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The concept of assurance the operating dependability of launching process monitoring subsystem for surface-to-air missile systems

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The article discusses the tasks and modes of operation the launching process monitoring subsystem for surface-to-air missile systems. The dependability structures of monitoring subsystem are presented. Selected issues of monitoring subsystem reliability and maintainability are characterized.

KEYWORDS: *operation, dependability, surface-to-air missile system*

Introduction

Developing the concept of ensuring operational reliability of complex technical systems is a difficult issue, especially at the stage of implementing the innovative solutions, for which operational data are not available. An example of such a complex object is the subsystem for monitoring the process of launching the surface-to-air missile systems (PZR) under consideration. In this case, it is necessary: in-depth analysis of the subsystem operation, acquisition of operational data at the stage of laboratory tests and analysis of other technical objects, similar in construction.

Subsystem for monitoring the process of shooting with PZR

The subject of the considerations in this paper is – in the context of the concept of ensuring the operational reliability – a subsystem for monitoring the process of launching the anti-aircraft rocket sets, which is part of the Land Safety System implemented at the Central Air Force Training Area (CPSP) in Ustka [5]. The subsystem for monitoring the process of shooting from the rocket set is to enable the transmission of data to a security position using a tele-technical network as well as their imaging and archiving. Data obtained from PZR should be sufficient for a full analysis of events occurring during the implementation of fire tasks and for an objective assessment of the crew's training level [3].

The monitoring subsystem is intended to perform, in particular, the following tasks [4]:

- ensure the real-time transmission to the security post of data documenting the work of the combat set and activities of crew officers, as well as recording and archiving of this data;
- provide a two-way rigid communication between the security post and the exercising crew and give supervisors the opportunity to control the activities of the exercising crew;
- ensure that it is possible to verify the functioning of data acquisition subsystems installed in PZR;
- provide the ability to simultaneously display data at the security post (SD) and the command post of training troops (SDCW) and at the command and observation point (PDO).

The considered shooting monitoring subsystem consists of basic, functionally separated parts (including dislocations at the CPSP):

- monitoring subsystems placed in PZR (up to 20 units) at fire stations (SO);
- imaging and control subsystem located on SD;
- archiving subsystem located on the SD;
- imaging and control subsystem on the SDĆW;
- imaging subsystem on PDO;
- data transmission and control signals subsystem.

Functional diagram of the monitoring subsystem under consideration is shown in fig. 1.

Knowledge of working methods and conditions is the basis for determining the reliability and serviceability as well as planning tests and reliability analyses.

Operating modes and structure of the subsystem

Depending on the needs of users of the subsystem, operating conditions and suitability of individual elements of the subsystem, different modes of its operation were defined.

Imaging and archiving mode at all imaging collection points

In this mode, all system components are operational. Data transmission subsystem distributes information to all required image reception points. The subsystem is started on PDO, SDĆW and at least one PZR. The main server, active devices and tele-technical network (archiving subsystem), located on the SD CPSP, are efficient and archive recordings in real time.

Fig. 1. Simplified functional diagram of the monitoring subsystem under consideration

Imaging and archiving mode on SD CPSP and PDO

In this mode, all system components are functional, although there is no need to transmit images to SDĆW. Data transmission subsystem distributes information to all required image reception points, excluding SDĆW.

Imaging and archiving mode on SD CPSP and SDĆW

In this mode, all system components are operational, although there is no need for transmission of imaging on PDO (no observers on PDO), or the subsystem on PDO is inoperative. Data transmission subsystem distributes information to all required image reception points except for PDOs.

Imaging and archiving mode on SD CPSP emergency

The master server crashed in this mode. Its work is taken over by the failover server. Data transmission subsystem distributes information to all required image reception points. The subsystem is started on PDO,

SDĆW and at least one PZR. The backup failover server (archiving subsystem) located on the SD CPSP is operational and archives the recordings in real time. If more than 10 subsystem cameras are connected, it is necessary to reduce the data streams (resolutions) due to the limitation of the server's backup saving capacity.

Archiving mode in the internal PZR emergency subsystem

In this mode, data transmission subsystem has failed or is not being used. The monitoring subsystem archives on internal data carriers (SD cards in cameras). No image transmission to SD, PDO, SDĆW. The imaging and control subsystem operator cannot control the subsystem operation. In addition, real-time transmission is not possible in this mode. Recordings can only be played back after completing the tasks. Rigid communication between SD and PZR is also not possible.

Fig. 2. Example of a subsystem structure in imaging mode at all points

Fig. 3. Reliability structure of the subsystem located in PZR

Functional structures determined in this way form the basis for identifying the reliability structure of the object, i.e. determining how the reliability states of the elements affect the reliability state of the system.

An example of the reliability structure, taking into account the main elements of the subsystem, in the imaging and archiving mode at all the reception points of the imaging is shown in fig. 2, and in fig. 3 – reliability structure of the monitoring subsystem in PZR.

The defined structure is necessary to determine reliability indicators characterizing the operational properties of the shooting subsystem under consideration.

Analysis of the operation process of the monitoring subsystem in PZR

Due to the presence of several sources of information, the subsystem in PZR can function in a limited way in the event of a failure of one of the elements, e.g. a camera.

In addition, in the event of a failure of the main transmission path, some of the sources have the option of recording on internal data carriers for later use. The subsystem is then partially functional, but in the sense of a real-time transmission (in a broader sense), it is not fit for the expected tasks.

It is important to ensure the subsystem's reliability by defining its most important reliability properties, which include reliability and serviceability [2].

The measure of reliability are indicators, e.g.

- probability of correct work,
- average time of correct operation until damage,
- average time of correct operation between damages,
- probability of repair within a specified time,
- average repair time.

The basis for their determination is the analysis of tactical and technical assumptions and the use of appropriate methods [1].

When developing the concept of ensuring the reliability of the monitoring subsystem in the scope of serviceability, one should address two issues: ensuring the susceptibility to maintenance works of the object structure and planning the service means [7].

Shooting monitoring subsystem is made in a way that guarantees the possibility of quick replacement of faulty devices. The design of most devices is modular, and the repair usually involves replacing the faulty sub-assembly with the one selected from the set of spare parts (ZCzZ), located in a warehouse located on the area of CPSP.

Key subsystems in the number of 20 pieces (usually not more than 10 pieces are used at the same time), located in PZR, provide interchangeability in the event of failure. As part of the current operation, the subsystem has undergone minor failures, while its basic elements – e.g. software server, subsystems on SO, large-format monitors – have not been damaged so far [6]. It can be predicted that the current service measures (ZCzZ and scheduled ongoing maintenance) will ensure the subsystem's efficiency for at least several years.

At the current stage of implementation of the shooting monitoring subsystem, there may be a problem with the availability of data necessary to perform the analyses. Their source is e.g. laboratory tests during design and implementation works, equipment tests in conditions similar to the target ones, laboratory tests of similar objects and databases of the monitoring subsystem contractor or contracting entity. It becomes important to organize a system for the acquisition and collection of operational data regarding the subsystem integrity and serviceability.

Verification of integrity can be carried out using analyses based on the results of laboratory tests and implementation tests of models of subsystem components and analysis of reliability characteristics based on operational data.

Summary

The work describes the tasks and modes of operation of the subsystem for monitoring the process of launching the anti-aircraft missile sets. Particular attention was paid to ways of imaging and archiving information at various points of imaging reception. On this basis, reliability structures have been developed. They are derived from the requirements for the tasks performed by the subsystem and are usually in a mixed (series-parallel) form.

The designated structures enable determination of reliability indicators characterizing the operational properties of the shooting monitoring subsystem. Reliability and serviceability are particularly important from the user's perspective. In the case of innovative solutions, which may include the subsystem under consideration, the difficulty is obtaining data for the estimation of reliability indicators. Very important here are: previous experience of authors of similar solutions, reliability data from subsequent phases of the equipment life cycle collected by them and the use of expert methods in estimating the operational reliability of constructed objects.

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