ELMO (Electromagnetic Layer for Multi-domain Operations) developing and testing activities

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ABSTRACT

The electromagnetic environment is an essential element for the understanding and conduct of future military operations. Its transversal characteristic permeates the operational scenario in a multi-domain perspective and, therefore, the comprehension and management of this physical dimension is crucial.

The NATO Modelling & Simulation Centre of Excellence (M&S COE) is conducting a project called "ELMO" (Electromagnetic Layer for Multi-domain Operations), which aims to create a synthetic environment for the virtualization of the so-called ElectroMagnetic Spectrum Operations (EMSO). In this context, M&S expresses flexible characteristics for the implementation of complex electromagnetic multi-domain scenarios, able to make visible in the scenario what is not visible or detectable in a real world environment. This feature would simplify the understanding of the main electromagnetic spectrum parameters and enhance the operational and informative characteristics, which the electronic assets provide within the Electronic Warfare context.
The EM layer was built using the Software Tool Kit (STK), developed by the AGI Company, and MATLAB, developed by the Mathworks Company. The integration of the two tools was exploited to generate ad-hoc synthetic military components such as Jammers and Radar Warning receivers.
A specific scenario was then built in order to simulate a military EM environment, where the STK synthetic assets, such as satellites, radars and communication systems, interact with the military components developed in MATLAB. The EM layer generated by the MATLAB-STK integration successfully provides a comprehensive visualization over time of the entire electromagnetic spectrum on the battlefield.
The tests performed in a demo scenario with interacting objects virtually operating in a comprehensive EM environment proved the capability of ELMO to develop a complex framework suitable, not only for Commanders' decision making, but also for capability Development and Experimentation.

Keywords: Electromagnetic Layer, Multi-domain Operations, M&S, decision making.

ABOUT THE AUTHORS

Author1 Name LTC (ITA – OF4) Piergiorgio Ventura graded in physics in 1998 with a specialization in Nuclear Physics. He then joined the Italian Army in 1999 with the rank of Lieutenant and start working within experimental firing ranges where missiles, weapon systems and ammunition were tested. After taking a PhD in quantum electronics and plasma physics in 2010, during which a remote sensing detection system to detect and identify chemical compounds, based on optical detection, was developed, he started working in the CBRN field for research, testing and procurement activities. Since January 2022, he is employed at M&S COE as M&S Concept Development Section Chief, where he is trying to develop new concept considering his expertise.

Author2 Name CPT (ITA – OF2) Salvatore De Mattia is an electronic engineer of the Italian Army, with specialization in radio frequency circuits. He is currently working at NATO M&S COE since October 2020, in the Concept and Experimentation Branch. In his first position, he was in charge of the Electronic Warfare (EW) sector, where he is mainly involved in the jammer systems configuration, for the protection against the RCIED (Radio-Controlled Improvised Explosive Device) threat. During this period, he worked both in Italy and abroad in various Operational Theaters in Afghanistan, Somalia, Lebanon (UNIFIL) and Iraq. He is currently working, as Subject Matter Expert, on projects concerning the use of Modelling & Simulation for Robotics and Autonomous Systems (RAS) and EMSO (Electromagnetic Spectrum Operations).

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PROJECT CONCEPTUAL IDEA

The conceptual idea of the ELMO project is described by an architecture that explains the functional interconnection of the main blocks used for the implementation. The modelling and simulation (M&S) architecture consists of the following elements of interest:

- Matlab/Simulink: used to perform the mathematical modelling of the fundamental electromagnetic blocks to build the virtual objects in the synthetic scenario. This modelling phase mainly focuses on the constitution of the functional and behavioral algorithms of the systems.
- AGI STK (Systems Tool Kit): used for the construction of the synthetic environment useful for scenario configuration and for electromagnetic simulations calculations. This is important for the definition of the electromagnetic component that, in military operations, affects the four fundamental domains.
- Matlab-STK interconnection: the project is based on dynamic and continuous data exchanging between EM (Electromagnetic) models synthesized in Matlab and simulation results provided by the STK tool. In particular, an interaction is carried out between the functional algorithms of the models and the real-time results of dynamic EM propagation provided by the simulators.
- Artificial intelligence: considering a possible long-term future development, it was conceptualized to merge potentialities offered by artificial intelligence with the described project, creating specific neural networks in feedback with the synthetic environment. In particular, by receiving data from STK, the neural network could be trained using multiple simulations. Furthermore, the deductive results produced by the neural network, could provide, the configuration parameters of the EM models, maximizing an objective function that considers new threats, scenario parameters, level of effectiveness and level of interoperability to be obtained.

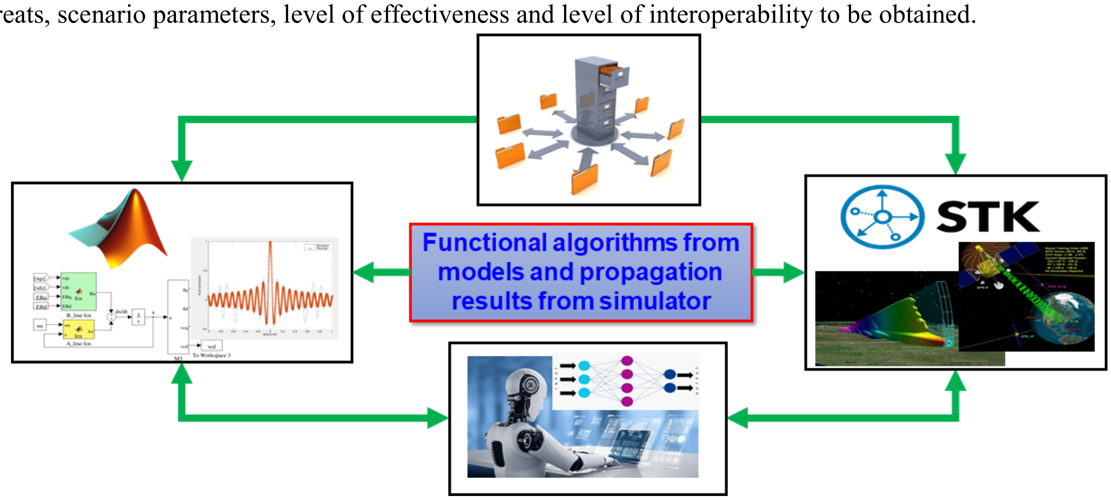

Figure 1: Conceptual idea of ELMO project (functional-logical architecture).

ELMO DATA INTEGRATION

To make an example, in order to replicate a complete operating cycle of the proposed synthetic electromagnetic environment, the following logical operations are reported, based on the creation of two generic models of receiver and transmitter:

- The transmitter model is based on the programming of a specific operating algorithm, which, depending on the input parameters, will provide a specific output. In particular, the spectrogram matrix of the generated output signal (time, frequency, power) could be calculated as output.
- Through a connection between the STK tool and Matlab, made for example with special APIs (Application Programming Interfaces), with bi-directional characteristics (input/output), the matrix values of the output signal, associated with a specific virtual object inserted in the simulator, constitute the input of the antenna to proceed with the calculation of the propagation results. The bi-directionality of the mentioned connection between a mathematical simulator and a scenario simulator, with mainly propagative purposes, would allow generating results in terms of input data for further mathematical models.
- The receiver model is based on the programming of a specific operating algorithm, which, depending on the input parameters, will provide a specific output. In particular, certain behavioral feedback connected to the functioning of the modeled receiver device could be provided as output. This information will be transmitted within the synthetic environment to provide electromagnetic situational awareness and, possibly, carry out actions of an operational, technical and/or informative nature.

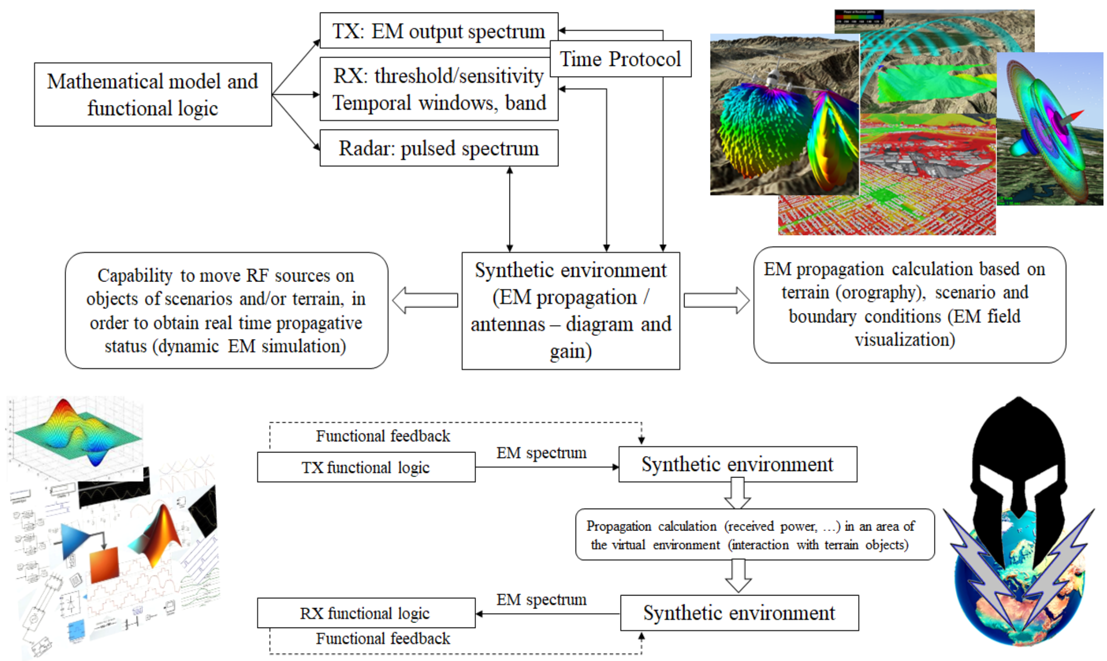

Figure 2: Flow chart for data integration implementation between the modelling and simulation component.

Therefore, Matlab/Simulink tool is a fundamental component of the ELMO project, especially in the modelling phase of peculiar EM systems, such as those used in a multi-domain electronic warfare context. In this case it is important to be able to create a behavioral model that reflects the functional logic of systems used in military operations (digital twin), defining the architectural blocks of a transceiver chain, except the radiating elements. In fact, the antennas will be inserted directly into the virtual environment defined by STK, obtaining the radiation pattern desired for the specific electronic system to which it is connected.
The construction of models is a complex engineering operation because it is important to define a specific technical level on which to structure a logical operation of behavioral algorithm and to make a general-purpose model. This last feature is significant since it enhances the importance of the M&S tool applied to the military technological sector, ensuring, firstly, versatility of use through the virtualization process. Having a generic model available allows performing multiple technical-operational configurations, easily replicating different system architectures that could be assimilated to specific types of equipment supplied to the Armed Forces. Results obtained by the ELMO system are therefore related to a specific behavioral models of EM systems defined in Matlab and, therefore, take on greater technical-operational value with respect to EM layer in multi-domain military operations characterization. The versatility inherent in the models is also a key point in the experimental phase of ELMO synthetic environment, concerning the definition of systems of systems, such as gap filler type. The availability of electronic system models

allows interfacing different apparatuses designed to cooperate for a common purpose, for example in Forces protection, and to exploit the ELMO synthetic environment to carry out technical and operational verifications, on the premise of any experimental activity in the field. This would have a benefit to analyze and maximize awareness of activities that, albeit with experimental premises, have a direct impact on operational and information structure.

PROJECT APPLICATIONS

The creation of a synthetic environment for electromagnetic operations provides an increasingly crucial aspect for the fulfillment of multi-domain missions complying with progressive technological increase of threats, in a context of Electronic Warfare. The virtualization of the EM operating environment and interconnection intrinsic transversal feature with the main military domains allows performing a computer assisted wargaming, in order to achieve the so-called best CoA (Courses of Action). In this regard, the conceptual analogy between a best CoA approach and obtaining technical, operational and information awareness aimed at defining the most effective electronic countermeasure (best countermeasure) is interesting. Once a scenario is virtualized, in terms of factions, types of platforms and systems, rules of engagement and objectives to be pursued, in line with the operation plan, by applying the concepts of computer-assisted wargaming, it is possible to develop technical and training skills to better manage the EM component, correlated to friendly and enemy Tactics, Techniques, and Procedures (TTPs). In addition, this situational approach would allow studying the perpetration of EM actions, from a multi-disciplinary point of view, mitigating any side effects (e.g. characterizing impacts in the cyber space used for the civil population).

The ELMO project can be used to integrate technical, operational and informative data. For instance, in an Electronic War context, the main identified impacts of using ELMO can concern using of electromagnetic countermeasures for Forces protection. The visualization and quantification of the electronic protection performance, albeit simulated, represents the starting point for expressing subsequent operational considerations and facilitate the decision-making process of the Commanders, providing information and feedback obtained from the electromagnetic component.

CONCEPTUAL ELMO SCENARIO

In order to implement a proof of concept for the project ELMO, a simulated scenario has been created. The main characteristics of this scenario are the following:

- The creation of a vignette in a multi-domain environment.
- The importance of the space domain for situational awareness increasing in the future operating environment.
- The key role of the electromagnetic spectrum operations for a military operation mission’s accomplishment through the generation of tangible and multi-factorial effects on all the military domains, acting on operative and informative elements.

The space domain has been highlighted for its intrinsic peculiarities, which make it very suitable for new concept development and for mission conduction, involving non kinetic effects through the use, the management and the control of the electromagnetic spectrum.

The implemented scenario has been developed in Orlando city, in Florida, where a digital terrain has been created for the simulation analysis and propagation calculations. Generally, a synthetic terrain in a modeling and simulation tool is composed of:

- Shape files, which contain vectorial data for geometric elements definition, such as lines, points, polygons, etc.
- Elevation files, which can include ASCII values with information of the terrain profile.
- Raster files, which is a georeferenced picture of the selected terrain.

Each modelling and simulation tool manages the terrain generation files in different ways. In STK, a synthetic terrain for analysis has been created from a jpeg file. In addition to the terrain file, a satellite photo has been overlapped to have a fully visualization of the synthetic scenario which is going to be created. In STK, it is also possible to add buildings present in a city, configuring a shape file containing, for instance, the polygons describing the buildings. The described operations have been done in Orlando city, in order to set the virtual terrain for analysis and for visualization of the simulation in a 3D perspective. Moreover, has been inserted a 3D tile object in the simulator, which simulates a military headquarter, in Exton, USA.

After the synthetic terrain definition, the virtual mission has been configured and, consequently the digital platforms with several attached devices. To better understand the implemented scenario, it is important to specify that the units are presented in two factions, blue and red forces, according to the electromagnetic military actions that are going to conduct in the synthetic environment.

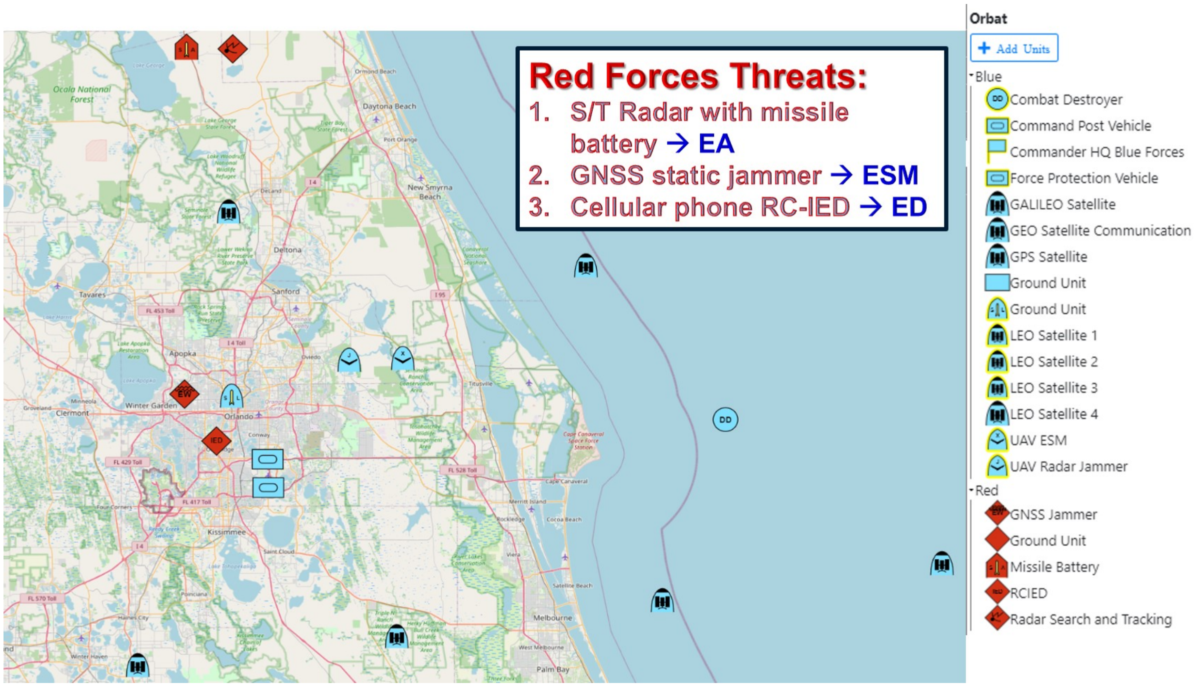

Figure 3: Scenario representation including blue and red forces units.

This scenario contains several EMSO actions, in particular:

- EA (Electronic Attack): the UAV performs an EA activating the on-board jammer toward the enemy radar;
- ESM (Electronic Support Measurement): the ground master station is able to send suspicious threats detected after a spectrum monitoring to LEO constellation for direction finder to geo-localize the enemy radar. In addition, the UAV is able to monitor the electromagnetic spectrum in an urban area, in order to send information to a ground vehicle jammer;
- ED (Electronic Defense): the ground vehicle is equipped with a hybrid jammer, automatically configuring system's reactive phases through UAV ESM actions and with a pre-programmed waveform in the active phases. These actions can be performed both in time sequence and in time parallel.
- Electromagnetic interoperability:
  - Time domain: 1PPS generated by GPS receivers of the platforms allows creating a synchronized time protocol regardless the military domain where the platform operates;
  - Modulation: the use of Galileo signal for Positioning purpose allows having a lower interference with respect to a high power and continuous wave L1 GPS jammer;
  - Antenna beam forming: the ability of a simulated phased array to create a null finder toward an interference source, providing, at the same time, maximum gain in satellite direction, which can improve the Signal to Noise Ratio of the communications.

EXTERNAL MATLAB MODELS

Matlab tool has been used to build digital models of electromagnetic systems, which are not available in STK. In particular, STK despite provide many embedded models for different electromagnetic systems, is not able to cover the overall spectrum of military electronic devices that can be employed in the future operating multi-domain environment. In particular, the military electronic devices are often designed as system of systems, implementing custom algorithms and based on specific logic connections and hardware architecture. For instance, at the same transmitter power and bandwidth, two different electronic counter systems designed with two different circuital architectures and with two functional logics, can show a wide difference performance in terms of level of effectiveness against the same threat, in the same scenario boundary conditions. Another important aspect to consider is the electronic waveform programmed and implemented inside the system defining methods for receiving and transmitting electromagnetic signals.

In this context, Matlab is considered as an expert modelling and simulation system where, through a code-based approach, it is possible to create a digital model of any specific device, which can be used in the EMSO context. The models are created as digital twin of a real system, in terms of behavioral and functional algorithms, for experimenting and verifying many results, obtained implementing different technical or operative configurations in the synthetic environment.

Among the models created within the ELMO project, two digital models of systems are reported below, in order to better clarify the concept expressed for the M&S supporting EMSO and to show potential capabilities defined by Matlab and STK integration. These Matlab models have been based on a specific and simple characteristic, which links the current and the future digital systems in the virtual environment: the flexibility of a general-purpose architecture, which represents the cornerstone for further considerations and experimentations. The achievement of the general-purpose characteristic is essential in a modelling and simulation project, since, in this way, it is possible to test many hardware and software configurations of the same systems, by changing input variables or applying minor changes in Matlab scripts, allowing the conducting of a multi-factorial analysis through the simulation. Furthermore, the need to be versatile and general purpose is crucial in the concept development and experimentation field, mostly for studying and analyzing a complex problem using a comprehensive approach method.

As first proof of concept, a military jammer has been created in Matlab, which integrates different functionalities:

- Active jammer: a device that involves only transmitter chains and it works, usually, with an electronic waveform created in pre-mission phase, according to radio frequency information of operation area.
- Reactive jammer: a device that involves both transmitter and receiver chains, able to create a radio frequency spectrum in response to the electromagnetic environment in the operation area, according to configured timing and frequency parameters.
- Hybrid jammer: a device that can perform both active and reactive phases, using a single chain (time sequence) and/or a multi chain configuration (time simultaneity).

The realized digital model of jammer system defined in Matlab corresponds to a hybrid system, since this is the most complex architecture, in terms of functional phase’s integration. For this reason, a specific setting of the input and control variables allow to simulate also an only active and an only reactive jammer. Furthermore, in this digital model is possible to choose the hardware configuration of the electronic counter measure system, in terms of number of transceivers and power amplifiers, and the software configuration expressed as configuration typology (single or multiple chain). These technical aspects make the model general-purpose and its scripts composition gives usage modularity, providing an easy way to create different system architectures.

SCENARIO DIFFERENT COURSE OF ACTIONS

The modelling and simulation supporting electromagnetic spectrum operations is a key technology, which allows studying and analyzing how this operating environment will influence transversally the military domains, in terms of informative, technical and operative aspect. In this scenario, although the multi-domain assets represented, the space domain has been highlighted, through which, in conjunction with the electromagnetic environment, it is possible not only to increase the situational awareness, but a comprehensive operative management of the future battlefield.

The synthetic scenario allows reaching a high level of versatility, meaning that by changing particular configuration variables of systems’ models it is possible to obtain completely different operative results. Different results will lead to several courses of action, which correspond too many scenario ramifications. The following situations can be easily generated and verified.

<u>Master station does not receive suspicious frequencies:</u> the LEO satellites constellation cannot be configured with received frequency and the estimation algorithm cannot be processed. Any UAV missions in the operating area can be detected and be destroyed by radar guided missiles.

<u>Master station receives suspicious frequencies:</u> the LEO satellites constellation can be configured with received frequency and the estimation algorithm can be processed. As a result, an estimation point is obtained associated to an uncertainty area.

UAV jammer is not able to inhibit enemy radar: the on-board single frequency jammer is connected to a dynamically change antenna, pointing to the estimated point of the target and whose directivity is proportional to maximum obtained uncertainty error. The uncertainty level of the ELINT system is able to change automatically jammer antenna gain and directivity, so it means that the EIRP can be strongly affected by FDOA results' precision. The inhibition of the radar is connected to the jammer parameters, to radar technological architecture implemented in the model and to the radar cross section of the target asset.
UAV jammer is able to inhibit enemy radar: the two UAVs of blue forcers are not detected, hence not destroyed, by enemy radar thanks to the electromagnetic attack performed through the UAV jammer. The search function is completely jam and the subsequent tracking phase for missile launching is not activated.

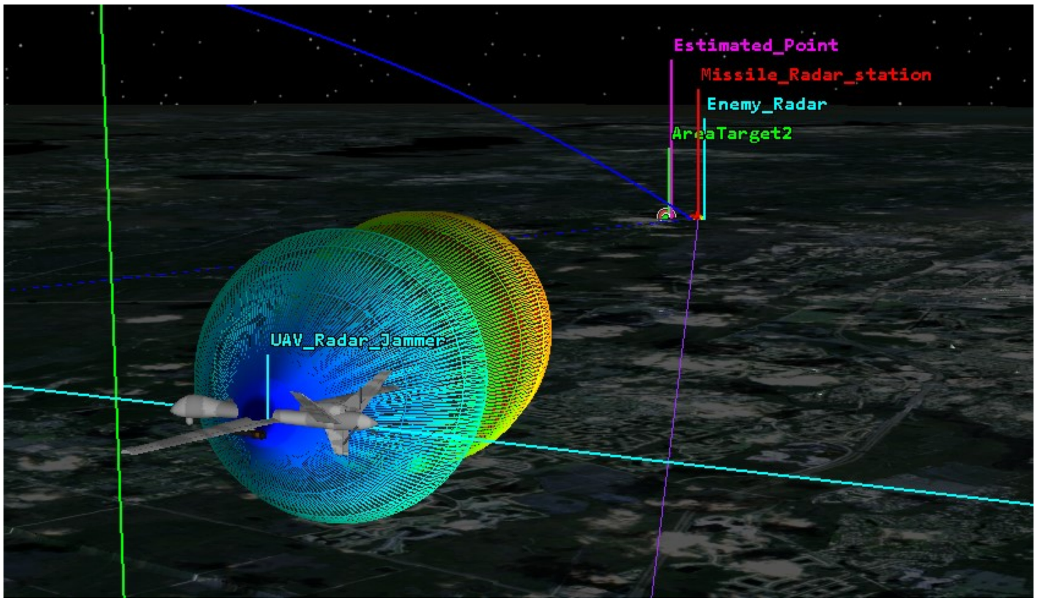

Figure 4: UAV radar jammer 3D object and antenna pattern view.

Galileo L1 modulation is affected by jammer: the use of a multi-constellation receiver on-board UAV ESM is a very important aspect in this simulation. A specific BOC modulation configuration has been chosen for satellite transmitters, in order to highlight Galileo signals resilience in a noisy environment (narrow band L1 jammer signal) with respect to GPS ones. The capability to use Galileo allows to UAV ESM to send the precise target (enemy GPS jammer) position to conduct a kinetic action on it and restore GPS receivers in the operating area.
UAV ESM detects BTSs and MSs: one of the mission performed by UAV ESM is to monitor radio frequency spectrum, in specific bands, over a high-density urban area. This electromagnetic surveillance is part of the a multi-domain architecture to implement a hybrid jammer waveform, where receiver stage has been conceptually de-localized with respect to the ground vehicle used for electronic force protection. The ESM receiver electronic configuration (e.g. instantaneous bandwidth and scanning technique) and the collected signals samples are fundamental for subsequent electronic defense actions. Based on an incorrect intelligence information or an incorrect model configuration, the effective threat signal cannot be detected or too many (environment) signals are collected. The latter situation is typical in an electronic support measure action performed in an urban environment and can result a jammer device to be completely ineffective, since it needs to spread its (limited) resources over many suspicious threats.

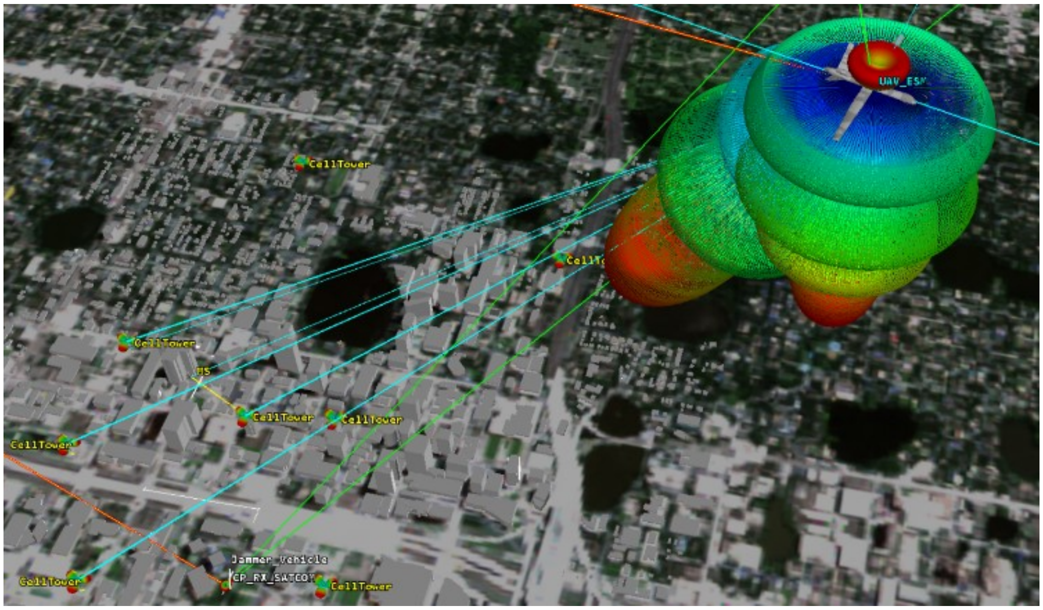

Figure 5: UAV ESM 3D object and antennas pattern view.

GPS jammer is not destroyed: the enemy GPS L1 jammer is placed in the operating area in order to avoid use of PNT devices by blue forces. The GPS jammer continuously disturb the electromagnetic environment making ineffective blue forces devices using L1 signal functionalities. In this situation, the ground vehicles mission is performed anyway, albeit with technical and operative limitations. As result, the jammer reactive part is filled with blank information, generating an only active waveform. The active waveform is configured in pre-mission phases and it is fixed, meaning that there is not a dynamic spectrum adaption according to the specific electromagnetic environment of the operating area. Since the resources of the jammer are limited in time, in frequency and in power, using an active waveform needs to have suitable informative support, in order to be effective inhibiting several possible threats. Mostly in an urban scenario and for multi-purposes devices (e.g. cellular phones), it is very difficult to have a priori detailed information concerning radio frequency possible threats.

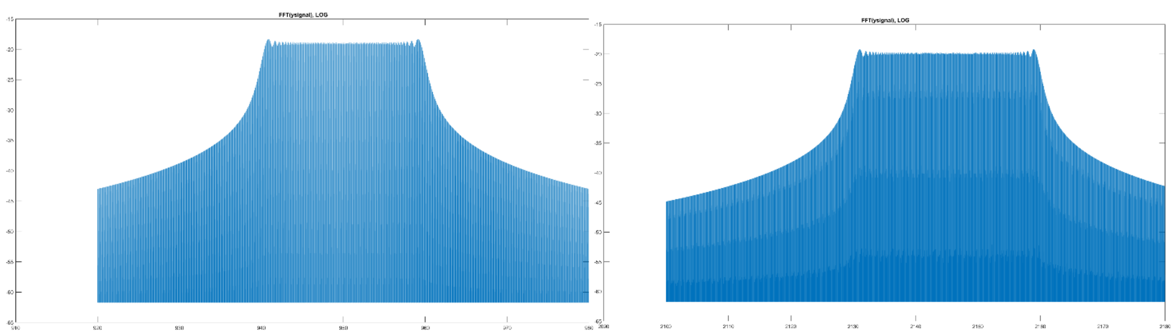

Figure 6: Matlab jammer external model spectrum in active waveform mode (2G left and 3G right).

GPS jammer is destroyed: the multi-domain electronic warfare system works properly, meaning that UAV ESM and ground vehicle are perfectly synchronized in time, sharing the same time protocol for data exchanging. The ground vehicle can receive data collected after UAV ESM action over the city, automatically generating its waveform in hybrid mode (reactive and active at same time). Jammer reactions are created on the detected frequency contributions, dynamically adapting the system's resources and transmitting an electromagnetic signal with specific characteristics, according to model configuration.

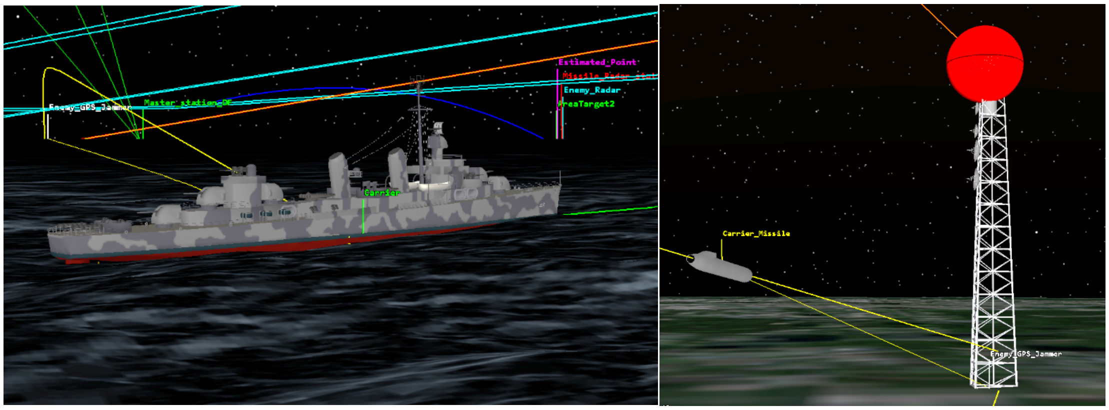

Figure 7: Military ship (left) and tomahawk missile (right) launched towards GPS jammer station 3D objects' view.

Ground vehicle hammer inhibits 2G/3G threats: depending on jammer waveform transmission (hybrid or purely active) the effects on radio controlled improvised explosive device threats can be very different. In this context, the obtained results are ranges of effectiveness with respect to the target vehicle (command post with satellite receiver), calculated in this specific scenario and using both J/S and Eb/ (N0+Io) thresholds. These thresholds have to be set correlating to threat's signal characteristics to jam (e.g. modulation, frequency, multiplexing, data rate, etc.). For these reasons, according to the jamming thresholds set in this scenario, it is possible to verify performance differences of using an active or a hybrid jammer waveform. At the same power, frequency, timing system resources, to have a theoretical waveform configuration better than another is impossible, since the informative, operative and technical variables that concur to force protection level are too many and not known a priori. Therefore, a creation of a synthetic environment able to model and simulate these peculiar aspects is important to manage the current and the future electromagnetic spectrum operations, increasing operational value of the M&S supporting military sector, through a representation of these non-kinetic effects.

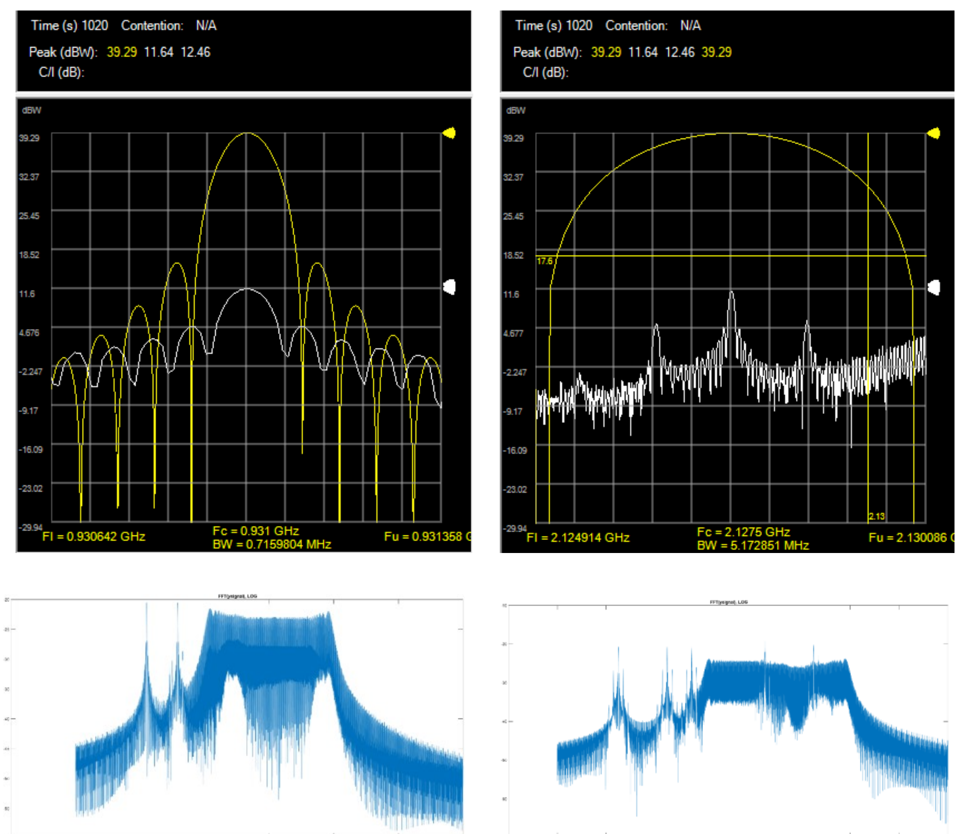

Figure 8: STK spectrum analyser and **Matlab** jammer external model spectrum (see text for details).

In figure 8, you can visualize these different performances. In details, STK spectrum analyser in MS GSM receiver is visible on the top-left, and MS UMTS receiver is visible in the top-right, showing the jammer waveforms (white) and cellular communication channels (yellow). Matlab jammer external model spectrum in hybrid waveform mode is shown for 2G on the bottom-left and for 3G on the bottom-right.

<ins>Ground vehicle's satellite receiver communicates with HQ:</ins> depending on jammer waveform transmission (hybrid or purely active) the effects on the command post ground vehicle's satellite receiver can result very different. A more effective jammer system and its waveform can unintentionally increase the noise interference level towards a friendly communication device. In this case, since the inter-vehicular distance is very close, in order to provide better electromagnetic protection by jammer actions, and due to a very low level received signal coming from satellite downlink connection, it is very important to simulate the devices electromagnetic interoperability. The interoperability evaluation is obtained by calculating quality of satellite communication, according to the vehicles' mission, interference contribution and satellite communication receiver configuration. This configuration is conducted essentially by changing phased array antenna pattern, defining a null finder capability, showing its effect on radio frequency source attenuation with respect to desired signal.

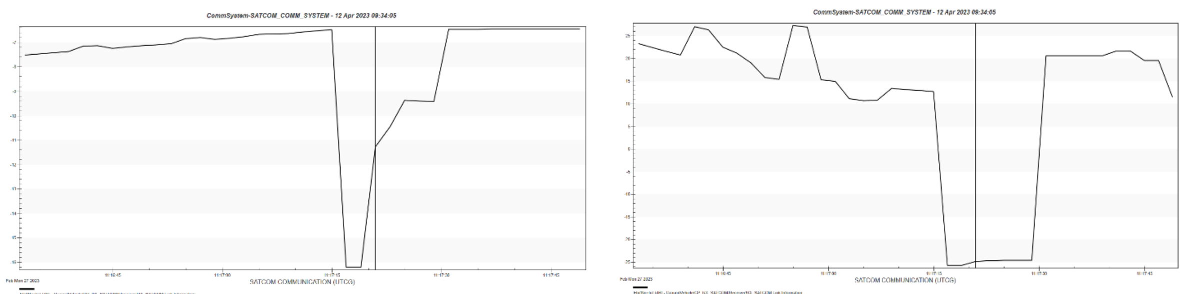

Figure 9: STK graph of satellite communication Eb/(N0+I0) parameter configuring the phased array antenna without null finder capability (left) and with null finder capability (right).

The electromagnetic interoperability has been studied using the Eb/(N0+I0) temporal envelop, shown in two dirrent situational scenarios:

1. Phase array receiver antenna does not implement the null finder functionality: maximum Eb/(N0+I0) value is around -8 dB, meaning that there is no satellite communication, since the downlink path is distorted by jammer interferences;
2. Phase array receiver antenna implements the null finder functionality: maximum Eb/(N0+I0) value is around 27 dB, meaning that there is satellite communication and the command post ground vehicle is able to receive all the military information by military HQ. In this case, the jammer interferences in L band are strongly attenuated by antenna radiation diagram.

Therefore, by using the null finder algorithm capability on a phased array antenna, it is possible to earn around 35 dB on Eb/(N0+I0), meaning that the satellite communication using the GEO satellite transponder is affected by a low bit error rate.

In STK simulator, a phased antenna model has been implemented using a MVDR (Minimum Variance Distortionless Response) beam former algorithm. Beam former algorithm can compute the weights of each array element, for shaping antenna's gain pattern. MVDR changes the amplitude and phase across the array elements to steer and shape the beam as well as the nulls. Therefore, the MVDR goal is to minimize the variance of the beam former output. If the noise and the underlying desired signals are uncorrelated, as is typically the case, then the variance of the captured signals is the sum of the variances of the desired signal and the noise. Hence, the MVDR solution seeks to minimize this sum, thereby mitigating the effect of the noise. In this model, a MVDR constraint of 3 dB has been set. This value is used to constraint the amount of main gain reduction, which can take place to null interference.

The decisional branches of this scenario are managed by Matlab code, whose effects are projected into STK simulator, structuring a conceptual decision tree diagram based on communication parameters thresholds. To evaluate a quality of a link budget, Eb/N0 (in normal situation) and Eb/(N0+I0) (in presence of radio frequency interference) have been calculated and verified. On these parameters, the thresholds have been set considering a common BER value (e.g. 1e-6) and considering the modulation chosen for communication links. This approach has been adopted to simply the decision tree conditional phases, although it can be easily modified with different threshold values and BER considerations.

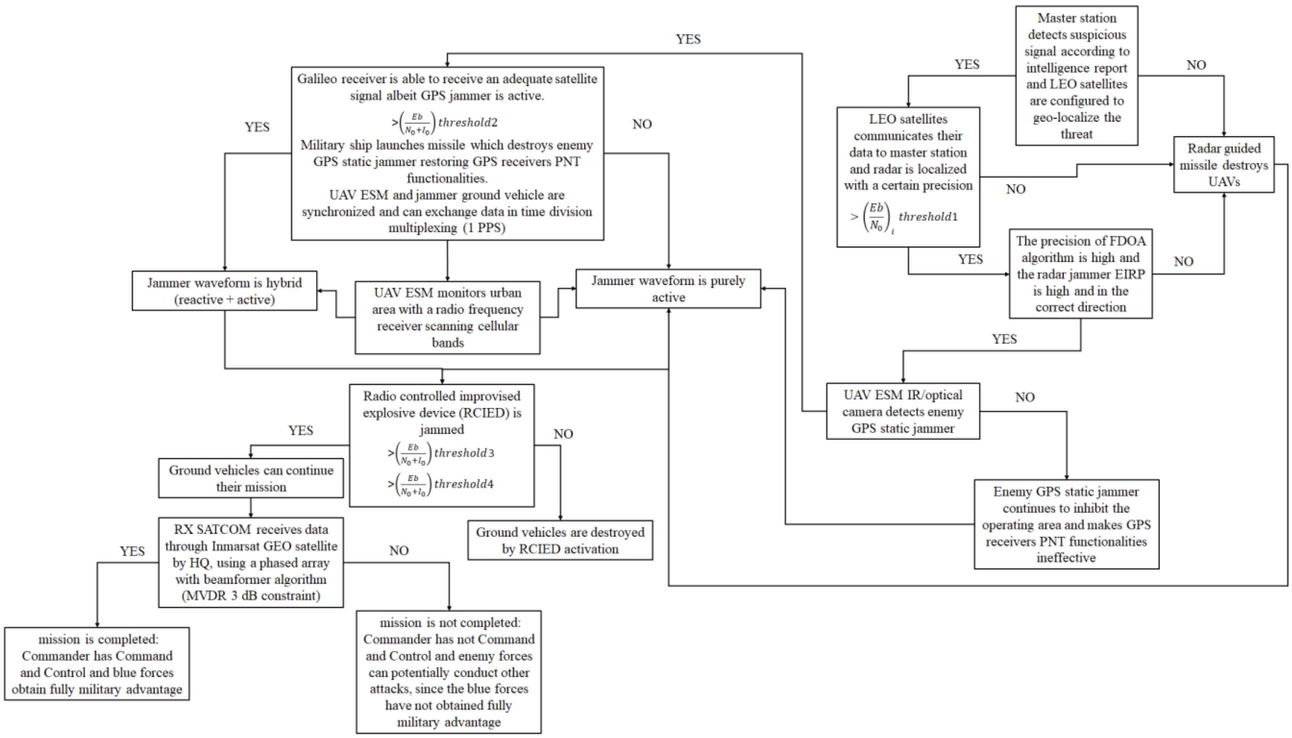

Figure 10: Scenario's decision tree developed based on conditional thresholds.

CONCLUSIONS

The Modeling & Simulation in support of electromagnetic operations could also allow system configurations, in order to understand how to counter new electronic threats, studying and characterizing, for example, the effectiveness of gap filler systems. The creation of a complex urbanized virtual scenario is an essential component in the analysis of the technical-operational effectiveness of the electromagnetic devices used in operation, both from a spectral and a physical point of view. In particular, the physical virtualization of the surrounding environment allows simulating the main propagative effects provided by the physical objects defined in the scenario, whose understanding and analysis allows obtaining a quantification of the performance effectiveness, in relation to the maximization of the efficiency of the technical and operational processes of the employed electromagnetic equipment.

Concerning to the ever-expanding technological dynamism within the military context, a winning approach will surely be a comprehensive one, where military professionals able to carry out interdisciplinary and heterogeneous analysis and assessments will increasingly a have fundamental role, in order to synthesize, within a single technical direction, declinations and operational applications. Shortly, it will become essential to model and to manage the future complex military challenges within a vast and diversified technological substrate, through capability developments characterized by a high technological level but with a direct and simple operational projection to support military operations.

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