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D.V. Perekrestov

*Kirovohrad flight academy of National aviation university, Kirovohrad*

## RELIABILITY AS THE MAIN INDICATOR OF QUALITY OF NAVIGATION SYSTEMS

*This article deals with the concept of navigation systems (NS) and devices (ND), and their impact on flight safety. It shows the modern stage development of navigation systems, their complexity and technological perfection. Reveals the concept of reliability and NS, shows their interrelation. Reliability serves as the main indicator of quality of navigation systems. Also, in the work are represented the most typical system failures. Special attention deserves "wandering failures", because of their danger and unpredictability of safety.*

**Keywords:** reliability, navigation systems, aircraft, flight safety, wandering failures.

### Introduction

The present stage of development of civil aviation (CA) is characterized by a steady tendency to growth of passenger and cargo traffic on domestic and international routes and to increase air traffic intensity. Natural consequence of such tendency is the increase of navigational aids role and importance to ensure the safety and regularity of flights. The navigation systems (NS) and devices (ND) which were widely used more than a decade ago aren't able to meet the increasing requirements for accuracy and reliability of navigation measurements. Progress in the area of ensuring flights navigation systems is followed by complication of the onboard equipment, use of new methods of signals formation and processing, expansion of opportunities of onboard devices. In the process of flights' navigation ensuring a wide range of experts from among technical and aircrew CA is involved. It is necessary to take into account that complication of onboard equipment sharply reduces reliability of modern navigation equipment. Decrease of reliability leads to economic losses, to unjustified increase of aircraft operation cost, in particular of training planes for teaching cadet-pilots [1].

### Main part

Navigation is a science about methods and means of mobile objects operation from one point to another on trajectories according to task character and conditions of its fulfillment. Means of navigation area set of various devices, including the navigation measuring instruments providing the solution of the main objective of navigation. Navigation measuring instruments according to methods of obtaining primary information are divided into aerometric, magnetic, astronomical, inertial, etc. Aviation navigation studies aircraft operation from one point of a terrestrial surface to another on certain 4-d operations trajectories. The main objective of aviation navigation is safe and economic expenses of aircraft time and fuel output in the set point at a given time with the steady state accuracy [2]. The main task of airplane control is to keep the set navigation mode of flight. The problem with reliability may occur due to: complexity of the navigation equipment; lag of quality of equipment

elements due to their quantitative usage; presence of the person operator when the equipment carries out the functions; difficult operational conditions.

All mentioned factors show the importance of the problem of navigation systems reliability. The analysis of failures reasons in the process of testing and operation and their classification in groups is of great importance in the study of reliability. Depending on reasons' type the failures may be divided into two groups. The first group includes failures which are a consequence of design defects, the production technology, operational documentation. Failures, which are caused by casual dispersion of characteristics of the completing elements within the established their admissions, casual adverse combination of operating modes belong to the second group. Such failures are caused by random non-repeating reasons of different system types. Failures of the first group, as a rule, have nonrandom character. During normal operation non random refusals meet exclusively seldom and in the theory of reliability aren't studied.

The theory of reliability considers only casual refusals for the purpose of clarifying regularities and definition of effective methods of elimination of the reasons causing their emergence. Refusals represent casual events. Therefore, as the main mathematical apparatus of the theory of reliability, methods of probability theory and mathematical statistics are used. Concretizing concepts of operating state and refusal in relation to the navigation system it is visible that the system is in operating state if it develops all navigation parameters with errors which certain characteristics do not exceed the set admissions. It is obvious that concept of operating state, as concept of reliability for the NS includes phenomenon of accuracy. Further we will consider that the event of refusal takes place in NS in a case when at least one of navigation parameters is developed with the raised error or isn't developed at all [2].

The event representing refusal of NS can be presented, for example, as emergence to realization of an error of the emission (limited on excess time) lasting not less than  $\Delta$  over the set  $x_0$  level or as emergence not less than  $n$  emissions lasting not less than  $\Delta$  during the set time interval  $(0, t)$ . In figure 1 examples of refusals of NS are given. And at the moments of  $t_1$ ,  $t_2$  and  $t_3$  there

are emissions of realization of an error which can be recognized or aren't recognized as refusals depending on the used refusal definition.

It is obvious that critical defects (refusals) of elements can lead to refusal. Further such refusals we will name technical. However, characteristic peculiarity of NS is possibility of its refusal also in case of critical defects absence in elements. Such failures as opposed to the technical will be named wandering. Important property of this sort of refusal is that after it the system restores itself, or for its restoration, just correction of its internal information is enough and replacements of elements are not required. The most frequent reason of occurrence of the wandering refusals and violations of reliability of NS is change of measurement parameters under the influence of physico-mechanical processes the speed of which is connected with climatic factors, with mechanical influences, with an overheat in side of a detail, and also with the chosen materials, coverings, constructive and operational design. Reliability of the navigation apparatus is largely dependent on the reliability of the elements therein. If elements possess low reliability, measures will be effective for ensuring reliability of all system. Elements of modern navigation instruments represent difficult and perfect technical devices [1].

Researching a problem of ensuring NS reliability, it is necessary to take into account that it consists of two parts: ensuring reliability of elements and ensuring reliable operation of the equipment. As a result of influence of operational factors in material structures of elements, various physical, chemical, and mechanical processes descend as a result of which there are reversible and irreversible changes in material structures. Reversible changes are determined by an element material exchange with environment due to sorption and a desorption, temperature changes of material properties, other phenomena. Irreversible changes are caused by chemical reactions in materials, development of microcracks in structure of materials and other processes. Accumulation of changes in materials leads to change of their properties, parameters of elements, and, eventually, to technical or wandering refusals. Thus there is a causal link between the event and the failure.

## Conclusion

The main indicator of navigation systems' and means of flights ensuring quality is reliability. Reliability is set at design stages and maintained at operational phases. In the presence of sufficient statistical data on the flight incidents connected with malfunctions of NS, expert's estimates of an aircrew, received on operating experience we can affect reliability of systems, by means of maintenance and repair, thereby to provide the demanded level of flights' safety. Obtaining enough information we can define indicators reliability of NS by one of three fundamental laws of distribution, depending on a sort of defects of system [1, 2].

**Exponential distribution.** Peculiarity of this distribution is the device intensity doesn't depend on time, i.e. the operating time of the device doesn't affect its reliability. **Normal distribution** is characteristic for products of the aircraft equipment if the process of refusal's emergence can be presented as consisting of a large number of stages. It can be a wear consequence with a constant speed, aging and influence of a large number of factors of properties of semiconductor devices' degradation, equivalent in size. The time of restoration of the repaired products, operating time to the full of non restorable products in some cases are also distributed in normal way to the law approximately. **Weibull's distribution.** Such distribution is characteristic for refusals of many non restorable products of the aircraft equipment. All this testifies that maintenance of reliable work of NS is an important problem of safety of flights.

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**Рецензент:** д-р техн. наук, проф. С.В. Козелков, Державний університет телекомунікацій, Київ.

## НАДЕЖНОСТЬ КАК ГЛАВНЫЙ ПОКАЗАТЕЛЬ КАЧЕСТВА НАВИГАЦИОННЫХ СИСТЕМ

Д.В. Перекрестов

В статье раскрывается понятие навигационных систем (НС) и устройств (НУ), и их влияние на безопасность полетов. Показан современный этап развития навигационных систем, их сложность и технологическая совершенность. Раскрывается понятие надежность и НС, показывается их взаимосвязь. Надежность выступает как основной показатель качества навигационных систем. Представлены наиболее характерные неисправности систем. Особое внимание заслуживают «блуждающие отказы» из-за их опасности и непредсказуемости для безопасности полетов.

**Ключевые слова:** надежность, навигационные системы, безопасность полетов, блуждающие отказы.

## НАДІЙНІСТЬ ЯК ГОЛОВНИЙ ПОКАЗНИК ЯКОСТІ НАВІГАЦІЙНИХ СИСТЕМ

Д.В. Перекрестов

У даній статті розкривається поняття навігаційних систем (НС) і пристроїв (НУ), та їх вплив на безпеку польотів. Показаний сучасний етап розвитку навігаційних систем, їх складність і технологічна досконалість. Розкривається поняття надійність і НС, показується їх взаємозв'язок. Надійність виступає як основний показник якості навігаційних систем. Також, в роботі, представлені найбільш характерні несправності систем. Особливу увагу заслуговують «блукуючі відмови», через їх небезпеку та непередбачуваності для безпеки польотів.

**Ключові слова:** надійність, навігаційні системи, безпека польотів, блукуючі відмови.