Image Captions and Descriptions
for the
5DT Haul Truck Training Simulator

Short form descriptions of the above simulator are supplied below. Image captions and image descriptions are also supplied.

Haul Truck Training Simulator

Introduction
The 5DT Haul Truck Training Simulator teaches the trainee haul truck driver how to drive a large off-highway haul truck. It also teaches the trainee how to position the truck for loading (by e.g. a shovel or a wheeled loader) and how to position it for dumping, both at the ore crusher and at the waste dumping area. The trainee is also required to drive with reduced visibility (fog conditions and dust) and to drive at night.

Simulator Setup
The system consists of a mock-up cabin that is mounted on a motion base, in the midst of three large projection screens. The three screens (left, middle, right) provide the trainee with a wide field of view (approximately 180 degrees). This is the same out the window (OTW) view that a real driver would experience in a real truck. The mock-up cabin is equipped with controls and instruments that mimic real controls and instruments in a real truck. The motion base provides realistic motion cues to make the trainee feel as if he/she is driving a real truck.

Interchangeability
The mock-up cabin may easily be interchanged with mock-up cabins of other mining vehicles. The simulator hardware (computers, large projection screens and motion base) may therefore be used for several different 5DT Training Simulators.

Virtual Environment
The virtual haul truck is driven in a photo-realistic virtual environment that emulates reality very closely. The virtual surface mine emulates a real mine, with a dispatch station, service station, loading area, ore dumping area (ore crusher), waste dumping area and a road network. Realistic computer graphics (visual) models of entities like haul trucks, shovels, wheeled loaders, water cars and light delivery vehicles were also developed. These models do not only look like the real thing, but they also sound like the real thing - real sound recordings were used for this effect.

Performance Measurement
The instructor monitors the performance of the trainee. This is achieved by means of real-time graphs, reports and a record/playback module. The trainee is presented with a detailed, categorized report after each session. The record/playback module records the entire training session. The session can be played back for detail analysis and evaluation.

Team Training
The 5DT Surface Mining Training Simulators may be networked together. A Shovel Training Simulator may be networked with a Haul Truck Training Simulator so that two human operators, in two separate simulators, can work together to complete a task. The 5DT Simulators are *'Network-Ready'*, which means that it has been designed to function together and that it can be networked without any problems.

Conclusion
The 5DT Haul Truck Training Simulator is the closest thing to reality you can get! The main advantages offered by the simulator is that one does not have to "borrow" a production-capable truck for training, that the trainee cannot damage or destroy the virtual truck and that the trainee can be exposed to life-threatening conditions and situations without putting either the trainee or the truck at risk.

Simulator Setup: Haul Truck Training Simulator
The mock-up cabin is situated in the midst of three high resolution, high brightness, projection screens for the left-, forward- and right view. The 3 screens provide the trainee operator with a wide field of view (180 degrees), similar to what he would have experienced in a real vehicle. The left side-view mirror can be seen on the left screen. The mock-up cabin is mounted on a high performance motion base that provides realistic motion cues to the trainee operator.

MINE_Surface_Truck_002
Simulator Setup: Motion Base (side cover skirt removed)
The mock-up cabin is mounted on a high performance motion base that provides realistic motion cues to the trainee operator. The motion base provides movement in 3 degrees of freedom (3 DOF); left-right tilt (also known as roll), forward-backward tilt (also known as pitch) and up-down movement (also known as heave). The Haul Truck Training Simulator has a realistic physics model (dynamic model) that calculates and predicts the movement of the truck. This model provides acceleration and deceleration inputs that are implemented by the motion base to subject the trainee to a very realistic driving experience.

MINE_Surface_Truck_003
Simulator Setup: Close-up of Truck Controls
Real controls are used in the simulator. These include the steering wheel, retarder lever, instruments, switches, the transmission control (foreground), pedals (accelerator, service brake, emergency brake) and the hoist control lever. All the controls are active (dynamic).

MINE_Surface_Truck_004
Virtual Haul Truck: Outside View: Manufacturer's Colors
Photorealistic computer graphics models provide for a very real learning experience. The simulator also includes other vehicles like computer controlled haul trucks, a shovel, a wheeled loader, water cars and light delivery vehicles.

MINE_Surface_Truck_005
Virtual Haul Truck: Outside View: Mine's Colors
Photorealistic computer graphics models provide for a very real learning experience. The color scheme of the haul truck may be customized.

MINE_Surface_Truck_006
Virtual Surface Mine
An accurate, photorealistic virtual surface mine has been developed for the Haul Truck Training Simulator. The mine was developed using Global Positioning System (GPS) data, aerial photographs, and close-up photographs of high detail items. Custom virtual surface mines may be developed on request. Such custom virtual mines are ideal to familiarize trainees with the real mine, without them having to drive around in real vehicles.

MINE_Surface_Truck_007
Virtual Dispatch Station
The dispatch station is normally the starting point of a training session. This specific dispatch station overlooks the mine.

MINE_Surface_Truck_008
Virtual Service Station
A visit to the service station is necessary if the virtual haul truck runs out of fuel. It is also necessary for the trainee to know where the service station is situated.

MINE_Surface_Truck_009
Going Down: View from the Cabin
This view from the cabin of the virtual haul truck shows the road to the bottom of the pit. The safety wall is shown on the left. The left side-view mirror of the truck is also shown. The orientation angles of these mirrors may be adjusted. An autonomous haul truck (computer controlled haul truck) is approaching on its uphill journey out of the pit.

MINE_Surface_Truck_010
Autonomous Trucks Queuing Up at the Loading Area
To ensure that the training is realistic, several autonomous haul trucks (computer controlled haul trucks) share the virtual surface mine with the haul truck driven by the trainee driver. Here some of them are queuing to be loaded by the virtual shovel. The virtual shovel may be operated by a human operator, with the Haul Truck Training Simulator *networked* to the Shovel Training Simulator. There is also an autonomous (computer controlled) shovel that will continue to load trucks until the instructor decides otherwise.

MINE_Surface_Truck_011
Action at the Loading Area
This image shows the loading area at the bottom of the surface mine. In the foreground a shovel is loading a truck, while another truck is ready to reverse into position for loading. More trucks are approaching in the background.

MINE_Surface_Truck_012
Haul Truck being loaded by an Autonomous Shovel (Computer Controlled Shovel)
Here the virtual haul truck is being loaded by the virtual shovel. The virtual shovel may be operated by a human operator, with the Haul Truck Training Simulator *networked* to the Shovel Training Simulator. There is also an autonomous (computer controlled) shovel that will continue to load trucks until the instructor decides otherwise.

MINE_Surface_Truck_013
Going Up: Outside View of Loaded Truck
A loaded truck starts its long journey out of the pit.

MINE_Surface_Truck_014
Dumping: Ore being dumped at the Virtual Crusher
A virtual truck dumps its load of ore at the crusher.

MINE_Surface_Truck_015
Dumping: Waste being dumped at the Waste Dumping Area
A virtual truck dumps waste at one of the waste dumping areas. Note the safety wall behind the truck.

MINE_Surface_Truck_016
Continuous Day-Dusk-Night-Dawn: Sunset over the Virtual Surface Mine
The instructor may switch the simulation to any time of the day or night. During daytime the sun position will be accurate. At night more than 2000 stars will span the sky.

MINE_Surface_Truck_017
Driving at Night 1
Once a trainee has mastered normal daytime driving he/she may graduate to night-time driving. Note the headlights.

MINE_Surface_Truck_018
Driving at Night 2
Once a trainee has mastered normal daytime driving he/she may graduate to night-time driving. Another truck is approaching. Note the stars in the background.

MINE_Surface_Truck_019
Environmental Conditions 1: Decreased Visibility
Visibility may be decreased by the instructor to expose the trainee to extreme driving conditions. This image shows an approaching truck that is almost obscured by fog.

MINE_Surface_Truck_020
Environmental Conditions 2: Dust

Special effects are used to provide for a highly realistic learning experience. Dust is kicked up by the wheels of the virtual haul truck. This will limit visibility, exactly like it would happen in reality.

MINE_Surface_Truck_021
Emergency Situations: Engine Fire
One of the biggest advantages of a training simulator is that one may subject trainees to life-threatening situations and conditions. Emergency situations may be programmed into a training session. The instructor may also induce emergency situations at any specific moment, e.g. a brake failure or an engine fire. The response of the trainee is evaluated. Note the highly realistic smoke of the fire.

MINE_Surface_Truck_022
Instructor Screen: Top-Down View
The instructor may select any viewpoint, and may also navigate around a viewpoint. This does not only enable the instructor to see top-down views, but he/she may also select side views, front views, back views, or any viewpoint that may be needed for a specific scenario. The instructor may switch to any entity in the mine. The task (training scenario) is shown in the left-top corner. Operator errors are shown just below the task. The load-mass of the selected truck is indicated in the left-bottom corner. A list of the stationary (passive) and dynamic (active) entities (e.g. other trucks) are shown on the right. The instruments and control indicators of the selected truck is shown at the bottom-center of the screen.

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