material.

To change texture material:
1. Right click on the section of the car that you want to change and select Properties.
2. Select a material from Common Material Index on the right side of the Common tab. That part of the car will take the properties of that material. This can help make the car look even more realistic.

Note: The aesthetics of the material can be further edited by altering the options within Operations → Set Polygon Options. For example, check Change under Graphic Material and select the desired material. It should match the material selected in the Properties menu. To increase the realism of the car, select the Materials→ Materials and Global Lighting. You can select and change the desired type of material to the necessary values.


2.1.5.2. ADDING WINDOWS TEXTURES

The windows will use separate textures from the rest of the car.

Note: The steps below use the image program Paint.NET but you can use any image program.

To add window textures to the car:

1. Open Paint.NET.
2. Start a new project maintaining the size constraints of textures.
3. Before adding color with the paint bucket, first erase the white background using the Erase tool.
4. Change the brush size to speed up the process by changing the Brush Width. After erasing, the square should be a checkerboard pattern of grey squares.
5. Select the More button on the Colors window.
6. Set the Transparency – Alpha slider to 50.
7. Select a color that will be the color of a window. Normal windows are a shade of light grey, but color tinted windows are possible.
8. Select the Paint Bucket tool and click the square to add a light layer of color. It should be translucent. Click a few times to make the color a little darker (two or three clicks are recommended).
9. Save the file as a .tga.
10. Open VTFEdit, and repeat the import and export process to export it as a .tga file in the Textures folder, as described in Section 5.3.5.
11. In XMR Editor, select the window(s) to texture.
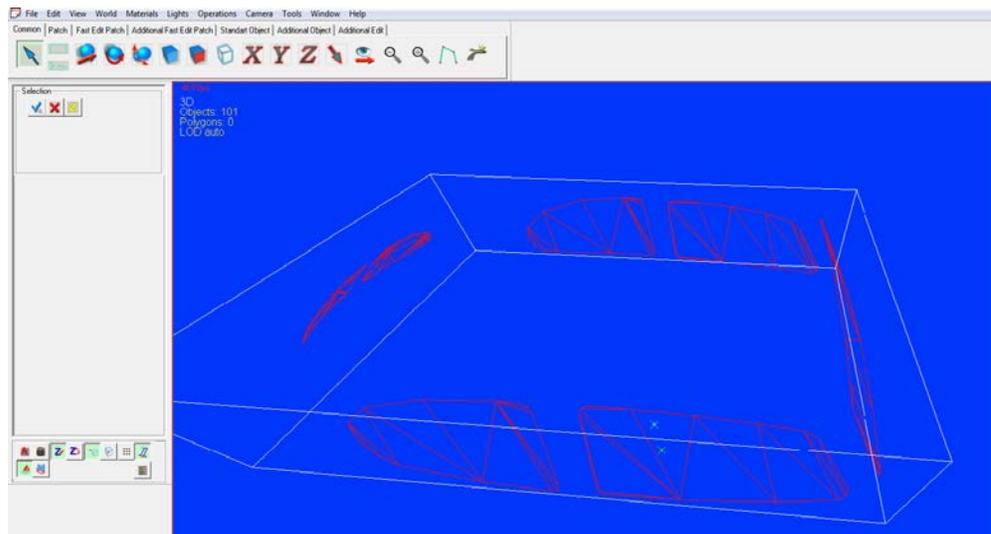
12. Select Operations→Set Polygon Options. Check the Change box under Graphic Material and set it to FVF_TEXTURE1_GLASS_SIDE1_LIGHTYES, and click OK.
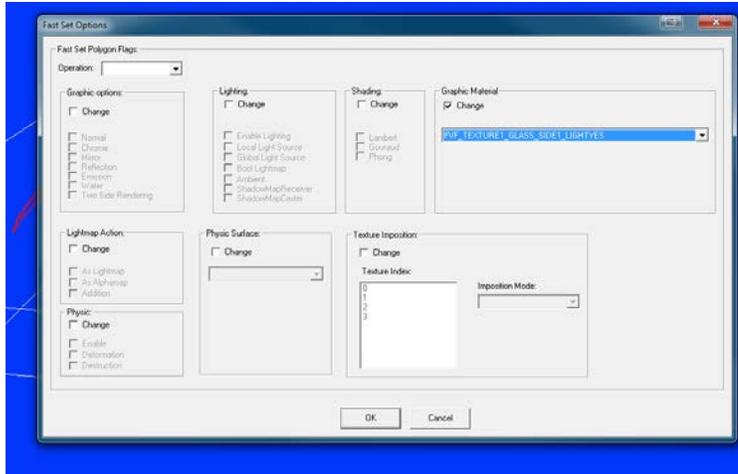
13. Add texture to the windows similar to other textures, except in the Texturing menu set the Texture Function to Transparent.

14. Set the physics of the window to glass:

    a. Right click on the window and select Properties→ PhysicsandDamageModel.

    b. Check the Active box.

    c. Under Damage Model Data, check the Deformation, Destruction, Visual Effects, and Glass Dest boxes. Values in each of the selections can be modified—the ranges are given in brackets next to each option.
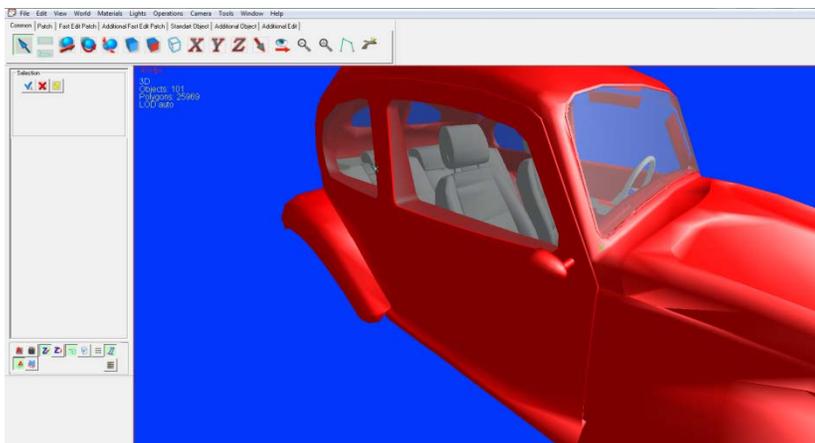
   d. Update the normals (in the menu bar: Lights→ UpdateNormals→All).

2.1.6. PHYSICS PROPERTIES

A myriad of physics properties can be altered in XMR Editor. When creating a custom vehicle, physics properties must be applied to specific parts of the vehicle in order for the car to respond realistically within the game. Wheels, suspension, barrel (brake), spring, and steering

are several of the main components on the vehicle that should have physics properties applied prior to game play.

To add a physics marker:
1. Right click on a part and select Properties→PhysicsAndDamageModel.
2. Check the Active box at the top.
3. Select the vehicle part in the Vehicle Dynamics drop down. For example, when working on the left front wheel, select LF_WHEEL.
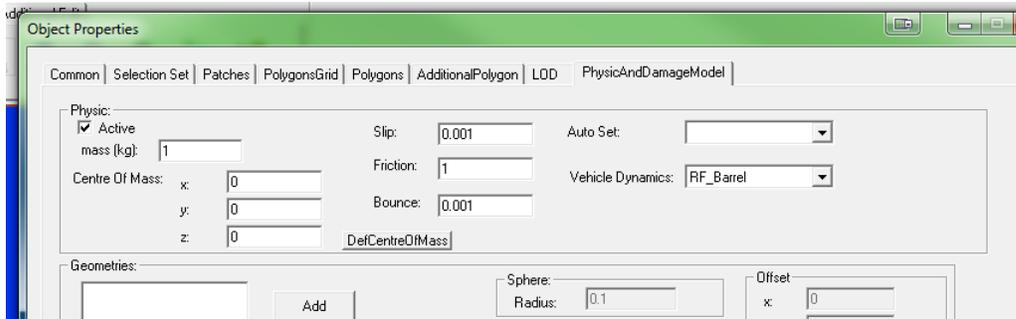
Note: If there are multiple components within the part, like rims and tires, then physical properties must be added for each component so that each piece will behave realistically within the game. Most other parts listed in the drop down menu, such as suspension, barrel, etc., should be marked.

2.1.7. ADDING WHEEL MARKERS

You need to add markers for the wheel joints and the axis of rotation of the wheel. The wheel joint is where the wheel and suspension meet, and the axis of rotation marker is the vertex that is directly in the center of the wheel.

To add wheel markers:
1. Select the Additional Options of Editing button in the left menu towards the bottom and check Wire Frame Added to view in wire frame mode.

2. Click on the point in the middle of the wheel and select World→Add Marker.
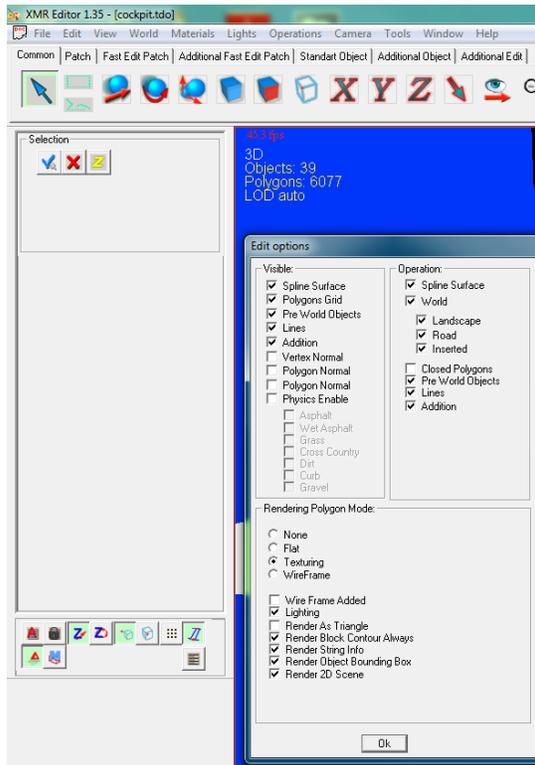
3. Turn the wire frame off, right click on the marker, and select Properties.
4. In the Short Desc: box, name the marker "left_front_wheel," or other appropriate naming convention for the current wheel being marked. Repeat this for each wheel and each wheel joint.
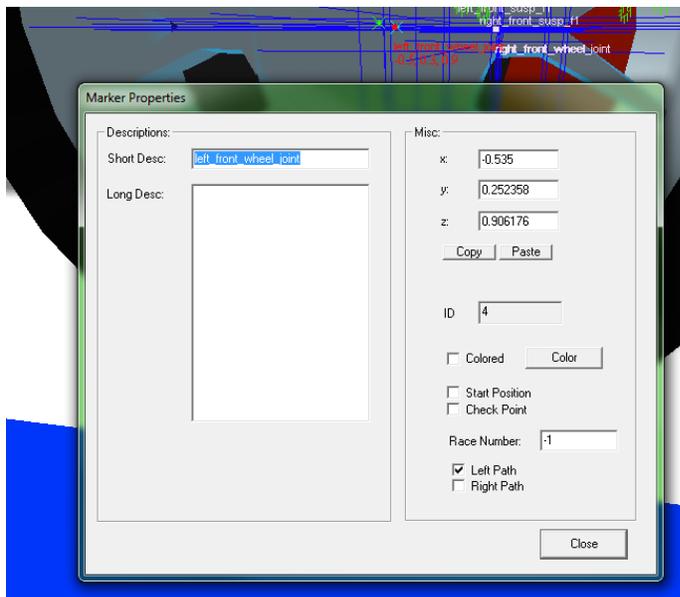
Note: Markers for suspension parts can be added as well. To keep the markers aligned (e.g., between left and right wheels), use the copy and paste function and change the positive or negative signs on the x, y, or z axes when appropriate (indicated by the marker coordinates in red on the model).

2.1.8. ADDING VERTEX IDS

You must add Vertex IDs to vertices where the suspension meets the body of car.

To add Vertex IDs:
1. Select the vertices needed using the select square region tool:
2. Select World →Set Vertex ID.
3. Change the value to 1. If there are several parts of the suspension that meet the body of the car, those values should be the number of the part. For example, if it were the second part, the value would be 2. Set IDs that need to be deleted to 0.

2.1.9. EXPORTING THE VEHICLE

It is necessary to export the vehicle for it to be usable by X-Motor Racing.

To export the vehicle:
1. Select *File→ Export*.
2. Name the file Car and save it as a .car file type. Two new files should be in the folder: car.trc and car.car.

Note: If an error message appears stating that a proper damage model needs to be applied to the car, click OK. The export process will not be affected.

2.1.10. IMPORTING CAR MODEL TO X-MOTOR RACING

To make the car a vehicle option in-game it must be imported into X-Motor Racing.

To import car to X-Motor Racing:
1. Locate the Cars folder in X-Motor Racing (the location should be similar to C:\Program Files (x86)\X-Motor Racing Demo\Data\Cars).
2. Make a copy of one of the car folders, preferably a vehicle that has similar physics to the exported model, and rename the folder the name of the model vehicle.
3. Copy the files (the textures folder and the car.trc and car.car files) from the model car folder on the desktop into the newly created folder in X-Motor Racing, overwriting the existing files (those three original files may need to be deleted first).

4. Open the car configuration settings file (car.ini) and change the name of the original car to the name of the model vehicle and save the file. The vehicle should successfully import into X-Motor Racing and appear in-game as a vehicle selection.

2.1.11. ADJUSTING THE PHYSICS IN-GAME

In X-Motor Racing, you must be in Developer mode to adjust the physics.

To adjust physics in-game:
1. Select OPTIONS→ Misc → and choose Developer in the GAME option to change the mode for any profile.
2. Test and modify the physics of the model car by going to start a new race in X-Motor and selecting HOT LAP. Note which physics model is being used on the car—you can check this by selecting Garage before starting a race; it will show base.phs or arcade.phs (generally, arcade is used with keyboard control).
3. Select GO! to start the simulator.

At any time, you can modify the car's physics by pressing the letter O on your keyboard, which will halt game play and open the *VehiclePhysics* control panel. Prior to adjusting functions and settings in *VehiclePhysics*, make sure that you are editing the correct model. The model name appears in a drop down on the far left. Once you have modified the settings, select *Update* on the left side to save the vehicle.

Table 1 includes a list of functions and settings and provides brief descriptions of the physics adjustments that may be made within the vehicle physics control panel.

Note: Turning on the Physics Contours for the vehicle is extremely helpful when adjusting physics. This will show where the game thinks the body of the car is and how big the wheels are. To turn on Physics Contours go to Menu → Options → Display → Physics Contours

Table 1. Function Description

TAB	FUNCTION/SETTINGS	DESCRIPTION
COMMON		
	Mass/Sprung	Adjusts the mass of the vehicle
	Front Wheel/Unsprung Mass	Adjusts the mass of the front wheel
	Rear Wheel/Unsprung Mass	Adjusts the mass of the rear wheel
	Width, Height, and Length	Adjusts the size of the car body on each dimensional

TAB	FUNCTION/SETTINGS	DESCRIPTION
		axis—fits values to the exact size of the vehicle
	Offset X, Y, and Z	Changes the position of the car body in the game space. Adjust these values until the car body is directly on the model for the car
	Front and rear wheel radius	Adjusts the size of the wheels. Adjust until the wheels fit exactly around the wheel model in-game
	Height Offset	Adjusts the height of the center of max. This should be centered in the car body
	Weight Dist	Adjusts the center of gravity of the car towards the front or back of the vehicle. This should be towards the center of the vehicle
	Driving Wheel	Adjusts whether the car has front wheel drive, rear wheel drive, or 4 wheel drive
STEERING		
	Max Front Steering Angle	Adjusts the maximum angle at which the car can steer. Higher max front steering wheel value = sharper turning
ENGINE		
	Max Engine Torque	Adjusts the amount of raw engine power the car has
	Min and Max RPM	Adjusts the minimum and maximum RPMs for the engine
	Start RPM: the RPM	Value at which the engine starts. Make this lower than the minimum RPM
TRANSMISSION		
	Gear Num	Adjusts the number of gears in the transmission
	Main gear ratio	Adjusts the gear ratio of the transmission. Higher gear ratio = higher acceleration/less speed (differential)
	Gear Ratios	Adjusts the gear ratio of each gear of the car

2.1.12. . TROUBLESHOOTING

This section provides information to assist in the diagnosis and avoidance of potential exporting, texturing, physics, and other issues.

Exporting Issues: If exporting into Blender does not work as expected, return to the SketchUp model and make sure everything is exploded completely. If it is not exploded completely, the dimensions will be distorted. The process is very delicate and it may take a few tries.

Texture Issues: If the textures do not work as expected, review the tutorials created by the developer in the XMR forums. Transparent textures can pose difficulty. Avoid applying a texture to the window before adding a transparent material. Also, be sure to copy the model car textures file into the folder created in the X-Motor Racing Car directory.

Physics Issues: The physics part of the tutorial is definitely the most challenging part for someone who is inexperienced with this type of program. If getting the physics correct in the game is difficult, the forum on the X-Motor website can help. There are many settings to adjust, and it can take a long time to create a very realistic car. Make sure that everything is named properly, because one mistake can cause the car to be dysfunctional. If the car drives backward instead of forward when not in reverse, then try flipping the shell of the car. This is a common occurrence.

Other Options: You can create a cockpit to use in the car but it is not required. Simply use the physics of an existing car like this tutorial does. For example, when an existing car folder is copied, renamed, and the model .car files are added, the original cockpit.car file is retained. Therefore, when driving the model car in the game, it will actually have the cockpit of the original XMR car. The developer-made tutorial has some instructions on how to set-up a cockpit.