Live training and disruptive technologies

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Abstract - Present technology offers now unprecedented capabilities and solutions to build live training systems which meet Army requirements. All the operational cases require having in real-time the players and entities status and positions very precisely, within open environments or inside buildings, embarked or disembarked. Their actions and associated effects on the whole battlefield need to be recorded to provide all the elements necessary to conduct a complete debriefing to all involved people. The French procurement agency DGA has ordered to Thales as Leader and its partner Ruag Defence France the CERBERE system which meets most demanding French Army requirements of live training. The technical approach is described, including some insights given on innovative solutions, with their first results, operational benefits and potential evolutions.

1 Introduction

Thales and its partners are building a new live training centre for the French Army, encompassing both open and urban environment. It is designed to provide in the same area an outdoor and indoor field of operations. It will be the main tool of the Army for training combined arms units up to 1200 soldiers and 250 vehicles on an opened terrain 12x12 km battlefield, and an 8x8km area including an urban zone equivalent to a 5000 inhabitants' town.

Fig.1: Urban area

On top of their usual weapons and equipment, all players and vehicles are equipped with firing combat simulators and location and communication devices. The town is instrumented not only with weapons effect creators simulating noise, smoke, attrition but also communication and video cameras in order to transmit all data to the training leaders in the operation centre as well as in the field. A training session can last up to 120 hours.

All the entities have to be accurately geo-located (very precisely indoor for duels). The players are connected through various Ethernet and radio networks depending on the exchanged data (audio, effects, damage state…).

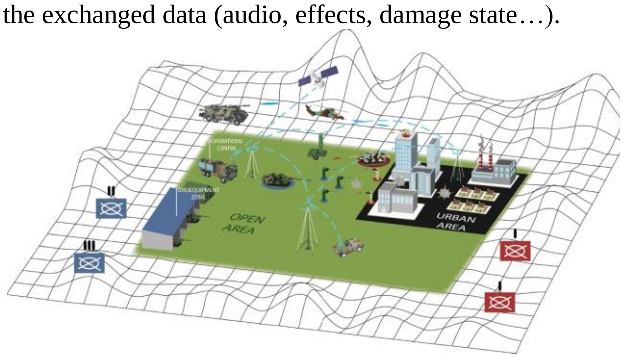

Fig.2: System overview

The whole battlefield is displayed to the training officers in the Training Operation Centre. Meanwhile, the commanding officers of the trained forces conduct the battle using the real military communication devices and C2. In parallel, all the actions and effects are recorded in real-time, as well as the videos captured on various terrain locations. Instructors and exercise directors can therefore monitor the situation and its evolution from the Operation Centre or in the field and prepare the debriefing sessions.

2 Technologies

Various technologies are used in the system, among others:

- Open space, in-vehicle, and indoor Geo-location
- Networks, communication and transmission
- Laser based TESS (Tactical Engagement Soldier System)
- Weapon effects rendering
- Cyber security

Meeting expected performances requires cutting edge solutions.
The main blocks and interfaces are depicted below:

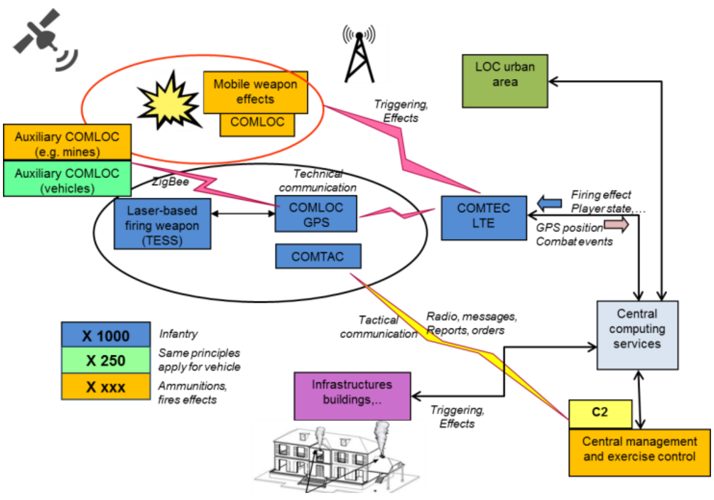

Fig. 3: Functional blocks diagram

System meets following requirements:

Table 1: System main performances

Feature	Performances	Comments
Number of entities	1200 soldiers 250 vehicles	In a camp of about 12x12 km
Position accuracy	<2 m outdoor <<2 m indoor	
Global latency	~1s for C2	
Global network bandwidth	< 5 Mbits/s	Depends on LTE and its bottlenecks, see section 3
Environment	Day/night All weather conditions With obscurants	No limitation on location performances
Autonomy	Soldier power supply 96 hours	Without battery swap
Interactions	Grenades IED Mines	Effects on concerned people an equipment

2.1 Geo-location

Requested accuracy is better than 2m for outdoor operations and better for indoor, with no topological error.

Outdoor location relies on a D-GPS device, whereas buildings are specifically equipped to track indoor soldiers and localize other devices. Indeed, navigation systems based only on IMUs cannot guarantee the requested accuracy for indoor operations. Possible smokes or obscurants prevent from using optical based solutions.

In-vehicule geo-location is performed thanks to equipment located inside the vehicle. The position of the soldier is replaced with the position of the vehicle he is mounted in.

For indoor operations, specific algorithms have been developed to guarantee the consistency of the location of the soldiers versus the building topology. The issue to address is to determine whether a soldier is on one side of a wall or the other. Moreover, location shall identify not only the 2D position but also the floor on which are the soldiers and manage the transition phase (so called 2,5D).

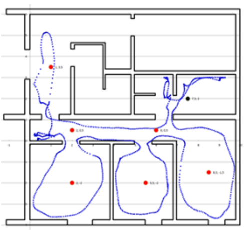

Fig.4: Example of indoor tracking

Due to electromagnetic interferences (e.g. metallic stairs), several combinations of sensors are used with a data fusion mechanism performed at the central server level to determine the right position.

During the transition outdoor-indoor, both results are merged to insure the positioning continuity.

2.2 Communications

Each entity needs to have the capability to exchange operational and technical information. Audio and C2 exchanges are performed through operational networks and equipment, whereas specific networks are used for the technical information, such as soldiers damage-state (operational, wounded, dead), their location or weapon effects.

Fig.5: Example of ruggedized tablet

Up to 8 concurrent technical networks are used to ensure the full consistency of the exchanged information with minimum network latency. C2 war room is updated every second.

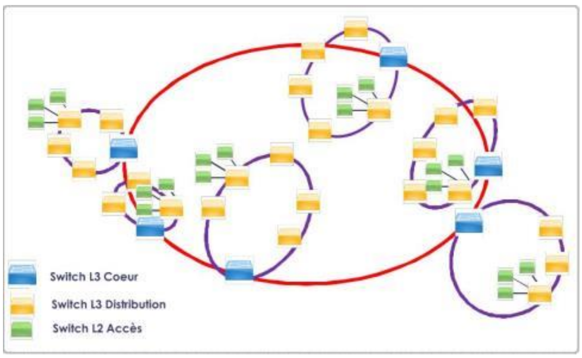

Fig.6: Network infrastructure

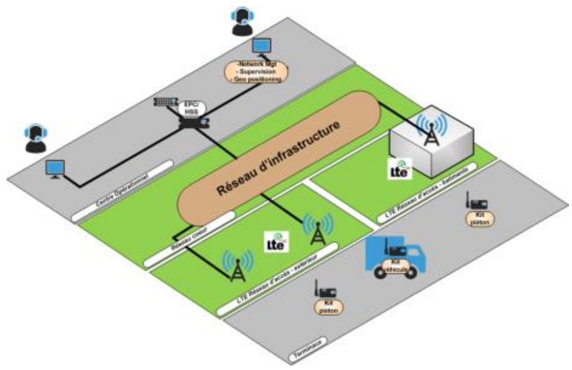

Fig.7: Technical network principles

Each mobile entity (soldier, vehicle, grenade...) has its own adapted "COMLOC" kit (communication-location) which guarantees the information exchange with the central computing server. This server receives the positions and actions, and returns results and damage state of the considered soldier or vehicle.

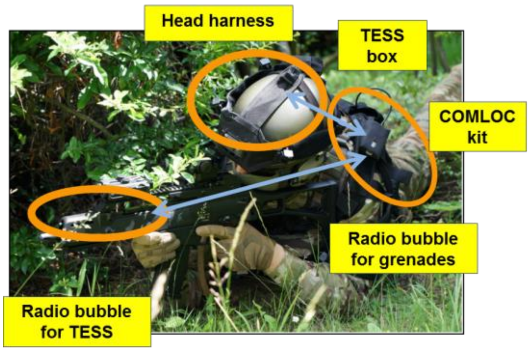

Fig.8: Example of Soldier equipment

Fig.9: Example of Vehicle equipment

Vehicles are also equipped with their own COMLOC device. A specific radio bubble is used to exchange with close soldiers coupled with an IR curtain to determine if they are embarked or disembarked.

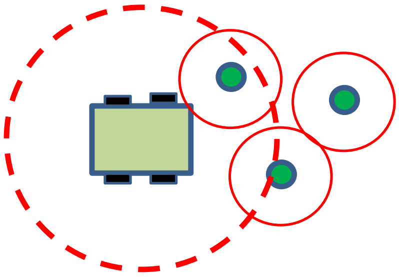

Fig. 10. Soldiers/vehicle communication

Communications equipment are based on COTS solutions, using standards protocols such as XBee, 4G-LTE for transmissions, UCATT for TESS or IoT for COMLOC transfer protocol.

3 First results

Field tests give expected geolocation results. Regarding indoor location, several tests results give an average accuracy much lower than 1m and no error on the room in which the beacon is. Such accuracy is great improvement of soldier training solution removing mistraining effect due to wrong location and wrong attrition. This is also a step ahead towards the technology of digital firing for soldier training.

Saving power is necessary to deal with long live training sessions; it drives the COMLOC device to use IoT solutions with IDLE mechanism. The IDLE mode allows the COMLOC device entering in sleep mode to save power. To guarantee enough reactivity due to LTE handover, the IoT parameters should be carefully tuned.

Finally, due to limited number of LTE beacons, it has been necessary to optimise the management of the large number of transmitters through the system. In order to reduce traffic, to have the best use of the bandwidth, and to remain maintainable and scalable for the future, the communication protocol uses standards brokers.

LTE performances are very dependent upon the relief, antenna positions, transceivers number and positions, network topology… Below is an example of the performances map with a non-optimised installation.

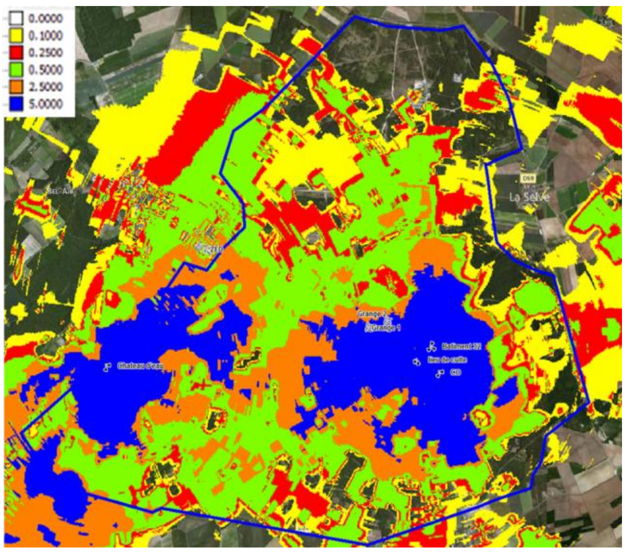

Fig.11: LTE performances on a given terrain

Antenna installation and localisation have to be optimised to reach a final global step meeting the expected performances on 80% of the terrain.

4 Evolutions

Such system needs to have a modular architecture to support future evolutions required to integrate new technologies and to answer to more demanding operational needs.

The main drivers for these evolutions are:

- Overcome limitations of laser based TESS solutions
- Extension of the battlefield

- Interoperability with training simulators and LVC

Innovative solutions will be developed by THALES to address these needs according to the operational needs of the end users.

4.1 Digital firing

Present TESS systems based on laser allow only direct straight firing and don't manage every kind of ballistics. Integration of such devices on helicopters, small aircraft, UAVs or UGVs is also a challenge considering the important regulatory constraints of the aerospace domain and the size of UAS. Moreover, a red force soldier partially hidden behind bushes or leaves may not be hit if his tags are occulted.
To overcome these limitations, Thales is developing a new digital firing solution based on image recognition and weapon sensors.
Digital firing allows also the use of weapons having effects beyond visual range such as mortars, taking into account the appropriate ballistics.

4.2 Battlefield

Present battlefields are never large enough to train Army soldiers with high performances weaponry and equipment. The use of digital firing combined with Augmented Reality (AR) technology will allow to train Army with virtual red forces located outside of the real battlefield.
AR will be also used to visualise virtual aircrafts, providing the 3rd dimension to the training exercise. These aircrafts can be managed through simulators or CGF.
THALES is able to propose solutions for these needs.

4.3 Interoperability and Live, Virtual, and Constructive (LVC) Simulation

These two last evolutions involve considering the full interoperability of such system with other training devices. The whole LVC concept and design principles will apply.
That requires a deep analysis of the operational use cases to determine the concept of operations and technological evolutions it may involve for the actor's equipment.
Solutions based on existing and pending standards will be privileged. THALES will also be active in this domain.

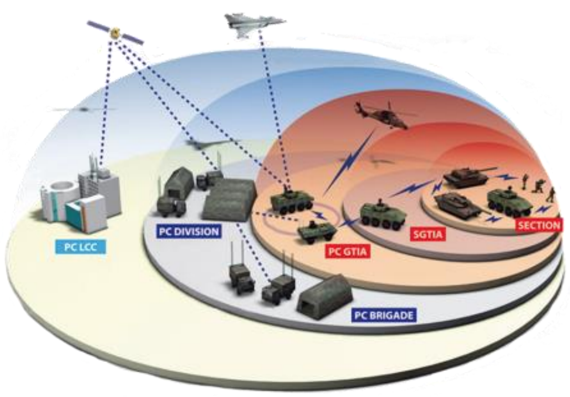

Fig. 12. System future

5 Conclusions

Present military operations and their specific context according to the countries involve training soldiers as close as they fight.
Live training system requires high performances and high-end technology to support all the mandatory features, from the communications to war effects.
CERBERE will demonstrate that technology today allows such solutions with an appropriate innovative design and architecture. Tomorrow Augmented Reality will be generalised and will extend the scope of use of Live training through a convergence with LVC systems.
Standardisation working groups, NATO or SISO, will have to propose evolutions of existing ones and possibly new ones to support this convergence.

6 Glossary

Acronym	Meaning
CERBERE	Centres d'entraînement représentatifs des espaces de bataille et de restitution des engagements
C²	Command & Control
CGF	Computer Generated Forces
COMLOC	Communication Localisation
DGA	Délégation Générale à l'Armement
IMU	Inertial Measurement Unit
LTE	Long Term Evolution (e.g. 4G)
LVC	Live Virtual Constructive
TESS	Tactical Engagement Soldier System
UCATT	Urban Combat Advanced Training Technology

Author/Speaker Biographies

Frédéric Turquet: Former colonel of the French Army, Frédéric served as a commanding officer of a combat helicopter regiment, before taking the direction of the Army Aviation doctrine and equipment department. He is now Product Line Manager at Thales strategy department in charge of the Land domain for Training & Simulation.

Bruno François-Marsal: specialist in complex systems program management, Bruno took recently the position of CERBERE project director. In the past years as program manager and product line manager, Bruno worked on innovating technologies: cloud computing, cybersecurity and data center. Previously, he managed Radars, Antiaircraft and Tactical Telecom projects for the Army.

Laurent Chantôme: Laurent has been involved in Electronic Warfare system engineering for 10 years. He joined Training & Simulation as a System engineer for Live training systems, especially the French Cenzub (Urban combat) definition study. Then he took the System Architect position for all Live systems, including CENTAURE and CERBERE French programs.