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## **G'VAL® TRAINING SIMULATOR PLATFORM**

### **PRINCIPLES**

The objective of this training simulator for operators of Roads & Tunnels is to provide them with a virtual reality tool that behaves just like their real working environment, using realistic information, both in terms of technical data and traffic images.

The platform's integrated software simulates the behavior of a range of different components (equipment, people, traffic ...) within a network and/or road system, with respect to not only the visual aspect but also the technical and the communication aspects also.

Connected to the SCADA system through an OPC link, the simulator is a training tool for use by the Supervision (HMI) and other Operational Support personnel. It is also a tool for generating awareness of the minimal conditions required for system operation and the proper application of the Rules of Operation.

A trainer PC is used to generate different events within the simulator and to drive all the simulator components (traffic, video, context ...).

The main features of the G'Val® simulator are as follows:

- Realistic modeling of structures/facilities in Virtual Reality (VR)
- Variable location of road equipment (through an ODBC database)
- Library of road equipment, vehicles and various 3D objects
- Basic characters (police & fire personnel etc.) with animations
- Special effects (smoke, fog, snow, rain, deluge ...)
- Traffic Management and control (type, density, speed)
- Control of equipment from the SCADA through the OPC link
- Rules of interaction of equipment and events with the traffic
- Feedback from sensor information to SCADA via OPC link
- Ability to drive in the VR space and interact with the environment
- Generation of cameras with variable PTZ and positions
- Switching cameras on dedicated video wall and monitors
- Management of complex communication network...
- Including: simulating telephone, radio and ECP networks
- Generation of telephone calls using a synthetic voice
- Recording video, events, actions and communications
- Production of a training report at the end of each session



## SIMULATOR COMPONENTS

A full G'Val® training simulator is composed of a number of fully integrated software modules:

- A SCADA system which should be the one used by the operator, or at least a SCADA system very similar to the one being used
- A virtual reality (VR) 3D environment built with the Forum8 software VR-Design Studio (UC-win/Road) (UCWR) to reproduce the real world as accurately as possible
- An equipment data base with all the interactive equipment of the tunnel or highway (VMS, LCS, Traffic light, road signs, barriers, ventilation, ...)
- The G'Val® system

All these software modules are embedded in three different PCs operating under MS Windows:

- The Instructor PC (PFO) with the G'Val® Instructor HMI module to preset all data inside the simulator and launch the various scenarios, a headset and a specific phone used to call the operator and stakeholders
- The Patrol Man PC (PPA) with the VR Design Studio (UC-win/Road) software, the specific VR files as well as the G'Val® plugin module and the equipment Data Base. On this PC are connected all the video outputs simulating the various CCTV monitors. This PC is equipped with a headset for the radio communications and of a gaming wheel with push buttons for the interactive driving functionality
- The Operator PC (POP). Depending on the choice made, this PC is either a Gateway to the real SCADA, converting the data from one world into the other, or a virtual SCADA designed with the same features and functionality as the real one. This PC is also equipped with a headset for the radio communications

The G'Val Simulator hardware architecture is shown below:

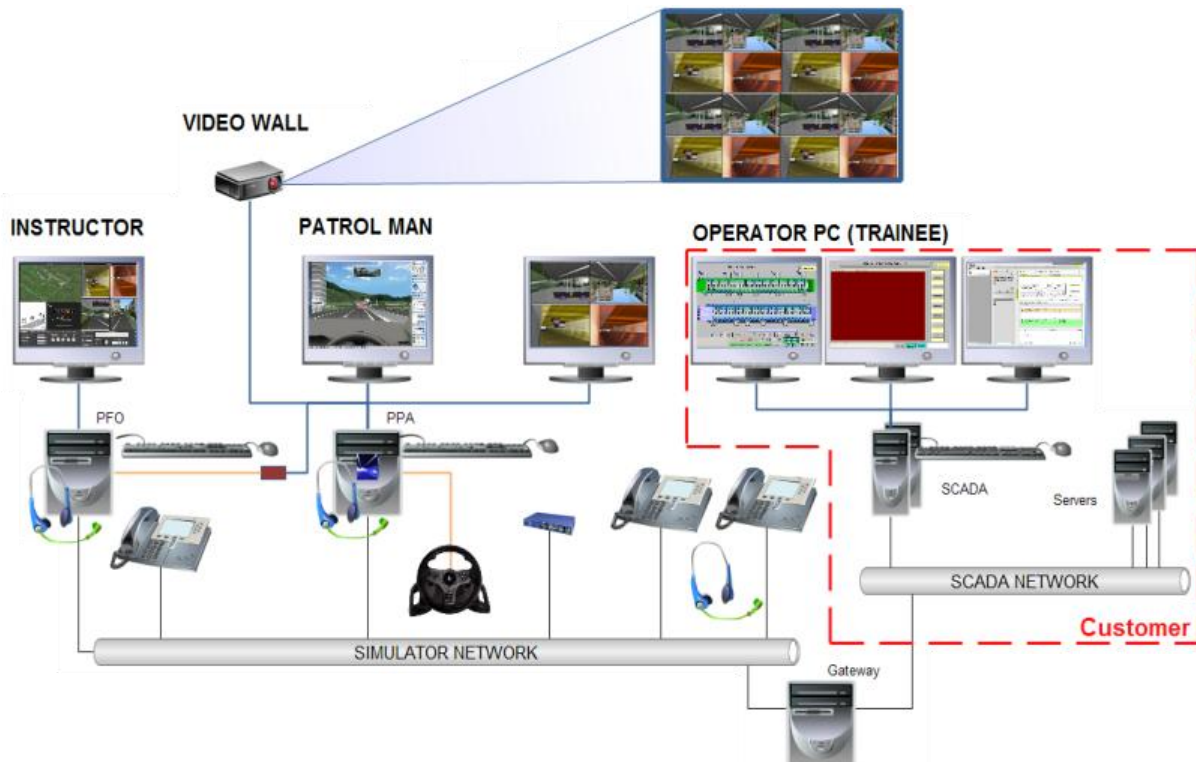


Fig. 1 : Using the real SCADA (connected platform)

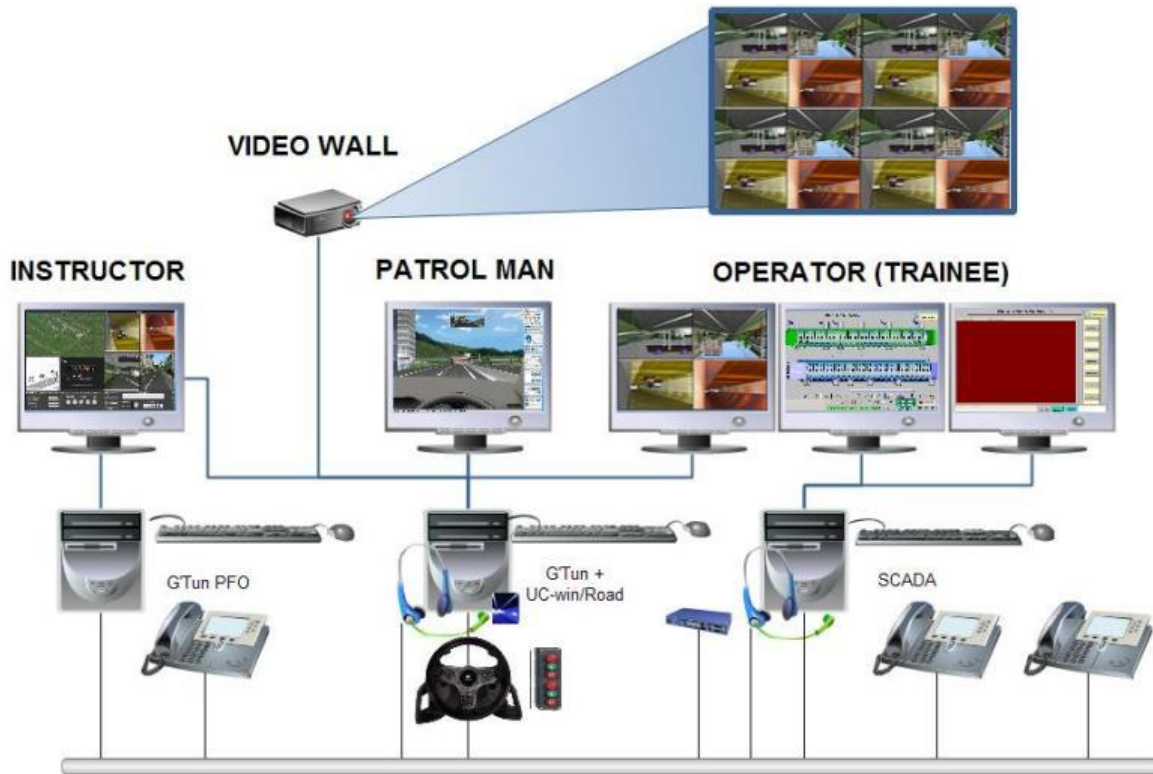


Fig. 2 : Using a virtual SCADA (standalone platform)

## THE G'VAL® SYSTEM

The G'Val® system is comprised of 4 simulation modules:

- The Visual Simulator - simulates traffic and pedestrians in a realistic interactive 3D environment. It generates traffic according to pre-set volume, speed, signaling and environmental conditions (time of day, geographic position, climate, light etc...). This module also simulates the behavior of field equipment and provides images of virtual cameras placed throughout the 3D environment (up to 4 cameras for the operator, 13 for the video wall and 4 for the trainer). The road side equipment, as well as the cameras, are automatically inserted inside the VR environment from the ODBC database which has been previously set with their name, position and texture. The action of the equipment is controlled through OPC instructions delivered by either the Operator or the Instructor
- The Equipment Simulator - simulates the behavior and response of the field equipment to the Operator and /or the Instructor commands. This simulator communicates to the SCADA and the Instructor PC through the OPC link
- The Communication Simulator – this is equivalent to an IPBX and features synthetic voice and recording capabilities. It simulates all voice communications related to the operation of the highway or tunnel (emergency calls, telephone, radio etc...)
- The Instructor Module - this controls both the Equipment and Communication simulators and triggers a set of scenarios and incidents through its editing and management GUIs. It is from this interface that we manage the different parameters of each of the simulators

The scenario editor of the Instructor Module manage two types of scenarios

- Preformatted traffic scenarios like :
  - Slow and stopped vehicle
  - Accident between vehicles
  - Oversized vehicle
  - Contra-flow vehicle
  - Object on pavement, debris, puddle and beaconing

- Wandering animal or person
- Injured person
- Fire and smoke on a vehicle
- Send Patrol car, Fire truck, Police car, Ambulance and Tow truck
- Complex scenarios previously programmed in a flowchart, describing step by step all the changes over the time of the various components of the incident (vehicles involved, events, equipment status etc...)

Scenarios can be positioned at any point in the road, in any direction and on any lane and they affect any piece of equipment. At any time in the course of a scenario, the Instructor can interfere and add any event or action of his choice to partially solve or make the situation more complicated:

- Inject any traffic type/density/speed on specific points of the VR environment
- Modify the weather conditions (context) inside the 3D VR environment
- Including: wind, fog, rain, snow, flood etc...
- Monitor and control all the equipment as well as its status
- Monitor traffic via the simulator's 4 monitors recorded in AVI format
- Generate calls (phone or radio) automatically (related to an incident) or not using a text to speech synthetic voice generator
- Generate a training report tracing the contexts of the training and the actions performed by all participants against a time scale

Thanks to the combination of Forum8's VR Design Studio (UC-win/Road) and G'Val® specific modules, a number of specific functionalities are available:

- It is possible from the Patrol Man PC to lead a patrol mission in the VR environment while driving and interacting with the incident through a range of the available commands (markup, signaling, pickup, etc...). Dialogue among trainees is established through the headset and the communications network (all conversations are recorded)
- Traffic, as in reality, generates data for the SCADA and the Instructor PC through simulated loops arranged in their corresponding locations
- Corresponding ADI (Automatic Detection of Incident) alarms are generated for the incidents on the first camera. Slow vehicles can be followed, through the successive ADI alarms.

The simulator system is based upon an OPC server centralized architecture. All the existing equipment is recorded in this OPC server thanks to an ODBC Database.

In this Database the following information is available:

- Original tag name and internal tag name
- Equipment type and function
- Equipment localization within the VR environment
- Input and Output of each piece of equipment

For the simulation to be efficient, a modeling of the behavior of each piece of equipment is needed, to create the embedded PLC program. This program will insure that the simulator delivers the right information to the SCADA and the Instructor PC, as well as processing all their commands.

For example, if the SCADA sends an “Open barrier” command, the PLC will deliver it to the VR in order to see the barrier opening and after few seconds return the information “Barrier Opened” in order to show the correct visualization of the barrier status on all supervision monitors.

The software architecture is as follows:

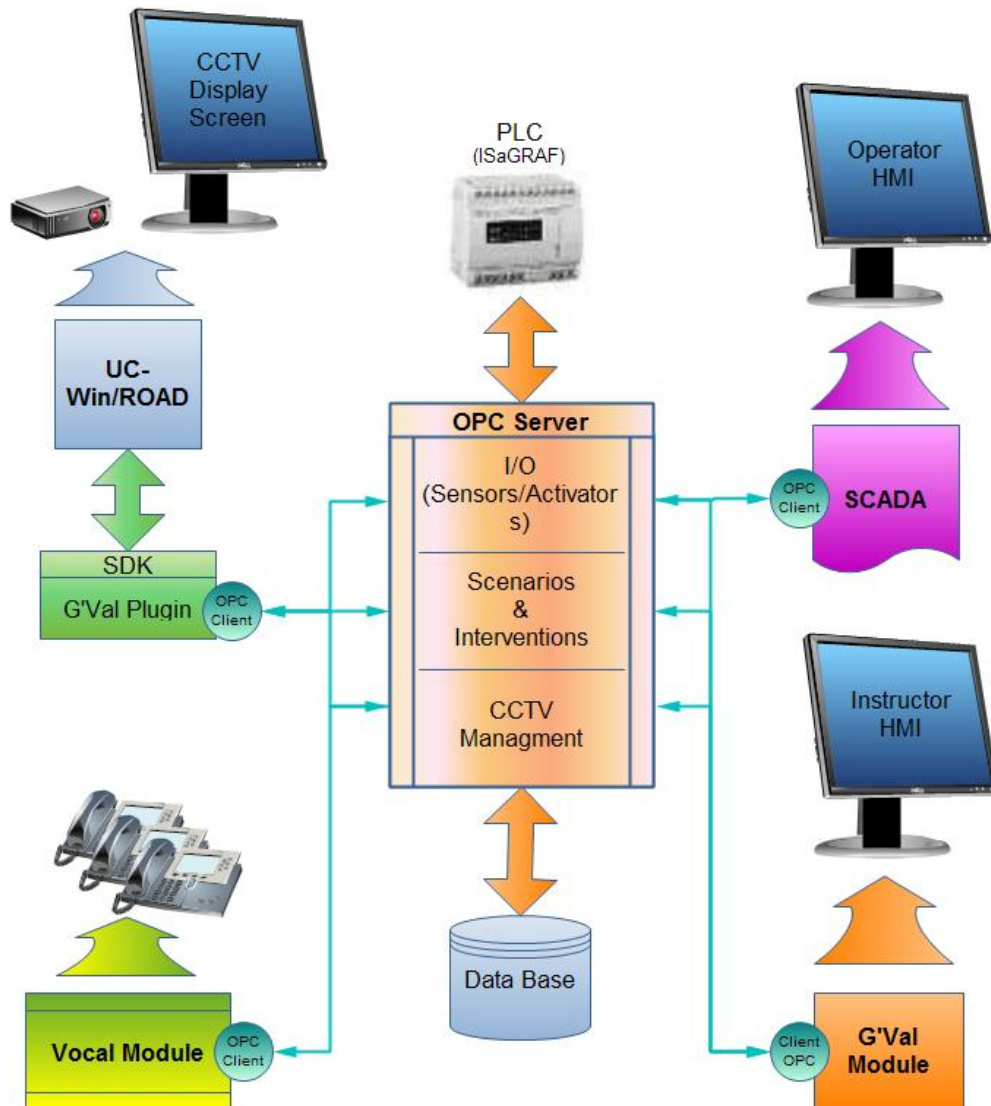


Fig. 3 : G'Val® standard architecture



## ADDITIONAL FEATURES

To maximize training time, stakeholders are always available and expected to be close to the incident (starting distance adjustable). Their journey is not impacted by the signs and traffic is supposed to facilitate their access. Following their departure from the incident site, they are automatically deleted after 500 m of route (configurable).

The behavior of the smoke during a fire/smoke event is linked to the application of a simple calculation implementing initial wind speed, cross section of the tunnel and the flow and speed of the jet fans and extractors. This data is used to calculate the wind speed inside the tunnel. Smoke, composed of elementary particles, will move according to this calculation. The particles are generated at the point of the fire and destroyed in the extractors. The simulator training system does not produce an exact simulation of smoke, but an indicator of its behavior within the tunnel.

Similarly, the ADI detection is not an accurate detection, but a simulated detection calculated in the neighborhood of the various incidents. Actually, the ADI is not permanently calculated at any point on the road but only at the incident points.

It's possible to replay each recorded scenario as and when required, however, in the basic version of the simulator traffic matching the incident is not registered to the vehicle, the actual traffic behavior is assumed constant. An optional extra is a recording system situated on a specific PC which can record all traffic movements and replay them at will.

The training report, which can be viewed and printed at any time, is filtered and ranked according to the initiator of each action taken (Operator PC, Patrol Man PC or Instructor PC) with its own timestamp. Optionally, the expected (action and timestamp) may be shown next to each action performed by the instructor as part of a scenario (provided you have been informed beforehand).

## G'VAL® BENEFITS

With the G'Val® simulator it is possible to educate and train the various stakeholders of a road network in different phases, ensuring in particular:

### **Before the Opening of a new Highway or Tunnel:**

Basic training on the use of the SCADA and checking its ergonomic suitability in light of the various procedures and operations

Training in the operating rules and procedures of the highway / tunnel network

Conducting pre-opening training on the simulator to alleviate the burden of project management during the commissioning phase

### **After Opening :**

Assessment of changes in operating rules and subsequent training

Awareness and training of new entrants or stakeholders

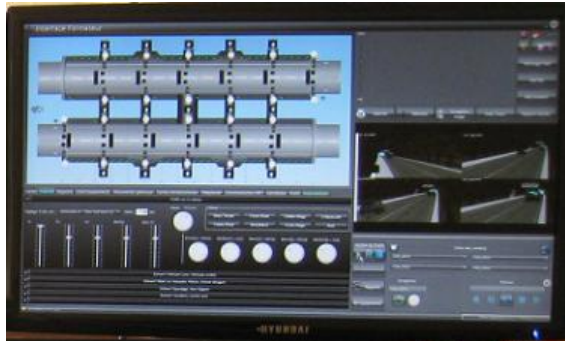
Training of operators using a continuous program with milestones

Training and awareness of the management personnel

Using the simulation platform G'Val® as a validation support tool for operators also allows a better understanding of the issues of exploitation by the maintenance services. The system facilitates dialogue between operators and stakeholders within the network.

### EXAMPLES

Instructor PC



Patrol Man PC



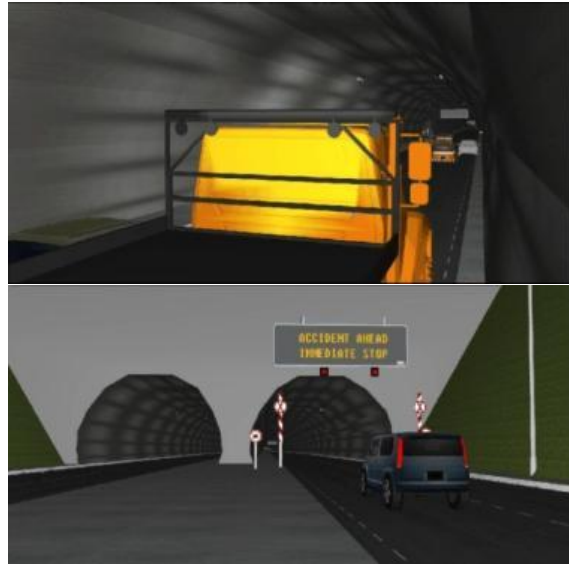
Operator PC



Stand alone compact platform for instructor training



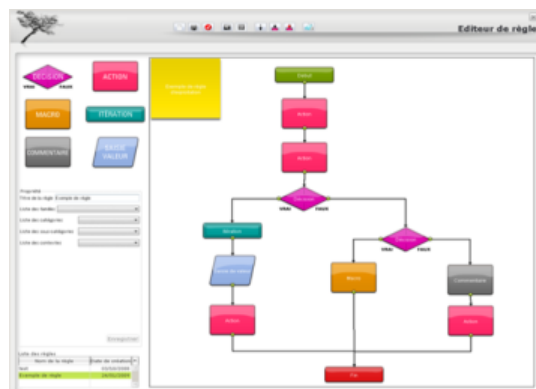
**Screen shots samples :**



**Pedestrian management :**



**Free scenario editor :**





**Instructor screen :**

The screenshot displays the instructor interface for the G'Val Training Platform, divided into two main sections: 'Interface Formateur' (top) and 'Gestion des Piétons' (bottom).

**Interface Formateur (Top):**

- Top Left:** A 3D schematic of a road layout with multiple lanes and traffic lights.
- Top Right:** A control panel for 'LCS\_002B (pm = 250)' with buttons for 'Arrêt/Éclair', 'Statut Equipement', and 'Valider/Annuler'. It also includes a 'Rapports' section with 'Enregistrer' and 'Rapport Final' buttons.
- Middle:** A 'Gestion des Camions' (Truck Management) panel with sliders for 'Vitesse', 'MOTUS', and 'RUS', and buttons for 'Basculer', 'Forcer Plein', 'Forcer Vide', 'Brouillard', and 'Forme Neige'. Below this are 'Choix des camions' (Truck Selection) dropdowns for 'CAM\_0001' through 'CAM\_0005'.
- Bottom:** A 'Gestion des Piétons' (Pedestrian Management) panel with fields for 'Modèle', 'Origine', 'Destination', 'Vitesse', 'Echelle', and 'Description'. It includes buttons for 'Ajouter', 'Modifier', and 'Supprimer'.

**Gestion des Piétons (Bottom):**

- Left Panel:** A 'Saisie nouvel Incident' (New Incident Entry) form with fields for 'Type d'Incident' (set to 'Accident'), 'Ouvrage', 'Voie', 'Sens', 'Modèle', 'PM\_Debut', 'PM\_Fin', 'Vitesse', 'Pomier', 'Patrouilleur', 'Départeur', 'SAMU', 'Niche', 'Extincteur', 'Blesse', 'Appel', 'Balsage', 'Feu', and 'Puissance'. A 'Commentaire' field contains 'Scénario de test'. Buttons for 'Annuler' and 'Valider' are at the bottom.
- Right Panel:** A 'Gestion des Piétons' control panel with a 'Modèle' dropdown (set to 'Vitesse'), 'Origine' and 'Destination' dropdowns, 'Vitesse' and 'Echelle' sliders, and a 'Description' field. It includes buttons for 'Ajouter', 'Modifier', and 'Supprimer'.

**Détails :**

This is a close-up of the 'Saisie nouvel Incident' form. The 'Type d'Incident' is set to 'Accident'. The 'Modèle' is also 'Accident'. The 'PM\_Debut' is 0 and 'PM\_Fin' is 0. The 'Vitesse' is 0. The 'Pomier' checkbox is checked. The 'Commentaire' field contains 'Scénario de test'. The 'Valider' button is highlighted.

This is a close-up of the 'Gestion des Piétons' control panel. The 'Modèle' dropdown is set to 'Vitesse'. The 'Origine' and 'Destination' dropdowns are set to 'RP1111' and 'RP1111' respectively. The 'Vitesse' slider is at 1.0. The 'Description' field contains 'Seuls les VMS de couleur verte'. The 'Ajouter' button is highlighted.

## **DELIVERY PRINCIPLES**

### **HARDWARE**

The required hardware necessary to build a G'Val® Simulation Platform is as follows:

- Patrol Man PC - based on an iCore 7/4GB equivalent PC with an OpenGL compatible Graphic Card with minimum 4GB RAM and 4 video outputs. LCD Screen, wireless headset, wireless mouse and keyboard as well as a Ferrari Thrustmaster gaming wheel (or equivalent with 2 sequential levers, 11 action buttons, D-pad and 2 programmable progressive pedals)
- Instructor PC - based on an iCore5/4GB equivalent PC with a full HD graphic Card and LCD Screen (1920x1080), wireless headset, wireless mouse and keyboard as well as a VGA to USB converter to capture the dedicated CCTV output from the Patrol Man PC
- Operator PC or Gateway PC - based on an iCore5/4GB equivalent PC with wireless headset, wireless mouse and keyboard
- Operator CCTV LCD screen
- Video projector for the CCTV video wall
- At least three IP Phones
- A Gigabit Hub with RJ45 cables for the simulator network

### **SOFTWARE**

- VR Design Studio (UC-win/Road) Ultimate license
- G'Val® plugin and instructor module
- Embedded PLC IsaGraf 3.3 and NT Target license
- IPBX Axon and Recording VRS license
- OPC server and tunneling license
- Soft phone and synthetic voice license

### **SETTING**

- 1) Infrastructure - one VR file is available for each network with a maximum area of 20km x 20 km. Terrain data can be imported from a variety of locations. Tunnel infrastructure can be built from CAD files (DXF, DWG ...) of the actual location, or from within VR-Design Studio's functionality
- 2) Equipment - the reference equipment Database will be designed to include the location, characteristics and traffic effects of each piece of equipment
- 3) Gateway or Equivalent SCADA - depending upon the customer choice, a gateway will be implemented that makes a logical and communication link between the existing SCADA and the simulation platform. Alternatively, a specific and equivalent Virtual SCADA can be designed with the same graphic screens as the real one and reproducing all operation functionalities.

The simulator platform is delivered with a standard library of scenarios. The G'Val® simulator will also allow any new scenarios to be implemented.

## **PRE-REQUISITE TO THE DELIVERY**

This chapter briefly lists the pre-requisites for the delivery of a G'Val® simulation platform.

### **VR ENVIRONMENT**

When building the 3D VR environment of a real highway or tunnel it is necessary to have the specific engineering plans, such as AutoCAD files, of the infrastructure in question so that you can accurately position the safety niches, exits, galleries, garages, etc...

A photographic survey of the facilities (sets, lighting scenes...) will be required to accurately reproduce the visual contexts of the infrastructure and deliver a satisfactory visualization within the CCTV images.

**The ability to directly import data from 3D models that have been previously made on the network is being developed**

### **EQUIPMENT**

All the required equipment (items) necessary to operate the network should be identified and positioned within the VR environment. There are three types of equipment used within the simulator:

- Static and visible equipment (road sign, jet fan, permanent lighting etc...)
- Visible and animated equipment (traffic lights, barriers, mobile lighting etc...)
- Invisible equipment with an effect on the traffic or the animation (cameras, extractors...)

The positioning will be made in X, Y, Z space with respect to KP0 and the pavement. The different elements within the animation should be determined (color, number, signs, size...). For cameras, image samples should be provided to fix the best angles, focal and zoom positions to obtain the best results.

### **SCADA**

A functional analysis document should provide:

Data flow to the road network (sensors and actuators)

CCTV command flow (automatic switching sequence, specific zones...)

Available functions for the operator (commands and macro-commands)

All available SCADA screens for the operator

Eventual data flow to other system servers like communication servers

After studying these documents a further analysis will be nevertheless be necessary.

### **OPERATION**

To prepare various scenarios the following documents will be needed:

The Emergency Response Plan and the rules of intervention on site

The Rules of Operation manual

The Minimum Operating Conditions