than the right side of the road. A simple representation of a dashboard is displayed at the bottom of the screen. The dashboard shows the trainee several gauges including speedometer, gearing indicator, and tachometer. The dashboard in combination with the steering device give the trainee a feel for where some of the gauges are located.

As the trainee drives, he/she is presented with hazards to avoid. MVDS supports two types of hazards, static and dynamic. Each presents the trainee with different types of situations to deal with. Static hazards, such as parked pickups, can be hard for trainees to see. Dynamic hazards, such as moving people, present trainees with the problem of trying to figure out where the hazard will be moving and whether a change course is needed to avoid the hazard.

3.2 *Product Customization*

Once the first prototype of MVDS was completed, the trainers that used it asked whether training scenarios could be added. In order to allow on-site trainers to create new scenarios, we have developed the MVDS setup program, shown in Figure 6. This program will allow on-site trainers to make new scenarios for trainees to navigate as the mine and operating regulations change. It can also be used to familiarize current vehicle operators with pits with which they are not familiar. The trainers will be able to change the mine by moving shovels, loaders, etc. and by closing routes the trainee may have used in the past.

When designing a scenario, the trainer can add static and dynamic hazards. To place a hazard, the trainer selects a location in the mine and chooses a hazard to go in that location. If the trainer is placing a dynamic hazard, the location is a path (or series of locations) the hazard will follow at a pre-defined speed. Figure 7 shows the placement of a dynamic path in a mine scenario. The bubbles show the path being selected by the trainer for a dynamic hazard. These can be turned on and off in the setup program. Any object that is modeled in an Open Inventor-compatible file format can be added as a static or dynamic hazard. We currently provide cones, people, pickups, loaders, and other vehicles.

Once a scenario is fully configured, this information can be saved to a file which is used by MVDS. Scenarios can be modified to reflect changes in the mine and MSHA regulations over time. This gives trainers the flexibility to build a library of scenarios used to accurately test the skills of vehicle operators.

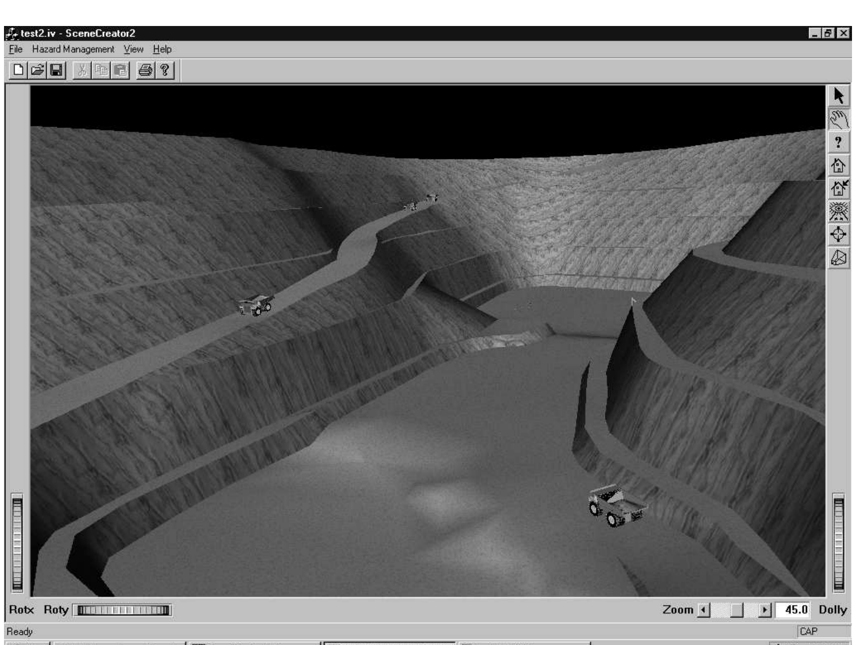

Figure 6: A Completed Scenario Created in MVDS Setup.

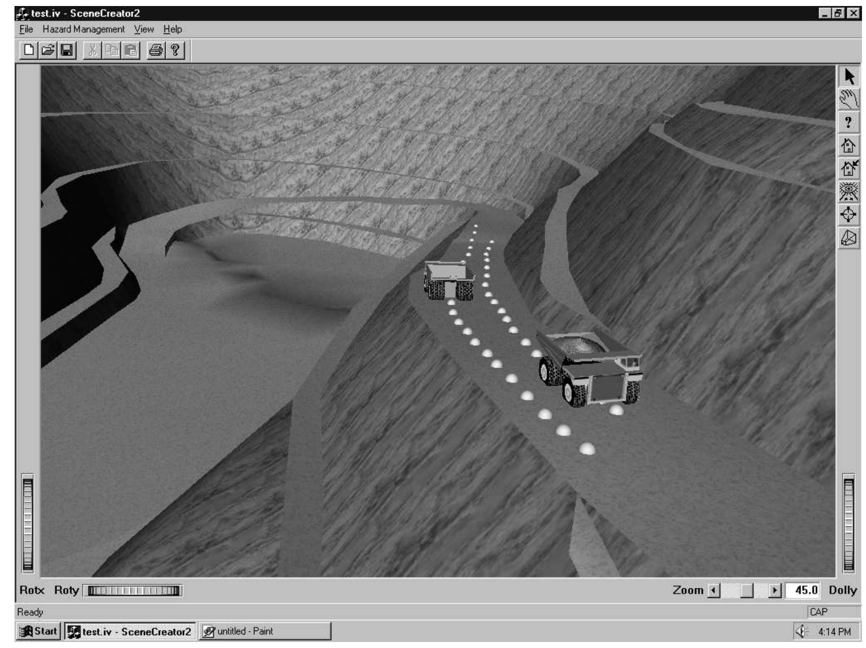

Figure 7: Creation of a Dynamic Hazard Path.

3.3 *Future Enhancement*

MVDS is an ongoing project that is continually being enhanced and modified to assist our customers in safety training. We have begun the design of enhancements including an improved physics model, improved simulation interaction, an expanded feature set, and a distributed architecture that will allow multiple drivers in the same pit.

3.3.1 *Improved physics model*

One of the key components of our next implementation of MVDS receiving the most attention is the physics model. The physics model of the simulation is responsible for interfacing user input with a simulated physical world in VR. The physics model determines vehicle simulation and environmental simulation. Vehicle simulation simulates the mechanical capabilities of the vehicle itself including turning radius, acceleration, braking capabilities, most of which change depending on whether the vehicle is loaded or unloaded. Environmental simulation is responsible for managing the physics of environmental conditions present in a mine. Environmental conditions we are considering adding include rain, snow, and high wind. These poor weather conditions greatly affect a driver's ability to safely operate a vehicle. For example, rainy weather not only reduces a driver's visibility, which will be selectable by the trainer, but also degenerates haulage roads causing vehicles to respond much differently than in dry weather conditions. In our new physics model, these examples of simulated physics and more will be implemented to give drivers a more accurate image of not only how a vehicle handles, but also how to safely operate a vehicle in various weather conditions.

3.3.2 *Improved interaction*

The effectiveness of any VR simulation is directly related to the level of realism of its user interaction. We can improve the user interaction of MVDS with the addition of force feedback steering wheels. These steering wheels have a motor in them to allow the wheel to be forced in a certain direction. If a mine vehicle driving down a haul road hits a berm on the side, the steering wheel will be forced very hard in the opposite direction. With a force feedback steering wheel, we can cause the wheel to do the same thing in the simulation.

3.3.3 *Expanded hazard options*

During initial evaluation, training professionals began to ask for more hazard selections. We are considering adding