RESEARCH ON THE MAINTENANCE OF AIR SURVEILLANCE SYSTEMS MANAGEMENT IN THE CONTEXT OF TECHNOLOGICAL DEVELOPMENT INDUSTRY 4.0

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***Abstract**: Air surveillance systems (especially radars) have evolved by virtue of technological progress. In order to benefit from Industry 4.0 features, systems and their maintenance management need to be reconsidered, reinterpreted and updated. The article wants to highlight on the one hand the current status of the approach to the topic of maintenance of air surveillance systems management and on the other hand the need to implement the Industry 4.0 concept to increase efficiency and keep systems operational.*

***Keywords**: air surveillance systems, maintenance management, Industry 4.0, radars, self-maintenance, digital transformation*

1. INTRODUCTION

Air surveillance systems, in all forms in which they are designed, built and optimized, are special electronic equipment in the defense system which, when efficiently operated, is the primary source of information on in-flight aerial platforms. Target detection and location, as well as their identification, is the main goal. This would be almost impossible without proper maintenance to maintain the operating systems 24/7, as any disruption could cause security breaches in your own airspace, a vulnerability that can be exploited badly.

2. SCIENTIFIC BACKGROUND

Specialized articles that dealt with the issue of the evolution of the maintenance of systems used in industry together with the development of communication and information technologies have had an increasing trend (Fig.1.).

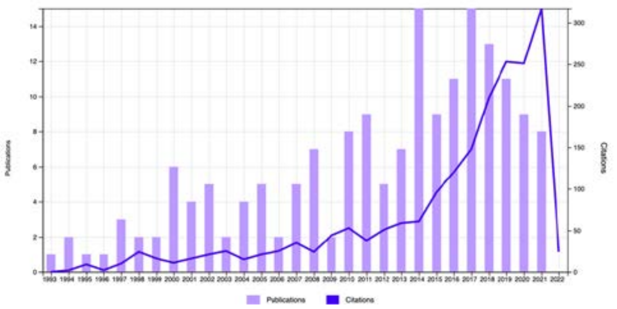

FIG.1 Trend of interest about evolution of the maintenance management

Concepts used in the past, such as corrective, preventive, electronic maintenance, and intelligent maintenance systems [1], were later developed by Industry 4.0 and related key technologies (IoT - Internet of Things, physical cyber systems, etc.). Currently, the attention of the scientific literature is focused on items such as condition-based maintenance and PHM (Prognostics and health management) [2], [3], [4], [5]. Even under these conditions, in the existing literature we have identified a lack of understanding of what it means to achieve digitized production for maintenance organizations along the hard (technical) and soft (social) dimensions [6], [7].

3. IDENTIFYING AND HIGHLIGHTING THE NEED TO TREAT / RESEARCH THE SUBJECT

Following the research of the bibliographic resources found in Web of Science [8] and the interpretation of the results with the WOSviewer software [9]. Using the keywords “air surveillance”, “management”, “maintenance” we identified the fact that the proposed topic is not adequately treated in the scientific literature. Based on the research carried out in the scientific literature, we highlight in fig.2. The links between the most used concepts of air surveillance and maintenance. The lack of the Industry 4.0 concept draws our attention. On the other hand in fig.3. We tried to associate Industry 4.0 with the topic of maintenance in air surveillance, the last term not being found in the search list.

It is obvious that the air surveillance systems are special, dedicated systems that require special maintenance both hardware, software and training of the human factor that operates and maintains it. Implementing the Industry 4.0 concept at the level of air surveillance systems is a challenge as stability and 24/7 operation are the major goals.

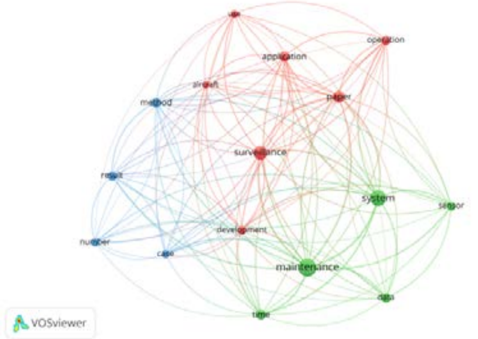

FIG.2 Links between elements of interest

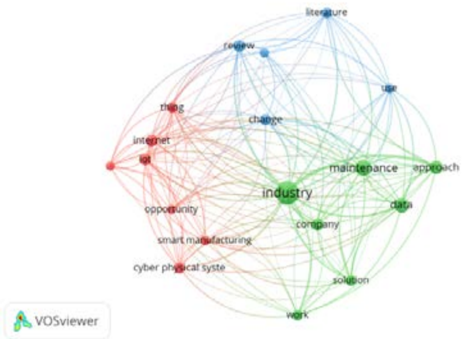

FIG.3 Industry 4.0 – maintenance connection

4. EVOLUTION OF AIR SURVEILLANCE SYSTEMS ARCHITECTURE

It is easy to understand that in order to deal with the topic of maintenance of air surveillance systems, it is extremely important to understand the evolution of its architecture. The first air surveillance systems with significant technological advances that proved to be effective were used during World War II to defend England [10] from German air raids. We identify in the past in step with the evolution of technology at that time, analogical radars that used high emission powers, with high consumption of resources, whose protection against interference was limited. Also, the data links were non-automated, the data transmission being made by telephone connections with significant delays from the observation point to the decision-making point. Technological evolution has also left its mark on air surveillance systems, so that digital and digital analogical radars are currently in operation that perform signal processing using powerful processors.

The latter using the characteristics of phased antenna systems have the advantage of using low power, high sensitivity receivers. These systems benefit from jamming protection - RF bandwidth modes, networking (automated data links/ transmissions) and secondary radar features with IFF. The future is expected to be great for air surveillance systems, using the benefits of networking multiple sensors and using AI to identify threats and make decisions about targeting cognitive radar.

5. MAINTENANCE OF INDUSTRIAL SYSTEMS, INDUSTRIAL REVOLUTIONS AND THE EMERGENCE OF INDUSTRY_4.0

The evolution of the maintenance of industrial systems is directly related to the typology of systems architecture. In the past, the equipment was robust, with few checkpoints, excessive maintenance, expensive mainly corrective. Currently, multiple sensors (stroke, vibration, lubrication quality, etc.), system computers equipped with error display software make it possible to perform maintenance especially preventive. For the future, the evolution of maintenance leads to the use of data acquisition, processing and display systems using multiple sensors, contextual, AI, optimization, maintenance focused on reliability so-called predictive maintenance.

Man and society in terms of needs have evolved, the stages being called industrial revolutions [11]. These were classified as follows:

I - mechanization with the power of water and steam;

II - mass production, with the help of electrically operated conveyor belts;

III - the digital with the use of electronic and IT products to automate production;

"4.0" - Software (Programs), which are usually called a new version in major changes, the first digit of the version number is incremented by one and at the same time the second digit starts from zero. The basic organizational principles of Industry 4.0 [12] are well known: interconnection, transparency of information, technical assistance, decentralized decisions.

6. IMPLEMENTATION AND EFFECTS OF INDUSTRY 4.0 [13] ON LOGISTICS AND MAINTENANCE OF MODERN RADARS

Logistics in general and maintenance processes in particular, have a huge gain by implementing the organizational principles of Industry 4.0. I bring to your attention a few points related to the optimized organization of logistics elements (storage, maintenance, transport, etc.), the identification of degradation/ wear of system components and those in need of repairs. IoT can automatically report system degradation and generate reports for maintenance needs. Respectively automatic generation of orders for spare parts.

The evolution of technology has brought ease in maintenance processes. Thus in modern radars are used with high performance components and redundant systems that due to miniaturization (solid state technology) are less expensive. We also identify interconnected software components (operation, identification and reporting of out-of-tolerance, mission parameters) [14] and offer the possibility to update. The organization chart distinguishes between team members [15] and outlines clear tasks (software operation/ software intervention of engineers/ maintenance) with the possibility of remote intervention. Staff training using e-learning methods, with the possibility of distance learning using AR [16]. It is obvious that the trends in the use of AI lead to a reduction in downtime.

7. THE VULNERABILITY OF RADARS AND THEIR SECURITY IN THE FACE OF TECHNOLOGICAL CHANGE INDUSTRY 4.0

The integration of air surveillance systems into the network brings with it an exposure to the data and information conveyed and creates security vulnerabilities. In Industry 4.0 via IoT, the challenges are the same, with the possibility of data being transmitted over the network through cyber attacks. This challenge requires securing: the physical communication channels used and the electronic one by encrypting the packets of data carried between the IT systems used.

CONCLUSIONS

In order to benefit from the technological advance, it is important to keep up, to achieve the development with the essential condition of maintaining the stability of the system. To achieve this goal, it is necessary to address the identified challenges: adapting the human factor to technological change, acquiring systems / interfaces that allow the use / integration of current air surveillance systems in the IoT compatible platform for Industry 4.0 and reducing system vulnerability by securing it.

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