

# THE PLATOON GUNNERY SIMULATOR (PGS) : A REAL TACTICAL TRAINING TOOL

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## ABSTRACT

The training requirements and the project schedule for the PGS (Platoon Gunnery Simulator) will be presented by the French counterpart of the PM Trade. Then the firm under contract for the design and manufacture of the PGS will give a more detailed presentation of the equipment, emphasizing the system features : - an equipment unique in its kind, providing combat training in a classroom for the crews of a platoon of tanks - total compliance with ergonomic aspects - extraordinary detail and realism of the landscapes into which are inset up to 8 fixed and/or mobile targets - consistent representation of all the effects of firing (noise, flash, recoil, observation of the shell trajectory) - perfect adaptation to each type of turret - versatile and easy to use for the instructors.

Two simulators are to be delivered to the French Army in 1984 - 1985.

### PGS PROGRAM DESCRIPTION

In 1979, the French Army Staff Headquarters issued a requirement for a training device providing initial training and continuation training for crews of AMX30-B, AMX30-B2 and AMX10-RC tanks.

#### Objectives

Classroom training and instruction for tank crews in all the listed combat actions (observation roles, observation, detection, reconnaissance, identification, allocation of targets, engagement of targets by main gun with appropriate firing sequence, adjustment of aim for second shot). These objectives need a representative (high fidelity), realistic and high performance training tool.

#### 1. Who is to be trained

- (a) The two most important members of the turret crew - the tank commander and the gunner.
- (b) All the "pairs" (gunner and commander) from the tanks in a platoon under the command of a platoon commander.

Justification : It is generally true that platoon commanders are either excellent platoon commanders, in which case they tend to lose touch with their own tank ; or they are excellent tank commanders who tend to lose touch with the platoon.

Platoon commanders must therefore be specially trained in company with the tank crew teams they are commanding. Only a high performance training tool incorporating effective monitoring devices and operated by one or more instructors is capable of solving this training problem.

2. Simulator destination. Two simulators have been ordered :

- No. 1 Pre-range training with platoon gunnery at CPCIT, CANJERS.
- No. 2 Ecole d'Application de l'Arme Blindée et de la Cavalerie at SAUMUR (school roughly equivalent to Fort Knox).

3. Staff Headquarters recommendations and requirements.

(a) Visual system of high quality. The landscape must have excellent definition, enabling targets such as tanks, helicopters and all-terrain vehicles to be detected in a real vegetation at ranges up to 3500 meters in daylight.

(b) The device must be fully utilized. To achieve this, the device must have the following qualities :  
- simplicity of use,  
- realism of scenarios, turret space, aiming and firing sequences and effects of fire,  
- reliability.

(c) The device must have reasonable acquisition and maintenance costs, and provide :  
- reduction of instruction and training time, accompanied by an improvement in quality of gunnery,  
- savings in resources such as carriers, fuel, ammunition, ranges.

(d) The device must be set up as quickly as possible, ideally in the same time as the operational equipment.

(e) The device must be capable of being easily modified to keep pace with changes to the operational equipment and its uses.

#### 4. Organization of the analysis, design and manufacture

The French Army Staff Headquarters gave the DTAT responsibility for developing the program. This responsibility was delegated to the electronic center, the SEFT. THOMSON-CSF Division Simulateurs was chosen to design and manufacture the simulators and provide logistic support. Previously, at SEFT's request, THOMSON-CSF participated in discussions with various Staff Headquarters subordinate organizations to delineate the capabilities of currently available techniques. The outcome of this analysis phase was a good definition of the two identical simulators in the form of a precise, detailed and complete design specification. Subsequently, THOMSON-CSF was awarded the contract, but the discussions continue in the form of four permanent working groups (Man/machine interfaces, Scenarios/exercises, Facilities, Role of the instructor and definition of the instructor's station).

#### 5. Schedule

Preliminary statement of requirement : III/79  
Analysis ..... III/79 to III/80  
Final statement of requirement ..... : III/80  
Design specification ..... : I/81  
Contract award ..... : III/81  
Acceptance of 1st PGS ..... : II/84  
Delivery of 1st PGS ..... : III/84  
Acceptance of 2nd PGS ..... : I/85  
Delivery of 2nd PGS ..... : II/85

#### PGS TECHNICAL DESCRIPTION

PGS is, at the present time, the only genuine platoon gunnery simulator in existence. Its innovative aspects lie both in general performance and in the technical designs of visual and recoil generation systems. We shall give subsequently :

1. the PGS general description
2. description of the visual and recoil generation systems.

#### PGS GENERAL DESCRIPTION

The PGS achieves simultaneous basic and tactical training of crews of 3 turrets either in individual or in platoon mode.

Personnel to be trained are :

- 1st turret : 1 platoon commander and 1 gunner
- 2nd turret : 1 tank commander and 1 gunner
- 3rd turret : 1 tank commander and 1 gunner

The platoon has to react to tactical situations occurring in a 90° forward angle. Hull-up and hull-down movements are simulated and so are relative occultations resulting

from distances between each of the three turrets on the field. Main features of PGS are given in tables below. They confer to the PGS the following characteristics :

- high training realism,
- multipurpose simulation,
- variety of operational conditions,
- powerful and easy-to-use instructor's facilities,
- maintainability,
- flexibility for future evolution.

(a) High training realism. A highly realistic environment was one of the major basic requirements. This realism is necessary when simulating the mechanical, visual and aural environments.

- Mechanical environment. Simulator turrets faithfully reproduce the internal arrangement of real turrets. This is achieved by means of well known techniques using both real and simulated equipment. An important initial requirement was to provide the simulator with a good recoil simulation. It is very important to train pupils not to be taken by surprise when they fire, remaining ready to observe their own results. It is therefore a must to have a good mechanical reproduction of the recoil effects when rounds are fired. For this purpose, the PGS includes a very realistic recoil system acting not only on the sights but on the whole turret. The design of this system is described in detail below.

- Visual environment. The quality of a gunnery simulator is closely linked to the quality of its visual system. Training in tactical operations such as observation and detection of targets in the landscape requires a particularly high degree of realism in visual simulation. Basic requirements of this visual system are given in the tables above. System design is described in detail below.

- Aural environment. PGS reproduces main sound effects such as - report when shot is fired - idling noise of the main engine - turret drive system.

(b) Multipurpose simulation, versatility, flexibility. PGS is designed to meet all the training needs of the training centers.

- Functioning according to different modes : Platoon or separate crew mode. The instructor has the capability of programming simultaneous training of the three turrets facing a common tactical situation (platoon mode). In this case, each turret can observe the firing effects of the other turrets in the platoon. Platoon training can be conducted by a single instructor. Separate training can also be achieved (separate crew mode). In this case training of each turret is quite independent. Separate mode requires 3 instructors.

PGS MAIN FEATURES

- CREWS TRAINED SIMULTANEOUSLY = 3 TURRET CREWS

TANK COMMANDER	PLATOON COMMANDER	TANK COMMANDER
GUNNER	GUNNER	GUNNER

- TRAINING AIMS

TURRETS TRAINING	<ul style="list-style-type: none"> <li>. INITIAL TEST OF TURRET (FIRE CONTROL, RADIO, SIGHTS ...)</li> <li>. DETECTION, RECOGNITION, IDENTIFICATION OF TARGETS</li> <li>. AIMING</li> <li>. USE OF FIRING SYSTEM (QUICKLY AND ACCURATELY)</li> <li>. FIRE OBSERVATION AND ADJUSTMENT</li> <li>. MALFUNCTIONS</li> </ul>
PLATOON TRAINING	<ul style="list-style-type: none"> <li>. COMMUNICATION BETWEEN TURRETS, AND WITH THE INSTRUCTOR(S)</li> <li>. ALLOCATION OF TARGETS BY PLATOON LEADER</li> <li>. FIGHTING AGAINST 8 TARGETS IN THE COMMON LANDSCAPE</li> <li>. PLATOON FIRE OBSERVATION AND ADJUSTMENT</li> </ul>

- SIMULATION FIRING EVALUATION CAPABILITIES :

- PLATOON TRAINING = FIRE COORDINATION BETWEEN TURRETS
- PLATOON AND TURRET TRAINING = FIRE QUALITY :
  - . SUCCESSION OF BASIC PHASES OF FIRING SEQUENCE
  - . ACQUISITION OF FIRING PARAMETERS (WIND ...)
  - . AIMING, RANGEFINDING (DOUBLE-ECHO), TACHIMETRY ...
  - . FIRING
  - . ADJUSTMENT OF FIRE FOR NEXT ROUND

- STATIONARY POSITION . HULL-UP, HULL-DOWN MOVEMENTS
- TURRET TYPES :

3 x AMX 10 RC  
or 3 x AMX 30 B2  
or 3 x AMX 30 B

- TRAINING MODES

- PLATOON MODE (PLATOON + TURRET TRAINING)
- SEPARATE CREW MODE (TURRET TRAINING)

- SIMULATION OF ALL PLATOON VIEWING DEVICES WITH PROPER MAGNIFICATION

- GUNNER SIGHTS
- TANK COMMANDER SIGHTS
- PERISCOPE

- SIMULATION OF RECOIL EFFECT ON THE WHOLE TURRET

- RELATIVE OCCULTATIONS RESULTING FROM DISTANCE BETWEEN TURRETS

- N.B.C. TRAINING

## PGS VISUAL MAIN FEATURES

### LANDSCAPE

- REALISTIC : COLOR  
NATURAL TERRAIN FEATURES  
HIGH RESOLUTION
- CHOSEN BY USER
- FIELD OF VISION (F.O.V.) = 90°
- EASY TO PROVIDE ADDITIONAL LANDSCAPES
- EASY TO CHANGE
- VARIOUS LIGHTING CONDITIONS

### TARGETS

- REALISTIC
- STATIONARY - MOVING
- MANY SIMULTANEOUSLY (UP TO 8)
- DIFFERENT TYPES : MAIN BATTLE TANK  
LIGHT ARMORED VEHICLES  
HELICOPTERS
- REALISTIC ATTITUDES ACCORDING TO THE  
TERRAIN. INTELLIGENT BEHAVIOR.
- MASKING EFFECTS : TARGETS - TARGETS  
TARGETS - TERRAIN
- HIGH DETECTION/RECOGNITION RANGES

### FIRING EFFECTS

- GUN FLASH AND SMOKE
- IMAGE MOVEMENT IN SIGHTS WHEN SHOT IS FIRED
- TRACER WITH PROPER BALLISTICS (AMMUNITION TYPE, WIND...)
- IMPACT ACCORDING TO : AMMUNITION TYPE  
GROUND  
WIND
- MASKING EFFECTS : IMPACT - TARGETS  
IMPACT - TERRAIN

- Training on any type of tanks. French PGS allows training on three different types of tanks : AMX10RC, AMX30B, AMX30B2. The PGS includes :

- 3 AMX10RC simulated turrets
- 3 AMX30 (B,B2) simulated turrets.

Switching between AMX10RC and AMX30 (B,B2) training is achieved by :

- changing of simulated turrets (crews move from one turret type to the other).
- selection of appropriate software program by the instructor.

Switching between AMX30B and AMX30B2 training is achieved by :

- substitution of specific equipment in the simulated turrets.
- selection of appropriate software program by the instructor.

These operations require only a few minutes.

(c) Variety of operational conditions.

One of the major requirements was to provide a large number of exercises. The reasons were :

- To have a set of progressively difficult lessons.
- To achieve effective training by preventing the trainees from becoming accustomed to repetitive tactical situations.

The PGS gives the following capabilities :

- Several landscapes : Initially, units are delivered with 2 different landscapes. Simulator design makes it possible to change the landscape on the simulator and to create new landscapes very easily.
- Large number of pre-programmed exercises (200).
- Possibility of modifying a set of parameters such as target speed - wind - temperature - optional recoil effects - at any time.
- Several kinds of targets - main battle tank - light armored vehicle - helicopters.
- Insertion of malfunctions of firing system.

(d) Powerful and easy to use instructor's facilities. An ergonomic study by the users and manufacturer established two requirements :

Versatile instructor stations capable of :

- programming of various exercises,
- modification of main exercise parameters,
- supervision of trainees actions - display of firing results - use of training aids such as play-back, freeze, trainees evaluation ... etc.

Easy-to-use equipment : all these functions are achievable by means of very simple operations.

(e) Maintainability. Maintainability factors were taken into account at the very beginning of the design of the PGS. Proven technologies and a modular design have been used whenever possible. A full set of built-in tests are provided to achieve :

- Quick tests to check the overall correct operation of the simulator.
- Diagnostic tests for the visual system isolating the faulty board (and often the faulty components on the board).
- Adjustment tests and associated tools for easy bore-sighting of the system.

(f) Flexibility for future modifications. It was of great importance to provide the PGS with the capability of being modified as a result of changes in operational or technical requirements. Here we can give some examples of the possibilities of evolution which have been taken into account in the initial design :

- Addition of a 4th turret in the platoon.
- Additional landscapes.
- Additional types of targets.
- Night firing.
- Head up and binocular vision.
- Programming of exercises by the instructors.
- Additional simulated sound effects (closing of breech, cartridge ejection).
- Adaptation to any kind of firing system.

## VISUAL SIMULATION

### General organization

The visual simulation system is designed to provide independent images for the various viewing devices of the turrets. These viewing devices are the following :

- Sights : PGS provides each sight with images at the correct magnification. Each sight allows independent observation anywhere in the landscape. The sights simulated are the gunner and tank commander primary and auxiliary sights. Identical performance is simulated for primary and auxiliary sights of the same trainee. This allows the use of only one generation system for both sights. Therefore, the total image generation system consists of 6 independent sights simulations (3 gunners and 3 tank commanders).
- Periscopes : the three frontal periscopes of each turret are simulated. Together they cover the field of view of 90° (3 x 30°), equal to the total field of view (FOV) of the simulation.

3 main sources are used to build the images :

- landscape generator,
- targets generator,
- firing effects generator.

#### Landscape generator.

This source generates the images of a realistic color landscape over a 90° FOV for each viewing device, with appropriate magnification.

(a) Limitations of available techniques. A first step in our study was to investigate the use of available techniques. Unfortunately, all of them revealed some important limitations with regard to the requirements.

CGI systems have been developed and used in many aircraft applications. In the case of gunnery simulation, they have proven suitable when their application is limited to aiming and firing operations. But we have to rule them out as soon as tactical training is considered. This is currently due to their lack of realism for a reasonable price. If and when future improvements in this technique make them suitable for these applications, PGS configurations may then be able to utilize them.

Model board techniques give a relatively high degree of realism. This advantage, together with a reasonable cost makes them particularly suitable for some applications such as Tank Driving Simulators. Unfortunately, model board techniques have a serious limitation in that it is practically impossible to insert a large number of moving objects (targets, firing effects) while ensuring a high flexibility in their trajectories and attitudes.

Another solution is to store a digitalized photograph of the landscape and to observe at any moment the relevant part of it for each viewing device. Such a solution requires high capacity memories when color and many viewing devices are requested. It also requires high data exchange speed between mass memory and working memories.

(b) PGS solution : flying spot scanners. The chosen solution consists of a color slide and a flying spot scanner for each viewing device. The color slide represents the whole landscape at magnification dependent on the field of view of the simulated sight.

The flying spot scans the portion of the landscape to which is directed the object lens of the simulated sight. It delivers a high resolution color TV signal (875 lines). Aiming of the gun in azimuth and elevation is simulated by moving the landscape slide. Slide movements are produced by a carriage system servo controlled by the general purpose computer in accordance with operation of the aiming controls.

The flying spot scanner system has the following advantages over a TV camera : 875 lines standard resolution, no registration problem, easy to adjust, better signal to noise ratio.

The advantages of this solution are the following :

- high realism, due to the color slides,
- high resolution due to 875 lines TV standard,
- ease of adding new landscapes,
- ease of changing landscapes,
- possibility of inlaying moving objects (targets, firing effects) by the use of TV techniques.

#### Target generator

The target generation system inlays up to eight targets in every viewing device of the PGS. Attitudes of targets are very faithfully reproduced according to the terrain.

We have chosen a specific technique which consist of :

- storing every possible target attitude in a digital library,
- inlaying the correct attitude in the terrain image after processing (size adjustment, masking effects, etc...).

The following paragraphs give a brief explanation of the target processing which is achieved by mean of a fast computer CRP 24 especially developed by THOMSON-CSF for visual applications.

(a) Target storage. Every possible attitude of the target in rotation, roll and pitch is stored on a disk.

The number of different attitudes is 2500. The angular increment varies from 1° to 3° according to the position of the target (front of lateral position). These increment values give excellent continuity in target movement. Size of the stored targets correspond to the largest apparent target size according to target type, target range and sight magnification.

Each attitude is stored in a matrix of 64 x 32 points. PGS is provided with files corresponding to three target types :

- main battle tank,
- light armored vehicle,
- helicopter.

(b) Choice of correct attitude. The general purpose computer also includes a file describing the relief of the landscape. This file is organized as a grid of altitudes. Minimum distance between 2 altitudes is 30 meters. This is sufficient to faithfully describe the relief.

At any time the computer can choose the correct attitude by comparing the position of the target with the relief file.

Use of a high resolution TV standard gives long detection or recognition range. The table below gives the resolution in TV lines of a target 2.5 m high, seen through a simulated optical system of 107 milliradians (sight) and 533 milliradians (periscope).

Target range	Resolution	
	FOV 107 mrd	FOV 533 mrd
800 m	24 lines	5 lines
2000 m	10 lines	2 lines
3500 m	6 lines	2 lines

(c) Masking generation. The general purpose computer possesses a masking file describing the outlines and ranges of landscape elements.

Descriptions of masks around targets are input to the fast comput CRP 24 which processes the masking priority between target, firing effects and landscape.

We must stress how easily the relief and masking files are created. They can be generated by semi-automatic procedures using PGS equipment.

(d) Scale processing. The fast specialized CRP 24 computer performs real time scale processing on targets according to :

- their range,
- sight magnification.

(e) Target inlaying in the landscape. Each target is inlayed in the lanscape image of each viewing device by means of video techniques.

Anti-aliasing is used to provide very continuous target motion in the image (increment of 1024 pixels on a TV line).

(f) Target Trajectories. Target trajectories are defined in a very simple way in a specific file containing segment descriptions. Insertion of targets trajectories in the landscape is then achieved automatically by means of the processing described above.

Creation of new trajectories can be easily accomplished by the user. This operation requires no equipment other than the existing equipment of the simulator.

Targets can be assigned an intelligent behavior. A program sends them realistically to the nearest cover when they come under fire from the platoon.

#### Firing Effects Generator

Simulation of the visual effects related to firing consists of reproducing :

- the effects when the shot is fired - burst of flame, then smoke interfering with observation,
- the tracer of each shell,
- the effects of impact - explosion, smoke, target hit.

(a) Firing of the Shot. The simulator reproduces the difficulties of observation when the shot is fired, created by the burst of flame from the gun muzzle and the smoke.

These effects are simulated as follows :

- burst of flame : yellow coloring of the images observed through the simulated sights,
- smoke : transition from yellow to white of the images observed through the simulated sights. The smoke then gradually dissipates.

#### (b) Tracer

- The tracers of all the shells fired are simulated.

- The shell's trajectory faithfully simulates the real trajectory. It takes into account the ballistics specific to each type of ammunition and the influence of cross-wind, air temperature and altitude.

- Dipersion of the weapon/ammunition pair is simulated by random functions, highly representative of real dispersion.

- The tracer is masked when the shell penetrates a "soft" mask (bushes, leaves) and when it passes behind a "hard" mask (building, tree trunk or the target itself) but does not hit it.

(c) Impact. The flash and smoke of impact are displayed in the periscopes and the sights. In platoon mode, the same impact can be observed by all the turrets of the platoon.

In individual mode, the crews see only the impact of their own shells.

- Target hit : this hit is viewed as an explosion with release of yellow light. The target which has been hit continues to move a few meters under its own impetus then stops after turning blackish.

- Target miss : in the event of a target miss, impact of the shell on the ground is viewed as a release of smoke, the amount of which varies according to the type of ammunition and the shape of which depends on the cross wind. The smoke may be fully or partially masked when impact with the ground occurs behind the target, a building, a clump of trees or in a fold of the terrain. It may also mask a target or a terrain feature when it takes place in front of the target or terrain feature. All these effects are generated by video methods.

#### RECOIL SIMULATION

##### Purpose

A very realistic simulation of recoil was a key initial requirement. In this simulation, we have developed a recoil system moving the whole simulated turret.

##### Description

Turrets are mounted on guide rails. The recoil simulation system moves the cabin horizontally in the axis of the gun when shots are fired. The amplitude and variations of the movement as function of time are such that the crew perceives it as the recoil due to real fighting. The recoil simulation system includes :

- a fixed structure with anchor points for the guide system,
- a moving structure to which the cabin is attached,
- a pneumatically controlled motion system recreating : - a violent reaction at gun recoil and longitudinal oscillations - the damped return of the turret to its initial position.

The recoil system includes protective systems designed to ensure personnel safety.

Simultaneously, the images through the sights move vertically, giving the trainees complementary cues of turret motion due to the firing effect.

#### TRAINING PGS POTENTIAL

Preliminary tests conducted in 1979 on a research prototype gave the conclusions of the next table.

TRAINING PGS POTENTIAL (Example) (8 hours/day - 21 days/month)			
CREW	TRAINING	PLATOON	TRAINING
<u>DAILY</u>			
96	exercices 15'each 1400 shells	16	exercices 30'each 1000 shells
<u>MONTHLY</u>			
2000	exercices 30000 shells	330	exercices 20000 shells

The equipment is capable of being used if necessary, 16 hours a day, 7 days a week.

#### CONCLUSION

PGS appears to be an efficient tool to achieve basic and tactical training of platoon crews.

Operational advantages of PGS are twofold :

(a) Training is more realistic than on an exercise terrain because the simulation gives a better approach to combat situations. This has been proven by the research prototype. Reasons are the following :

- the battlefields are absolutely natural and more realistic than the bare, shell raked firing ranges on which the location and displacement of the targets is overly familiar to the crews.
- the battlefields are interchangeable, which is not the case with firing ranges of which only a limited number exist.
- the targets are identifiable and viewed at all attitudes.
- as in combat, the targets bound, zigzag in open country, remain exposed for a minimum time and are difficult to detect and hit.
- as in combat, the large number of enemy attack scenarios make it impossible to remember previous target trajectories.
- as in combat, when a target receives a direct hit, it blackens and stops moving.
- as in combat, a target under attack heads for the nearest cover.

## ABOUT THE AUTHORS

- finally, and this is an essential point, simulation of the shot leaving the muzzle, its trajectory and its impact on the ground or the target, reproduces all the difficulties of tank gunnery and observation of the shots, and obliges the tank commanders to adjust the fire of the other vehicles in the platoon.

The multiple features of the PGS provide progressive training ranging from the initiation to gunnery procedures, to the tactical conduct of fire of a full platoon.

(b) Training is more effective and more rapid than with conventional means because :

- all the actions of a member of the platoon or a tank crew are immediately detected and any error can be corrected using the playback.
- continuous and detailed recording of firing results provides an objective evaluation of each crew member's performance, making a considerable contribution to crew motivation.

Innovative technical designs in the visual and recoil simulation bring a useful contribution to the family of existing systems. These solutions are ideal for many training applications (tanks, missiles, etc...). It is also interesting to note that the same techniques can be used to build turret simulators (gunner and tank commander) capable of being fitted in a tractor towed trailer, making it independent of all local infrastructures and readily available for use at different sites.

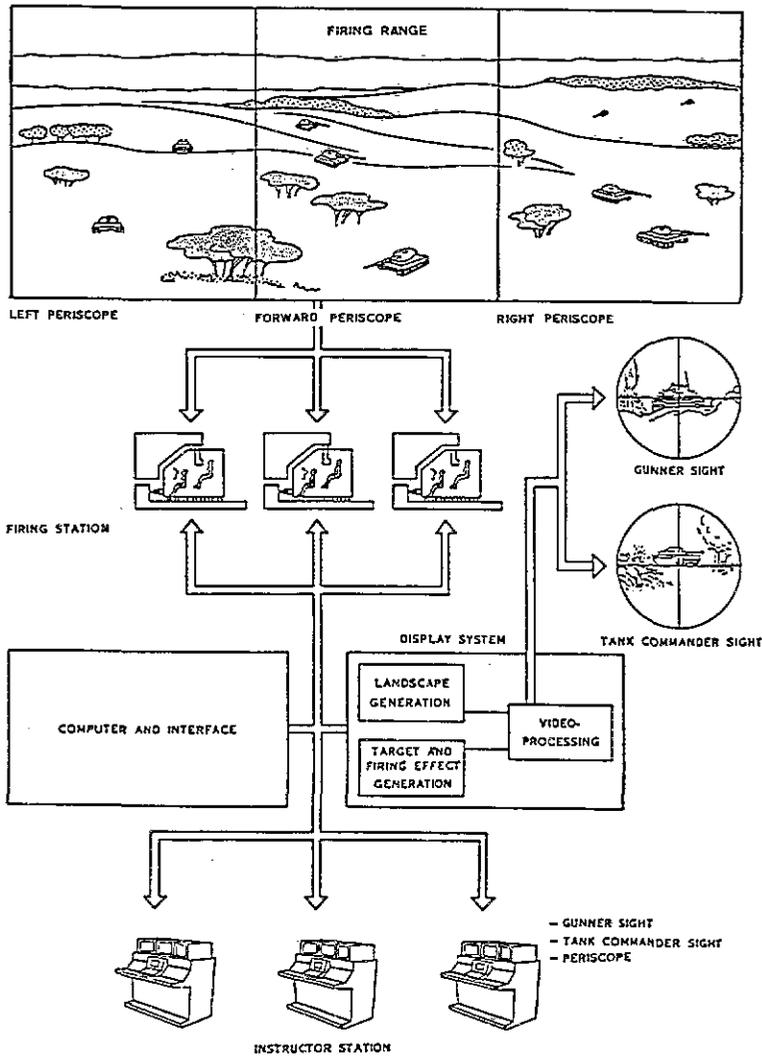
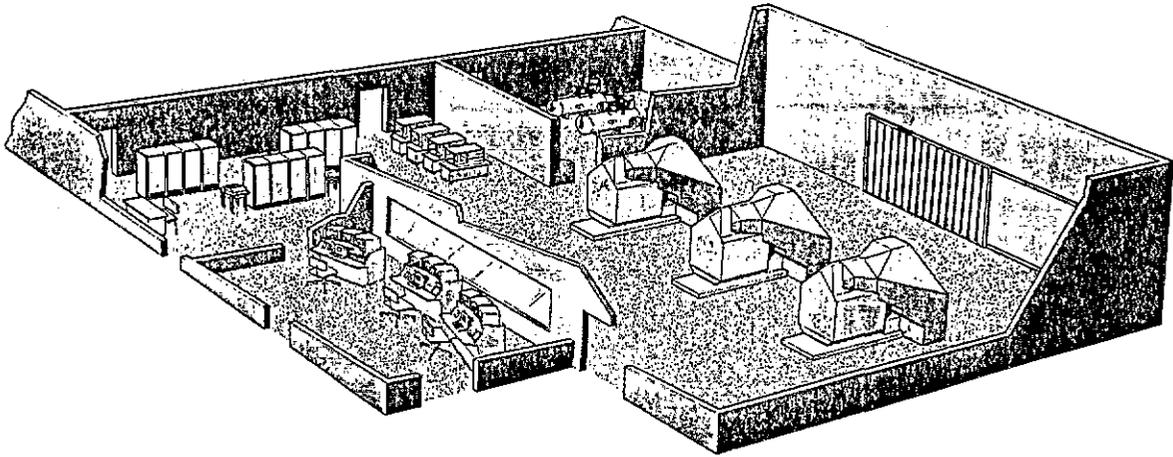
Claude J. QUINIOU, Ingénieur Principal l'Armement, obtained his engineering degree in 1964 from l'Ecole Technique Supérieure de l'Armement.

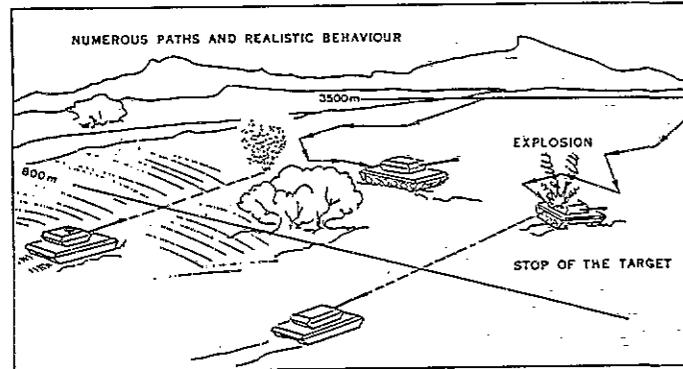
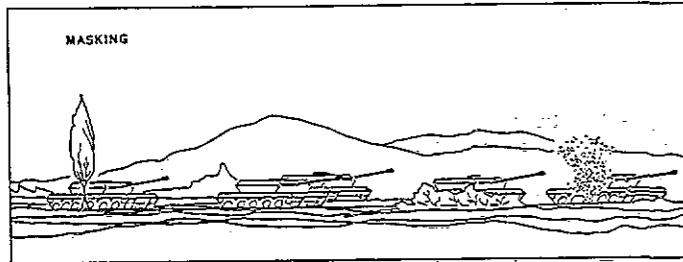
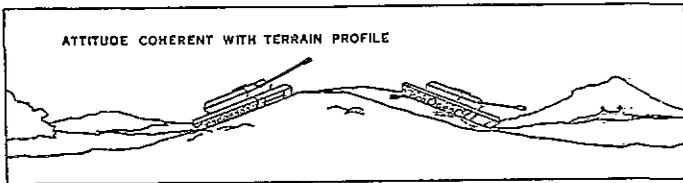
After graduating, he embarked on a career as a military engineer with the Délégation Générale pour l'Armement which is directly attached to the Ministry of Defense. He is presently head of the "Anti-tank and Simulators" department at the SEFT, one of the technical centers of Direction Techniques des Armements Terrestres (DTAT), roughly equivalent to DARCOM. He is the counterpart in France, of the PM Trade.

He assistant, Ingénieur de l'Armement Jean B. CORNELIUS, holds degrees from the Ecole Polytechnique (X 1971) and from the Ecole Nationale Supérieure des Techniques Avancées. Mr CORNELIUS has been with the SEFT since 1978 where he is a specialist in anti-tank and gunnery simulator problems.

Michel F. PERRIN is Project Manager for firing and driving simulators at the Simulator Division of THOMSON-CSF Company. He received an engineer IRG degree from Grenoble University in 1968.

PGS GENERAL ORGANISATION





REALISTIC SIMULATION OF TARGETS IN THE LANDSCAPE

REALISTIC SIMULATION OF FIRING EFFECTS

