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Hellenic Military Academy
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Invited Speaker**TITLE: Mathematical and Practical Aspects of Security****AUTHOR: Preda V. Mihăilescu**

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ABSTRACT: The talk is directed to a wide general public with interests in the practical aspects of information security and wishing to gain some understanding both of the mathematical background and of relevant aspects related to the practical implementation of information security methods – cryptography and others.

It will cover various aspects ranging from cryptography, bar codes, watermarking to biometry, while setting a net distinction between mathematically proved facts, widely accepted assumptions in cryptography and practical issues and tricks of the trade which are of importance to implementers' and project managers in security.

Keywords: *Cryptography, information security***Invited Participant Author****TITLE: Multisensor Multitarget Tracking Problems: Models and Extensions****AUTHOR: Panagote (Panos) M. Pardalos**

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Session 1 Operations Research /Operational Analysis Organization

1st Presentation

TITLE: **Operational Level of War**

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ABSTRACT: The operational level of war is a relatively new military principle introduced to the military lexicon by the US Army in 1982, almost out of the blue sky. Since then, the term was adopted first by the English speaking countries, and then by the NATO and eventually by the rest of the world's militaries. Before 1982 the term used by the military professionals and theorists around the world, including the American military establishment, was *operational art*. The latter was used for the first time by the Soviets in conjunction with the much wider terms *deep operations* and *deep attack*. The theory of deep operations was developed in the '20s and '30s based on the experience of the newly established (in fact renamed) Red Army from First World War, the Russian civil war and the often forgotten Russo-Polish war of 1919-1921. A series of Soviet theorists, including Mikhail Frunze, Aleksandr Svetsin, Mikhail Tukhachevsky and Vladimir Triantafillov ended up with the theory of deep operations which survived up until the dissolution of the Soviet Union. The art of conducting deep operations was named *operational art*.

For centuries the understanding was that war was planned and executed at two distinct levels, namely the strategic and the tactical level. Though this division of war was practiced by military leaders for centuries, it was theoretically documented by the great Prussian theorist and practitioner of war Carl von Clausewitz in his monumental work *On war*. In his work, he defined strategy as "*the use of engagements for the object of the war*" and tactics as "*the use of armed forces in the engagement*". While the definition of tactics remained unchanged until today, the one of strategy progressively changed because of major changes in the character of war and finally made space for another level, the operational level of war.

For the most part of the history of warfare, the dominant strategy of war was the single point strategy of the decisive battle. According that, the general, who was the political and at the same time the military leader, led its army to a predefined place, at a predefined time, to meet the whole of the

enemy army, in one decisive battle, whose outcome would produce also a decision for the war. The actual plan and execution of the battle was the realm of tactics.

The single point strategy of the decisive battle survived, in one way or the other, until the Napoleonic wars. The cataclysmic changes in warfare of this era led to subsequent changes in strategy. The enormous increase in the number of armies the nation-states were able to field and the improvement of the European road infrastructure led to important changes in the way the strategic commander conducted the war. Instead of the army moving in one column, it was divided in Corps, which, led by a lesser general, was sustained and moved independent towards the place chosen by the strategic commander to meet the enemy for the decisive battle. Even so, the strategy remained “*the use of engagements for the object of the war*” as defined by Clausewitz. The last battle fought in this way was the battle of Koningratz won by Moltke the Elder on behalf of the Prussian King against the Austrians.

Eventually the corps not only moved independently, but started fighting a series of battles for the purpose of the war independent of the rest of the army. This series of battles fought by parts of the army was called *operations*, and the art of conducting them *operational art*. The strategic commander, instead of planning and executing battles for the purpose of the war, he started planning and executing operations. With this new development, the war was planned and executed at three levels, the strategic, the operational and the tactical level.

It is obvious that the idea of dividing the planning and execution of the war into three levels was developed within the context of the industrial or 14lexiglas14n war. The question we need to ask ourselves, and most important to answer, is if this sort of distinction is applicable to other types of war. As noted by Martin van Creveld, the majority of the wars conducted worldwide after Second World War were of the type called limited war or Low Intensity Conflict. Even worst, the Armed Forces are progressively used in operations collectively characterized under the terms Military Operations Other Than War (MOOTW) or Peace Support Operations (PSO). The requirements for these “new” types of war are radically different vis-à-vis the old industrial or Trinitarian wars, causing doubts about the validity of the principle of the three levels of war. A thorough analysis of all factors involved shows that the principle of the tree levels of war should be applied with caution and on a case by the case basis, especially for Low Intensity Conflicts, MOOTW and crisis management operations, depending mainly on the purpose of the specific war decided by the politicians and pursued by the military.

Keywords:

Operational, war, level, operations, operational art, strategic, tactical

2nd Presentation

TITLE: **Operational Planning for Military Demolitions: an Integrated Systems Approach**

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ABSTRACT: Obstacle emplacement planning for defense operations is a critically important function and responsibility of (army) engineering units; this process includes a large number of interrelated actions that have to be undertaken to complete operations. Units have to estimate and allocate human and material resources and to establish appropriate access to demolition sites in an effort to create effective obstacles. This paper provides efficient operational models that can be applied by military/engineering units to estimate resources and plan logistic activities for obstacle emplacement. Further, an effective decision support tool particularly adjusted to real-time operations is developed and presented.

Keywords: *Linear-integer programming, decision support systems, obstacle emplacement, defense operations.*

3rd Presentation

TITLE: Risk Assessment Techniques as Decision Support
Tools for Military Operations

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ABSTRACT: The major objective of this paper is to analyze the most widely used techniques for risk assessment and to discuss their applicability as decision support tools for military operations. These are the qualitative and the quantitative risk analyses, which are commonly used for handling uncertainty in project management. Initially, the main processes for the implementation of each method are presented highlighting the most critical issues that should be taken into account by project analysts.

Further, it is discussed how these processes can be used by military operations analysts as decision support tools during the planning phase of a military operation. In particular, the main steps that should be followed by operations analysts are analyzed and the limitations as well as the benefits

of the specific techniques are also discussed. Finally, in order to demonstrate that these methods can be effectively applied as decision support tools to military operations, the paper presents two illustrative examples with the application of the qualitative and quantitative risk analysis.

Keywords:

Qualitative risk analysis, quantitative risk analysis, Monte Carlo simulation, risk matrix, military operations, random variables

4th Presentation

TITLE: **The Quantum Theory in Decision Making**

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ABSTRACT:

Humans do not always make the most rational decisions. As studies have shown, even when logic and reasoning point in one direction, sometimes humans “walk” to the opposite route, motivated by personal bias or simply “wishful thinking.” This paradoxical human behavior has resisted explanation by classical decision theory for over a decade. Scientists have shown that a quantum probability model can provide a simple explanation for human decision-making. In military, decision-making process is considered to be the most neuralgic one. With the recent interest in quantum computing and quantum information theory, there has been an effort to recast classical game theory using quantum probability amplitudes, and hence study the effect of quantum superposition, interference and entanglement on the agents’ optimal strategies. Apart from unsolved problems in quantum information theory, quantum game theory and decision –making, may be useful in studying quantum communication since that can be considered as a game where the objective is to maximize effective communication.

This paper discusses the idea of using quantum theory to decision making. The conclusions of this work are expected to be the presentation of the basics of the application idea of quantum theory to the decision making processes.

Keywords:

Quantum theory, game theory, decision making

5th Presentation

TITLE: **Mathematical Models of Strategic Defense:
Layered Defense and Theater of Ballistic Defense**

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ABSTRACT:

The first part of the paper will be devoted to the definition and study of a layered defense against simultaneous offensive weapons. Then we will discuss the layered defense against offensive weapons depending on the defensive or offensive strategy to be adopted by each opposing side. The solution will come with the help of game theory and is optimal both for defense and for attack. Next, we will give a solution to the problem of determining optimal penetration routes through a defensive grid. The resolution process includes the concept of the threat function, as well as the analysis of an effective defense against attacking fighters.

The paper will conclude with a description of the overall layered defense effectiveness against attacking invaders when the two opponent forces adopt **allocated** ballistic strategies. This case defines the concept of the theater ballistic defense. Towards this direction, we will examine three different tactics against offensive weapons: (1) random assignments of targets, (2) uniform assignments of targets and (3) shoot-look-shoot assignments of targets.

Keywords:

Strategic defense, layered defense, antiballistic missile defense, probability of penetration of missiles (or tanks), allocated strategy, probabilities of zero penetration

Session 2

Combat Models / Simulation of Operations

1st Presentation

TITLE: **Stochastic and Renewal Analysis of Irregular Warfare. Mathematical Models and Evaluation**

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ABSTRACT: If conventional warfare is a complex situation that is difficult to model in the best of circumstances, then unconventional warfare is a nightmare for military analysts. Irregular strategies rely heavily on deception and deceit. Many aspects of this type of Irregular Warfare (IW), such as recruitment, desertion, psychological warfare, etc. are based on individual human behavior and are very difficult to model. Our primary goal here is to provide a descriptive probabilistic method and efficient mathematical tool to help understand cause-and-effect relations in the context of IW directly related to the involved military forces or populations support and control.

The paper begins by providing a short explanation and review of contemporary IW attrition models, including terrorism-counter-terrorism struggle models, epidemiological models, spatial-temporal models, adversarial organizations destabilization models and risk assessment and decision making models.

Despite emerging perspectives, all these methods seem to be applicable only under a strict set of assumptions, such as having homogeneous forces that are continually engaged in combat, firing rates that are independent of opposing force levels are constant in time, and units that are always aware of the position and condition of all opposing units. All these models also contain a number of significant shortcomings, including modeling combat as a deterministic process, requiring knowledge of crucial and mutable “coefficients” (the values of which are, in practice, very difficult to obtain), inability to account for any suppressive effects of weapons, and failure to account for population behavior and/or terrain effects. Conceptually, there are two significant drawbacks to using these methods to model IW. First, these models are unable to account for any spatial variation of opposing forces and population (no link is established, for example, between movement and attrition). Second, they do not incorporate the human factor in combat (i.e., the psychological and/or decision-making capability of the human combatant and the member of population).

To address this deadlock, we will develop an IW's stochastic and renewal process theory for losses and escapes. To do so, we will consider the stochastic (random) variable $A(t)$ denoting the total losses number of *an agency or population Y involved in an IW's conflict* up to the moment time t from the beginning of the conflict. The first main result is that the distribution function for the associated IW-losses process with intensity λ is a Poisson distribution with parameter λ .

Next, we will consider intermediate times between successive losses for *an agency or population Y involved in the IW's conflict*, and we will prove that *the set $(W_v: v = 1, 2, \dots)$, where W_v is the waiting time up to the v^{th} IW-loss, forms a stochastic process with probabilities given by an Erlang distribution*. Moreover, it will be showed that *the successive intermediate times T_1, T_2, T_3, \dots between successive losses of an agency or population Y involved in the IW's conflict are independent and equidistributed random variables, with common **exponential density function***. The randomness character for a stochastic process of losses will be investigated and some reasonable and natural generalizations will be given.

Next, we will consider and study stochastic processes of IW-losses and reinforcements for a force with difficult access in the IW's conflict. After studying the fighting size probability distribution of Y 's remaining units, we will get IW-Chapman-Kolmogorov equations, and subsequently IW's Kolmogorov forward stochastic differential equations on corresponding transition probabilities. The above theory will be generalize to the linear stochastic process and stochastic differential equations ruling non-homogeneous processes for the IW-losses/reinforcements of any involved force in case where only a portion of reinforcing units has difficult access in the IW's conflict. In the same context, we describe the linear stochastic process and stochastic differential equations ruling non-homogeneous processes for the IW-losses/escapes of any involved population in case where only a portion of population units has limited ability to escape. As an application, we will compute the complete destruction probability of all involved force's units, as well as the complete destruction probability of all involved population units at any moment of the IW, specifically at the end of the IW. We will also outline the IW's Kolmogorov differential equations for the non-homogeneous stochastic process of IW-losses/reinforcements of a force with difficult access in the IW and, also, the IW-Kolmogorov differential equations of losses/escapes for an IW involved population with limited ability to escape.

A natural and direct generalization will be obtained by considering IW-losses with independent and equidistributed intermediate successive times, but without exponential (common) distribution density. We will discuss this generalization, by studying the renewal processes of successive IW-losses for each force or each population involved in an IW's conflict. Now, the function $A(t), t \geq 0$ will be called the renewal counting function for the IW-

losses of each force or population involved in the IW's conflict. We will also give basic definitions and properties on the expected number $M(t) = E(A(t))$ of IW's conflict losses in any time interval $[0, t]$ and we present renewal theorems for the IW's conflict losses. We will also describe the exact and asymptotic probability distributions for the three main time moment of IW-losses (: the following loss' time moment, the preceding loss' time moment and the successive losses' time moments). Next, we will outline a model for substituting fighting units, and we will describe to the so-called stationary renewal process of the IW's conflict losses. Finally we will formulate asymptotic properties for the counting function $A(t)$.

Keywords:

Irregular Warfare (IW), intermediate time between successive losses, randomness character for the stochastic process of losses, IW's Chapman-Kolmogorov/Kolmogorov forward stochastic differential equations, processes of losses and reinforcements with difficult access, processes of losses and escapes with limited ability to escape, complete destruction probability, IW's Kolmogorov differential equations, renewal processes of successive losses in the IW, renewal counting function for the IW's losses, asymptotic probability distributions for the three main time moment of losses (: the following loss' time moment, the preceding loss' time moment and the successive losses' time moments), stationary renewal IW process asymptotic properties for the counting function

2nd Presentation

TITLE: **Working Among Complexity, Uncertainty, Self-Organization and Predicting Collective Intentions in Thrace, Using Simulation Through Cellular Automata**

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ABSTRACT: Our intention is to show that a variety of evolutionary processes embedded in a computational environment using Cellular Automata (CA) can create a desirable structure in Thrace and finally, manipulating some

traits can grow a desirable ethnically oriented society in it. Using a method, we will demonstrate that certain sets of micro-specifications are sufficient to generate the macrophenomena of national interests.

Specifically, we give to multi-agents rules of behavior and then spin the CA system forward in time to see what macroscopic social structures emerge.

Keywords: *Complexity, self-organization, multi agents, simulation, cellular automata*

3rd Presentation

TITLE: **Numerical Methods for Sea Wave Simulation and Naval Applications**

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ABSTRACT:

The credible knowledge of the sea state conditions and the accurate forecast of them, in long or short time horizons are of great importance for a variety of activities today. Ship traffic and safety, tourism, renewable energy resources exploitation and, of course, navy applications can be listed among them. Today, operational forecasting centers and research institutes worldwide are based on the use of numerical modeling systems that simulate the sea state conditions. Such models solve the basic mathematical equations that govern the evolution of wave transport and incorporate available satellite or in-situ observations.

The Department of Mathematics of the Hellenic Naval Academy in collaboration with the Oceanography Department of the Naval Postgraduate School in Monterey, USA, and the Department of Physics of the University of Athens, Greece, has developed a fully operational wave modeling system able to operate on a very high resolution mode and provide detailed information for the sea state conditions at different areas of the

Mediterranean Sea. The main components of this system is the wave model WAM, one of the most commonly used and well tested models worldwide, and a number of algorithms based on recent advances in mathematical sciences for the optimization and the local adaptation of the results.

The system is running operationally at the Hellenic Naval Academy infrastructure and the results are daily provided to the Hellenic Navy Hydrographic Service for supporting fleet activities. Moreover, the obtained wave simulations are exploited for studying the offshore renewable energy potential in the Aegean and Ionian Seas in the framework of a new research project organized by the Hellenic Naval Academy and the Cyprus Oceanographic Institute.

Keywords:

Wave modeling, sea state simulations, fleet operational support, renewable energy applications

4th Presentation

TITLE: **On Conducting Defense Experimentations to Evaluate UAV Impact in the Tactical Context of a Mechanized Infantry Platoon Employing Military Simulation Software**

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ABSTRACT:

During recent years a rapid increase of the worldwide military conflicts complexity in tactical, operational, and strategic level has been observed. Said complexity combined with requirements regarding operational cost curbing, environmental protection, as well as increased force protection measures, led to the realization that Western armies need to focus on modernizing personnel training, on developing and testing doctrines reflecting the context within current conflict occurs, and on implementing new systems or upgrading existing ones in order to satisfy any set of realistic operational constraints and to furthermore achieve the expected goals in the best possible way (NATO WG CD&E 2011). Within the typical framework of a nation's Armed Forces the set of requirements along with the associated expected outcome is determined by the General Staff whereas the assessment of a proposed operational solution is carried out among others by a dedicated military simulation group tasked with defense experimentation. Given the highly technical nature of military simulation and the complex nature of conflict itself, in order to deliver meaningful answers to upper echelons this simulation group should be fully cognizant of

the details concerning both the underlying mathematical model ¹ as well as of the actual system (typically a combination of specialized software and hardware) implementing it.

Hellenic Army IT Center (HAITC), Military Simulation and Wargames staff section acts within the general framework of developing, evaluating, and deploying defense experimentation tools and systems in order to assist the Hellenic Army General Staff select the best possible alternative to satisfying Hellenic Army operational requirements. During spring semester of 2012 HAITC devised and oversaw the implementation of the first stage of a larger campaign of experiments ² where a group consisting of class III Cadet Officers initially obtained the skills necessary to use the latest edition of JANUS wargame and subsequently assumed the role of a typical in size and composition mechanized infantry platoon commander in the digital battlefield. An extensive series of simulations evaluated the impact of adding a suitably equipped UAV as a reconnaissance asset to the platoon commander's disposal. The underlying null hypothesis of the experiments was that UAVs had no effect to the overall platoon efficiency.

Given JANUS design, human-in-the-loop simulation methodology has been selected. According to the scenario a typical mechanized infantry scout platoon (blue force #1 in JANUS) operated by a Cadet Officer spearheads the advance of its parent company (blue force #2) ordered to capture a series of successive objective points code named P1, P2, and P3.

As blue force #1 advances, its commander is called to judge at different stages based solely on the reconnaissance data available whether or not to engage elements of the enemy defenses (red force) guarding critical points including P1 to P3. In each of these stages a rather accurate estimate of the opposing red force element strength is critical to mission success as the wrong decision may lead to unacceptable losses or long advance delays. Blue forces have no a priori intelligence regarding red force strength and location,

¹ See **Code of Best Practice "Experimentation"**, DoD Command & Control Research Program (CCRP) Publication Series, Alberts, David S., Hayes, Richard E, July 2002

² See **Code of Best Practice "Experimentation"**, DoD Command & Control Research Program (CCRP) Publication Series, Alberts, David S., Hayes, Richard E, July 2002; also **Code of Best Practice "Campaigns of Experimentation"**, DoD Command & Control Research Program (CCRP) Publication Series, Alberts, David S., Hayes, Richard E, March 2005; also **Guide for Understanding and Implementing Defense Experimentation (GUIDEx)**, The Technical Cooperation Program (TTCP), Version 1.1 February 2006

therefore blue force #2 relies heavily on blue force #1 for on-site information.

The number and composition of red force as well as the weather, both important experiment control variables, were the same across all scenario runs. Blue and red forces were equally lit and neither of them could exploit weather conditions to their advantage. Neither side had access to indirect fire or non-conventional weapons. In each scenario run JANUS linear congruential pseudo-number generator seed was always the same integer value. The following simulation termination criteria were enforced based on both national infantry military regulations and NATO guidelines:

- T1. Blue force #2 occupying and maintaining a garrison to P3 (victory)
- T2. Blue force #2 failing to capture P3 within 3 hours (defeat – unacceptable advance delay)
- T3. Blue force #1 losses exceeding 30% (defeat – scout platoon in need of replacements).

Although always an asset in real conflict, blue force #1 commander's personal performance factor had to be isolated from the UAV impact evaluation for fairness reasons. To this end, the 60 participating Cadet Officers were split to two equally sized subgroups A and B so that the weighted course grade average (taken as a measure of personal merit) distributions of the subgroups were almost identical. Subgroup A was operating a UAV whether B was relying on existing target acquiring systems. The dependent variables to be assessed were the engagement average distance, the number of objective points occupied and, wherever applicable, the time required to reach them, the percentage of missed shots, the number of objectives captured, and the kill exchange ratio of between blue and red forces.

One of JANUS known limitations³, circumvented in modern simulation platforms, is its lack of human behavior modeling. In any scenario execution friendly and enemy units carry out their orders with a varying degree of efficiency independent of combat events and general troop morale and affected primarily by unit operational status and type – for instance a sniper is better in target acquiring than a regular infantryman. Simulation results should be interpreted therefore under this light.

³ See JANUS Model Documentation, 2012 HAIRC

In total 8 scenario runs from both subgroups were deemed as outliers and were not examined further. Simulation data from the remaining 52 runs were processed using descriptive statistics and survival analysis in MATLAB and STATA and yielded the following results.

| | Subgroup A | Subgroup B |
|-------------------------------|------------|------------|
| Percentage of victorious runs | 10% | 0 |
| Average shots (std) | 90 (36.77) | 74 (30.41) |
| Average engage distance | 1581 m | 1369 m |
| Average casualties | 16 | 20 |

Subgroup A had in every aspect a better average performance than subgroup B, including an approximately 14% increased effective visibility and 20% less casualties. Finally notice that the above results are statistically significant as p was less than 0.05.

Results obtained through statistical analysis following the outlined experimentation methodology revealed assigning a UAV to a mechanized infantry platoon significantly improves its battlefield survival probability. Simulation results review indicated that UAVs compared to existing observation and target acquisition systems, extended blue force #1 effective visibility which in turn translated to more accurate shots over longer distances as well as to lower platoon commander average reaction time.

Keywords:

Constructive simulation, combat model, defense experimentation, UAV, military simulation, wargames, scout platoon, descriptive statistics, termination criteria

Session 3

Systems of Administration and Control

1st Presentation

TITLE: **Support System for Assignment Decisions (YSToS). A Mathematical Model**

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ABSTRACT: The rationale for YSToS (Support System for Assignment Decisions) DSS is to facilitate Human Resource Management decisions for the Hellenic Navy. A mathematical, multi-criteria optimization model was designed and a software environment was implemented employing this model to support job assignment decisions.

Assigning HRM resources in an optimal way while considering multiple criteria is a very difficult task. There are many attributes to be taken into account some of which contradict each other. The human mind has limitations when dealing with multi attribute problems and the associated set of multiple tradeoffs. Providing a mathematical solution to the problem with the ability to evaluate tradeoffs could offer useful insight to decision makers and help reduce bias in the overall HRM assignment process.

YSToS works as a decision support tool, providing recommendations for job assignments which the user can validate or ignore.

In December 2012 YSToS was successfully implemented for the first time for Navy Supply Corps Officers' transfers. Appropriate versions for Deck Officers and Engineer officers are under construction with testing scheduled for Summer 2013 and Winter 2013 accordingly.

Keywords: *Manpower systems, multi-criteria decision problem, Greek Navy, Hellenic Navy, Officer, Command, Officer's preference, human resource management, human resource management system, decision support system, optimization*

2nd Presentation

TITLE: **Battlefield Digitization**

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ABSTRACT: There are two common elements that characterize all attempts to prevail in the battlefield from ancient times until today: technology and domination of new “levels of conflict”. All successful wars were always based on some kind of technological excellence, a new weapon system, a new organizational method or combination of both the above.

The development and implementation of Electronics and Information technologies in the collection, processing, distribution and use of information at all levels and dimensions of the battlefield resulted in the battlefield digitization, improving the Command and Control capabilities which until the late 20th century were supported by the telegraph – telephone and radios, with the introduction and use of modern Command – Control – Communications – Computer – Information – Surveillance – Reconnaissance (C4ISR), which have been recognized and adopted by all modern armies as a force multiplier.

In the wars that will follow in the future the winner will not be the one who excels in numbers, but the one who will dominate in reliable and timely information in real time. Information is knowledge that modern C4ISR systems convert into direct reaction against the actions of the opponent, with the rapid accumulation and use of combat power greater than that of the opponent.

In this study an attempt will be made to provide a description of the battlefield digitization of the battlefield for which the following methodology has been adopted:

- Analysis and description of the environment, operational rules, dimensions and functional areas of the modern battlefield.
- Analysis and description of War Information.
- Analysis and description of the digital battlefield.
- Analysis and description of Network Centric Warfare.
- Analysis and description of the Digital Soldier.
- Analysis and description of Communications.
- Conclusions – Suggestions.

CONCLUSIONS

The modern battlefield requires consistency of information and full

exploitation of computer science, new information technology and automated tools to support the decision-making process at all levels of Command in order to achieve :

- Domination in the Maneuver through the Situation Awareness
- Precision Strikes
- Focused Combat Service Support
- Force Protection.

By using computer tools, the operational commander is fully aware about the current situation in relation to the enemy and the operational environment, so that he is able to envision the desired final outcome, which reflects the successful execution of the mission and the sequence of activities which will take place in order to achieve the ultimate goal.

The training and evaluation of various levels of Command should include all the spectrum of their activities, i.e. their transportation to a special exercise area (specifically configured to do so), their preparation to combat and the evaluation of all operational activities maneuver, fire support and Combat Service Support.

Informatics will have a leading role in creating the military information society and the development of military automated grid information (information grid), which will interconnect everything from the soldier and the weapon system with the relevant decision-making levels of command.

Informatics will also have an important role in the NCW, which will be crucial in future operations.

Finally, it is necessary to stress that although the integration of dynamic information in the way the Armed Forces operate is critical to succeed, technology alone cannot create Commanders who have an automatic perception of the battlefield. It is required that the Commanders should have and implement in the battlefield their personal and professional leadership skills, which, combined with technology will allow them to have real-time picture of the battlefield in order to decide quickly and correctly.⁴

Keywords:

Information age, digital battlefield, Command–Control–Communications–Computer–Information–Surveillance–Reconnaissance (C4ISR), decision making process, Network Centric Warfare (NCW), digital soldier, simulation – training

⁴ **General References:** White Paper, Ministry of Defence, Athens 2001; also, **Revolution in information affairs, tactical and strategic implications of information warfare and information operations**, Manuel W. WikDefence Materiel Administration SE-114 58 Stockholm; also, **EU Information 151-1 Battle Information**; also, **FM 100-5, Operations**; also, **ML 30-1 Staff Tasks**; also, **FM 100-6, Information Operations**; also NATO, R & T AGENCY; also, **Science & Technology. Weapon Systems. Dominate the Maneuver Battle**; also, **Texts of ASP Lecture for 1999**; also, **Information Systems and Analytical Tools for Defence** of Professor Alexander Polimenopoulos, Special Advisor to MoD; also **Study HAGS “DEFINITION OF MODEL ARMY OFFICER IN THE BEGINNING OF THE 21ST CENTURY”**; see also www.mod.mil.gr.

3rd Presentation

TITLE: **Search and Rescue Information System Analysis–SaRISA**

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ABSTRACT: During search and rescue (SAR) operations, maximum coordination, effectiveness and timely execution are factors of life and death importance. The presenter will demonstrate SaRISA, an integrated information platform that combines data from various military and non-military sources, in order to produce a combined and clear tactical picture of SAR sea and air operations. Also, a description shall be provided of the time-evolving probability model that predicts drift of castaways, raft and boats by utilizing a plethora of meteorological, current and other data. The system produces optimized search area and patterns that significantly increases the likelihood of timely detection, but also plans, tracks and evaluates SAQ operations. Finally, statistics demonstrating the success of SAR operations conducted with the help of SaRISA.

Keywords: *Search and Rescue operations, trajectory prediction models, operational forecasting, rescue operations coordination*

4th Presentation

TITLE: **A New Methodology for Handling Complex and Multi-Thematic Georeferenced Information in Large-Scale Computer Systems**

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ABSTRACT:

In this work, the problems of the complex and multi-thematic character of the information organized in contemporary, large scale computer systems or clusters of computer systems are addressed. The development of very powerful servers for creating and maintaining sets of map-related information of very high volume has significantly promoted the inclusion of georeferenced information in a very large number of applications, including logistics applications, crisis management systems, systems for monitoring and control of operational procedures, and many others. The simple fact that in many areas of applications the georeferenced information is dominant, led to the development of high-volume georeferenced data sets by a multiplicity of independent institutions, organizations, and private companies. Moreover, many of these players do maintain the corresponding information sets. The use of selected data sets of this kind in military systems under development, or future military systems, may significantly reduce costs, as well development and deployment times. However, fetching in and organizing such information in an information system poses several problems, the most important of them being achieving interoperability of the different data sets, coping with the complexity of the data, as well as dealing with the multi-thematic character of the resulting information systems. In order to cope with these problems, the following are proposed:

- a) A novel internal organization of the relevant data and

programs of such a system and

b) a new methodology for maintaining, updating and upgrading such a system throughout its life cycle.

Both are based on the development of additional structures of suitable and properly organized metadata. These structures and their content are collectively called “teleological information” (or simply “teleology”) and used as a thematic and conceptual description and index of all data and programs of the system. The teleological information is produced and maintained under the guidance of experts in the thematic areas of the system, introducing this way expert knowledge in the day-to-day operations of such a system. New content (data, programs and the corresponding teleological data) can be gracefully integrated to the system at any point of its life cycle, reducing thus the risk that the system may become obsolete. Information systems built in this way have also other additional advantages: They are robust, gracefully expandable to very large volumes without losing efficiency or becoming unstable or unmanageable, and even reducible, if the need arises. They can also cope with severe thematic augmentations or changes, they can significantly resolve polymorphism of the data and, finally, they can be physically distributed in several systems connected through the Internet (or any private network), but still presenting a logical unity to the users.

Keywords:

Georeferenced information, large-scale computer systems, teleological information

Session 4

Military Logistics Chain

1st Presentation

TITLE: **Modeling the Uncertainties of the Provision of R Dispersed Attacking or Defending Units from a Logistics Center**

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ABSTRACT: Supplying military units is a paramount task for any military administration: the quantity of supplies and their replenishment rate directly affects how effective a team is during a military operation. Replenishing the supplies efficiently is thus a very important factor of success in the field. The unpredictable circumstances of a battlefield, such as weather changes, attacks or breakdowns in transport may slow down the process. Therefore, planning the replenishment service must take into account the variability of delivery time, both in expected and unexpected situations.

In this paper, we aim to evaluate how time variability in replenishing the supplies can affect military units during an operation; we hope to discover how to best organize the replenishment service of operating units. We suppose a central replenishment source and K scattered military units – each facing different pressures. The central source has sufficient supplies to cover any demand of the supported units, which communicate with it when

the fire power is critically limited. The normal time of replenishment varies, following an exponential distribution with a mean value μ_1 . Unpredictable events result in a delay of replenishment, which then follows an exponential distribution with a mean value μ_2 . Thus, the variability of replenishment time can be expressed as a Coxian distribution with two phases (1st phase: normal replenishment, 2nd phase: replenishment facing difficulties).

We based our modeling on Markov stochastic processes, which allowed us to evaluate different scenarios, each with certain parameters in place, such as:

1. spot of replenishment of each team s_i , where $i = 1, 2, 3, \dots, K$,
2. quantity of supplies q_i each unit demands,
3. mean time value of normal replenishment μ_{i_1} ,
4. mean time value of delayed replenishment μ_{i_2} ,
5. probability of unpredictable events occurring d_i ,
6. rate of consumption λ_i for the team.

Keywords:

Two-echelon defence supply network, performance measures, Markov analysis, split system

2nd Presentation

TITLE: **Applying Life Cycle-Cost to the Army's Weapon Systems**

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ABSTRACT: The Life Cycle Cost (LCC) is the procedure of the total cost estimation of an army weapon system. This cost comprises the cost of buying, maintaining and disposing the weapon systems and is based in two

pylons. The first one concerns the procurement of them and the second one the control of the existing weapons in the army's logistic system. The LCC must be one of the fundamental factors in decision makers. Under this prisma Hellenic army created an application which provides information for all the factors that affect the cost of the weapon systems.

Keywords:

Cost effective, procurement, maintenance, disposal

3rd Presentation

TITLE: **Modeling and Optimization of Integrated Picking and Sorting Warehouse Operations**

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ABSTRACT: This work introduces the mathematical formulation of a new combinatorial optimization problem arising in warehouse management practice. A hybrid metaheuristic-dynamic programming algorithm is proposed for the solution of the problem.

In large warehouses the two most time consuming tasks involved in order preparation are the picking of items from different warehouse positions and then the sorting (or packing) of the aggregated items at the dock exits for loading and dispatching. Order picking is considered to account for more than 50% of the warehouse operating costs (Facilities Planning. John Wiley & Sons, 2003). Organizing order picking in batches is a common approach for minimizing the total makespan. An efficiency curve shows that the relationship between the picking standard rate and the packing standard rate is important (IIE Transactions 2003, 35, 589–603). It is also shown (Int. J. Prod. Economics 2009, 121, 654–664) that the impact of workforce allocation is decisive for the optimal throughput time. There is a considerable trade-off between the picking efficiency and the sorting cost (J. Man. Tech. Man 2011, 22, 261-282). Through an integrated optimization approach, an optimal balance of batching and sorting can result in

significant time savings. Literature on optimization methods for order picking operations has so far neglected the contribution of sorting time to the total makespan.

The present work first introduces an integer linear programming formulation of the optimal throughput time calculation problem, which includes time windows, sorting times and TSP sub-problems with bin packing constraints. Because of its TSP component and the bin packing constraints, this problem is NP-Hard. Therefore no polynomial time algorithm is available for solving it, except for special cases (Operations Research 1983, 31, 507- 521) and (EJOR 2001, 133, 32–43). The present work develops an efficient hybrid metaheuristic-dynamic programming algorithm. The algorithm combines an evolving generation of perspective solutions that represent ordered batches and a Threshold Accepting criterion for avoiding entrapment into local optima. Candidate solutions are coded with a custom made matrix representation and new solutions are generated using specialized crossover and mutation operators.

Results are produced for artificial and real life instances and compared to the performance of the algorithmic simulation of conventional practices. Computational experience shows reduction of customer order throughput time on the order of 10%, in affordable computational times. By reinitializing the group of orders that currently are not collected, the algorithm can readily respond to new orders arriving stochastically.

Keywords: *Picking, sorting batching, warehouse operations, metaheuristics*

4th Presentation

| | |
|----------|--|
| TITLE: | E-Actions in the Army |
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ABSTRACT:

The idea came to the surface when army's equipment, which is out of the logistics system, was in demand by civilians. In addition, the current financial situation in the country pushed the army's experts rethinking about the way army's old staff is handling. Therefore, the first e-Auction application was established.

Keywords:

E-Auctions, codification, competition

Session 5

Humanitarian & Relief Logistics

1st Presentation

TITLE: **Optimizing Freight Transport Operations in Humanitarian Military Missions**

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ABSTRACT: Transportation is the second largest overhead cost to humanitarian missions after personnel. It is thus critical to optimize the movement of goods in such manner that could lead to reduction of waiting times and high service level provision. This paper presents the design and implementation of a decision support tool that aims at supporting military staff to seek near optimal intermodal transport solutions for movement of supplies during humanitarian missions. The decision support tool takes into consideration significant parameters such as delivery cost, transportation time, and risk and develops transportation plans using related OR techniques, requests offers from registered transport operators, and monitors the delivery of goods. The paper presents also some initial results of the decision support tool from real-life cases.

Keywords: *Vehicle routing, relief logistics, network design, combined transport*

2nd Presentation

TITLE: **A Fuzzy Multicriteria Methodology to Assist Interagency Interaction in Relief Operations**

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ABSTRACT:

Humanitarian Assistance and Disaster Relief (HADR) operations place problems that are at the cross roads of many knowledge domains and involve many actors from Nations, International Organizations, Governmental Organizations, Non-Governmental Organizations, from several civil and military Departments.

HADR operations, and their logistic support, require a Comprehensive Approach (CA), i.e. call for Unity of Effort. The gaps and requirements for an effective implementation of the CA are thoroughly addressed in literature⁵. In a Gap Analysis done by the NATO Allied Commander Transformation the main category gaps for Civil-Military Interaction on what HADR is concerned were identified as being related with situational awareness, communication and information sharing, cultural awareness, education and training, planning and resources⁶.

Thus, HADR require strong Crises Management capabilities and this calls for decision support tools. Current technology offers the means (platforms and tools) to develop solutions that can contribute to deal with a

⁵ e.g., UNOCHA: **Guidelines on the Use of Military and Civil Defence Assets to Support United Nations Humanitarian Activities in Complex Emergencies** ("MCDA Guidelines"), UN Office for the Coordination of Humanitarian Affairs, 2003; also, NATO: **Strategic Concept For the Defence and Security of The Members of the North Atlantic Treaty Organisation**, 2010; also USJFCOM: **The Joint Operating Environment (JOE) 2010**, US Joint Forces Command; also C. Wendling: **The Comprehensive Approach to Civil-Military Crisis Management a Critical Analysis and Perspective**, Institut de recherche stratégique de l'École Militaire, 2010; also Simões-Marques M, Nunes IL: *Gestão de emergência. Desafios e impactos do conceito comprehensive approach (Emergency Management. Challenges and impacts of the Comprehensive Approach concept)*, in: C.Guedes Soares APT, C.Jacinto (eds.) Riscos, Segurança e Sustentabilidade, pp 203-220, 2012.

⁶ See ACT: **Civil-Military Interaction Gap Analysis Report**, HQ Supreme Allied Commander Transformation, 2010.

substantial part of the problem, but not all of it. One has to note that some key issues for the implementing a CA go far beyond technology and they relate, for instance, with organizational structure, policy, culture, values and will⁷.

This paper focuses in Emergency Management as an integral part of the HADR operations and addresses the main requirements to comply by emergency management systems considering both the desired level of interaction maturity among organizations and the characteristics of such systems. It further presents the SINGRAR (Integrated System for Priority Management and Resource Assignment) which is an emergency management model developed for implementing fuzzy distributed emergency management expert systems that

- (i) provide a common platform for the compilation of the incident status,
- (ii) include decision support system features that provide support for managing priorities of alternative courses of action based on the current operational context,
- (iii) support the command and control process,
- (iv) act as an expert system advising lines of actions, and
- (v) federate different databases which are used in conjunction with the knowledge base⁸.

Keywords:

Emergency management, fuzzy decision support system, humanitarian assistance and disaster relief, SINGRAR

⁷ See Simões-Marques MJ, Nunes IL: *A Fuzzy multicriteria methodology to manage priorities and resource assignment in critical situations*, in: Vasileios Zeimpekis, Soumia Ichoua, and Ioannis Minis (ed) **Humanitarian & Relief logistics: Research issues, case studies and future trends**, Series Operations Research/ Computer Science (ORCS), Springer, forthcoming.

⁸ See Simões-Marques MJ, Nunes IL: *A Fuzzy multicriteria methodology to manage priorities and resource assignment in critical situations*, in: Vasileios Zeimpekis, Soumia Ichoua, and Ioannis Minis (ed) **Humanitarian & Relief logistics: Research issues, case studies and future trends**, Series Operations Research/ Computer Science (ORCS), Springer, forthcoming; also, Simões-Marques MJ: *Sistema de Apoio à Decisão para a Gestão de Prioridades de Reparação de Equipamentos e Afectação de Recursos, em Navios, em Situação de Combate (A fuzzy decision support system for equipment repair priority and resource assignment management, in ships, under battle)*, FCT - UNL, Lisbon, Portugal, 1999; also, Simões-Marques MJ, Ribeiro RA, Gameiro-Marques A.: *A fuzzy decision support system for equipment repair under battle conditions*, **Fuzzy Sets and Systems** 115 (1)(2000)141-157; also, Simões-Marques MJ, Pires FJ.: *SINGRAR - A fuzzy distributed expert system to support Command and Control activities in Naval environment*, **European Journal of Operations Research** 145(2003) 343-362.

3rd Presentation

TITLE: **Military Enhanced Logistics Information System and Automations (MELISA): An Advanced Information System for Supply Chain Management**

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ABSTRACT: Modern supply chain management emphasizes the importance of IT technology and use of automation in complimenting materiel flows with relevant and up-to-date information flows, traceability of assets and proper coordination of logistics activities. The presenter shall demonstrate the MELISA Warehouse Management System –an information platform based on open source software utilizing standard portable devices, barcode and RFID technology- and describe HAF initiative and efforts to introduce and implement commercial best practices, applied to the specific demands of military logistics. The presentation shall also include multimedia demonstrating efficient and effective execution of standard warehouse operations and elaborate on the potential synergies and expected benefits of a full implementation of the system.

Keywords: *Military logistics, supply chain management, warehouse management system, barcode, RFID, portable devices*

Session 6

Portfolio of National Defense

1st Presentation

TITLE: **Military Applications of Portfolio Analysis:
A Literature Review**

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ABSTRACT: Allocation of large governmental budget proportions for national defense projects in several countries on a worldwide basis constitutes an apparent

observation and strategic choice of diplomacy. Thus, serious enhancement of military decision making technologies is a matter of paramount importance. Our purpose in this paper is to capture and classify all existing research activity concerning the application of portfolio analysis in military decision situations. We meticulously demonstrate actual and potential benefits of exploiting portfolio analysis in various types of military applications. The outmost aim of the study is to document that the modeling framework of portfolio analysis offers the most solid methodological basis for resolving the inherently complex nature of most military decision problems.

Keywords:

Military decision making, portfolio analysis

2nd Presentation

TITLE: **Combining Mathematical Programming and Monte Carlo Simulation to Deal with Uncertainty in Project Portfolio Selection**

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ABSTRACT: Mathematical Programming is the most common tool for modeling and optimization of various systems. Usually systems' planning and optimization assumes the knowledge of future situation which is usually known with limited certainty. Therefore, the parameters of the model (data which assumed to be known during the modeling process) have usually a degree of *uncertainty*. Various methods have been proposed for dealing with this uncertainty, the most common ones being fuzzy programming, chance constrained programming, robust programming, and stochastic

programming. In this work we consider the implied uncertainty in the parameters as being of *stochastic* nature. Each uncertain parameter is characterized by a probability distribution. Subsequently a *Monte Carlo* simulation samples the values from these distributions and the mathematical programming models with the sampled values are solved. This process is repeated many times (1000) in order to have an adequate sample for drawing robust conclusions. Relationships between the values of these parameters (i.e. interdependent parameters) can also be incorporated in the Monte Carlo process. In the current work we introduce the *Iterative Trichotomic Approach (ITA)* that separates the projects into three sets: the *green* set (selected under all circumstances), the *red* set (rejected under all circumstances) and the *grey* set (need further elaboration). This task is performed combining Monte Carlo simulation and Mathematical Programming. The whole process evolves in *decision cycles* and gradually enriches the green and the red set by exploiting additional information for the projects of the grey set. Eventually, the final output is not only the final portfolio, but also information about the certainty of participation or exclusion of every project in the final portfolio. A case study is elaborated in order to illustrate the method.

Keywords:

Project portfolio selection, capital budgeting, integer programming, Monte Carlo simulation

3rd Presentation

TITLE: **Defense Portfolio Analysis**

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ABSTRACT: Our study presents a systematic analysis and comparison of Portfolio Analysis (PA) methodologies relating to decision processes with respect to

the national defense of the U.S. Modern Portfolio Theory was introduced by Harry Markowitz with his paper “Portfolio Selection”. Portfolio Analysis is used by businesses to measure everything from money to performance. In general, successful companies, such as IBM, Microsoft, Motorola etc., take a disciplined approach to prioritizing needs and initiating a balanced mix of executable development programs. The PA decision-support process analyzed in the study is used by the U.S. Department of Defense (DoD) to allocate resources to satisfy national strategic goals.

Portfolio Analysis is the art of allocating scarce resources to satisfy strategic objectives, or determining how to best spend limited amounts of money. It also provides tools for organizing and managing a set of projects in a portfolio of projects in order to meet portfolio’s goals. A set of projects tracked across the entire portfolio in a timely and effective manner helps senior leadership make sound decisions, data-based decisions supported by analysis of cost, schedule and performance risks.

Keywords:

Defense portfolio analysis, decision-support process, resource allocation

Session 7 **Game Theory. Missile Allocation Strategies and
Target Coverage**

1st Presentation

TITLE: **Robustness of Fictitious Play in the Vehicle
Target Assignment Game**

AUTHORS: **Michalis Smyrnakis ⁽¹⁾**
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ABSTRACT: Decentralized optimization is a key topic in the theory and application of multi-agent systems, including sensor networks and resource allocation tasks. Because of the computational complexity of these problems and due to limitations on communication capabilities it is often intractable or impossible for a central decision maker to perform these optimization tasks efficiently and that a decentralized approach is instead more promising. It is now well known that decentralized optimization tasks can be represented as so-called “potential games”. An example of a resource allocation problem that can be cast as a game is the so-called “vehicle-target assignment problem” originally proposed by Marden et al. In this scenario there is a network of vehicles whose overall aim is to maximize a global reward, i.e the total number of targets the ensemble of vehicles will destroy. In order to do so the vehicles have to “negotiate” with each other and choose targets inside their respective sensing areas, keeping in mind the actions of the remaining vehicles in order to e.g. avoid duplication of targets.

Learning algorithms from the literature on game theory, such as fictitious play, can be used as coordination and negotiation mechanism for the vehicles. According to fictitious play algorithm agents maintain some beliefs about the other agents’ strategies and based on these beliefs they choose the action that maximizes their expected reward. In the case of potential games all the agents share the same reward function.

In this work we examine the robustness of fictitious play, when a fraction of non-cooperative players, s , choose a random or greedy action. In particular we will consider a version of the vehicle target assignment game where a fraction of agents decide to choose a random action instead of choosing to destroy a target that will maximize the expected global reward. This addresses situations in which there is e.g. a malfunction of some units. In our simulations we consider cases where the non-cooperative agents communicate their proposed action to the other agents and cases in which they do not announce their actions (e.g. in the case of a breakdown of communication). We measure the robustness of the fictitious play algorithm by comparing the global reward these configurations produce with the global reward agents could gain if all of them coordinate.

We test the robustness of fictitious play for instances for different values $0 < s < 1$ of the fraction of non-cooperative players (malfunctioning units) and for different numbers of available targets. In particular we vary the ratio b of the number of targets over the number of vehicles, $0 < b < 1$. We observe that there is always a critical value of s , up to this fraction of non-cooperating agents the performance of fictitious play is the same as if everyone were able to fully cooperate and communicate. Above the critical value of s the performance is affected. The critical value of s is found to depend on the ratio, b , of the number of targets over the number of vehicles. We also observe that for both cases, where non cooperative agents shared and did not share their action with others, for $s \leq 0.3$ and independently to the values of b we tested, the performance of fictitious play was the same as in the case where all the players were able to coordinate. We also observe that even if 60% of agents do not cooperate and share their information then the final reward will be the 85% of the reward of the case where everyone cooperates.

We believe that our model and results are applicable to a number of optimization and resource allocation problems with decentralized command structure and in which a fraction of units may fail to cooperate to act towards a common goal and/or in which communication structures may break down.

Keywords:*Fictitious play, learning in games, vehicle target assignment game*

2nd Presentation

TITLE: **Missile Allocation Models for the Attack of
Defended Targets**

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ABSTRACT: The models presented here are for the allocation of missiles to defended targets with a fixed force of imperfect defense missiles. The attackers will be directed first at the defense sites then at the targets themselves. The imperfect defenders are used against the attackers on a one-for-one basis as long as defenders remain. If any attacker penetrates the defense site, all the defenders at that defense site are destroyed. The problems addressed are the offensive problems of determining how many attackers to send to each defense site and to the target complex. The necessary mathematical relationships are derived and used to obtain graphical results.

Keywords: *Missile allocation models, imperfect defense missiles*

3rd Presentation

TITLE: **Information Warfare and Game Theory**

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ABSTRACT: In this short paper we present some examples of modeling the information Warfare as a game. Using Game theory we could find and determine the different requirements for an effective playing strategy. We will try to examine if different strategies are effective in achieving and

maintaining a dominating position in the long term when a single step game is repeated many times.

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Keywords:

Information warfare, dominate strategy

4th Presentation

TITLE: **A Hybrid Exact – Heuristic Algorithm for the Weapon Target Assignment Problem**

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ABSTRACT: The Weapon Target Assignment (WTA) problem is a fundamental problem arising in defense-related applications of operations research. This problem consists of optimally assigning n weapons to m targets so that the total expected survival value of the targets after all the engagements is minimum. The WTA problem can be formulated as a nonlinear integer programming problem and is known to be NP-complete. There do not exist any exact methods for the WTA problem which can solve even small size problems (for example, with 20 weapons and 20 targets).

Though several heuristic methods have been proposed to solve the WTA problem, due to the absence of exact methods, no estimates are available on the quality of solutions produced by such heuristics. In this paper, we

suggest a hybrid heuristic – exact algorithm, where small sub-instances of large scale problems are heuristically singled out, then separately solved and finally their special solvability features are exploited to produce partially optimal results. Partial results are amended to satisfy weapon availability constraints and fit in the overall solution of the big instance.

We present computational results of our algorithms which indicate that we can solve moderately large size instances (up to 80 weapons and 80 targets) of the WTA problem optimally and obtain almost optimal solutions of fairly large instances (up to 200 weapons and 200 targets) within a few seconds.

Keywords:

Weapon target assignment, hybrid algorithms, metaheuristics, mixed integer non linear programming

5th Presentation

TITLE: **Quality Assurance Practices for Distant Supervision of Postgraduate Academic Projects**

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ABSTRACT:

Distant postgraduate (MSc) thesis guidance is not an easy task. Actually it is quite a complex process with high outcome uncertainty that requires increased teaching effort, advanced leadership skills and frequent feedback control measures. There are three parties involved. The first is the student who wishes to embark on this distant postgraduate thesis authoring challenge. The next is the industrial supervisor who conducts the distant mentoring and tutoring of the complete project. And the final party is the group of academic supervisors who conduct the final assessment of the work and assign a grade.

The need for distant postgraduate thesis authoring is enhanced quality of the thesis content. Because the industrial supervisor must be a subject matter expert on the thesis field, yet it is difficult to find an industrial supervisor who will be a member of the award granting institution. Thus an open international call for highly skilled industrial supervisors enriches the mentoring and teaching dynamic range of a University's Faculty. And this impacts overall well on the institution's quality of studies.

Distant teaching practices have characteristic differences and direct similarities with the field of virtual team collaboration. For example in usual virtual team collaboration schemes all members are very competent on the required subject through previous rigorous experience and employee profiling. Also there is a high degree of communication efficiency between the parties because of long previous professional interactions. Moreover those parties have a good understanding about leadership and project management issues. Additionally the final product of this collaboration is a group effort of all involved parties. The complementary of these issues characterize a postgraduate distant taught scheme. The industrial supervisor and student have great gaps of knowledge in the subject matter. And the teaching effort is required to bridge this gap and then enable the student to produce the postgraduate project material as a solitary effort. Moreover rigorous profiling of the student before the initiation of the distant collaboration is limited. On the other hand the main similarities are three. First a secure web server is required to host the teaching data of the project

and the feedback from the student. The other is the building of trust between the parties that must be cultivated in order to have a successful outcome. And the third is that failure management processes must be well established at the beginning of the project.

In this paper we argue that quality assurance practices must be in place in order to raise the distant postgraduate thesis authoring program's probability of success. We will prove our arguments by using quality assurance metrics which will in turn show the program's quality objectives. In detail we will analyze all the quality assurance verification and validation processes and audits that must be used in order to ensure the participation fitness and performance potential of supervisors and students alike. Finally we will present actual quality assurance results drawn from the running of this program at London South Bank University.

Keywords:

Industrial/Academic Thesis Supervision Scheme, distance learning, quality assurance metrics

Session 8

Scientific Computing and Applications

1st Presentation

| | |
|-------------------|--|
| TITLE: | Numerical Solution of the Defense Force Optimal Positioning Problem |
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ABSTRACT: In this paper we investigate the numerical solution of the defense force positioning problem in order to handle in an efficient way the forces of the attacker⁹. The scope is the minimization of the conquest territories¹⁰. The basic types of defense are the distributed static and the concentrated mobile defense. The defense forces should swoop rapidly to any point of the defense locus in order to protect their territories. The selection of the “optimal” defense forces position should be placed is a difficult problem and it aims at the minimization of enemy’s penetration. This minimization results to systems of non linear equations.

There are many classical methods for solving such systems. The most known one is Newton’s method which requires the computation of the inverse of the Jacobian matrix at every step. This can be avoided by solving an equivalent system of equations. Another well known algorithm for solving the previous non linear system of equations is Broyden’s method. Many other approaches, such as quasi-Newton methods¹¹, solve the system in a faster way by approximating the inverse of the Jacobian matrix

⁹ See N. J. Daras: **Operations Research and its Military Applications. Volume2. Issue2. Theater Missile Defense and Tactical Engagements of Heterogeneous Forces** (in Greek). Hellenic Arms Control Center (HACC), Athens 2007, pp. 143, <http://ekeo.gr/wp-content/uploads/reports/daras/operations2.pdf>.

¹⁰ See R. Gupta, **Defense Positioning and Geometry**, the Brookings Inst., Washington, DC, 1993.

¹¹ See C. Brezinski, *A classification of quasi-Newton methods*, Numer Algor, Vol. 33, 123-135, 1997

reducing significant the required complexity of the algorithm¹².

The main difficulty in all the pre-mentioned methods is the selection of the initial point, which has many times to be very close to the solution¹³. We study the behavior of the procedures for various initial points and small perturbations of the data in order to present stable procedures which compute efficiently the solution of the system of non linear equations, leading to the optimal selection of the position, on which the forces of the defender should be placed.

All the proposed methods are tested for various sets of data and useful conclusions arise. The algorithms are compared in respect of the computational complexity and stability through error analysis concluding to useful results.

Keywords:

Newton's algorithm, quasi Newton algorithm, optimal positioning of defense forces

2nd Presentation

TITLE: **Dimensioning of Electric Propulsion Motors for War-Ships Using Finite Element Method**

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ABSTRACT: The electrification of war-ship propulsion system is a very attractive solution, as it provides increased safety, survivability, maneuverability, precise and smooth speed control, reduced machinery space, low operation and maintenance costs, low noise and low pollutant emission levels. In this paper the basic principles of dimensioning for warships electric propulsion motors using finite element method are presented. The respective example which will be shown synoptically is a low rotational salient pole synchronous motor connected to the propeller axis directly (without gearbox). Finally, current trends for warships electric propulsion motors are reviewed shortly.

Keywords: *Electric machines, finite element method, warship*

3rd Presentation

TITLE: **Mathematical Approach of Electromagnetic Interference Analysis and Safety Radiation Zones Identification**

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ABSTRACT: From fourth generation fighter aircrafts to hand held soldier's equipment everything has to be designed with the state of the art technology in order for the army to be competitive. Despite though the great progress, there is no chance for any army to operate properly unless a variety of telecommunication systems are installed inside military bases. Therefore, after installation of a new system inside a site, it is important for it to operate without limitations caused by interference with the already installed systems and clockwise. Furthermore, the risk of personnel health exposed to electromagnetic radiation should be reduced in order to avoid unfavorable consequences.

In the current paper a modelling approach of systems interference analysis and electromagnetic radiation exposure identification, suitable for using inside a modern military base is described. A theoretical introduction is presented in the first part of the paper followed by a critical review of the regulatory regime. Then, the mathematical models are used in a real case scenario. Technical details and confidential information are purposely altered in order for our work to be unclassified. Different kind of environmental effects are considered. Furthermore the personnel of the military base are divided to two different categories, based on their duties, which are treated separately.

Characteristic results of interference are presented both for wanted and unwanted radiation frequencies. In addition, graphically presentation of the personnel safety zones is given. Identification of critical parameter values and some preliminary comparison with experimental measurements are included.

Keywords: *Interference, radiation safety zones, telecommunications systems*

4th Presentation

| | |
|-------------------|--|
| TITLE: | Optimal Operation of War-Ship Electric Power System Equipped with Energy Storage System |
| AUTHORS: | Kyriakos Tafanidis ⁽¹⁾ (Commander, Hellenic Navy General Staff) Konstantinos Tajidis ⁽²⁾ (Lieutenant, Hellenic Navy General Staff) George J. Tsekouras ⁽³⁾ Fotios D. Kanellos ⁽⁴⁾ |
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| ABSTRACT: | The electrification of war-ship power systems has become a very appealing alternative for the development of more efficient and environmentally friendly ships. Energy storage systems (ESS) will have a key role in such systems as they can lead to fuel consumption reduction and increase overall ship efficiency and reliability. In this paper the operation of a war-ship power system equipped with ESS is analyzed from the economical point of view. The proposed method leads to a Lagrange non-linear mathematical equation and the respective solution could be a convenient tool for the technical-economical assessment of such systems. It |

is applied to total load demand of Hellenic Navy MEKO type frigate indicatively and the usefulness of the respective results for the power system operation are commented.

Keywords:

Economic dispatch, war-ship power system, energy storage system, system marginal cost

Session 9

Ballistics/ Modern Arming Systems

1st Presentation

| | |
|-------------------|--|
| TITLE: | Robust Flight Control Synthesis for Spin-Stabilized Fin-Guided Projectiles |
| AUTHORS: | Spilios Theodoulis Dr. Eng ⁽¹⁾ Thomas Brunner ⁽²⁾ Vincent Gassmann Dr. Eng. ⁽³⁾ Philippe Wernert Dr. Eng – Dpt. Head ⁽⁴⁾ |
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| ABSTRACT: | <p>This work details the design of a Skid-To-Turn autopilot for the pitch/yaw axes dynamics of a 155mm spin-stabilized, fin guided projectile concept. Two pairs of rotating canards are used as means of aerodynamic control of the weapon trajectory throughout its flight. The nonlinear dynamics of the system are initially given and then are linearized for any point of its flight envelope. This linearization results to a so-called <i>quasi</i>-Linear Parameter Varying (<i>q</i>-LPV) mathematical model which is subsequently used for the design of the flight control autopilot. The latter is designed using modern multivariable \mathcal{H}_∞ control theory and its goal is to ensure that the projectile airframe perfectly tracks desired reference acceleration signals issued from a guidance loop. For the implementation of the autopilot a so-called 2DoF fixed control structure is used: the feedback part ensures disturbance rejection whereas the feed forward part</p> |

ameliorates the model matching properties of the loop. The control law proposed is tested for robust stability with respect to modeling uncertainties on the aerodynamic coefficients of the system using μ –analysis and several simulation results are also given in order to illustrate the effectiveness of the proposed solutions.

Keywords:

Guided ammunition, robust control, LPV modeling

2nd Presentation

TITLE: **Joint Theater Missile Defense Interoperability**

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ABSTRACT: Global proliferation of weapons of mass destruction is tied to the rapid development of theater ballistic missiles. A Commander is faced with the problem of optimizing own-force theater missile defense assets as well as those of coalition partners. Underpinning the issue of theater missile defense resource allocation and employment are the problems of interoperability and integration of Joint Force, i.e., service component unique, Battle Management/Command, Control and Communications (BM/C3) systems into information architecture that support theater missile defense. The problem of BM/C3 interoperability is aggravated in coalition or multi-national warfare, where all theater missile defense players do not have equal access to information.

BM/C3 tactical data processors have embedded data correlation or data fusion algorithms as the “brain” of the system used to develop a common picture of the battle space. These data correlation algorithms may take the form of mathematical equations or logical rules. The differences between data correlation algorithms is reflected as differences in the common picture displayed in a BM/C3 system among the various theater missile defense players and the Commander.

Keywords:

Theater, ballistic, missile, defense, interoperability, global command and control system, theater missile defense

3rd Presentation

TITLE: **Pitching and Yawing Motion Analysis of a Spinning Projectile Firing Sidewise from a Helicopter Machine Gun**

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ABSTRACT: The present study investigates the pitching and yawing motion phenomenon of rotationally symmetric projectiles applying the 6-DOF free flight dynamic simulation modelling for small-yaw along flat-fire trajectories. The computational results are compared with the corresponding classical second order linear differential solution. The solution shows that the pitching and yawing motion of a symmetric projectile is epicyclic in nature and consists of two modes, or arms, that rotate at different angular velocities, or frequencies. The ammunition will be used for the epicyclic motion investigation is the .50 API M8 bullet firing from M2 machine gun on high-speed subsonic helicopter launched horizontally from different firing angles. This analysis contains all the significant aerodynamic forces and moments that affect the above epicyclic parameters.

Keywords: *Bullet projectile type, computational trajectory simulation, epicyclic analysis, pitching and yawing motion, symmetric projectiles, subsonic helicopter*

4th Presentation

TITLE: **Submarine Launched ICBM Trident II D5 and Conventional Trident Modification**

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ABSTRACT:

This work concerns the submarine launched Intercontinental Ballistic Missiles (ICBM) and especially the Trident II D5. The first ballistic missile developed during the 2nd world war from German and is known as V2 or A4, its creator was Walter Dornberger. It's first succeed launch was on 3rd October 1942 and its mass production began in 1944. Ballistic missiles can be launched from fixed sites or mobile launchers, including vehicles (transporter erector launchers, TELs), aircraft, ships and submarines. The first practical design of a submarine-based launch platform was developed by the Germans near the end of World War II. Ballistic missile submarines have been of great strategic importance for the USA and Russia and other nuclear powers since the start of the Cold War, as they can hide from reconnaissance satellites and fire their nuclear weapons with virtual impunity. This makes them immune to a first strike directed against nuclear forces, allowing each side to maintain the capability to launch a devastating retaliatory strike, even if all land-based missiles have been destroyed. **UGM-133 Trident II**, or **Trident D5** is a submarine-launched ballistic missile, built by Lockheed Martin Space Systems in Sunnyvale, California, and deployed with the US and Royal Navies. It was first deployed in 1990, and is still in service. It carries four nuclear warheads up to 475 kt each one. The US program would have converted existing Trident II missiles (presumably two missiles per submarine) into conventional weapons. The U.S. Navy in August plans to conduct a flight test of Trident submarine-launched ballistic missile technologies modified for conventional strike operations. A second related flight test is scheduled for late 2012 or early 2013.

Keywords:

Missile, launch, trajectory, conventional modification

Session 10

Laser Radiation / Directed Energy Weapons

1st Presentation

TITLE: **Laser Technology. General Aspects-Suitable Lasers for Ballistic Defense**

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ABSTRACT: **General**

The concept of using lasers for ballistic defense has been initiated during the period of "Cold War". In 1962 U.S. Pentagon proposed their use in order to confront the nuclear threat. In 1979, a tremendous advance in the specific field has been achieved with the U.S.'s SDI (Strategic Defense Initiative) program, widely known as "Star Wars". Nowadays, the wide spread of weapons of mass destruction led U.S.A in the development of the ballistic defense program called NMD (National Missile Defense). The intension of this program is to shield the whole Country from the threat that comes from incoming large or medium range ballistic missiles that carry nuclear, biological or chemical cargo. In order to make an effective missile defense, laser technology was the base for the development of the required technological innovations in the scientific field of directed energy weapons.

A crucial factor in the design of a laser weapon system is the evaluation of the exact laser's energy that is necessary for the destruction of the enemy's missile. In order to destroy a ballistic missile with a laser beam, an over-heat, melting or evaporation of its' outer casing is needed. In order for this to happen, the laser system must concentrate the energy of the laser beam in specific spots of the missile and retain the aim and focusing of the laser beam stable for enough time so as to heat the material until the point of failure. The laser's effectiveness depend on the power of the beam, the duration of the pulse, the wavelength, the atmospheric pressure and temperature, the material of the missile, the velocity of it and the thickness of the outer material of missile's casing.

Lasers in the Ballistic Defense

a. The program "Space-Based Chemical Laser Program (SBL)" tends to hit enemy's ballistic missiles during their boost phase and before the re-entering of their independent warheads in the atmosphere. High power lasers are installed in space platforms and they can radiate a laser beam in ranges that exceed 4000 km. In the SBL chemical lasers HF (Hydrogen

Fluoride) are used. The laser's beam wavelength is between $2.7 - 2.9 \mu\text{m}$ and with specific manipulations it can radiate in $1.3 \mu\text{m}$.

b. The AirBorne Laser (ABL) is consisted of a Chemical Oxygen Ionide Laser – COIL, with power in the order of several MW, installed in a Boeing 747-400F, with an operational altitude over 40000 ft ($\sim 12\text{km}$), providing it with the capability of destroying enemy missiles during their boost phase. The excited Iodine atoms are responsible for the transmission of a laser beam in the wavelength of $1.315 \mu\text{m}$ which is smaller from those of HF and DF lasers. The advantage of this laser is that it permits the use of smaller optics than those used in other high energy lasers. Additionally the laser beam is propagated in the atmosphere with fewer losses due to absorption from water vapor molecules with respect to HF laser.

c. An initial design for the Ground Based Laser (GBL) is consisted of the installation of a number of lasers on ground and the retransmission of the laser beam towards the target through special reflecting mirrors that are in an orbit around the globe. In order for the laser beam to penetrate the atmosphere with significant losses due to atmospheric absorption, the laser type is DF or COIL, with a wavelength between $3.5 - 4 \mu\text{m}$. The required laser power has to be somewhere around 15.7 MW.

d. The Mid Infrared Advanced Chemical Laser (MIRACL) is one of the most powerful laser systems designed for military applications. It is a DF chemical laser Continuous Wave – CW, with a power output of several MW, that operates in 10 different lines of the electromagnetic spectrum between $3.6 \mu\text{m}$ and $4.2 \mu\text{m}$.

e. In the Tactical High Energy Laser (THEL) the type of laser is DF and it is designed to protect ground forces against the threat of incoming small range rockets, artillery projectiles and Anti-tank projectiles. The laser beam can heat steel up to the melting point, from the minimum distance of 200 m.

f. The Free Electron Laser (FEL) can operate in wavelengths from UV up to mm. It is based on the transmission of an electron beam inside a variable magnetic field which forces the beam to oscillate and to emit radiation. The FEL is designed to hit missiles towards sea targets. It has a range from 5-10 km. The typical output power of FEL is $\sim 1\text{MW}$.

Laser Beam and Atmosphere

The influence of the atmosphere in the laser's beam propagation is one of the most crucial factors in order to understand its capabilities. While in space the propagation of radiation is almost 100%, the propagation in the atmosphere depends on the wavelength of the laser beam. The reasons for the attenuation of the radiation in the atmosphere are scattering and absorption from the air's molecules.

Additional problems create the phenomenon of turbulence of the atmosphere. The difference in temperature and pressure in the atmosphere

have as a result the existence of different refractive indexes. This effect has a negative influence in laser propagation because the beam acts like it passes through various mirrors (convergent – divergent) and finally it loses not only its' focus but also its' intensity when it hits the target.

Finally, the thermal blooming takes place when the absorbed energy heats the atmosphere having as a result the decrease of the density and the refractive index. Through the atmospheric absorption, energy from the laser beam is transferred in air molecules which in turn they change energy state. This procedure creates a series of divergent mirrors that influence the divergence of the laser beam. Additionally this divergence decreases the intensity in the centre of the beam where the maximum power for the destruction of a target is anticipated.

Conclusions

Nowadays, in the unstable global environment and the dispersion of technology and weapons of mass destruction creates the necessity of a multi-level antiballistic defense. The development of laser systems for ballistic defense will complement the defense in Joint Operations Level while the medium term benefits from the cost of developing such systems will counterbalance the cost of the expensive guided missiles due to the fact that laser technology is difficult to overcome.

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Keywords: *Laser, ballistic defense, Space-Based Chemical Laser Program (SBL), AirBorne Laser (ABL) , Ground Based Laser (GBL), Mid Infrared Advanced Chemical Laser (MIRACL), Tactical High Energy Laser (THEL), Free Electron Laser (FEL), turbulence, thermal blooming*

2nd Presentation

TITLE: **Taming Intense Laser Fields and Deposition of High Powers at Remote Targets**

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ABSTRACT: During the last ten years the nonlinear propagation of intense short pulse lasers has been a subject of extensive study. Such strong lasers have a very spectacular propagation behavior in the form of self-guided intense laser and plasma strings (called filaments). Filaments can extend in the atmosphere over many kilometers delivering remotely high powers as well as secondary radiation fields. We will review the progress in the field with an emphasis on security and military applications. We will discuss research performed in Greece as well as in the frame of 2 big US Air force projects.

Keywords: *Lasers, strong field, filaments, THz radiation, non-diffracting waves, Airy beams, photonic lattices*

3rd Presentation

TITLE: **High Power Laser Radiation and Interaction with Matter: Fundamental Research and Military Applications**

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ABSTRACT:

The rapid development of high power laser systems over the last years has opened new perspectives in the battlefield. Lasers are frequently used in the tactical level as target designators/range finders. However, an extremely intense laser beam can cause damage when it hits on a solid target, thus providing the possibility to use lasers as directed energy weapons. For this purpose, we present a short overview of existing high power lasers worldwide, which emit in the infrared regime with wavelengths $\lambda \geq 800$ nm. Especially, we focus on ultra-short, strong laser radiation which is generated by recently developed solid state lasers and we discuss the potential use of such pulses for military purposes. Strong infrared laser pulses with few cycles interact with the molecules of the atmosphere, resulting to non-linear phenomena (focusing of the laser beam) and ionization of the propagation media (defocusing of the laser beam). The combination of the two competing phenomena leads to propagation of laser pulses over long distances, forming “laser filaments”. These structures are characterized by extremely high intensity and consequently sensitive electro-optical systems will hardly resist during laser impact. We provide an overview of the theoretical analysis of processes which appear during the laser interaction with matter and which occur in microscopic level, e.g. multiphoton atomic and molecular ionization, high harmonic generation. Furthermore, we investigate the role of the pulse parameters (wavelength, pulse duration and intensity) on the ionization process, using quasi-classical and quantum approaches. As ultra-fast laser technology advances towards longer wavelengths, in a regime highly interesting for military applications, we examine the atomic response during mid-infrared ($\lambda > 2000$ nm), few cycle, laser pulse radiation.

Keywords:

High power lasers, mid-infrared few cycle pulses, atomic/molecular ionization

Session 11

Geography of Modern Arming Technologies

1st Presentation

| | |
|-----------------|---|
| TITLE: | Geopolitical Consequences of the Chinese Revolution in Military Affairs |
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| ABSTRACT: | Within the framework of the presentation we will examine the weapon systems, operational methodologies, concepts, doctrines and war philosophies that constitute the so called 'Chinese RMA'. Also, we will examine how these Chinese innovative military capabilities can affect the global stability and security. The scientific paradigm that this presentation adopts is that of Chaos and Complexity (<i>ChaoPlexity</i>). Consequently, the potential influence of the 'Chinese RMA' to the international system will be examined within this framework. |
| Keywords: | <i>ASBM, ASCM, HEAT, A2 / AD, AirSea Battle, Aegis</i> |

2nd Presentation

| | |
|-----------------|--|
| TITLE: | New Weapon Technologies and their Operational Repercussions |
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| ABSTRACT: | During the last decade, and despite the fact that all over the world defence spending and the armed forces' structures are being constantly reduced, a new generation of highly advanced weapon systems utilizing exotic technologies are being developed by the international aerospace and |

defence industry. Weapon systems that in the past were hosted only in the science-fiction comics and movies today are rapidly approaching their maturity and their operational exploitation by the Armed Forces.

The introduction into service of these weapon systems will result in dramatic changes in the operational doctrines and tactics, a fact that dictates the in-depth study of the weapon systems and the respective technologies, in order to become part of the Hellenic Armed Forces' transformation.

Keywords:

Laser, high-power microwave, mobile nuclear power, direct energy weapons, robotics, cybernetics, biotechnologies

3rd Presentation

TITLE: **A New Future for the Hellenic Air Force (The Shape of Things to Come for the Hellenic Air Force)**

AUTHOR: **Dimitrios Stergiou (Journalist)**

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ABSTRACT: The Hellenic Air Force has been going through two major restructuring and modernization programs since the end of World War II. The first one was initiated in 1952 with the delivery of the first F-84G fighter jets and the second started in 1974 and ended in the early eighties. For more than 30 years (1980 up to the present day) the Hellenic Air Force did not manage to overcome its most important all time problem. The problem of having to sustain a large number of various aircraft types of different origin, age and capabilities. Despite the fact that no less than four F-16 variants were acquired from 1985 onwards, along with two Mirage 2000 batches, the Greek fighter fleet was never homogenized in order to produce better operational performance with much less cost.

In the mid nineties a decision was made for the first fighter modernization program (Peace Icarus 2000) in the history of the Hellenic Air Force. Today this option, meaning the modernization of the F-16 fleet,

along with the acquisition of a low cost, truly multirole fighter, seems the only alternative for the future. Not only for Greece but for many other countries with aggressive neighbors around the world... New state of the art and highly effective systems and weapons have been installed and certified on older fighters, enabling them to a round of operational life.

Keywords:

4th Presentation

TITLE: **Stealth: Reality and Fantasy**

AUTHOR: **Faidon Karaiosifidis (Defense Journalist)**

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ABSTRACT: Technologies about reducing the «signature» of weapon systems to various detection systems (electromagnetic, electro-optical, acoustic etc), known as «stealth» became wide known and skyrocketed to the world attention the first days of the first Gulf war, when F-117 strike fighters of the United States Air Force hit targets in Bagdad, in January 1992. But such technologies already existed for some decades, mainly in advanced aerial weaponry. From that point onwards, «stealth» became the tip of every weapon evolution program in all fields of warfare, aerial, ground and naval, and weapon systems of «low/very low observable» (LO/VLO) characteristics dominate all new designs. On the other hand, «stealth» technologies, mainly integrated into the structural design and manufacturing process is very difficult even impossible to evolve after been applied to weapon systems, opening the possibility that constant evolution of detection technologies will make very expensive stealth weapons and platforms obsolete. Since history in weapon technology and counter-technology repeats itself, were are looking into the reality and fantasy of «stealth», true promises and exaggerations of LO/VLO designs, successful technology applications and countermeasures, future trends and related weapon evolution.

Keywords: *Stealth, weaponry, low/very low observable, warfare, technology*

Session 12

Geography of Military Programs and
Special Operations1st Presentation

TITLE: **Thoughts About Asymmetrical War Scenarios in the Hellenic-Turkish Geopolitical System**

AUTHOR: **Konstantinos Grivas**

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ABSTRACT: Within the framework of the presentation we will examine how innovative weapon systems and warfare concepts and methodologies can influence the military balance between Greece and Turkey and how can undermine the Hellenic deterrence strategy. One of the factors that can have exceptional influence on the strategic balance between Greece and Turkey is the potential application of a 'projectile centric warfare' model, based on networks constituted of 'smart' and 'brilliant' projectiles of different kinds.

Keywords: *Ballistic missiles, antiballistic defense, TCS, LORA, SOM*

2nd Presentation

TITLE: **CONFRONTING IRAN. Military Options Against Tehran's Nuclear Program & A2/AD Strategy**

AUTHOR: **Evangelos Pagotsis (Defense Journalist)**

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ABSTRACT: In a September 27, 2012 speech before the United Nations General Assembly, Israeli Prime Minister Benjamin Netanyahu warned that, if not

blocked, deterred or convinced otherwise, at current rates Iran could reach the final uranium enrichment stage for a nuclear weapon by the spring or summer of 2013. With those dates rapidly approaching, the US and Israel being conspicuously silent on this issue and Tehran remaining seemingly undeterred, it is high time to examine military options for a preventive strike against Iran's nuclear facilities, as well as for defending against its retaliatory capabilities such as ballistic missiles, Anti-Access/ Area Denial (A2/AD) and proxy warfare strategies.

Keywords:

Enrichment, Natanz, Fordow, Esfahan, Arak, Ballistic Missiles, Hezbollah, Hamas, Sea Mines, Anti-Ship Missiles, Submarines, Speedboats, Swarm Tactics

3rd Presentation

TITLE: **The Course of Turkey's Ballistic Program**

AUTHOR: **Dimitrios Manakanatas (Defense Journalist)**

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ABSTRACT: During the past 25 years Ankara managed to put itself on the ballistic-missiles "map" through carefully planned actions and co-operations. The year 1988 was important for Turkey's missile program because US denied Turkey both a know-how transfer and a domestic production of the M26 missile of the MMS-MLRS system. Something that led Turkey to develop a similar system with Pakistan. Since then Turkey's important steps on the field of missile development culminated in the recent announcement for the construction until 2014 of a 2500 km-range new ballistic missile.

Keywords:

TBM threats and their determent, TR-300 Kasinga, J-600T Yildirim, Babur (Hatf VII)

4th Presentation**TITLE:** **The Future of the Hellenic Military Aviation****AUTHOR:** **Eythimios Petrou (Defense Journalist)****ADDRESS:** **9, Anthimou Gazi Str.
Athens 10561, Greece****E-MAIL ADDRESS:****ABSTRACT:** Within the framework of the presentation will be examined low cost solutions for the future Military Aviation of the Hellenic Army. More specifically will be examined how the Hellenic Military Aviation can extend the operational life of legacy systems using modernization technologies and potential low cost but innovative systems for aerial power projection and ISR tasks.**Keywords:** *'Huey' helicopters, Hydra rockets, dual use technologies, low cost power projection capabilities.*

Session 13

New Cryptographic Methods

1st Presentation

TITLE: **A Chaotic Random Bit Generator Based on a Logistic Map realized with a Microcontroller**

AUTHOR: **Christos K. Volos**

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ABSTRACT: In the last decades an interesting relationship between chaos theory and cryptography has been developed. This occurs because many properties of chaotic systems such as: sensitivity on initial conditions or system's parameters, ergodicity, deterministic dynamics and structural complexity can be considered analogous to the diffusion with small change in plaintext or secret key, confusion, deterministic pseudo-randomness and algorithmic complexity properties of traditional cryptosystems. As a result of this close relationship several chaos-based cryptosystems, which play important role especially in military operations because of the significant strategic advantage that these systems provide, have been put forward since 1990.

In one of the stages of the development of chaotic stream ciphers, the application of discrete chaotic dynamical systems in random bit generation has been widely studied recently. In this work, a novel Chaotic Random Bit Generator (CRBG) based on a well-known logistic map, which is realized by the Arduino, an open-source physical computing platform based on a simple microcontroller board, is presented. Finally, the generated by the proposed CRBG bit sequences are subjected to the most stringent tests of randomness, the FIPS-140-2 suite tests, to detect the specific characteristics expected of random bit sequences.

Keywords: *Chaotic random bit generator, chaos, Logistic map, discrete nonlinear map, Arduino microcontroller, FIPS statistical tests*

2nd Presentation

| | |
|------------------|---|
| TITLE: | Induced Quantum Ordered Phases in Correlated Nanostructures and the Fields of Spintronics and Quantum Computation |
| AUTHORS: | George Livanas ⁽¹⁾ George Varelogiannis ⁽²⁾ |
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| ABSTRACT: | In strongly correlated electron systems (compounds involving rare earths, perovskite oxides etc.) a number of quantum ordered phases emerge. Characteristic examples are various superconducting condensates possibly unconventional as in high temperature superconductors, various charge and spin density wave states, Pomeranchuk states, ferromagnetic states etc. It became evident in recent years that nanostructures involving these quantum ordered phases will be at the base of emerging or future technologies especially in the fields of Spintronics and Quantum Computation. We will first present a brief selective overview of some of the challenges in these fields and their potential practical implications. Finally, we will briefly present some of our results on induced quantum ordered states in correlated metals and nanostructures with emphasis on the novel possibilities they provide in the above fields. |
| Keywords: | <i>Superconductivity, magnetism, spintronics, quantum computation, correlated electron systems</i> |

3rd Presentation

| | |
|----------|--|
| TITLE: | Cryptool 2 Software in Teaching Cryptography |
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ABSTRACT: Considering the value it had in the past, has continued to the present and will continue to have, perhaps to an even greater extent in the future concealing information during transmission or transport, leads automatically to attempt to discover the importance and the value of the means, methods and techniques used to implement the concealment.

Cryptography is a branch of computer science attracts the attention with its great utility that has nowadays. Given therefore deemed necessary to standardize, analyze and present the encryption algorithms to learning and training on the operation with as efficiently and easily as possible. Having in mind that the theory must be accompanied by practice and examples that help to consolidate the syllabi material, we felt that the analytical presentation of an educational tool on learning algorithms of cryptography is a way of learning while embedding.

The learning tool cryptool 2 is an implementation of all the above, and through this we will try to show, those essential functions, which help the user with visual and practical way, to see in detail all the properties and functional details of the algorithms contained, will present representative examples of functioning algorithms, we proceed to create digital signatures and will implement the cryptanalysis algorithms.

The above is an object of study and teaching in the professional area of land, in the field of communications and transmissions-service systems.

Knowing, however, that historically since the antiquity, first we Greeks, we use encryption in a simple form, for military purposes, but later down through the years and fighting wars around the world, the art encryption and decryption evolved and became object of all armies and weapons. This created great interest, mobilizing science and development of complex thinking that eventually evolved into an autonomous discipline.

Keywords: *Cryptography, Algorithms, AES, DES, RSA, Hash Function, Cryptology*

Session 14 Cryptology and Computational Number Theory**1st Presentation**

TITLE: **On the Representation of the Number of Integral Points of an Elliptic Curve Modulo a Prime Number**

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ABSTRACT: It is important in cryptography to know the number of integral points of an elliptic curve modulo a prime number in order to evaluate the difficulty of solving the discrete logarithm problem in the group of points of an elliptic curve.

In this talk, we shall investigate the problem of the representation of the number of integral points of an elliptic curve modulo a prime number p . In particular, we present a way of expressing an exponential sum which involves polynomials of third degree in explicit non-exponential terms. In the process, we present explicit formulas for the calculation of some series involving the Riemann Zeta function.

Keywords: *Elliptic curves, integral points, Discrete logarithm problem, Riemann Zeta function*

2nd Presentation

TITLE: **Studying Elliptic Curve Cryptography**

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ABSTRACT:

Cryptographic schemes based on elliptic curves are considered to be an important part of public key cryptography in today's applications such as more and more scientists have been involved in their study. The main advantage of these systems compared to conventional cryptographic systems is that they use less parameters and keys, while they offer the same level of security.

This paper stands for the following researching objectives:

- a. The idea of the elliptic curve cryptography.
- b. The advantages and disadvantages of ECC.
- c. The applications and implementations of the ECC.
- d. The use of ECC schemes in the on the fly cryptography.
- e. The integration of an already developed ECC algorithm in an on the fly open source application.

In order to achieve these, this paper consists of 4 parts; The first one presents the fundamentals of the elliptic curve cryptography and its advantages-disadvantages, the second outlines their applications focusing on military systems, the third one presents the implementation of an ECC library in the true crypt software and the last one proposes conclusions and future research.

The methodology used in order to answer the aforementioned researching objectives is the following:

1. Researching and presenting the related cryptographic methods, and especially the way that ECC cryptography works
2. Researching the application of the ECC methods focusing on military applications.
3. Integrating one ECC library in the truecrypt open source software, in order to ensure on the fly encryption by these methods.

The conclusions of this work are expected to be the presentation of the elliptic curve cryptography methods applied to military and other systems, as well as the adaptation of an on the fly open source suite using ECC schemes.

Keywords:

Elliptic curve cryptography, true crypt , on the fly encryption

3rd Presentation

TITLE: **A Short Exposition of Topological Applications to Security Systems**

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ABSTRACT: For many years algebraic topology has been considered as an abstract mathematical field with none or few practical applications. But as history has shown over and over again even the most abstract mathematical idea might find unexpected applications in real-life problems. That is what is happening in the last couple of years with algebraic topology. Theories and techniques created by mathematicians in order to answer abstract problems are being used to answer problems such as protein docking, image analysis, data analysis and space coverage by sensor networks.

This article focuses, mainly, on the last two cases i.e. applications of algebraic topology to sensor networks and data analysis. A brief introduction to the necessary mathematical background is given in the beginning of the article. Then an exposition of results of various researchers follows. Some of the results are:

- criteria for deciding if a network of simple sensors (for example sensors with no positioning capabilities) covers a given area,
- techniques for detecting sensors around a hole in the network's cover,
- ways for finding redundant sensors in a network and thus placing sensors in standby mode without affecting the network's coverage,
- ways to infer important characteristics of an object from a sample of its points,
- data clustering techniques.

Keywords: *Persistent homology, Euler integration, sensor, coverage, data analysis*

4th Presentation

TITLE: **Balanced Integer Solutions of Linear Equations**

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ABSTRACT: We use lattice based methods in order to get an integer solution of the linear equation $a_1x_1 + \dots + a_nx_n = a_0$, which satisfies the bound constraints $|x_j| < X_j$.

Keywords: *Linear Equations, lattice reduction, LLL, closest vector problem*

Session 15**Cyber War/Security****1st Presentation**

TITLE: **Challenges and Objectives for the National Cyber Security Beyond 2020**

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ABSTRACT: While the prediction of cyberspace future landscape is quite difficult, Greece must seek to define the potential threats and understand the forces that are formulating the national, regional but also the global future of Cyberspace in order to modulate influence and adapt to these changes. As we look toward 2020 and beyond, it is crystal clear that there are significant challenges, issues and functions that might need to be taken under consideration. However, in order Greece to form an effective cyber defense strategy, a significant number of future challenges need, to be taken into account. Till now independent practical steps and incoherent cyber defense initiatives are under implementation. The majority of NATO nations but also a significant number of non-NATO nations developed their own national strategies in order to establish an efficient and effective response mechanism and roadmap for the future. The answer for Greece to all these future requirements, is a comprehensive mid-term strategic framework, through which the nation will guide its activities and will react to all changes and advances in technology, in order to actively meet both the threats and opportunities. Greece requires an “early warning-early response” cyber defense strategy in order to articulate the framework to 2020. The goal must be to keep technological efficiency and effectiveness in close cooperation and coordination with our allies and other critical stakeholders, in order the nation to be able to respond faster than vulnerabilities and threats will be exploited. Through this roadmap Greece will meet its vision for a safe, secure and resilient cyberspace and will

establish a strong foundation for all efforts in the future full of challenges
complex cyberspace environment.

Keywords:

Cybersecurity, strategy, cyber-defense, cyber space, cyber terrorism

2nd Presentation

TITLE: **The Use of Body Motion Analysis as Method for
Personal Identification**

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ABSTRACT:

Introduction

There is limited evidence to suggest an optimal biometric method in order to achieve an enhanced level of information security as well as recognition accuracy¹⁴. Recently, novel approaches for the development of practical biometric identification systems have shown that body motion analysis seems to overcome most of the risks and vulnerabilities related to security and privacy and also characterized by simplicity and precision.

Purpose

This study examined the ability of a body motion analysis system to accurately identify individuals throughout specific periods of time.

Methods

Specifically, sixteen males have performed three trials throughout a single day as well as pre and post an eight-week period. A high speed (800 frames /s) video camera was used to collect recordings of the sagittal plane of a full stride (two consecutive steps), sampling at 250 Hz. Analysis of the video data was performed using a digitizing hardware system¹⁵. After video analysis, various kinematic variables related to foot motion (total time, stride rate, stride length, flying time, contact time, velocity) were compared in order to measure body motion analysis' recognition efficiency. These kinematic variables are the inputs for a classical artificial neural network (ANN)¹⁶, which is used for the person's recognition. The output is the identity of the person.

The ANN's is optimized regarding the values of crucial parameters such as the number of neurons, the time parameter and the initial value of the learning rate, etc. Using the evaluation set. The evaluation criterion is the successful percentage of the person's identification. RESULTS: Statistics showed that trials' variations throughout day and the eight-week period for most kinematic variables were small, indicating high data reproducibility.

The respective initial ANN results are encouraging and indicate an increased efficiency of body motion analysis on personal identification. In

¹⁴ See Cavoukian A, Stoianov A. Biometric Encryption. In: *Encyclopaedia of Biometrics*, Li SZ (Ed), Toronto, Ontario, Canada, 2009, Springer, 1-14

¹⁵ See Paradisis G, Cooke CB. *The effects of sprint running training on sloping surfaces*, **J Strength Cond Res.** 20(4) (2006), 767-777

¹⁶ See Tsekouras GJ, Hatziaargyriou ND, Dialynas EN. *An Optimized Adaptive Neural Network for Annual Midterm Energy Forecasting*, **IEEE Transactions on Power Systems**, 2006, 21(1)(2006), 385-391

future, more measurement-trials per person during the reference period time and a larger participant sample may allow the results' generalization. It is also suggested that in order to obtain fast and accurate biometric identification even after a relatively long period of time, one may prefer body motion analysis over other biometric methods.

Keywords:

Artificial neural network, body motion, person identification

3rd Presentation

TITLE:

Consensus Algorithms within the C4ISR Architecture

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ABSTRACT:

Ubiquitous computational devices, usually referred as agents, sense their environment, collect data and disseminate them with various degrees of precision and trust. The state where every agent has the average knowledge of all agents in the area is called average consensus. This is a typical distributed objective in these systems with numerous industrial and military applications.

This paper reviews the recent theoretical developments in the area of distributed consensus with applications to unmanned vehicles navigation and discusses their integration into the C4ISR architecture. Simulation results are presented and evaluated. Future applications are considered with the adoption of more enhanced control methods.

Introduction

Distributed systems analysis and design is an active area of research

with both commercial and military applications. C4ISR architecture is a framework issued by the Department of Defense (DoD) to provide a standard approach to deal within the complex virtual and real digital environment with emphasis to military distributed applications¹⁷.

Every node or agent in this environment collects this information and tries to achieve the knowledge of all the other despite the noise, malicious interference etc. The communication is based on message passing to neighbor nodes with or without infrastructure. The most common approaches propose control algorithms to accelerate and tune the overall performance¹⁸.

The applications are numerous in transportation systems¹⁹, mobile robots²⁰, military applications²¹, etc. Artificial intelligent algorithms derived from biology like fuzzy methods and artificial neural networks have been used in distributed models²².

Objectives

A theoretical background of the consensus problem in distributed systems is formally defined in both continuous and discrete time systems. The lack of a global clock is mentioned and is managed using the notion of “happened-before” concept of Lamport logical clock²³.

The network is described as an indexed set of nodes and links that connects them. If all nodes are connected to all other nodes, the networked is called fully connected mesh network. In most cases the nodes are

¹⁷See A.H. Levis, L.W. Wagenhals: *C4ISR architectures: I. Developing a process for C4ISR architecture design*, **Systems Engineering**, 3(4)(2000)225-247. See also, BP Zeigler, S Mittal: *Enhancing DoDAF with a DEVS-based system lifecycle development process*, **IEEE Trans on Systems, Man and Cybernetics**, 2005.

¹⁸See P. Yang, R. A. Freeman and K. M. Lynch: *Multi-Agent Coordination by Decentralized Estimation and Control*, **IEEE Trans on Automatic Control**, 53(11) (2008)2480-2496. See also S. Kraus, et al.: *A Study on Gossiping in Transportation Networks*, **IEEE Trans. on Vehicular Technology**, 57(2008)2602-26037.

¹⁹See S. Kraus, et al.: *A Study on Gossiping in Transportation Networks*, **IEEE Trans. on Vehicular Technology**, 57(2008), 2602-2607.

²⁰See A.N. Tsapanoglou, D.P. Iacaleous: *Fuzzy Tuned Gossip Algorithms in Mobile Ad Hoc Networks*, **17th Mediterranean Conference on Control and Automation, Makedonia Palace**, Thessaloniki, Greece, June 24-26, 2009.

²¹See N. Doukas, A. Drigas and N. G. Bardis: *Design of an Interactive Game for Teaching War Ethics*. In “**Technology Enhanced Learning. Quality of Teaching and Educational Reform Communications in Computer and Information Science**”, Springer-Verlag, Berlin Heidelberg, vol. 73(2010), pp. 558-564. See also N. Bardis, A. Drigas, N. Doukas and N. Karadimas: *Optimised Information System Reliability Techniques for Knowledge Society Acceptance*, **Int. J. Knowledge and Learning**, 5(3/4)(2009)207-221.

²²See A.N. Tsapanoglou, D.P. Iacaleous: *Fuzzy Tuned Gossip Algorithms in Mobile Ad Hoc Networks*, **17th Mediterranean Conference on Control and Automation, Makedonia Palace**, Thessaloniki, Greece, June 24-26, 2009.

²³See B. Sundararaman, U. Buy, A.D. Kshemkalyani: *Clock synchronization for wireless sensor networks: a survey*, **Ad Hoc Networks**, 3(3) (2005) 281-323.

connected to a small portion of neighboring nodes due to physical obstacles and the limited range of the antenna. In this context, connection is considered as bilateral.

The nodes are modeled using suitable communication transition matrices. Conventional or evolutionary control methods can be used to design the feedback and control input functions as well as time or energy constraints. The problem derives to an optimization

Methodology

Consensus can be studied using experimental and simulation methods. A mathematical model is used in the simulation and compared to experimental data. Furthermore, evolutionary algorithms are used to compensate the noisy environments and the random messaging errors.

Main results

A typical network of five nodes or agents is used. If the agents are still, the model is static and if they move, in any new arrangement may result to possible delays or isolations.

The network is described in the C4ISR architectural with equivalent principles using UML elements in the three views, namely operational, system and technical. The representation of the system response is interpreted accordingly to every architectural view.

Evaluation and conclusion

The consensus algorithms are placed in the C4ISR architecture. The simulation results are compared in a variety of control methods and considered satisfactory. Finally, guidelines to applications and their interpretation in military environments are discussed.

Keywords:

Distributed algorithms, consensus, performance evaluation and control in multi-agent systems, C4ISR architecture, DoD application framework

4th Presentation

TITLE: **The RFID's Security with a Critical View**

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ABSTRACT:

Traditionally, RFIDs have been used to identify assets, objects which have some value. They have become a durable equivalent of the barcode for container tracking. First invented in the 1940s this technology began to be expanded in the 1980s due to its falling prices. Today's RFIDs are in a lot of application that need identification.

This paper regards the RFID security reviewing with a critical view of the existing literature on the corresponded field.

The followed method as also the structure of this work is the following:

1. First at all, in order to understand RFID technology, it is considered to be important to have a briefly presentation of the fundamentals of RFID.
2. A brief presentation of the security properties that RFID must service as also a brief presentation of the potential dangers, attacks and methods, is consider to be necessary.
3. The presentation of the existing security protocols and techniques, focusing on the latest one proposed comes next.
4. Every section-technology is accompanied by comments. At the end of the paper, reader can find a total overview.
5. At the end of this paper the vulnerabilities of the RFIDs are proved through the presentation of an RFID virus always with an engineering view.

In order to achieve these, this paper consists of 5 parts; The first one presents the fundamentals of the RFID, the second describes the characteristics of the malware and the corresponded solutions, the third one outlines the existing security technology (policies and protocols) that applied on RFIDs, with a critical approach, the fourth points out some vulnerability's examples in action and the last one proposes conclusions and future research.

Useful conclusion comes up through this paper. Considering the range of the implementations of the RFID, security is an essential element of the

total project. Many policies, algorithms, protocols have come out in order to protect RFID from corresponded attacks. The limitations due to limited memory of the tag exist, but the outgoing work is going to fix this.

Authentication protocols for RFID tag/reader are important both for secure implementations as well as for allaying consumers' concerns with regard to their privacy/security in environments involving RFID tags.

The engineering part of the current paper proved that RFID are in danger in case of use, this must be taken in serious consideration.

Keywords: *RFIDs, tag, reader, security*

5th Presentation

TITLE: **Voice over Internet Protocol**

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ABSTRACT: The aim of this project is to illustrate the interconnection of common telephony centers through the Internet, as well as to understand Voice over Internet Protocol (VoIP) technology and the importance of its application by the military.

Voice over IP or telephony via the Internet, characterizes a set of protocols/technologies [H.323, Session Initiation Protocol (SIP)], which provide vocal conversation in real time with relatively good quality at little or no cost, thanks to worldwide broadband connections. Traditionally, such conversations took place exclusively through a PC which was connected to the Internet and with the aid of a microphone, headphones and the appropriate software (soft phones). The call ended up in another similarly equipped PC at no extra charge other than the one needed to access the Internet, since this specific type of communication does not require a provider of standard land-line services, but only the Internet.

In addition to this, there are autonomous telephone devices (VoIP SIP Phones) and analog telephone adaptors (ATA) on the market which directly connect to an IP network, like the Internet. With the right adjustments and

assembly and without the need of a PC, use of this service is facilitated making VoIP even more accessible to its users.

The object of this presentation is the study, realization and operation of an initially autonomous system of telephony via the Internet protocol (VoIP) and subsequently, its connection to other telephony systems (either via the Internet or traditional telephony), for their intercommunication, using the advantages of VoIP.

First, the existing phone network [Public Switched Telephone Network (PSTN)] as well as its development is retraced. Then, VoIP technology is analytically presented along with its functions, protocols used, as well as its advantages and disadvantages. The quality of the service (QoS) offered by VoIP and the factors that affect its quality are also studied. As we continue, the importance of IP Private Branch eXchange (PBX) and the additional services they provide will be presented. In conclusion, an application of VoIP for military use will be executed so as to enable the military to reap the benefits it offers.

Keywords:

PSTN (Public Switched Telephone Network), VoIP (Voice over Internet Protocol), SIP (Session Initiation Protocol), H.323 Protocol, QoS (Quality of Service), PBX (Private Branch eXchange), IP sec (Internet Protocol security)

Session 16

Statistical Modeling and Applications

1st Presentation

TITLE: **Interval Reliability of Discrete Time Semi-Markov Systems**

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ABSTRACT: Reliability modeling was first brought into use during the World War II in order to achieve certain operational requirements. So far, dependability measures (i.e. reliability, availability, maintainability, safety, etc) have been applied to various activities of a military organization, such as the operational planning, the maintenance function or the supply activity. Considering a repairable equipment or system (e.g. an aircraft), we may be interested if it is available for a particular mission or if it successfully completes this mission. System malfunctions or deterioration can be the underlying cause of all the planning.

Two of the most important and used dependability measures are the *reliability* and the *availability* functions, and they have been addressed as essential elements of mission capability. Reliability is given as the probability of the equipment or system functioning without failure, when operated as prescribed for a given interval of time, under stated conditions. Availability is a measure of the degree to which an item is in an operable state and can be committed at the start of a mission when the mission is called for at an arbitrary fixed point in time. An alternative measure called *interval reliability* has been proposed in order to generalize the reliability and availability measures, defined as the probability that a system is in

operation at a point in time and will continue to operate over a finite-length observation interval.

The evolution of a system is modeled by a stochastic process in continuous or discrete time, whose finite state space is partitioned into two disjoint subsets: the subset of operational and non-operational states, respectively. Finite Markov models have been extensively used as a standard tool to describe a systems behavior. Relaxing the Markovian hypothesis, the so-called *semi-Markov* models can be applied. Here, the evolution of a repairable system is assumed to be modeled by a discrete time finite semi-Markov process.

The reliability semi-Markov model is presented and the interval reliability is derived. Moreover, the limiting interval reliability is given. A numerical application is provided to illustrate the applicability and the flexibility of the interval reliability.²⁴

Keywords: *Semi-Markov model, interval reliability, availability, reliability*

2nd Presentation

TITLE: **Optimal Preventive Maintenance of a Production-Inventory System when the Action of "Idling" is Permissible**

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²⁴ Here are some general references:

- [1] Barbu, V. S. and Limnios, N.: **Semi-Markov Chains and Hidden Semi-Markov Models toward Applications**. Springer, New York, 2008.
- [2] Birolini, A.: **Reliability Engineering: Theory and Practice**. 5nd edition, Springer-Verlag, Berlin, 2007.
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ABSTRACT:

In this paper we consider a manufacturing system in which an input generating installation (I) supplies a buffer (B) with a raw material and a production unit (P) pulls the raw material from the buffer with constant rate $d > 0$ (see Figure below).



Figure. The three components of the system

The capacity of the buffer is equal to K units of the raw material. The input rate p is assumed to be a discrete random variable whose possible values belongs to the set $\{d, d + 1, \dots, d + K - x\}$ where $x \in \{0, 1, \dots, K\}$ is the content of the buffer. The installation deteriorates as time evolves and the problem of its preventive maintenance is considered. There are three possible decisions when the installation is at operative condition:

- (i) the action of allowing the installation to operate,
- (ii) the action of leaving the installation idle and
- (iii) the action of initiating a preventive maintenance of the installation. The objective is to find a policy (i.e. a rule for choosing actions) that minimizes the expected long-run average cost per unit time. The cost structure includes operating costs of the installation, maintenance costs of the installation, storage costs and costs due to lost production when maintenance is performed on the installation and the buffer is empty.

Using the dynamic programming equations that correspond to the problem and some results from the theory of Markov decision processes we prove that the average-cost optimal policy initiates a preventive maintenance of the installation if and only if, for some fixed buffer content x , the degree of deterioration of the installation is greater or equal to a critical level $i^*(x)$ that depends on x . The optimal policy and the minimum average cost can be computed numerically using the value iteration algorithm.

Extensive numerical results provide strong evidence that there exists, for fixed buffer content x , another critical level $\tilde{i}(x) \leq i^*(x)$ such that the average-cost optimal policy leaves the installation idle if its degree of deterioration is smaller than $\tilde{i}(x)$ and allows it to operate if its degree of deterioration is greater or equal to $\tilde{i}(x)$ and smaller than $i^*(x)$. A proof of this conjecture seems to be difficult.

Keywords: *Dynamic programming, maintenance, production-inventory system*

3rd Presentation

TITLE: **Reliability of Military Operations and Systems**

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ABSTRACT: After defining different types of system operations (such as a series system of operations, a system of parallel operations, a system of operations with active or standby redundancy, a system of combined operations), we study the operational reliability variation as a function of the time. In particular, we consider reliabilities with different types of distributions (exponential distribution, normal distribution, log-normal distribution and Weibull distribution). We also study the instantaneous failure rate of the system operations, the so-called hazard function, and we provide experiment computation of the reliability function using the probability graph method and the Kolmogorov-Smirnov test method. Further, we investigate the maintainability of weapon systems and the operational availability of military systems.

Keywords: *Series system of operations, system of parallel operations, system of operations with active or standby redundancy, system of combined operations, operational reliability, exponential distribution, normal distribution, log-normal distribution and Weibull distribution, hazard function, probability graph method, Kolmogorov-Smirnov test method, maintainability of weapon systems, operational availability of military systems*

4th Presentation

| | |
|-------------------|--|
| TITLE: | Signature-Based Analysis of Combined k-Out-of-n and Consecutive k_c-Out-of-n Systems |
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| ABSTRACT: | In this paper we study reliability properties of combined k -out-of- n and consecutive k_c -out-of- n systems with exchangeable components. We apply a Markov Chain approach in order to reach the generating function of the survival function of special cases of the aforementioned reliability systems' family. Furthermore, we provide recurrence relations for the coordinates of the signature vector of combined k -out-of- n and consecutive k_c -out-of- n systems, while several stochastic comparisons between reliability structures lifetimes using their signatures are presented. Finally, some interesting applications of the aforementioned results are also illustrated. |
| Keywords: | <i>Combined k-out-of-n and consecutive k_c-out-of-n systems, Samaniego's signature, Markov chain method, stochastic ordering</i> |

Session 17 **Systems of Monitoring and Spatial Analysis****1st Presentation**

TITLE: **Electric Machine Experimental Monitoring System Based on Labview Environment**

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ABSTRACT: It is widely accepted that contemporary scientific experimentation on electrical machines requires extensive measurements and acquisition of various data. The equipment used for this purpose is usually quite expensive and dedicated to a specific application. In this paper the development of a programmable, versatile and inexpensive system based on Labview environment is described. This is able to perform an essentially limitless number of simultaneous measurements on any kind of experimental or applied installation. Furthermore, the same system is able

to perform extensive signal conditioning and processing, in order to automatically produce complex graphs and facilitate the drawing of conclusions. Finally, the same system may actively control electrical equipment allowing for even more complex experiments to be performed. In this case, an ac/ac converter supplies power to an electric motor. Six differential voltages and six currents are measured and recorded in real time, while power, total harmonic distortion etc are calculated, in order to determine whether the use of the ac/ac converter is efficient or not.

Keywords:

Signal processing, electric machines, Labview environment

2nd Presentation

TITLE: **Abductive Reasoning in 2D Geospatial Problems**

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ABSTRACT: Spatial Analysis has been using so far Spatial Reasoning, but it mainly confines itself to spatial statistical analysis of the observed phenomena searching for pattern analysis, geostatistical indices etc. A trivial example is the spatial analysis of the crime phenomenon in a given region, which will result in finding subregions that are statistically characterized by high rates of crime. The most common strategy in response is the increase of policing in those subregions. However, that kind of strategy does not affect the cause of the phenomenon under consideration, i.e. the criminals, but only the observations of the phenomenon. Thus, the crime will either shift or spread out to the remaining space, as the increase of policing in a set of subregions implies the decrease in the rest, which in turn implies that criminals are offered now new opportunities to carry out their illegal activities in those exact under-policing subregions.

The scientists Shakarian P., Subrahmanian V. S. and Sapino M. L. are the first who examined the possibility of extending the Spatial Analysis in

finite, discredited, 2D space with the incorporation of Abductive Reasoning, which originates from the cognitive field of Artificial Intelligence and it is related to the analysis of causation of the phenomena under consideration. In order to solve the new class of Geospatial Problems, the Geospatial Abduction Problems or GAPs, which are generally proven to be NP – complete, they introduced appropriate formalism, they proposed methodology and they analyzed algorithmic design. They primarily focused on a version of GAPs named Improvised Explosive Devices Cache Detection Problem, or IED Cache Detection Problem, and they carried out experiments with real world data from Bagdad.

A technique which reduces the total computational cost of GAPs and which can be applied in any version of GAPs will be introduced in this paper. Additionally, by leveraging the results of algorithmic design for k – SEP (k – Simple (α, β) Explanation Problem) an exact algorithm for MINSEP (Minimal Simple (α, β) Explanation Problem), which is the natural optimization problem associated with k – SEP as it concerns finding an (α, β) explanation for a given set of observations that is of minimal cardinality, will be presented. Finally, it will be proven that the complexity of the above algorithm is

$$O\left(\frac{\log_2 k}{(k-1)!} \cdot ([\pi \cdot (\beta^2 - \alpha^2)] \cdot |O|)^{(k+1)}\right).$$

Keywords:

Abductive reasoning, geospatial abduction problems, spatial problems, IED cache detection problem

3rd Presentation

TITLE: **A Distributed Low Cost Acoustic Surveillance System Urban Threats Detection and Classification**

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ABSTRACT:

The main functionality of a surveillance system is the early detection of potential threats. The system should be able to detect, identify and classify potential threats the soonest and with the best available resolution and or confidence. The effectiveness of such a system lies in early detection of a threat at a safe distance, before they become extremely dangerous for the security of the site.

The implementation of surveillance systems is based on various types of sensors, such as acoustic and seismic sensors, optical sensors, infrared and magnetic sensors, and radar systems. These sensors can be used by a system, either alone or in combination with other types of sensors to provide better and more accurate results. The most common combination of sensors, enabling reliable and economical detection of both personnel and vehicles, providing information on the nature of the target, the direction of movement and speed is the use of acoustic and / or seismic sensors.

In this article, a secure surveillance framework is presented. This framework is based on the utilization of acoustic signals, emitted by the movement of targets, in order to detect and recognize threats. The acoustic sensors are integrated into wireless nodes, which communicate with each other by creating a Wireless Sensor Network. The wireless nodes are small in size; in order to be feasible their placement to small non-friendly places (such as soldier's uniforms or vehicles). The detecting and characterizing methods that are used are distinguished by their low complexity, low requirements on computer power and energy, but also for their high efficiency. Furthermore, the specific framework includes low power encryption algorithms, which ensure the security of nodes and measurements.

Keywords:

Wireless sensor network, acoustic sensors, urban surveillance framework, live, forensic framework, TESPAP characterization method, WSN synchronization, Aurora

4th Presentation

TITLE: Special needs for acquisition and organization of georeferenced data in information systems for monitoring and control of military operational procedures

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ABSTRACT: In this work, typical examples of operational procedures, executed at multiple levels of geographical detail, have been examined, in order to determine the kind of information needed for properly designing and executing these procedures. The interesting result is that most of this information is, directly or indirectly, connected to a variety of maps. Even for a single operation, maps of varying thematic content and granularity may be needed. Moreover, the examination of this information has confirmed that, in most cases, large parts this information may already have been acquired and organized by military or civil institutions or

organizations, or even by private companies. Subsequently, the typical internal architecture of the relevant information used by the various, mostly independent, institutions for organizing and maintaining this information in computer systems has been considered. The purpose was to examine whether it is possible to fetch on demand the various sets of this information in a computer or cluster of computers and make them interoperable, so that the resulting complex database can be effectively and in a timely way used for the design, monitoring and execution of a an operation, or for the quick and mostly automated production of an information system for the support of this operation. This consideration has confirmed that in most typical cases, it will be difficult, expensive and time consuming to do so. For this reason, certain guidelines for the proper and timely organization of such data sets of, directly or indirectly, georeferenced information have been produced, and a novel and flexible internal architecture for the suitable organization of typical sets of this information has been proposed. Special consideration has been given to the fact that several players or organizations with quite different needs for information may be involved in a single, typical operation of this kind.

Keywords:

Georeferenced information, information systems, complex databases, Military operational procedures

Session 18 **Digital Signal Processing / Pattern Recognition****1st Presentation**

TITLE: **Design of Two-Dimensional Filters for Military Image Processing**

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ABSTRACT:

Keywords:

2nd Presentation

TITLE: **Image Segmentation Using IR Images**

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ABSTRACT:

This paper deals with the problems of object recognition and image segmentation, having as aim their objective combination. The image segmentation is typically used to locate objects and boundaries (lines, curves etc) in images. Existing methodologies and existing software packages require user's intervention, which makes the segmentation's results subjective. In this frame:

- Methodologies were implemented and completed in Matlab environment, based on the approach of active contours and mathematical morphology in the partition of rock layers, mainly based on known algorithms.
- An original methodology of segmentation of images was automated.

The methodology used in order to answer the aforementioned researching objectives is the following:

1. Researching and presenting the theory of image segmentation methods as also as image processing.
2. Using two known algorithms, segmentation and processing will be applied to images taken by IR surveillance systems.

The conclusions of this work are expected to be the presentation of the basic theory of image segmentation and its known algorithms. Discussion about the appropriate algorithm for each problem will contribute to the final result. Finally, two algorithms will be applied and their results will be resented by a critical point of view.

Keywords: *Image segmentation, matlab, object recognition, image processing*

3rd Presentation

TITLE: **Load Estimation for War-Ships Based on Pattern Recognition Methods**

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ABSTRACT:

The load estimation for every type of war-ships is crucial information, because it is the necessary base for a series of studies and operations, such as economic operation for different kind of generators, load shedding and power management systems. In this paper a pattern recognition methodology is presented, which consists of four steps:

- (a) the data selection,
- (b) the data pre-processing, in order to modify or delete the values that are obviously wrong,
- (c) the application of pattern recognition algorithms and
- (d) load estimation.

The clustering algorithm used is a modified k-means algorithm, which is properly calibrated regarding the ratio of within cluster sum of squares to between cluster variation (WCBCR). This methodology is applied to total load demand of Hellenic Navy MEKO type frigate indicatively and the usefulness of the respective results for the power system design and operation is proved.

Keywords:

Electric load profiles, pattern recognition, warship power system operation

Session 19 Robotics, Automatic Control and Intelligent Systems I

1st Presentation

| | |
|------------------|---|
| TITLE: | Area Coverage Using Rotorcraft VSTOL-Unmanned Aerial Vehicles |
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| ABSTRACT: | <p>This article focuses on the area coverage problem of a region using Vertical Short Take-Off and Landing (VSTOL) Unmanned Aerial Vehicles (UAVs). The non-convex region is tessellated based on the geodesic-Voronoi scheme and regions of responsibility are assigned to each UAV.</p> <p>A decentralized control scheme is employed that guarantees monotonic increase of the surveyed area. The suggested scheme can be applied in search-and-rescue and/or pursuer/evader missions.</p> <p>Simulation and experimental results are offered based on University of Patras' prototype rotorcraft UAV.</p> |
| Keywords: | <i>Unmanned Aerial Vehicles, Area Coverage, Search and Rescue mission</i> |

2nd Presentation

| | |
|------------|---|
| TITLE: | Pilot-Scale Development of a UAV-UGV Hybrid with Air-Based UGV Path Planning |
| AUTHORS: | Nikolaos Giakoumidis ⁽¹⁾ Jin U Bak ⁽²⁾ Javier V. Gómez ⁽³⁾ Arber Llenga ⁽⁴⁾ Nikolaos Mavridis ⁽⁵⁾ |
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ABSTRACT:

Traditionally, UAVs and Mobile Robots are viewed as two separate entities. However, upon closer examination of their synergies, a more unified conception of a closely-coupled system of the two could easily justify a view where both are just seen as separable parts of the body of a unitary hybrid symbiotic system – essentially, one robotic entity, whose body parts can separate temporarily, and get together again later. In this paper, we will describe a prototype system consisting of a small-scale indoor pilot version of a much larger outdoors full- scale system, as an illustration of this concept. Such indoor pilot versions have multiple advantages, as we shall show. In our prototype, a mobile robot UGV serves as a transport as well as recharge station for a lightweight quad-rotor UAV, while the UAV serves as a separable long-range vision system for the UGV, providing top-down views of its environment, which are stitched and transformed into maps, and which are utilized towards the navigation of the robot hybrid. Multiple avenues of extension of our system and the concept are also introduced, illustrating the power of the separable-body heterogeneous symbiotic multi-robot system concept.

Project's video link:<http://www.youtube.com/watch?v=RqdwuKcUPfU&feature=youtu.be>**Keywords:***UAV, UGV, hybrid robot, pilot-scale*

3rd Presentation

TITLE: **A Control Scheme Towards Accurate Firing While Moving for a Mobile Robotic Weapon System with Delayed Resonators**

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ABSTRACT:

In the present paper a mobile robotic weapon system is considered. The system comprises a ground vehicle equipped with a robotic manipulator carrying a gun. The goal is to perform accurate firing while moving and despite the vibrations due to uneven ground and reaction weapon forces.

The improve tolerance to vibrations; the vehicle is considered to be equipped with passive and active suspension systems. The active suspension involves delayed resonators feeding back the resonators' acceleration. Using the Euler-Lagrange approach, the model of the system is derived in the form of a nonlinear neutral time delay mathematical description.

From the system design point of view the goal is formulated as a command following problem with simultaneous disturbance attenuation, under appropriate constraints. To achieve these goals an algebraic control scheme based on the linear approximant of the system's model is proposed. The controller is of the measurable output feedback dynamic type.

Despite the complexity of the system's model the derived controller is realizable in the sense that no predictors are required and is enough simple to be implemented to low level computer platforms. Thus the proposed controller offers itself to upgrade traditional armed ground vehicles. The upgrade appears to be of low cost. The good performance of the proposed controller is demonstrated through computational experiments using the nonlinear model of the system.

Keywords: *Ground vehicles, mobile robotic weapon systems, active suspensions, delayed resonators, command following, disturbance attenuation*

4th Presentation

| | |
|-------------------|--|
| TITLE: | Teaming Methods of Airborne and Ground Assets for Organizing Effective Surveillance |
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| ABSTRACT: | As Unmanned Aerial Vehicles become more prevalent on the battlefield, ground forces will have to increasingly rely on them for intelligence, surveillance, and reconnaissance, as well as target marking, and over watch operations. Simulation analysis tools are used to study of aspects of Unmanned Aerial Vehicles surveillance characteristics in conjunction with ground-based interdiction teams. The goal is to reduce the time required to intercept and capture targets of interest. Through screening analysis, significant factors can be determined to build a model that will provide a ground commander with insights to aid in the tactical employment of his assets. We examine different teaming strategies and coordination measures between searching and interdicting assets in order to study the effectiveness of the interdictor possessing an organic, tracker Unmanned Aerial Vehicles. Our objective is to quantify the benefit or penalty of an additional Unmanned Aerial Vehicles asset that is organic to a quick reaction force, in the context of the overall surveillance and interdiction operation. |
| Keywords: | <i>Unmanned Aerial Vehicle, Unmanned Aerial System, linear regression, logistic regression, manned unmanned teaming, teaming, autonomous systems</i> |

5th Presentation

TITLE: **Teaming Methods of Airborne and Ground Assets
for Organizing Effective Surveillance**

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ABSTRACT: In this paper a finite state machine that reads the sensors and controls the robot with evidential reasoning is proposed. The mission of this robot is to control efficiently the boundaries of a camp using rules of computational geometry by minimizing the outposts of the Guard. The simulated experimental results demonstrate that the control system is able to automatically control the robot behaviors via evidential control rules, which can be designed by humans or automatically extracted using machine learning technologies. Thus, the control system gives a capable approach to transfer human knowledge to an autonomous robot.

Keywords: *Computational geometry, control system, data mining*

Session 20 Robotics, Automatic Control and Intelligent Systems II**1st Presentation**

TITLE: **Parametric Design and Optimization of Multi – Rotor Aerial Vehicles**

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ABSTRACT: This work addresses the problem of the optimal selection of propulsion system components for a multi-rotor aerial vehicle (MRAV), for a given payload, payload capacity, number of rotors and flight duration.

Considering that the main components include the motors, propellers, electronic speed controllers (ESC), and battery, steady state modeling was conducted for each component using simplified models. The brushless direct current (BLDC) motors are modeled as DC motors using a 3 – constant model. The lithium polymer (LiPo) battery power source consists of battery cells modeled as voltage sources with internal resistance, and connected in series and parallel. ESCs are modeled as a constant resistance, equal to the average value of the ESC transistor ON – Resistance. A simplified propeller model, based on momentum and blade element theory and on experimental data of model airplane propellers, made possible the expression of any two – blade propeller power and torque coefficients as functions of the propeller diameter and pitch. This lead to the calculation of the performance characteristics of a two – blade propeller as a function of propeller rpm, diameter and pitch. Combining each component model into a total model, we were able to describe the whole system performance at hovering and at maximum thrust.

Additionally, based on technical specifications of commercially available batteries, motors and ESCs, component functional parameters

identified earlier were expressed as a function of component size, in terms of an equivalent length. We did the same with propellers using available experimental data. Furthermore, equations were developed, which correlate airframe dimensions and weight as a function of propeller diameter, number of rotors and maximum thrust. As a result, we were able to calculate the whole system performance as a function of a design vector which consists of each individual component equivalent length.

A Matlab program was developed which calculates the optimal design vector using Matlab's 'fmincon' function. As objective functions, the total energy consumption and the vehicle's diameter were considered. As a result, for a given payload, payload capacity, number of rotors and flight duration, we were able to calculate the size of each component that leads to a design which consumes the least energy or to design a MRAV with the smallest dimensions.

Finally, using the developed program, we were able to study the influence of the payload, and of the number of rotors, on the design vector and the MRAV size. The results obtained by the program were compared to existing commercial and research MRAVs, showing that the developed methodology yields designs close to reality. In addition, this methodology provides an MRAV designer with the tools to improve an existing design.

Keywords:

Multi-rotor aerial vehicle design, parametric design, constrained optimization

2nd Presentation

TITLE: **Stabilization and Tracking for Swarm Based UAV Missions Subject to Time-Delays**

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ABSTRACT: It is well known that time delay is often inherent in dynamic systems, which can be an important source of instability and degradation in

the control performance. In particular, when safety is concerned for Unmanned Aerial Vehicle (UAV) applications, neglecting the presence of time delay in the measurable states may jeopardise or result in catastrophic failures for operations.

In this letter sufficient conditions for the existence of fuzzy state feedback gain are proposed for the stabilization/tracking problem of swarm based UAV missions subject to time-delays. The nonlinear model of the dynamics is represented by Takagi-Sugeno (TS) fuzzy models which offer a systematic analysis for stabilization/tracking problems. Through a special property motivated by the Razumikhin theorem it allows the design of the distributed control law to be performed using tools from Lyapunov theory. The control law is composed of both node and network level information. The design follows a two step procedure. Firstly feedback gains are synthesized for the isolated UAVs ignoring interconnections among UAVs. The resulting common Lyapunov matrix is utilized at network level, to incorporate into the control law the relative differences in the states of the agents, to induce cooperative behavior. Eventually stability is guaranteed for the entire swarm. The corresponding design criteria, proposed, are posed as Linear Matrix Inequalities (LMIs) where performance for the entire swarm is also stressed.

The benefits of this analysis is that the design of the controller is decoupled from the size and topology of the network, and it allows a convenient choice of feedback gains for the term that is based on the relative state information.

The novelty of this work is that it proposes a methodology for the analysis of a network of nonlinear systems. An intermittent step (the creation of an equivalent TS representation form) allows a decoupled structure of the network into node level dynamics to be exploited. This structure facilitates a systematic analysis using Lyapunov theory for stabilization/tracking. An illustrative example based on a UAV tracking scenario is included to outline the potential of the analysis.

Keywords:

Graph theory, multi-agent systems, distributed control, time-delay, parallel distributed compensation, Takagi-Sugeno fuzzy model, linear matrix inequalities.

3rd Presentation

TITLE: **Developing an In-House IPMS for the Hellenic Navy Gunboats**

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ABSTRACT: It is widely accepted that mil-spec systems are very reliable even under harsh battle conditions. However, their incomparably high cost lead most navies to adopt lower-quality but cheaper commercial products. Such compromise turned out to be quite unsatisfactory for the Hellenic Navy, as commercial systems still seem overpriced and rarely live to its expectations.

In an attempt to cope with this problem, the Hellenic Navy began developing its own systems at minimal cost and with surprisingly good results. In this paper, the “έποψις” (epopsis) Integrated Platform Management System installed onboard the POLEMISTIS-class gunboats is presented.

Keywords: *IPMS, έποψις (epopsis), in-house, SCADA, monitoring, control*

Session 21 Satellite Communications and Remote Sensing**1st Presentation**

| | |
|-------------------|--|
| TITLE: | Detection of Air Pollutants in the Atmosphere by using the Laser Remote Sensing Technique |
| AUTHORS: | Panayotis Kokkalis ⁽¹⁾, Alexandros Papayiannis ⁽²⁾, Alexandros A. Serafetinides ⁽³⁾ |
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| ABSTRACT: | <p>Objectives The main objective of this paper is to present the state-of-the-art on the detection of air pollutants in the atmosphere by using the pulsed laser remote sensing (lidar) technique.</p> <p>Methodology The pulsed laser remote sensing of the atmosphere is an established research and monitoring tool to characterize the earth's atmosphere and to obtain the profile of various meteorological parameters, of trace gases, and of aerosol particles of various chemical compositions. By scanning a pulsed laser beam into a 3-dimensional atmospheric volume, one can obtain a "tomography-like" 4-dimensional image (time being the 4th dimension) with very high temporal (about 1 min) and spatial resolution (about 1-3 m).</p> <p>Lidar applications A brief overview of the meteorological parameters (atmospheric temperature, density, relative humidity, wind direction and velocity field)</p> |

and trace gases measured by lidar systems (CO_2 , CH_4 , SO_2 , H_2O , NO_x , NH_3 , SF_6 , HF Hg, Fe, K, Na, Ca, Li, etc.) will be reviewed. Additionally, some special lidar applications will be discussed (atmospheric measurements of clouds, biogenic aerosols, explosives, tree pollen, quartz aerosols, urban-biomass-volcanic-dust aerosols, etc.).

Main results

In this paper some selected case-studies of aerosol measurements and characterization obtained with the advanced Raman lidar system of the National Technical University of Athens (NTUA) will be presented.

Keywords:

Lidar, atmosphere, air pollution, meteorology, toxic gases, explosives

2nd Presentation

TITLE: **Wavelet Transform in Remote Sensing with Implementation in Edge Detection and Noise Reduction**

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ABSTRACT: In image processing, the Fourier transform has a serious drawback as only frequency information remains whilst local information is lost. In order to involve localization in the analysis, the Short Time Fourier transform (STFT) is adapted where the image is windowed. The drawback is that the window is the same in all frequencies. In principal, a more flexible approach is required where the window size varies in order to determine more precisely either location or frequency. Wavelet analysis allows the variation of the window based on the frequency information. Wavelets have limited duration and an average value of zero and thus they are irregular and asymmetric with short duration. Wavelets can be used in the field of edge detection and enhancement, image compression, noise reduction, and image fusion. In this review paper wavelets are used in quite opposite applications such as edge detection and noise reduction of remote sensing

images. Thus, the flexibility and versatility of the wavelets is exposed. The challenge is to choose the appropriate wavelet for a particular application which is not known a priori.

Keywords:

Wavelets, remote sensing, multiresolution, scale, edge detection, noise reduction

3rd Presentation**TITLE:****Optimal Coverage of Theater Targets with Small Satellite Constellations****AUTHORS:**

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ABSTRACT:

It is well known that time delay is often inherent in dynamic systems, which can be an important source of instability and degradation in the control performance. In particular, when safety is concerned for Unmanned Aerial Vehicle (UAV) applications, neglecting the presence of time delay in the measurable states may jeopardize or result in catastrophic failures for operations.

Aims

The daylight passes of a low-Earth orbit satellite over a targeted latitude and longitude are optimized by varying the inclination and eccentricity of an orbit at different altitudes.

Methodology

This investigation extends the work by Emery et al, in which the optimal Right Ascension of the Ascending Node was determined for a circular, matched inclination orbit. The optimal values were determined by a numerical research method based on Emery et al.'s Matlab program.

Applications and main results of the paper

Results indicate that small increases in inclination raise the number of daylight passes up to 33%. These optimal inclinations depend on the satellite semi-major axis. Eccentricity increases also improve daylight pass numbers, but at a cost of increased range to the target.

Keywords: *Low earth orbit satellite, optimal coverage, metaheuristics*

4th Presentation

TITLE: **Satellite Communications in the Military
Advantages Limitations and the Networking
Challenge**

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ABSTRACT: This paper analyzes the impact and benefits resulting from using modern satellite telecommunications in the military. During the last two decades, satellite telecommunications are considered as the most significant and prioritized tool of information superiority in any operational theatre.

As it will be explained, their extensive use encompasses not only the traditional strategic military telecommunications but tactical networks as well. However, their effective and efficient use necessitates the proper evaluation of their capabilities and their limitations. Starting with a brief historical reference, we proceed by considering their advantages, together with modern modulation and networking technologies used to limit their drawbacks.

Finally, it will be shown that the most effective approach to exploit their capabilities is to include in a common network architecture all available means of wideband telecommunications, terrestrial and wireless. The idea can be further applied to provide high performance connectivity for a networked sensors C4ISR infrastructure.

Keywords:

Satellite telecommunications, tactical networks, networking, modern modulation techniques, networked sensors, wide band telecommunications, C4ISR

Session 22

Modern Radar Techniques

1st Presentation

TITLE: **Modern Radar Techniques for Air Surveillance & Defense**

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ABSTRACT:

During the last sixty years Radar systems have evolved from auxiliary electronic devices to the heart of every modern weapon system on the ground, sea, air and space. In the course of their evolution the Radar systems started with a few simple, but extremely useful, capabilities for providing ranging of remote objects and radio-location, while continuous advances of the Radar technology added many more capabilities like precise navigation, targeting, guidance, mapping, imaging, target recognition, target identification & classification and more yet to come.

The evolution of the Radar Technology has caused the birth and development of a new field of science, the Electronic Warfare, whose main objective is to provide countermeasures to the Radar threats. Moreover, responding to the threat of detection by Radar, the targets started becoming more elusive by incorporating 'stealth' techniques in their design.

The Radar designers are exploiting the advances in electronics technology and computer science to achieve the accurate detection of low RCS targets in a diverse environment of Clutter, interference and jamming.

The modern radar techniques are focused in the fields of: adaptive antenna arrays, receiver sensitivity and real-time digital signal processing. Also, the advances in computer science that can now provide immense processing power, has allowed the emerging of new Radar configurations

beyond the classic mono-static case: The passive and poly-static Radar systems. Although, these new configuration are still in the experimental phase, they have already showed interesting properties, especially at the detection of low RCS targets.

In the present article, the modern techniques in the design of new radar systems, as well as the upgrade of existing systems are presented and their performance and prospects are analyzed. It is considered that Radar will remain the centerpiece of all new Air Surveillance & Defense systems in the 21st century and will continue to evolve following the advances of science and technology and responding to the requirements of the modern warfare.

Keywords: *Radar, jamming, RCS, clutter, signal processing*

2nd Presentation

TITLE: **An Auto-Focusing Post – Processing Algorithm for ISAR / SAR Radar Imaging and ISAR / SAR Image Classification Using Fractal Techniques**

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ABSTRACT:

Autofocusing is a technique for improving inverse synthetic aperture radar (ISAR) imaging. In this presentation, a novel autofocusing method will be presented for high-resolution stepped-frequency ISAR imaging. Non-uniform rotational motion is compensated through the proposed post-processing methodology. The proposed CPI-split autofocusing process (where CPI stands for 'Coherent Processing Interval') results in well-focused ISAR images for high angular acceleration periods. Furthermore, ISAR image entropy dependencies are examined through various simulation results, leading to an acceptable range of entropy values for the autofocusing process.

In addition, regarding classification of ISAR images obtained above, the 'Modified Fractal Signature' (MFS) method will be presented, which uses the 'blanket' technique to provide useful information for image classification. It has been used earlier in the literature in order to provide classification results for texture classification, document analysis purposes and biomedical image classification. It is based on the calculation of the volume of a 'blanket', corresponding to the image to be classified, and then on the calculation of the corresponding 'Modified Fractal Signature' (MFS) and 'fractal dimension' of the image. We will present numerical results concerning the application of MFS method to the classification of Inverse Synthetic Aperture Radar (ISAR) images. In these results it is clearly seen that the focusing of the ISAR radar image clearly correlates with the value of MFS signature.

Finally, it is our intention to present the application of the above mentioned methods for the case of SAR imaging geometry, as well (for both cases of airborne and spaceborne SAR), where both simulated and real radar data will be used.

Keywords:

ISAR / SAR radar imaging, autofocusing post – processing technique, Modified Fractal Signature (MFS) image classification method

3rd Presentation

TITLE: **Synthetic Aperture Radar Applications to Modern Warfare Environment**

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ABSTRACT: A Synthetic Aperture Radar (SAR), or SAR, is a coherent mostly airborne side looking radar system which utilizes the flight path of the platform to simulate an extremely large antenna or aperture electronically, and that generates high-resolution remote sensing imagery. The resolution of the produced images is independent of the distance between the target and the sensor and it is related only to physical dimensions of the real antenna. Recent development on electronics and mainly signal processing techniques, allowed SAR to be implemented on modern aircraft radar systems as a separate mode of operations supporting mainly tactical air to ground operations.

While SAR is often used because of its all-weather, day-or-night capability, it also finds application because it renders a different view of a “target,” with synthetic aperture radar being at a much lower electromagnetic frequency than optical sensors.

Currently SAR systems are mainly used for long range target imaging and as the system can provide real time target coordinates, it is widely used for GPS guided weapons release. Based on that it is thus of paramount importance to investigate the performance of the traditional camouflage technologies used on SAR systems and their operational used to target protection.

A detailed presentation of the SAR systems in modern digital battlefield is given to this paper. Operational use of SAR mode of operation to target mapping from long range and smart weapons guidance is also given. Finally real SAR data from modern camouflage technologies will be presented and the performance will be analyzed.

Keywords: *Synthetic aperture radar (SAR), targeting technologies, imaging techniques, SAR signal processing, smart weapons guidance*

4th Presentation

TITLE: **Integrated SAR /GPS / INS for Target Geolocation Improvement**

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ABSTRACT:

Keywords:

5th Presentation

TITLE: **Low Observable Principles, Stealth Aircraft and Anti-Stealth Technologies**

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ABSTRACT:

During the last decades, stealth technology has proven to be one of the most effective approaches to the quest for hiding from electronic detection systems, mainly from radar systems. Especially for military aircraft, stealth technology has become ubiquitous: all new aircraft types are

designed taking into account “low observable” principles and techniques, while existing aircraft types are considered for modification in order to reduce their radar signature. Low radar signature for a target means that it is detected and tracked at a shorter range from radar.

However, low observability does not mean complete disappearance from the radar screens. Furthermore, stealthiness comes with a price. Apart from the development cost, stealth aircraft have higher flyaway cost and important maintenance costs as well, while they have significant operational limitations due to the specific aircraft shape and materials used, and also due to the limited fuel and weapons, which have to be carried internally.

Having observed the capabilities of stealth aircraft, many countries have been developing “anti-stealth” technologies. The following systems have been reported to be potential countermeasures to stealth threats: passive / multistatic radars, very low frequency radars, over-the-horizon radars and sensitive IR sensor systems. It is noted that the US exhibit an important advance on the stealth domain, while Russia and China are leading the “anti-stealth” effort, followed by other countries.

This paper will begin by exploring the basic concepts of low observable technology, mainly reduction of RCS – Radar Cross Section. A short presentation of the most important stealth aircraft types will follow, focusing on the Lockheed Martin F-35. Taking into account an open source approach to the estimation of the F-35 lower fuselage RCS, there will be an attempt to calculate the expected maximum detection ranges for a number of representative radar systems. Finally, there will be a brief presentation of systems which are reported to have “anti-stealth” capabilities. Considering all such “anti-stealth” proposals, it will become evident that no system alone seems to be capable of providing adequate protection: a suitable combination of radar, sensors, weapon systems and tactical links should be employed to effectively counter stealth threats.

Keywords:

Stealth aircraft, low observable, RCS, passive radars, multistatic radars, VHF radars, IR sensors, IR Search and Track

Session 23

Unmanned Vehicles

1st Presentation

| | |
|-------------------|--|
| TITLE: | Present Usage of Unmanned Aerial Systems (UAS) and Future Challenges: A Mission Oriented Simulator for UAS as a Tool for Design and Performance Evaluation |
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| ABSTRACT: | This paper summarizes background fundamentals of unmanned aerial vehicles (UAVs) as related to terminology, history and diverse applications. This information is followed by a discussion on the challenges that need to be overcome in order to take full advantage of what UAV systems may offer, focusing on UAV reliability improvement using fault tolerance methods and concepts. A UAS simulator built at the Technical University of Crete capable of simulating multiple vehicles is presented. The simulator is mission oriented and is focused on the design and performance evaluation of Unmanned Systems. |
| Keywords: | <i>UAV, fault tolerant control, simulation</i> |

2nd Presentation

| | |
|----------|--|
| TITLE: | Conical Slot Antenna for Air and Sea Vehicle Military Applications |
| AUTHORS: | Irene Karanasiou ⁽¹⁾ Michael Gargalakos ⁽²⁾ Panagiotis Farantatos ⁽³⁾ Grigorios Stromatias ⁽⁴⁾ (2nd Lieutenant, Hellenic Army General Staff) Ioannis Vafakis ⁽⁵⁾ (2nd Lieutenant, Hellenic Army General Staff) Spiridon Gotzias ⁽⁶⁾ (2nd Lieutenant, Hellenic Army General Staff) Ioannis Chalkiadakis ⁽⁷⁾ (2nd Lieutenant, Hellenic Army General Staff) |

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ABSTRACT:**1 Introduction**

Antennas constitute a decisive component of all military communications abilities. The development of ground, air, sea, and space-based antennas must totally comply with the state-of-the-art and beyond advances in vehicle communications systems. Mobility, bandwidth demands, gain and radiation efficiency as well as low cost and simple integration are requirements that need to be met concurrently. In cases where conformality is also a prerequisite, planar and slot antennas prove to be optimal solutions. In this context, a conical slot antenna for vehicle military applications at VHF-UHF operation frequencies is herein presented. The simulation and the measurement results show that the proposed slot antenna provides efficient radiation pattern while being lightweight, low cost and simple to manufacture and integrate²⁵.

2 Modeling of slot antenna

A slot antenna is made of a flat metallic plane, in other words a metal surface comprising a hole or slot cut out. When the plane with the cuts in question is driven as an antenna at a specific operating frequency, the slot radiates electromagnetic waves resembling to the way a dipole antenna radiates. The shape and size of the slots and their position on the metal surface, determine the antenna operation frequency and radiation distribution pattern. The antenna dimensions are 133cmx20cm and the slot, which is shaped like the greek letter "lamda", forming a conical slot antenna, is 2mm thick. The antenna is made from 1mm thick copper and

²⁵ 8th Military Antennas September 12 - 15, 2011, Washington Marriott, USA

the substrate used in the simulations is air. In Figure 1, a magnification of the slot used can be observed. The feeding of the antenna was realized using a 50 Ohm lumped port.

After the model setup, the airbox and appropriate boundary conditions were set and meshing was performed.

Following, the sweep frequency parameters setup took place and finally the simulation results were viewed and plotted. The analysis of the electromagnetic problem is approached numerically using commercial simulation software (High Frequency Structure Simulator, HFSS, Ansoft Corporation)²⁶.

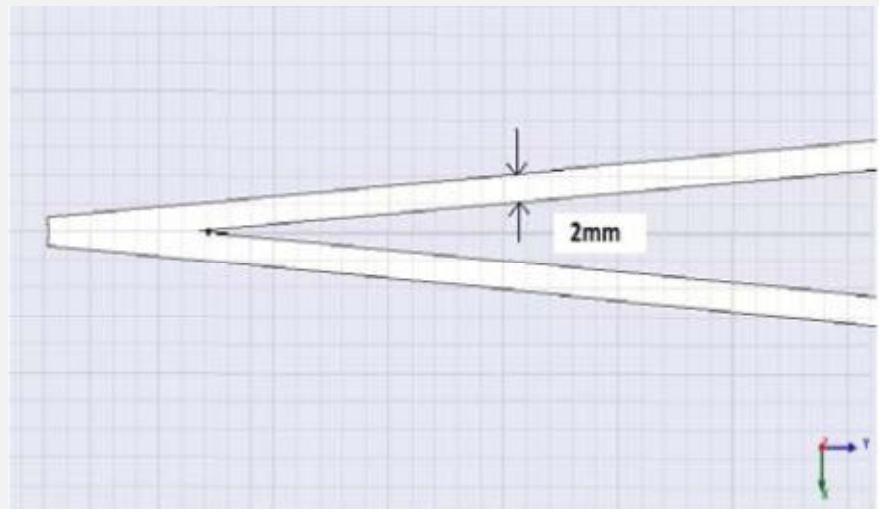


Figure 1: Magnification of Figure 1 where the exact geometry and dimensions of the slot can be observed.

(2) Simulation Results

After performing simulations using sweep frequency setups over the whole frequency bandwidth of 30-500MHz, the S11 parameter values and the antenna radiation pattern were calculated. Multiple resonant frequencies are achieved over the whole bandwidth with the most efficient S11 value of -8dB is reached at 400-450MHz. The back side lobes are suppressed and the antenna radiates above, below and at the side.

(2) Measurements

Following the simulation results, the proposed antenna was developed at a 1:5 scaling. The scaling was chosen in order to facilitate both the antenna construction and the subsequent measurements. Two identical models of the antenna were developed and were placed on 127lexiglas in order to achieve better mechanical stability and at the same time facilitate the laboratory measurements without interfering with the antenna design parameters. The final scaled dimensions of the antenna were 27cmX 4cm and the measuring range was set to 5 times the simulation range (30MHz X 5-500MHz X 5). The model of the developed antenna is shown in figure 2.

²⁶ www.ansys.com



Figure 2: The 1:5 model of the proposed antenna

Measurements were carried using the HP 8510C network analyzer at the 150MHz-2.5GHz frequency range. At first the S11 parameter of the antenna was measured. Following the measurement of S11 the two identical antennas were placed in a back to back configuration in order to measure the coupling between them. The measurement results for S11, S22 and S12 are shown in figure 3.

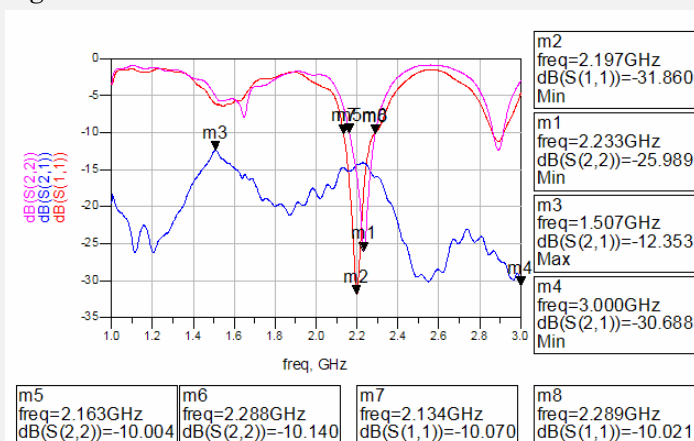


Figure 3: Experimental results of S11, S22 and S12 for both slot antennas

5 Discussion and Conclusion

A slot antenna for vehicle and military applications is presented in this paper. The antenna operates at VHF/UHF frequencies and is extremely low cost and lightweight. Antenna resonant and radiation pattern characteristics are efficient as simulation and measurement results have showed. The proposed slot antenna seems a viable solution meeting all requirements and minimizing risks at the same time²⁷.

Keywords:

Slot antenna, UAV, VHF-UHF, radiation patterns

²⁷ See K. Sarabandi, R. Azadegan, Design of an Efficient Miniaturized UHF Planar Antenna *IEEE Transactions on Antennas and Propagation*, Vol. 51, No. 6, 2003, pp 2531-2538. Als, o M.S. Sharawi, O.A. Rawashdeh,, D.N. Aloji, 2.4GHz Printed Antennas Embedded in Small UAV Wing Structures, *Journal of Electromagnetic Waves and Applications*, Vol. 24, 2010, 463-474

3rd Presentation

TITLE: **Implementing an Autonomous Unmanned Wireless Surveillance Mobile Node**

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ABSTRACT: The last decade the science of robotics and mechatronics has made huge steps concerning the development of robots. Having in mind this “new trend”, a robotic unmanned vehicle working as a surveillance wireless node is developed. More particularly, the developed robotic vehicle will have the capability to track and avoid obstacles, by moving on a specific line. Suitable will provide wireless surveillance of the area around the vehicle.

The methodology used in order to answer the aforementioned researching objectives is the following:

1. Researching and presenting the theory of robotics and surveillance systems
2. The following case study will be analyzed: an unmanned vehicle must surveillance an area defined by a white line on the ground. The vehicle will also have the capability to avoid obstacle if necessary.

The conclusions of this work are expected to be the presentation of the advantages of using autonomous wireless mobile nodes in order to surveillance areas of great interest (such as airport etc).

Keywords:

4th Presentation

TITLE: **KERVEROS I: An Unmanned Ground Vehicle for Remote-Controlled Surveillance**

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ABSTRACT: Recent technological advances have made possible the development of Unmanned Ground Vehicles (UGV), which are able to perform various tasks efficiently, such as patrolling and surveillance, sparing human resources. In fact, a UGV is a perfect candidate for patrolling missions, since it can provide enhanced mobility, endurance and surveillance capabilities, day and night and in adverse weather conditions. In this way, it can be used to ensure the security of various areas and military facilities.

Following these principles, a UGV prototype has been constructed, operating on electrical power and receiving commands via remote control software from a computer, featuring a day – night surveillance IR camera. It is based on a simple tricycle chassis and it is powered by a high capacity automotive battery, which provides adequate power for several hours of use. A small electric motor moves the vehicle quietly and efficiently, while the vehicle motion controller receives commands via a secure Wi-Fi link. The combination of a common 12 Volt battery and the electric motor provides a reliable and relatively low cost solution to the UGV mobility issue, minimizing maintenance requirements.

The vehicle carries an IR camera, which is also remote controlled, and is able to transmit real time image and sound, day and night, through a

wireless network. Both the UGV and the camera can be remote-controlled, using a web-based interface.

This prototype is proposed as a basis for further development. The construction was deliberately kept as simple as possible, allowing for future upgrades and keeping the development cost low. As a potential future improvement, the UGV could be made more autonomous and “intelligent”, by adding local navigation capabilities, by the use of sensors (e.g., ultrasonic sensors), in order to navigate to a target, while avoiding any obstacles. Further upgrades could be the addition of a GPS receiver, an inertial navigation unit, or additional sensors, such as gas sensors. Apart from the various sensors, this UGV could be considered as a platform for some kind of weapon, lethal or non-lethal, such as a machine-gun or a grenade launcher.

This project was developed at its early stages to fulfill the requirements of a dissertation thesis by students of the Hellenic Air Force Academy, so it is noted that the proposed UGV was designed having in mind a typical Air Force Base, i.e., a large, rather flat area, without bumpy roads. In order to be used in rough environments, some mechanical improvements should be considered, i.e., a suspension system or a more powerful motor/engine.

The adoption of such an unmanned vehicle as a surveillance – monitoring system would contribute to the improvement of safeguarding military facilities, reduce the risk of human injuries and losses, as it could undertake potentially lethal missions, and finally would permit the downsizing of the personnel engaged in installation’s security and safeguarding.

The presentation will include a short introduction, covering the most important UGV types which have appeared until today. Then, the proposed UGV prototype will be analytically presented, including construction and operating details. Finally, certain potential upgrades will be proposed.

Keywords:

Unmanned Ground Vehicle (UGV), IR camera, remote control, surveillance

Session 24

Multiplicative Factors of Force

1st Presentation**TITLE:** Invisibility Regions and Regular Metamaterials**AUTHOR:** George Dassios**ADDRESS:** Faculty of Chemical Engineering
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Patras 265 00, Greece**E-MAIL ADDRESS:** gdassios@otenet.gr**ABSTRACT:**

For more than half a century, people are trying to develop effective methods of remote sensing. RADAR and SONAR systems are the most advertized techniques towards this end, and the contemporary level of sophistication of both of these modalities is really amazing. In fact so many things have been achieved with these identification methods that the inverse question has been naturally raised: Is it possible to isolate a region in space where nothing can be detected via scattering techniques? Much to our surprise the answer to this question is “yes” and the way to achieve it is known as “cloaking”. This is possible through the construction of a material, called “metamaterials”, surrounding the cloaked region, which has some particular preassigned properties. Cloaking has a history of less than a decade and almost all realistic cloaking regions share the shape of a sphere. However, spherically cloaked regions demand metamaterials with singular conductivity tensors, a consequence of the highly focusing effects of the spherical system as it collapses down to its center. We will demonstrate an ellipsoidal cloaking region, which, as a consequence of the fact that the ellipsoidal system springs from its characteristic focal ellipse, the necessary metamaterial that creates the invisible region is regular throughout, leaving this way its realization at the level of engineering construction.

Keywords: *Metamaterials, ellipsoidal system, invisible region*

2nd Presentation

TITLE: **The Development of Sensors for the Purposes of National Defense**

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ABSTRACT:

Keywords:

3rd Presentation

TITLE: **Expertise, Experience, Real Operational Needs: The Key Factors for High Effectiveness and Minimum Cost in Military Operations Today**

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ABSTRACT: It is well known that the level of knowledge and experience characterize a technician's performance and his art is supported by various sciences. In accordance to this, the militaries today being professionals must have complete and specialized knowledge, coupled with expertise, dedicated knowledge which would ensure effective action and fulfillment of any given mission, with minimal costs in human and material. In parallel, the military sciences must not only follow the latest technological developments, but ought to evolve and adapt the scientific knowledge to the needs of military technology, to analyze the current and emerging threats, to supply with the appropriate knowhow, dedicated technique and methodology that is directly

or indirectly involved staff in military operations.

Following to the above reasoning, the aim of this presentation is to highlight the need of forced coexistence of knowledge and expertise with experience to the current members of Armed Forces. However it is briefly represented, in the form of mathematical equations and with simple operational examples, the chain of relationship among the involved forces and the outcome of the battle in a modern military operation.

It is specifically noted, in all three phases of a military operation, (planning, preparation, execution), the determining factors of the participants' professionalism and the means' quality-technology, (friendly – opponent), which are combined with the extensive knowledge and experience of the opponents, determining the respective plan of action, applied tactics, and involvement in general operational needs.

It is also underlined the importance of those key factors of mission success, affecting efficiency and the cost elements, particularly critical for Greece today. The cost – effectiveness is a function of the applied military action, the particular expertise of the planner – executor and effectiveness of the involved forces and means, (tactic, weaponry, technique, timing, power of strike) and especially the used force multipliers.

Undoubtedly the operational effect will be proportional to the product of the applied quantitative and qualitative force in a given time and a natural consequence of the quality performance of the involved armed forces and the technology used.

However the main obligation – duty of the military Leadership should be to maintain the combat effectiveness of the armed forces (personnel & weapons – means), to apply the appropriate policy on force multiplier basis, (cost effective solution), that aims to update knowledge, to increase the operational experience – readiness, to plan with realism, to implement programs which meet the real needs of military education – operational training and to keep the appropriate readiness status (personnel – equipment) in accordance with the current and projected threat – desired result.

Keywords:

Operational need, military experience, technical knowledge of defense systems-expertise

3rd Presentation

TITLE: **Unmanned Aerial Systems For Border Surveillance**

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ABSTRACT: Even more so than surveillance of public places generally, law enforcement agencies are granted significant deference to conduct surveillance at or near borders. Government has a significant interest in protecting borders from crossings by persons attempting to enter unlawfully, drug trafficking, and, perhaps most importantly, the transit of weapons and persons seeking to do harm to people and infrastructure.

This paper assesses the activity for UAV systems to long endurance border surveillance and monitoring having high level requirements in term of reliability and safety and being affordable for potential users in terms of safety.

Keywords: *UAV systems, external borders, surveillance, law enforcement, protection*

5th Presentation

TITLE: **Future Force Warrior Integrated Analysis**

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Konstantinos Papapostolou (2)
(2nd Lieutenant, Hellenic Army General Staff)
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ABSTRACT:

It is well known that the level of knowledge and experience characterize a technician's performance and his art is supported by various sciences. In accordance to this, the militaries today being professionals must have complete and specialized knowledge, coupled with expertise, dedicated knowledge which would ensure effective action and fulfillment of any given mission, with minimal costs in human and material. In parallel, the military sciences must not only follow the latest technological developments, but ought to evolve and adapt the scientific knowledge to the needs of military technology, to analyze the current and emerging threats, to supply with the appropriate knowhow, dedicated technique and methodology that is directly or indirectly involved staff in military operations.

Tactical Military Systems are subjected into necessary test periods which will show their effectiveness when they are extended to the battlefield. This work provides a methodology for developing primary Measures of Performance, Measures of Effectiveness and an Integrated Analysis Framework for the Future Force Warrior program.

The **Future Force Warrior** (FFW) project sought to create a lightweight, fully integrated infantryman combat system. It was one military advanced technology demonstration project in a series of network-centric, next-generation infantry combat projects the military have developed over the past decade. The key concept envisioned the radical use of technologies such as nanotechnology, powered exoskeletons, and magnetorheological fluid-based body armor to provide the infantry with significantly higher force multiplier than the opposing force. However, the stated concept was not Army doctrine, and was not intended to answer

every situation that Army After Next (the Army's buzzword for future fighting forces) would face; rather, the concept was meant to serve as an end goal to strive to reach or to compromise with current technologies and to stir imagination and dialogue on how these technologies and concepts could help soldiers in the near future.

Future Force Warrior consists of:

- The subsystem **Headgear**
- The subsystem **Combat Uniform**
- The subsystem **Weapon**
- The natural position control organs subsystem **Warfighter**
- The subsystem **Power**
- The subsystem **Air Warrior Block 2**
- The subsystem **Air Warrior Block 3**

All these subsystems will improve the soldiers' operational capabilities, proving them the potential to integrate all of their defined missions, under any battle circumstances.

This work provides a methodology for developing primary *measures of performance*, *measures of effectiveness* and an *integrated analysis framework*.

Keywords:

Future Force Warrior, systems of systems, measure of performance, measure of effectiveness, infantry warrior simulation, joint conflict and tactical simulation, agent based model, agent-directed-simulation, C4I systems

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