RELATIONAL APPROACHES TO MODERNIZING OPERATIONAL LOGISTICS RELATED TO INDUSTRY 4.0 AND SUPPLY CHAIN MANAGEMENT 4.0

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The evolution and continuous changes of the operational environment require advanced technologies and combat systems generated by Industry 4.0, taken over and managed by supply chain management 4.0, based on innovative conversion and distribution processes, high-mechanized, robotic, digitized and of special performance.

All military logistics actions in support of tactical and/or joint forces require leaders and logistics specialists with availability and skills to apply digital procedures, automation, etc., according to functional procedures at the levels of top-management, midle-management, low-management and execution in the conditions of continuous and cybernetically protected communications in order to achieve the flows of logistical goods and services, adequate to provide sufficient logistical support to consumers and users of the combatant military structures in order to fulfill their missions.

Because the relevance of modernizing operational military logistics, also known as consumer logistics, is given by its systemic and subsystemic functional nature, I will further highlight some innovative elements, generating efficiency, related to some of its essential functional areas At the same time, the holistic dimension of the effective and efficient management of the logistic support structures will be presented by revealing some aspects of the improvement of the operational logistics planning.

***Key words**: Industry 4.0; supply chain management 4.0; operational logistics; flows of goods and services; modernizating operational logistics planning; information, cyber and of other type protection.*

1. INTRODUCTION

Achieving victories by opposing armies in all historical centuries - before and after Christ - highlights the importance and role of logistics, as an old and complex field of war, through the management, managing and timely provision of all resources and means of combat necessary to prepare and conduct successful military actions.

The increasingly complex military challenges of the 21st century lead military experts and researchers to identify innovative solutions that enable operational logistics to become more effective, efficient and increasingly resilient. Under these conditions, operational logistics must ensure through its structures, adequate to any maneuvering entity, the potential involved by the requirements of the combat forces'missions.

From immemorial time emperors, kings and great army commanders who won or lost battles in military confrontations with their state opponents have relied on the operational level of logistics, focused on resilience, and survival [1].

Therefore, the appropriate combinations of *strategy, tactics and logistics* have been the subject of thinking and building plans for campaigns, battles and fights that are based on important resources (human, material, informational). The effects of the mentioned combinations were studied (and then applied in the wars) in the XVIII-XX centuries, in detail, first by the Swiss *Francoise Antoine Henry Baron de Jomini* (1779-1869) [2].and later by the American George Cyrus Thorpe (1875-1936) [3] Subsequently, the British military expert Basil Liddel-Hart (1895–1970) defined the *concepts appropriate to the physical and mental dislocation of the enemy, but also those related to the separation of its combat structures and the interruption of the normal functioning of their supply lines.* According to the famous expert, this desideratum determines the *creation of all the premises for the unconditional capitulation of the opponent, in order to avoid his total destruction* [4].

Based on the experiences of the wars of the XVIII-XX centuries, but also of the first two decades of the XXI century, the operational logistics has known, over time, transformations and evolutions in full agreement with the requirements of military strategy and tactics. In recent years, the integrated logistics of the operational structures of NATO bodies has undergone important transformations both as a result of technological innovation, and especially due to the increasing complexity and action efficiency of the armies of the States opposing the Alliance.

2. FUNCTIONAL AND RELATIONAL DETERMINATIONS OF MODERN OPERATIONAL MILITARY LOGISTICS

2.1. Overview of Industry 4.0 and Supply Chain Management 4.0

At the end of the 60s of the last century, the famous American specialist, Henry Eccles, revealed the special importance of military logistics, as a *bridge between the national economy and the operations of the com* [5]. Therefore, starting from this stimulus of thinking, today, in the new conditions determined by the transformations of automated and digital nature, new requirements appear to capitalize on the new technological potential in the economic and logistical fields.

Considering first the economic field, I consider that it is important to present a synthetic image on the Industry 4.0, as well as of the supply chain management 4.0.

Technological advances at the industrial level and economic ones at the societal level have led over hundreds of years to the continuous leap towards a new performance, allowing the transition to the fourth industrial revolution, also called Industry 4.0. As a concept, Industry 4.0 is known, initially, starting with 2011 and then recalled in 2013, at an industrial fair in Hanover, as a result of an initiative of the German government to modernize industrial manufacturing processes, by capitalizing on the potential new technologies, in full complementarity with their functional automation and digitization [6].

Figure 1 shows a model of determinants and systemically integrated to Industry 4.0.

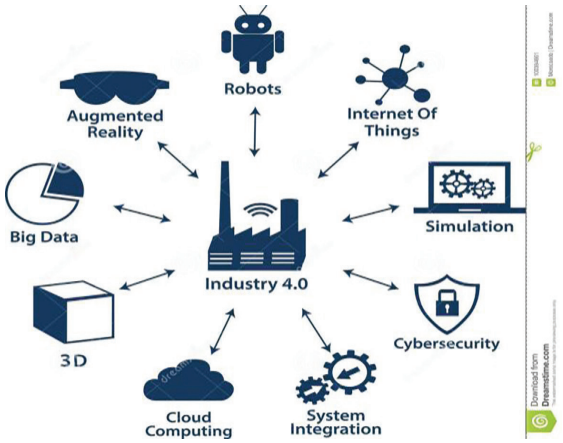


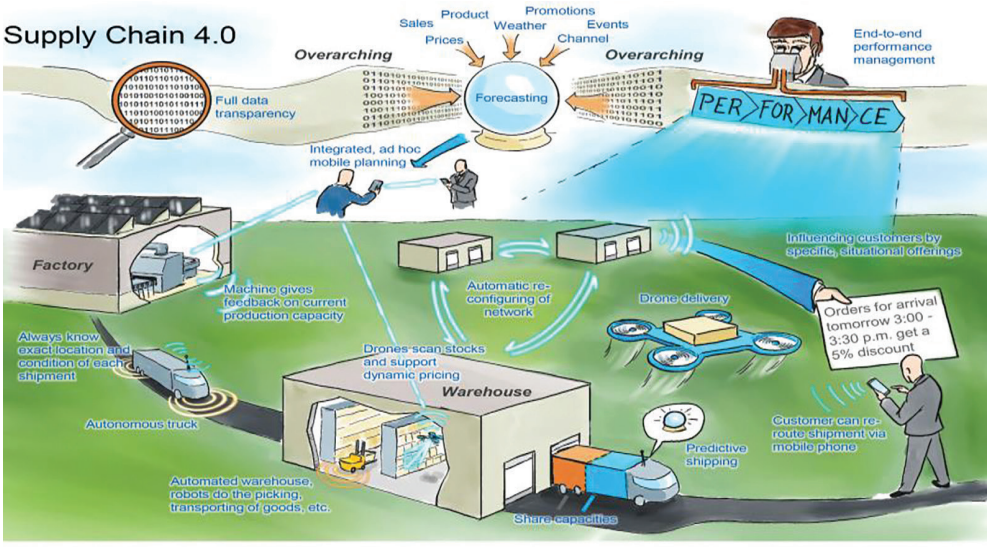
Fig. 1. Determinants of industry 4.0 [7].

The functional determinations of Industry 4.0 are evident in the design, implementation and modern systemic operation of national and multinational supply chains. The obvious relationships between the Internet of goods, advanced robotics, advanced data management, extended automation, placement of sensors in any process, generalization of network operation are obvious objectives to increase performance standards in the efficient operation of the each supply chain management, for full satisfaction of customer requirements, as beneficial effects of Industry 4.0. In order to reveal those mentioned in figure 2, I present an overall vision, a model.

In the conditions of their technological and digital innovation and modernization, the supply chains 4.0, compared to the traditional ones, allow the continuous increase of the efficiency of the flows of goods and related services from suppliers to beneficiaries with minimizing the costs related to supply, manufacturing and distribution to end customers [8].

2.2. Influences of industry 4.0 and supply chain 4.0 management on operational logistics

Considering the essence of the functioning of the operational logistics integrated in each structure of the component of the united



SOURCE: McKinsey

Fig. 2. Synthetic vision on the supply chain management mechanism 4.0.[9].

national combat forces, as well as of those of the Alliance, it is understood, out of the aspect of innovation and modernization, a specific, intersystemic relationship of Industry 4.0 and supply chain management with the types of logistics in the military field, first through *production logistics*, then through the creation of supply chains from domestic producers of the defense industry or from external suppliers to the *logistics structures "in service*" and, further, to *operational logistics entities*. From here, the actions of supply and resupply of the operational forces begin assembled with modern technical systems and combat materials, as well as with effective and efficient means of movement and transport, all with adequate facilities for masking, self-protection, deployment and use in complex environments confrontation with the opposing forces, related to the war of the future.

Figure 3 shows the list of types of military logistics in order to provide the necessary goods and services to consumers and users in the composition of operational military organizations.

The modern operational logistics is the essence of the success of all military actions and has as main attributes: agility;

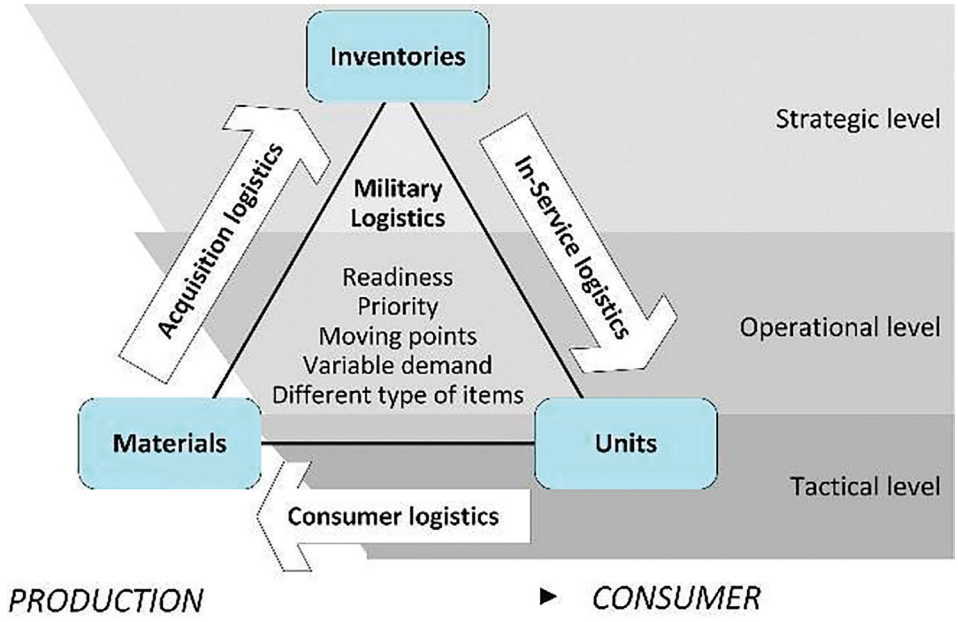


Fig. 3. Relation of the types of military logistics in the process of achieving the logistical support of the joint operational forces [10].

resilience; survival; the immediate ability to respond to the demands of combatant forces; effectiveness and efficiency. All these elements must be adequately correlated with the missions of the fighting structures, in Joint type combinations to allow (together) the successful projection of the established force by carrying out complex actions aimed mainly at: generating operational force; increase the level of readiness; deployment in the theater or area of operations; integration in the tactical device of the assembled operation; redeployment (after completing the mission) and restoration or regeneration [11].

In order to successfully meet the above requirements, military logistics managers and their subordinates in all areas of operational logistics support are those who must ensure the combined procurement, installation and use, for efficiency generation, of new technologies, already widely used in the digital society, including artificial intelligence, such as: "*big data; cloud computing; Internet of Things (IoT); autonomous vehicles; robotics; 3D printing*", s.a. Through their specific hardware and software, for assembly and functional integration, the mentioned technologies functionally determine modern and complex digital mechanisms, which must ensure the increase of the power of the operational logistics [12].

Therefore, the products, technique and materials, which are the subject of rapid acquisitions and distributions to military operational organizations, involve the efficient application of 4.0 marketing and 4.0 logistics within the supply chain management 4.0. All these three disciplines present functions adapted to artificial intelligence and focused on the evolved requirements of the combatant military entities, according to their functional particularities and missions.

The flow of ideas presented also reveals the implications of Industry 4.0, on the modernization of operational military logistics, which is explained precisely by the modern operation of specific processes in supply chains 4.0 (of profile) by using intelligent sensors, RFID systems, smart software, automation and digitization. All these serve the operations of design and realization of fast and efficient flows of goods and services in order to satisfy the needs of consumers and military users (individual and organizational) [13].

In figure 4 I present in essence some factors that determine modernity in operational logistics.

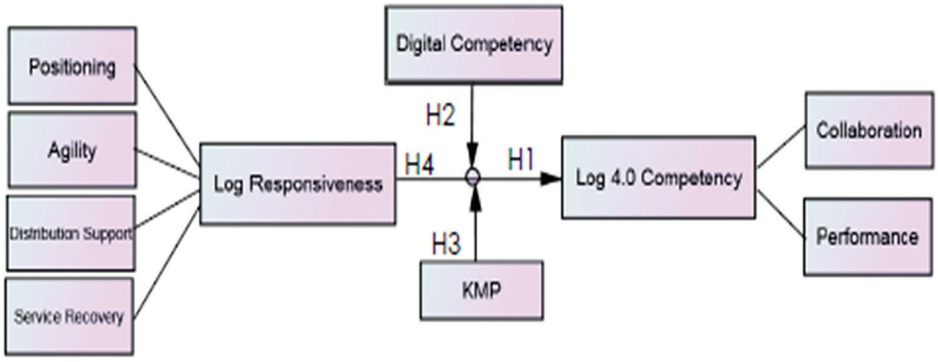


Fig. 4. Essential functional elements of logistics 4.0 integrated to operational logistics [13].

The nature of military logistics is much more complex today, due to the specific support to be given to operational structures in each category of military forces, which requires adequate information and cyber protections (along with other forms of force protection).

3. ESSENTIAL ELEMENTS OF THE MODERN FUNCTIONING OF OPERATIONAL LOGISTICS

The optimal functionality of modern operational logistics is determined by the efficient engagement of its fields within the complex mechanism of timely granting and the efficiency of the logistical support necessary for the combat forces within the Alliance bodies.

In order to fulfill the missions by the operational forces, the practice of war has shown that a continuous correlation must be made *between the pace of supply / resupply and the pace of operations.*

According to US General Walter Bedell Smith (*Chief of the Allied Expeditionary Staff at Supreme Headquarters*), it is not necessarily a matter of changing and adapting action plans as a result of the effects of adverse forces' operations, "*but modified tactics are much more difficult"*[14].

Technological, economic and communication innovations through particularly easy Smart-Tech means are also revolutionizing the military logistics integrated into the operational structures, destined to be deployed and act in theaters or areas of operations [15].

The current requirements for the defense of Romania's territory,

correlated with the strategic objectives of NATO and the United States, have led to national development of endowment programs with modern technical combat systems, to allow operational military organizations to carry out actions in complex environments confrontation with the forces of any opponent. Under these conditions, the tactical structures of logistical support are forced to respond to the new challenges related to ensuring the proper functioning of the new equipment purchased, in order to be used in the operations involved in future conflicts.

The new requirements for the integration of operational forces in a future, complex conflict environment, highlight important connections and interactions between technological and economic systems particularly innovative and efficient, which involves supply chains in a permanent interdependence to honor contracts of the beneficiary entities within the combat forces structure.

The military supply chains (modernized according to SCM 4.0 requirements), adequate for the integration into the mechanism of timely provision of logistical support to operational forces, must allow speed, effective and efficient operation, adaptation and augmentation possibilities, to respond immediately to unforeseen requests, imposed by the immediate and continuous changes of the actions of the fighting forces, sustained [16].

It results, obviously, that the specifics of the national operational forces, as well as of those in the structure of the Alliance require the creation of supply chains that will continuously respond to the requests for goods and services in continuous dynamics. Here, it is added the timely provision of spare parts and aggregates necessary for the repair of technical and armament systems, which are often manufactured by unique manufacturers, without a profile market (for example: engines; transmissions; housings, etc.) [17].

At the same time, the reverse circuit of spare parts and replaced aggregates must be considered in order to transform or repair for the reuse of component alloys. In this way a supply-delivery chain with a closed-loop *("closed-loop" supply chain)* is formed [18].

Figure 5 shows a used model of the supply chain, for the logistical support of the United States operational forces.

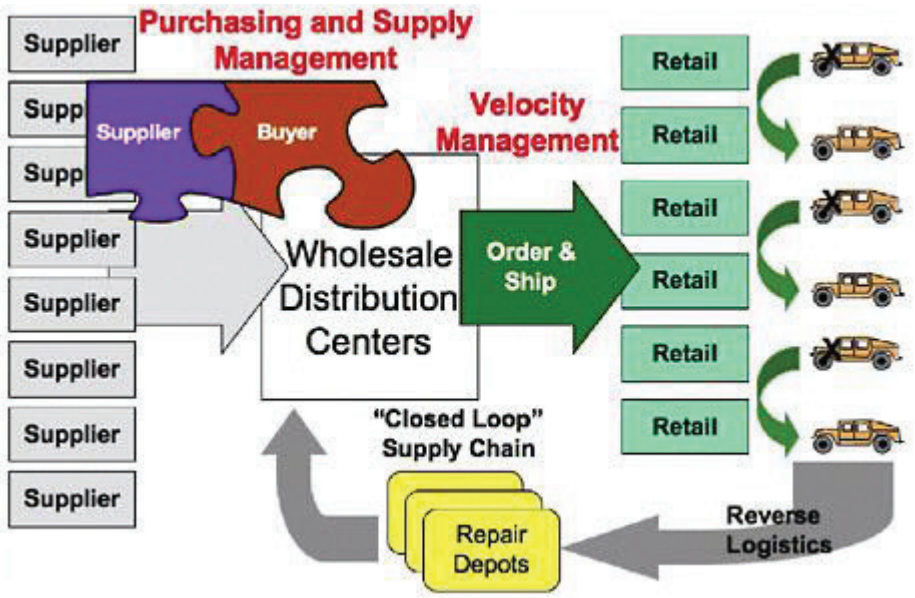


Fig. 5. A model of the supply-delivery chain
for the logistical support of the operational forces [16].

The efficient functioning of the previously presented model, in order to increase the performance, was be based on the progress factors revealed by figure 2.

In a retrospective view, it is important to note that in preparation for Operation *Iraqi Freedom*, logistical support structures and formations were deployed to Kuwait, potentially equivalent to more than 150 "*Wal-Mart*" stores to meet the functional requirements of about 250,000 fighters in the land, air and naval forces [19].

Therefore, rapid technological, economic, digital and managerial developments only allow the commanders of operational forces and their subordinate logistics leaders to plan, ensure and use quickly, agile, efficient, effective and in real conditions of protection all logistical resources at disposition in order to increase the operational power and to facilitate the achievement of the success of the missions received by the subordinate forces, regardless of the conditions of time, season and weather in the theater or the area of military actions.

Next, the logistics managers and the specialized logistics (subordinates) will carry out, from my point of view, those planned and monitored actions, meant to determine fast and protected movements of material goods (products; technique; materials) through supply chains (civil and/or military) which include, in full functional harmony:

• *suppliers (civilian or military) of all types (including suppliers' suppliers);*

• *different national or multinational producers (from the defense industry or not);*

• *central distributors (which can be: civil distribution centers - zonal and local;*

• *adequate support structures for the joint force at the level of the third logistic support line* - from the organic Joint Logistic Support Group;

• *support groups or modules for the execution of the logistic support at the level of the second line of logistic support;*

• *wholesalers and material warehouses of ANRPS or economic operators;*

• *entities from the first line of logistic support, respectively: military logistic structures of execution (of level support group, unit, subunit, transport formation, storage, maintenance and medical support));*

• *various retailers;*

• *advanced logistical structures intended for the logistical support of companies (similar) such as battle supply points/groups, injured evacuation points/groups, observation points/groups, technical evacuation, etc.;*

• *military consumers and users of the combat structures.*

According to the above, I appreciate that supply chains (civil, military or mixed) must have the infrastructure and related modern technologies, which allow continuous inflows and outflows (material, financial, informational and of another nature), to meet the appropriate requirements of the logistical support necessary for the operational forces in a certain theater or area of operations.

Although the data and logistical information necessary to support the profile of operational forces are today fully computerized, capitalized and transmitted properly, according to military experts in modern armies, there are still no efficient and secure technologies (platforms, systems, etc.) which would allow a total and continuous visibility of the existing resources in transit, pre-positioned, on the beneficiary military organizations, as well as of the operations related to them [20].

The revealed aspects aim, on the one hand, possible manifestations of insufficiency of the agility and resilience of the supply chains, and on the other hand, non-conformities in the continuous, timely and efficient information of the logistics managers and implicitly of the leaders of the maneuver and support structures with recent and truthful information, in the appropriate places and times for operational situations, which may lead to incomplete replenishment [21].

The demands of the new operational requirements, involved in the current and future military challenges, determine that *movement and transport* represent an essential area of logistical support, adequately related to the supply chain management. Therefore, in order to fulfill the missions received by the fighting and support forces, important types and quantities of logistic resources must be provided in the indicated places and at the opportune moments, allowing the rapid deployment, integration and engagement of operational forces in nonlinear offensive and/or defensive, hybrid and asymmetric actions, to fulfill the missions of the Alliance's force structures engaged in joint multinational operations [22].

The great military powers of the world have implemented different concepts of deploying operational capabilities in theaters or areas of operations. For example, as a military superpower, the United States has implemented the *"strategic triad"* in accordance with the provisions of its own military doctrine (Figure 6). Therefore, the concretization of the mentioned concept includes three fundamental elements: • *strategic air transport capacities;* • *maritime transport capacities;* • *important stocks of materials pre-positioned according to the requirements of the operations designed to be carried out in theaters of operations outside the national territory* [22].

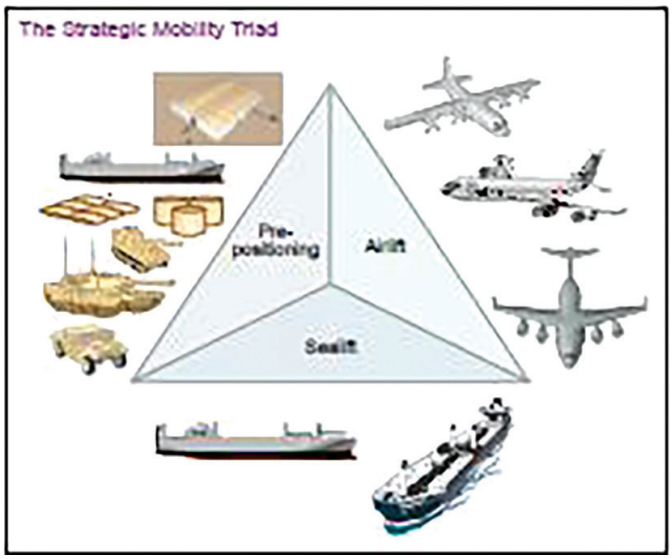


Fig. 6. The *strategic triad* model implemented by the U.S. military.[22]

The transport potential for the realization of the mentioned triad includes first of all strategic means of transport (military and commercial) adequate to the two air and naval modes, but also transport and storage capacities necessary to achieve the pre-position of materials (on land and on logistical support ships) confrontational environments in various theaters (areas) of operations around the world (Joint) [22].

Depending on the concrete action situation, the requirements of the logistical support of the combat forces increase in complexity and as such exceed their own movement and transport capacities (according to land, air and naval transport modes) and can engage the transport potential of civilian capabilities involving reference territorial infrastructures, respectively highways, railways, airports, sea and river ports, as well as adequate operational resources, such as road, rail, air, sea, river means of transport, warehouses, etc. For increased effectiveness and efficiency, here are very important investments to achieve or modernize the mentioned assets (by areas) in accordance with the requirements and standards for implementing the requirements of Industry 4.0 and supply chain 4.0 [14] [26].

From my point of view, for the deployment of forces and means in order to carry out timely and effective defensive operations in areas of operations (imposed by threats and anticipated hostilities) on the national territory, although there are, on categories of forces, a significant number of adequate transport means, they are insufficient; at the same time, in support of the joint operations, the continuous development and modernization of the critical transport infrastructure, as well as of other adjacent territorial capacities must be taken into account. Therefore, depending on the scenarios developed for defense at the strategic, operational (joint) and tactical levels, I believe that in the field of movement and transport there must be (in peacetime) all the necessary logistical resources (human, material and financial and other) to allow the successful fulfillment of the missions of the operational forces.

In the current conditions, the transformations related to the industrial revolution 4.0 determine that the *maintenance management specialists act in order to increase the performance of the maintenance of technical combat systems* in the management of operational military logistics by streamlining the resources employed (human,

material, financial, informational and other), maintaining their functioning at their standard parameters during their life cycle. Currently in the army forces of N.A.T.O. members the emphasis is on the predictability and proactivity of maintenance systems. In this context, the logistics leaders and specialists in the field of maintenance emphasize the functional reliability of the equipment of the operational forces, by monitoring the use and continuous analysis of their functional state [23].

According to American experts, in the action environment of the future (with non-contiguous areas of operations that may include long and insecure lines of communication), for the rapid deployment of joint forces there must be no logistic footprint developed with multiple protection implications. Therefore, in accordance with the new operational requirements, the logistics managers of the North American military are considering, for increased effectiveness and efficiency, the immediate implementation of a modern maintenance system for the equipment of the operational forces with two divisions, namely:

- "*field maintenance" or "on-system maintenance*", which will combine the level of "*unit maintenance*" with the level "*direct support*"; here, specific operations will take place for the evacuation and repair of defective equipment, following their return to users;

- "*sustainment maintenance*" or „*off-system maintenance*", which will combine the „*general support*" level with the „*depot level*" type; essential operations appropriate to the repair of the evacuated equipment were carried out, followed by their distribution to the beneficiary users by resupplying [23].

It follows, therefore, that in order to achieve the modern support for the maintenance of the equipment of the operational structures it must exist on all the necessary resources, which must allow real-time communication and interventions for evacuation, repair, restoration or replacement of severely damaged equipment in order to fulfill missions received by the fighting and support structures within the actions planned and carried out in a multinational context (on the national territory or outside it.[24].

4. ASPECTS OF MODERNITY IN THE PLANNING AND REALIZATION OF OPERATIONAL LOGISTICS

Modern operational logistics planning is very important in

planning an operation at the tactical and joint levels, because it offers the commander of a combat structure the opportunity to resiliently employ sufficient resources, according to his decisive option, to achieve full victory after confronting opposing forces.

According to the tactical and joint requirements, in the field of operational logistics, decisions must be taken correctly, prudently and intelligently based on the data, information and visibility necessary to carry out the planning processes and timely provision of logistical support to combat operational structures depending on the mission received [14].

Based on the highlights, the concept of "*Sense and Respond Logistics*" or "*Logistics that perceives and responds*" is particularly current and useful. This concept perfectly suited to operational logistics 4.0 is focused on the systemic facilities of communication networks and logistics within the combat tactical echelon. In this functional framework are very important the physical processes of logistical support, achievable with adequate human, material, financial and informational resources, which allow anticipation, adaptation and coordination according to the requirements of operational dynamics [25] [26].

In figure 7, within the "*Sense and Respond Logistics*" system, a connectivity from the support source to the point of use in the network is generically highlighted. Here, it results that, within the S&R control node (C2), the traded information is processed in real time, according to the set standards. From here, filtered signals are sent to users (from the support network to the request network).

Given the need to meet the requirements of S&RL officials, according to NCW principles, US military specialists state the need to stimulate innovation, test, verify and validate methods and techniques in support of the effective and progressive use of the S&RL concept. Therefore, this way obviously facilitates the actions of the logistics leaders involved in the decision-making processes of logistical support of the combat forces at the tactical and joint levels [24].

The requirements of the United States' 2017 national security strategy highlight the focus in the future on expeditionary operations effectively supported with the necessary resources within existing bases on their national territory. For this purpose, the stocks necessary for the forces that will prepare and carry out the mentioned operations

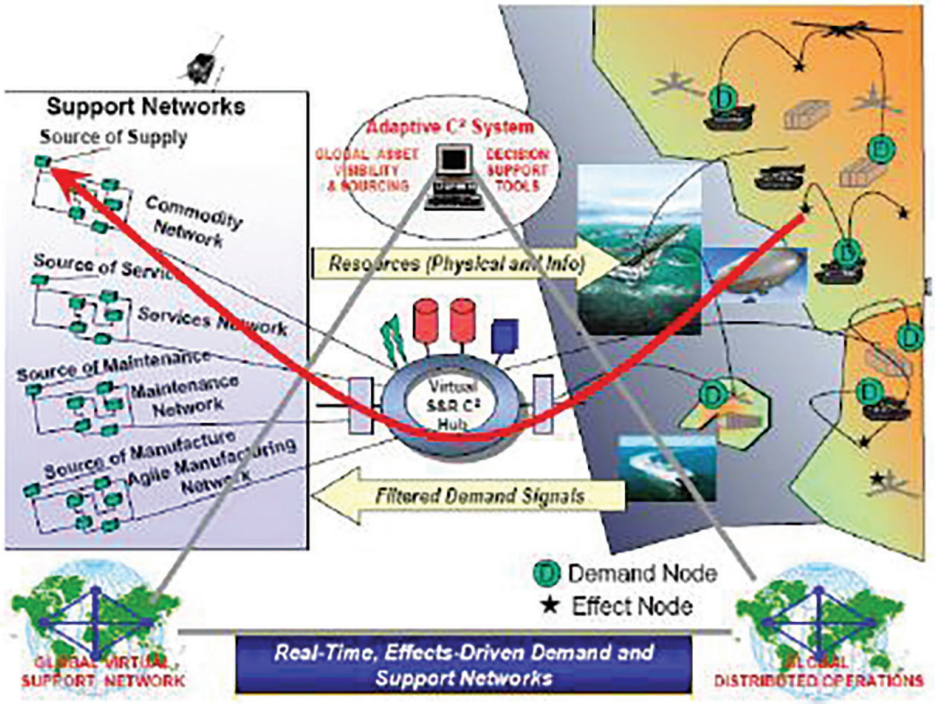


Fig. 7. Generic relevance of the "*Sense and Respond Logistics*" mechanism [25].

will be pre-positioned in advance, taking into account the support of additional forces.

Based on the mentioned security strategy, a team of military specialists (active and reservists from North Carolina) created and implemented a specific system for *military logistics network planning (MLNPS*). This modern (planning) mechanism allows user military logisticians to quickly analyze the data and information needed to identify, establish, evaluate and compare options to support of the possible courses of action for the successful conduct of military expeditionary operations 2020). [20].

Therefore, according to the research results of the military experts mentioned, currently, the MLNPS program allows the identification of logistical bottlenecks, facilitating the short-term highlighting of their consequences. It is obvious that in order to ensure the continuity of supply flows adequate to support the combat actions of the expeditionary operational structures, their logistics

managers have the opportunity to estimate, in due time, possible delays downstream of a supply-delivery chain (military, civilian or mixed). For example, due to functional disturbances, a supplier (contractor) can progressively reduce, for objective reasons, the production established to be delivered to customers (beneficiary maneuvering and support structures). Under these conditions, the logistics leaders will proceed to inform the commanders immediately with viable procurement alternatives in order to make urgent decisions to maintain adequate supply flows, necessary for the fulfillment of missions by the dispatching operational forces [20] [23].

According to the military experts, it is obvious that, based on the functional modernizations brought, the evolved systems of command and logistics control (from the endowment of the operational forces of the North American military) will be able to ensure adequate agility, even if enemy forces would disrupt communications through hostile actions of cybernetic and electronic type. For the mentioned purpose, the continuous technological modernization of the logistics data transfer systems, from the digital processes to the analog and functional modes, is particularly important [44].

5. CONCLUSIONS

The tactical, joined and strategic requirements of future conflict operations determine the leaders of combatant structures to ensure sufficient availability to understand and decide quickly and efficiently on the modern logistical capabilities available to create superior combat power to destroy a potential enemy. To this end, the logistical networks of the operational forces (*technologically superior, informally organized and continuously protected from the aggressive actions of the enemy*) will be permanently functional and employed by military logistics leaders, according to their agility and tactical flexibility in order to achieve the established support objectives.

It results, therefore, that the continuous optimization of storage and transport capacities, in order to meet the requirements of distribution logistics, will determine that both the leaders of operational structures and those of logistics support entities

to be more skilled and proactive in allocating effectively and efficiently the available resources. In this sense, they will seek the continuous realization of the concept of "*just-in-time*" in the process of *overlapping the logistical effort over the operational one*, allowing the rapid attack, encircling and destroying the aggressive forces of the enemy, in a theater or in a joint operations area.

The organizational changes and transformations of the tactical maneuvering and support structures have determined the training and development of their commanders`and subordinate logistics leaders`abilities to deploy, integrate and support the resources of the fighting power of organizations led in complex combat environments, dominated by hybrid, nonlinear and asymmetric operations.

All the mentioned desideratum are based on viable and highly evolved options (as a result of the short transition to the implementation of industry 5.0 and, implicitly, to the management of the supply chain 5.0), which will allow the effective and efficient implementation of operational logistics functions in full accordance with the missions and requirements of operational structures, regardless of time, season and weather.

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