

**Installation for the simulation of the state of radio communication between entities
engaged in an operation**

The present invention relates to a simulation installation for simulating the status of radio communications between entities engaged in a simulated operation of the type comprising :

- an entities generator providing the ability to define a set of entities engaged in the operation and a status data base of the status of entities grouping together, at each time instant, the covering status of each entity ;

- the scenario development means for developing a suitable scenario, capable of describing the sequencing of actions to be performed in the operation and a status data base of the status of the scenario grouping together, at each time instant, the current status of the scenario ;

- a radio traffic generator capable of simulating the radio traffic between the various different entities ;

- a central simulation module for simulating the operation, capable of executing the scenario and defining the consequences of the actions provided for by the scenario and capable of integrating these consequences in the progressive unfolding of the scenario ; and

- a rendering module for rendering of the status, over time, of the radio communications between entities engaged in the simulated operation.

In order to assess the feasibility of certain civil or military operations, it is a known practice to use simulation software that provide the ability, in addition to simulating field operations on the ground, to reproduce by means of simulation as faithfully as possible the status of communications between the entities while keeping pace with the unfolding simulated execution of the operations. These software programmes provide technical information and data with respect to the status of communications between the various entities involved over due course of time. In particular, they provide information items such as the existence or otherwise of possible communications between the entities, the quality of service available over each link, the rate of utilisation of each link, the number of data items not transmitted to the receiver, etc.

These communications, which are effected via radio means, may be of varied nature. They are very sensitive to the relative positions of the transmitter - receivers, to the geography of the terrain, and to the potential eventual congestion of the bandwidth over the course of operations.

Some communications blackouts or degraded communications can make the operations difficult, or even render them materially impossible in reality.

Thus, such simulation software programmes are particularly useful in the definition of the means to be engaged in an operation, in the definition of the planning of this operation, or even in the definition of the technical means of communication that are to be used in order to ensure optimum execution of the planned operation.

5 These simulation software programmes are also very useful during the specification, of the conception - design and validation of new communications equipment by the manufacturers. They make it possible to define the desired behaviour of the new equipment units, to verify the proper operation thereof, to extrapolate the overall system performance levels when they are used in an operation. They also provide the ability to
10 study and ensure the interoperability and compatibility with existing and already deployed resources.

In practice, the simulation software programmes currently known implement processes in which, for the entire simulation, assumptions of traffic between the entities are defined based on independent statistical assumptions of the actual evolving
15 developments of the simulation, or by means of programmable logic control units generating a periodic traffic.

The invention aims to provide a simulation method for simulating the status of radio communications that provide the ability to more effectively take into account the behaviours of the various entities over the course of the simulation.

20 To this end, the object of the invention relates to a simulation installation of the aforementioned type, characterised in that the central simulation module is capable of executing the scenario based on the status, over the course of time, of the traffic of radio communications between the entities engaged, as simulated by the radio traffic generator; and

25 the installation includes the scenario modification means for modifying the scenario in the status data base of the scenario, based on the status of the scenario executed by the central simulation module and by taking into account the status of the communications traffic.

30 According to particular embodiments, the installation includes one or more of the following characteristic features:

- the installation includes the means for modifying the entities engaged in the operation in the entities status data base, based on the status of the scenario executed by the central simulation module and by taking into account the status of the communications traffic;

35 - the installation includes the process modification means for modifying, during the scenario, the processes assigned to each entity in the process assignment means, for

assigning processes to each entity; and

- the installation includes the matrix modification means for modifying, during the scenario, the matrix of exchanges in order to modify the policy and rules of exchanges by radio communication.

5 The invention will be better understood upon reading the description that follows, given purely by way of an example and with reference made to the drawings, in which:

- Figure 1 is a schematic view of an installation according to the invention;
- Figure 2 is a schematic view of the main functional modules of the installation shown in Figure 1;

10 - Figure 3 is a view of a display showing the entities involved and the terrain on which the successive phases are represented;

- Figure 4 is a view of a display showing the processes associated with the entities; and

15 - Figure 5 is a view of a display showing procedures implemented in the processes.

The installation 10 illustrated in Figure 1 is designed for the simulation of the status of radio communications between entities during a simulation of an operation, for example a conflict between two opposing groups of entities such as two enemy armies.

20 In the following sections, each entity formed for example by a vehicle equipped with a radio, a soldier equipped with a radio or any fixed or mobile radio equipment, such as a relay is designated by a node.

The installation includes a central data processing unit 12 capable of running a software programme consisting of a suite of appropriate programmes, a data base 14 for storing data and programmes, as well as at least two terminals 16A, 16B connected to the
25 central data processing unit 12.

These terminals 16A, 16B are capable of configuring the conditions of the simulation for each party engaged, for example an army. Each terminal is capable of modifying, over the course of the simulation, the evolution of the operation for the entities or nodes of the army for which it has control. A terminal is also capable of being used for
30 directly controlling the operations for an army, the other army being managed only by an engine of the simulation.

As illustrated in Figure 2, the software programme includes a central simulation module 200 capable of receiving data originating from the terminals 16A and 16B and simulating, based on a simulation engine, the unfolding of operations over the course of
35 time. It is capable in particular of simulating the radio communications by evaluating the possibility of their being established or not and the quality thereof. The central simulation

module 200 will be described in greater detail later.

The simulation module comprises a data base 202 containing in particular a computerised communication model, a model for the radio equipment units in each node, and models for propagation of radio communications based on the conditions.

5 In order to enable the simulation, each terminal 16A, 16B comprises an entities generator 220 to be used for defining a set of entities engaged in the operation. This generator is in particular capable of defining the vehicles and human operatives engaged with their radio means, each forming an entity or node within the scope and context of the simulation. It provides the ability to define, for each entity, the equipment units available to
10 them and in particular the radio equipment units at their disposal along with their precise technical specifications.

For this purpose, the entities generation module 220 comprises the means for inputting and storage of all of the entities engaged, along with, for each of them, the radio communication means at their disposal.

15 For each communication means, a description of the radio means is saved and stored. This description includes the specifications of at least one of the behaviour methods from among the methods used by the radio means for transmitting the electromagnetic data to other radio means while minimising the natural adverse effects (weakening due to the distance, electromagnetic noise, barriers linked to the terrain or to
20 building structures, interference from other radio means operating over the same zone), the methods used by the radio means for allocating and optimising the time slots and fragments of the electromagnetic spectrum necessary for any exchange of information and the methods used by the radio means in order to find the routes that may be used to exchange data and information with constraints related to quantity, quality and integrity of
25 data.

The entities generator 220 defines in addition, the operations, the assigned military missions, the nature of the terrain, the military platforms engaged, the mode of deployment, the organisation, the manoeuvres, the rules of engagement, the behaviours, the meteorological conditions, the time of day and possible external elements of the
30 environment, such as the presence of individual snipers.

These entities are stored in a status data base 201 of the status of entities controlled by the entities generation module 220 and the central simulation module 200. This data base stores, during the simulation, the status of each entity.

Each terminal includes, under the control of the entities generator 220, the display
35 means for displaying the entities for the associated army, the characteristics and statuses of these entities such as is included in the data base 201.

By way of an example, the entities involved that constitute an army are illustrated in Figure 3 in a zone 221 of the screen of a terminal 16A. These entities are each represented by a rectangle 222 associated with one or more ellipses 224 illustrating the means of communication that are at the disposal of the entity 222.

5 The entities are represented in an organisational manner, for example hierarchically, for example on 4 levels. With each hierarchical level having prerogatives and particular needs, the entities are equipped with means of communication that vary from one hierarchical level to another.

10 The ellipses 224 are each provided with an interior frame representative of the technical characteristics of the communications equipment units with which the entity is equipped. All of the telecommunication technologies not being compatible with each other, only the entities having ellipses with the same frame are assumed to potentially be able to communicate with each other.

15 In addition, each terminal 16A, 16B comprises the means 240 for developing a scenario capable of defining the trajectories, the kinematics, the orientations, the altitudes, and attitudes of the entities over the course of time. They are capable of defining in particular the successive phases of progression, the actions on the terrain, as well as the triggering mechanisms whether or not conditional, for triggering certain events.

20 For example, the scenario includes, for the successive phases, a phase I of travel in convoy of the entities engaged, then a phase II of observation and finally a phase III of combat.

25 For the conditional or non conditional triggering mechanisms, the scenario developed from the means 240 defines a sensitive geometric zone defined on the mapping of the terrain and associates a conditioned triggering mechanism. For example, the mechanism is such that when one or more entities enter into this sensitive zone, an activity or a process is triggered, such as the destruction of the entity, the jamming of the radios and/or the attacking of the convoy.

30 The scenario development means 240 for developing a scenario are capable of enabling the input of actions to be executed and zones of the terrain in which these actions are to be carried out and of illustrating them on the terminal concerned.

A data base 241 of the status of the scenario groups together the characteristic data of the scenario at each time instant of the simulation. This data base is read and populated by the central simulation module 220 and the scenario generator 240.

35 In figure 3, is presented, in a zone 242 of the screen, a map of the region of the operations which is divided into several zones 244A , 244B and 244C, each associated with one phase of the operation.

For each of these phases, particular processes specific to each entity engaged are defined.

A process is an organised system of activities (for example a process of observation in the military domain), which uses resources whether or not co-located (personnel, equipment, materials and information) in order to transform input elements (for example observations) into output elements whereof the expected end result is a service or a product (for example a summary report of observations carried out in a zone). The process has an owner who is responsible for ensuring the proper execution and successful completion thereof.

The scenario defines the processes that need to be implemented in the simulation. These processes are conditioned according to the progressive unfolding of the simulation and may thus be modified, either automatically by the simulation engine, or by an operator from the terminal 16A.

The processes are defined by the scenario development means 240 for developing the scenario.

The simulation module 200 is associated with a data base in which is stored an operational function reference framework 300. This reference framework includes a set of processes. Each process groups together multiple activities and may be implemented by the various different entities engaged.

The processes are grouped together within operational functions, with all of the operational functions forming the reference framework 300.

Thus, a military reference framework groups together various different 'operational functions' to which the entities can contribute. The operational functions, 14 in number in this example considered, are illustrated by visible blocks for the entities 302A, 302B, 302C in Figure 4 showing an example of a screen of a terminal 16A, 16B.

For example, protection, observation, combat are the operational functions of the military reference framework.

Every operational function groups together a set of procedures that may be implemented in accordance with the circumstances being faced by the entity.

The processes for an operational function that contain the basic activities to be carried out by the operational function are of multiple levels. The processes thus have different activities per level. For example, the operational function 'protection' in the military domain has a Level H for the protection of the overall military force, Level H-1 for the protection of a part of the organisation, and a Level H-2 for the individual protection of 'its' platform.

The basic activities by operational function and by level necessitate input data,

which is subject to treatment processing implemented by activity and produce output information and data.

Each process comprises one or more activities chosen from a set of activities that are predefined for the entity or entities considered.

5 Examples of processes that span multiple entities situated across entities of different hierarchical levels 302A (Level H), 302B (Level H-1), 302C (Level H-2), are shown in Figure 4. Illustrated in this figure for a typical entity of each hierarchical level, are the operational functions implemented for each entity, as well as the sequencing of the data flows between these entities.

10 Each entity implements processes that contribute only to certain operational functions. Thus, for a given entity to whom processes are assigned, only the operational functions indicated in a light colour are assigned thereto and thus, only the processes included in these operational functions may be implemented by it.

15 For example, the entity 302A, executes in the simulation, the operational functions of planning, observation, gathering information pertaining to tactical situations, reporting on positions, tactical coordination, logistics management and coordination of support functions. However, it does not have the operational functions of combat or protection to be executed.

20 As illustrated, the operational functions of the entities 302B, 302C are different, although these entities are involved in a same given scenario.

Each of the processes is programmed by an operator and saved and stored in the reference framework 300 from the scenario generator 240. The sequencing, synchronisation and orchestration of these processes is the means of conducting the operations.

25 When a process implements the activities located over different entities, spread out over a theatre of operation, the information items (data, orders, validations, authorisations, signatures) are exchanged, processing operations are applied to the data prior to executing the subsequent activity in the process. The process may include phases that are iterative, procedural, and conditional. All the requirements for exchanges between
30 entities that are needed to ensure the proper progress of the process during the execution of the operation constitutes 'the communications needs'.

Each activity of a process, as well as the process itself, is executed under very specific conditions. In particular the input information must adhere to a number of criteria, and first of all to a criterion of quantity: the information items necessary for the activity
35 should all be available on the node that will perform the treatment processing related to the activity, followed by a criterion of quality: the input data must be current when they are

tested on the basis of purge date or constraints related to lead or lag times and subsequently, a criterion of integrity: the input data must not be corrupted or lost, or invalidated or repudiated.

5 The malfunctions in the system or the means of communication such as the inability to establish radio communication or difficulties in these radio communications can significantly impact the execution of the operation by disrupting the information flows between activities and processes. This could involve, for example, congestion, famine, isolation, blocking, degraded modes etc.

10 The central simulation module 200 is capable of reviewing these criteria, over all of the entities engaged in implementation in the operation. It provides the ability to assess the effectiveness, the performance aspects, the efficiency and yield of the system, and the radio communications equipment units. It is capable of rendering these assessments on the terminals 16A or 16B so as to make these assessments available to a user.

Examples of procedures are described in Figure 5.

15 Each process 301 includes a flow chart having activities sequenced together possibly with eventual tests between the activities that condition these activities.

Certain activities implement communications with other entities in accordance with particular predefined modes of communication, with particular throughput rates and during predetermined time periods. In particular, the activities define the communications that are
20 to take place with the entities of higher -, identical -, and lower hierarchical level. The activities only provide for the intended recipients of the communications without defining thereof the content, the mode of coding, the throughput rate, or the volume, all which are defined by means of a policy and rules of exchange defined elsewhere.

Thus, for example, an activity defines the recipients for the communication.

25 Each of these activities is input by an operator and is saved and stored in the reference framework 300 from the scenario development means 210.

The processes provide for the activities carried out in case of difficulty, or degraded performance levels in communication during an activity, for example in the form of alternative branches, degraded modes, change in configurations or organisational
30 changes.

Thus for example, a process provides that in case of non-communication, the result is an activity of displacement of the entity to another point on the terrain, or on the contrary, an activity of stopping the latter or even an activity of increasing the transmission power of the radio means associated with the entity.

35 The simulator includes a data base 310 containing the status of the activities and processes of each entity at each time instant.

The simulator also includes a traffic generator 260 capable of simulating the radio traffic between the various different entities based on the activities of each entity at the given time instant as provided for by the processes implemented in the scenario.

Each entity is capable of participating in certain processes of certain operational functions (not all) by contributing through activities. The capacities of the entities in terms of activity, processes, operational function are defined by means of general policies - for example, by hierarchical level - (programmed through the use of the 'traffic generator' module 260). These general policies may be substituted by specific policies, or even by individual processes if need be.

This traffic generator is associated with a matrix 280 of exchanges, that is to say, a set of data defining the policy and the rules of exchange of information and data between the entities. For example, this policy stipulates that each entity should report to the hierarchically higher placed entity over a predetermined radio frequency with a pre-established periodicity. Similarly, this entity should disseminate to the entities placed at the hierarchically lower level a set of orders over a predetermined radio frequency with a defined periodicity dependent on the phase of operations.

For example, a report should be made to the hierarchically higher placed entity every 10 minutes, over a given frequency with a given coding system by transmitting images and text accounting for a volume of data comprised within a predefined range.

The traffic generator 260 simulates the communications as defined in each activity, and by applying the policy and the rules of exchange of the exchange matrix. In particular, it determines whether the communication can take place, taking into account the other communications in progress, the status and position of the entities, and if this communication cannot take place properly, it simulates the degraded or absent state of this communication.

In order to do this, the traffic generator 260 takes into account, for each activity, a description of the radio fluxes between the engaged entities.

The description of the radio flux stored for each entity includes specifications with respect to at least one of the modes of exchange of data or information from among the exchange protocol, the degree of reliability of exchanges, the degree of priority, the type of security and encryption, and the purge date of the data exchanged.

The generator 260 also takes into consideration the description of the radio means implemented for each entity.

A data base 281 includes the current status of communications at each time instant as provided by the traffic generator 260. The contents of the data base 281 are used by the central simulation module for the implementation of the simulation taking into

account the current status of communication of each entity.

The simulation software programme includes the first 420 and second 440 modification means for respectively modifying the entities, and in particular the mobility, behaviour, rules of engagement, or even the organisation) and/or the scenario development means for developing the scenario based on the actual evolving developments of the operations simulated by the central simulation module 200 and the state of communications.

In Figure 2, these first modification means for modifying the entities 240 are illustrated by feedback loops 420 acting from the communications status data base 281 to the entities status data base 201.

For example, an external event, a warning - alert, triggers the stopping of one part of the organisation and is followed by the landing of soldiers who are also equipped with communication means, and who will have their own activity.

Similarly, the simulation software programme comprises the second modification means 440, capable of ensuring the modification of the scenario and then acting on the data base of the scenario statuses 241, through an additional feedback loop 440, in order to take into consideration the difficulties, and more generally the communications statuses, this being in accordance with the consequences defined in each of the procedures figuring in processes derived from the reference framework 300.

For example, the destruction of a part of the organisation requires a reconfiguration of the manoeuvre, activities and communications.

Finally, the installation includes a rendering module 520 that enables through the terminals 16A 16B the provision of information on:

- the technical state, over the course of time, of radio communications between entities engaged in the simulated operation. This rendering is done for example in the form of numerical metrics, performance indicators, chart diagram representing the number and type of communication that has failed, as well as the transmission rate over a network.

- the 'Quality of Services' (QoS) of operational services made available to entities. This rendering is done for example in the form of numerical metrics, performance indicators, chart diagram indicating the quality of service such as the capacity to hold voice conferences, sending of command messaging, broadcasting of video streams, and determining the position of friendly forces.

- the 'Services Agreements' (Service Level Agreements SLA), which are commitments between clients (entities or categories of entities) and service providers (services and means of communications). They evaluate the expectation of the parties on

the content of services (for example the availability of the voice conference service), the modalities of execution thereof (only one voice conference at a time at the lower levels), service level guarantees (for example 95% availability of the voice conference service for 85% of the entities on a mission with a duration of 4 hrs).

5 The simulation software programme also includes two additional correction loops 560 and 580 capable of acting, either on the activities status data base 310, or on the traffic generator 260 and/or the associated exchange matrix 280.

 Thus, the loop 560 is capable of acting on the activities status data base 310 in order to adapt certain procedures and activities to the status of communications (and/or
10 QoS, and/or SLA), or to create an operating margin in the aftermath of unexpected events for example an attack or an accident. These modifications are done by an operator or in an automatic manner from the rendering means 520 for example in order to favour a category of entities at the expense of other entities when the status of communications is measured to be degraded.

15 For example, depending on the context of execution of the scenario, certain services may be favoured at the expense of other services: the Voice service is maintained, even to the point of degrading certain 'data' services for example.

 According to another example, depending on the context of execution of the scenario, the quality of voice services at the level of the combatants is favoured, and the
20 operational messaging services for the command levels are favoured.

 In addition, the loop 580 is capable of acting on the traffic generator 260 and the associated exchange matrix 280 in order to adapt the traffic to the status of communications (and/or QoS, and/or SLA), and/or to create an operating margin in the aftermath of unexpected events for example an attack or an accident. These modifications
25 are done for example through changes in traffic policy for certain categories of entities.

 For example, the following measures are taken so as to alleviate traffic:

- Entities placed at low hierarchical levels send their observation reports half as often in order to relieve the communications routes; and/or
- Transfers of images and photographs are forbidden.

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CLAIMS

1.-A simulation installation for simulating the status of radio communications between entities engaged in a simulated operation of the type comprising :

- an entities generator (220) providing the ability to define a set of entities engaged in the operation and a status data base of the status of entities (201) grouping together, at each time instant, a covering status of each entity;

- a scenario development means (240) for developing a suitable scenario, capable of describing the sequencing of actions to be performed in the operation and a status data base of the status of the scenario (241) grouping together, at each time instant, the current status of the scenario;

- a radio traffic generator (260) capable of simulating radio communications traffic between the various different entities;

- a central simulation module (200) for simulating the operation, capable of executing the scenario and defining the consequences of the actions provided for by the scenario and capable of integrating these consequences in the progressive unfolding of the scenario; and

- a rendering module (520) for rendering of the status, over time, of the radio communications traffic between entities engaged in the simulated operation;

characterised in that this central simulation module (200) is capable of executing the scenario based on the status, over the course of time, of the radio communications traffic between the entities engaged, as simulated by the radio traffic generator (260); and

it includes a scenario modification means (440) for modifying the scenario in the status data base of the scenario (241), based on the status of the scenario executed by the central simulation module (200), and by taking into account the status of the radio communications traffic.

2.-The installation according to claim 1, characterised in that it includes a means (420) for modifying the entities engaged in the operation in the entities status data base (201), based on the status of the scenario executed by the central simulation module (200) and by taking into account the status of the radio communications traffic.

3.-The installation according to any one of the preceding claims, characterised in that it includes a process modification means (520, 560) for modifying, during the scenario, the processes assigned to each entity in a process assignment means (300), for assigning processes to each entity.

4.-The installation according to any one of the preceding claims, characterised in that it includes a matrix modification means (520, 580) for modifying, during the scenario,

a matrix of exchanges (280) in order to modify the policy and rules of exchanges by radio communication.