

MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE  
NATIONAL TECHNICAL UNIVERSITY OF UKRAINE  
“KYIV POLYTECHNIC INSTITUTE”

AERO SPACE SYSTEM DEPARTMENT

# **Intelligence. Integration. Reliability**

**Abstracts**

**VIII international students and young scientists conference**

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**МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ  
НАЦІОНАЛЬНИЙ ТЕХНІЧНИЙ УНІВЕРСИТЕТ УКРАЇНИ  
«КИЇВСЬКИЙ ПОЛІТЕХНІЧНИЙ ІНСТИТУТ»**

**ФАКУЛЬТЕТ АВІАЦІЙНИХ І КОСМІЧНИХ СИСТЕМ**

## **ІНТЕЛЕКТ. ІНТЕГРАЦІЯ. НАДІЙНІСТЬ**

**Тези доповідей учасників  
VIII міжнародної конференції  
студентів та молодих вчених**

**20 квітня 2015 року**

**м. Київ**

Київ Варшава  
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## VIII International Scientific Conference “Intelligence. Integration. Reliability”

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*В авторській редакції*



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**Aleksander Masłowski**

## **BALLON DIVISION - STREAMING VIDEO TO OCULUS RIFT FROM FLYING STRATOSPHERIC BALLON**

In 2012 a few people from our association formed the Balloon Section. Their main objective was to prepare a universal Polish platform which could fly students' experiments to the stratosphere. They were inspired by European programme BEXUS.

Last year, Balloon Section was granted a funding from university to prepare aforementioned platform. With this money, members of the Section have built two gondolas and prepared one test flight. The flight took place at the beginning of July 2014 and tested a small version of our APRS module, a high school students' experiment which examined temperature and pressure, and a 30 meter test antenna – Cursus-1. We purchased the equipment needed to transport gondolas and new parachute. In December 2014, a team from our Section was on Preselection Workshop for Rexus / Bexus campaign in ESTEC in Netherlands. We presented BuLMA project – Balloon Life and Micrometeorites Assembler. We took part in interesting workshops, however, due to high quality of other projects, we did not get to the next phase.

Despite this, in this year we started a new project. Streaming video to Oculus Rift and remote control camera's manipulator. Virtual Reality Glasses are recently very popular and many companies develop their own products. However, because of the availability of the Oculus Rift, the first glasses of this type, we use them in our project. Our goal is to transmit video from a distance of 45 km and control manipulator placed on the gondola in real time. The models of this system and documentation of concept phase will be presented.

We would like to have new data from our instruments in next flights, which could be used to prepare better components. In the near future we are going to design and construct the stratospheric glider with FPV (first person view) and Very-Low-Frequency transmitter.

**Maciej Piaskowski, Jakub Woźniak**

## **HISTORY AND RECONSTRUCTION OF SL-1 AKAR GLIDER**

The SL-1 Akar was created by students of Warsaw University of Technology in 1923. The Faculty of Power and Aeronautical Engineering, called the Mechanical Faculty at that time, was the place of origin for the Students Mechanical Society with its Aviation Section, which was the predecessor of today's Students Aviation Association.



It was designed mostly by Adam Karpiński, to participate in First Competition of Gliders in Białka in 1923. Basic dimensions: wingspan 9,3 m, length 5,5 m, height 1,7 m, wings surface 12,3 m<sup>2</sup>, aspect ratio 7. Made of wood and canvas, high-wing, twin fuselage.

Reconstruction by Students Aviation Association started in late 2014, with help from glider renovation facility in Jeżów Sudecki. Glider will be not flyable, and have to be completed until 13<sup>th</sup> May 2015 to take part in exhibition. Works take place in specially dedicated room, with use of mostly basic tools. Glider is made of spruce wood and birch plywood, was re-designed with use of historical photos and drawings of original aircraft. After exhibition it will be hung in one of the lecture rooms at Faculty of Power and Aeronautical Engineering.

**Michał Rodak**

## **ULTRA FUEL EFFICIENT ETHANOL-BASED ENGINE**

Students' Association of Vehicle Aerodynamics (SKAP) takes part in the Shell Eco-marathon event each year, therefore one of our main goals is to win the competition by getting the highest score based on vehicle's fuel efficiency. That is the reason why along with the work on various elements of the new model of our Kropelka (the Droplet) we couldn't do without consideration of the drive unit.

So far, the prototype vehicle Kropelka was powered by general purpose engine often used for lawn mowers, pressure washers, generators, water pumps, and a wide variety of other equipment. Due to its series production resulting in insufficient parts quality and much energy loss, members of SKAP decided to create their own engine from scratch, which will be designed for maximum fuel economy. Prototype's engine features were clear right away: highest possible thermal and mechanical efficiency reducing fuel consumption along with capability of frequent, certain startup and fast warming up to operating temperature imposed by our strategy based on periodic use of the drive unit during the competition.

After indispensable analysis, we have chosen ethanol as the most convenient fuel considering its high Research Octane Number (equal to 108,6). Another reason was the opportunity of a significant increase in engine efficiency through the use of high compression ratio (even 17:1) while maintaining the ability to use standard components of the fuel system. To effectively use the heat generated in the combustion chamber, it was concluded that the engine should use the Atkinson cycle, which have extended compression stroke in comparison





with the typical engine using the most common Otto process. Having considered different crank systems we determined the classic one.

Countless hours of work and huge commitment of many people resulted in a precise 3D model of an engine, which satisfies all the criteria set out earlier. After performing hundreds of calculations, throughout the last year SKAP members managed to build the designed engine that has a chance to be one of the most fuel efficient in the world. Tests and work optimization will be carried out soon.

### **Pavlo Kozin, Tadeusz Górnicki** **STUDENTS' SPACE ASSOCIATION: PREPARATION OF CANSAT LAUNCHER BY ROCKET DIVISION**

The rocket division was established by the members of Students' Space Association five years ago. One of the main goals was to improve skills and practical knowledge of participants by solving design, construction and organization issues.

Our first series was A1, a subsonic single rocket which was first launched on 6.08.2011 reaching 400m during flight. Its successor first flight took place two years later, A2 two stage solid rocket ascending 700m. After testing family A rockets our team took up a challenge of creating more advanced constructions. Named H1, the supersonic single rocket achieved 9000m altitude with maximum speed of 3mach.

Since then our division made contacts with various institutions and companies which supply us in solid propellant and their laboratory support enabled us conducting tests at their facilities.

The upcoming main project was set quite a long time ago. The long-term goal was to build a rocket able to launch small science craft so called CanSats, size of standard beverage can (350ml). Our platform will launch them at supersonic speed in the lower part of the atmosphere. These scientific experiments can be prepared by university or school students on base of competition. Best models would be selected and launched. We are planning to use reliable and tested H1 engine in a modified version. CanSat Launcher (CSL) rocket will be able to carry 8 CanSats to the altitude of 5500m which is definitely higher in comparison to similar projects.

Our team is open for cooperation with other educational institutions, even from abroad, interested in taking part in CanSat competition.



**Robert Samplawski**

## **SUPER ECONOMIC VEHICLE'S BODY – STRUCTURE AND AERODYNAMICS**

The Student's Association of Vehicle Aerodynamics has been operating at the Faculty of Power and Aeronautical Engineering since 2005. Today it has nearly 60 members focused on developing vehicles with extremely low fuel consumption. The Association achieved success in various fields of activity with greatest feats coming in the Shell eco-marathon in which we participate annually in both main categories: Urban Concept and Prototype.

The focus will be on the latter. our first Prototype class car is called Kropelka (The Droplet). We have been using it in competitions for the past few years. During 2012 Shell eco-marathon edition we have accomplished the best run among any other Polish team. A record then set – 659 km/liter still has not been beaten.

This result may be impressive, but our ambition is to match the performance of the top teams in the world which is normally around 3000 km/liter. In order to do that, as well as to meet changing rules of the competition, we are developing brand new vehicle.

Demands for an extremely efficient car are very strict. Our team has to assure superb engine productivity, minimal rolling drag, low aerodynamic drag and very small mass. Last two of these conditions are met mostly thanks to the vehicle's body design.

The body's basic goal is to fully cover and keep together all the car's components as well as to assure a safe position and the required field of view for a driver. However, our absolute priority in the early stage of design was minimizing the aerodynamic drag. The current vehicle's shape is a result of thorough two-step CFD analysis.

Our team has also addressed the mass issue. Extraordinarily, the weight of the nearly 3 meters long construction of the body is only 2,5 kg! This is a result of using advanced carbon fiber laminate for the entire monocoque. The minimal thickness of the sheathing was calculated using the finite element method. Moreover, to produce it we have used the most technologically advance way of producing carbon fiber composites – infusion. This method provides the best possible resin to fiber ratio and flawless condition of the surface.

The paper introduces the process of making a body of a record-braking vehicle from the ideas to the production. It will include details of the computations used in the designing process and the employed technologies.



**Baranovska I.**

## **CALIBRATION OF INERTIAL MEASUREMENT MODULE**

Accuracy of inertial measurement module in modern navigation is a primary task for nowadays. This is why, recently, for precision improving of such devices structural types of technological assemblies are being used widely, where primary measurement unit blocks inside module are angled relatively to inertial measurement module planes.

Given type of assembly allows orienting sensors relatively to priority axes of loadings and decrease biases of output signals. However, during calibration process pointed method of orientation causes substantial errors, which depend on primary measurement unit's axes orientation relatively to inertial measurement module axes.

In work considered method of angular relation definition between ascribed measuring axes of sensors and ascribed measuring axes of inertial measurement module with usage of TRIAD algorithm and Cauchy-Schwarz-Bunyakovskii inequality. Implemented corrections into metrological model of inertial measurement module, which included such coefficients as: transform factors, coefficients of cross-sensitivity and bias coefficients of output signals; also meanings of angles of primary measurement unit's orientation and errors of redefinition of sensors axes relatively to inertial measurement module axes in view of its nonorthogonality are added.

During calibration process by selection-method the best initial test-position was defined, which showed convincing and appropriate results in terms of conducted calculations and showings of output signals; also was found that measurement errors are lowest. In accordance with initial conditions and test-positions using output signals required calculations are made, also defined angles of primary sensors measuring axes incline  $\alpha = 45.497393^\circ$ ,  $\beta = 34.951763^\circ$ .

Results of conducted calculations of inertial measurement module instrumental errors with usage of  $\alpha$  and  $\beta$  angles nominal figures faced next values: for measured  $g$  result was  $\Delta g = \pm 4 \cdot 10^{-4}$ ,  $m/s^2$ ; for measured angular rate  $\pm 156$ ,  $deg/hour \approx 0.04$ ,  $deg/sec$ .

Designed method of angular relation determining enables to perform calibration with higher precision and increase output signal accuracy of measurements of inertial measurement module.

**Biryukova I., Shantyr S.**

## **SOFTWARE STATISTICAL TESTS RANDOM SEQUENCE**

In the construction of simulants it is necessary to make possible generation of random variables on the theoretical laws of probability distributions with the required parameters. To generate random variables deterministic algorithms are often used, and the obtained values are pseudorandom. Then, before applying of a pseudorandom value in the simulation, it is necessary to determine just how close it is similar in its behavior to a random one. During statistical tests of random variables most commonly used methods are: the frequency tests, serial tests, interval tests, cyclic tests, spectral tests, autocorrelation tests, and others.

The aim of the work: development of a package of software modules that implement test methods using chi-square and Kolmogorov-Smirnov, statistical tests software package of pseudorandom values with the laws of frequency distribution with the present parameters.

Program complex of pseudorandom values statistical tests comprises a set of software components, realizing methods, the frequency tests, methods of serial tests, methods of interval and cyclic tests. To implement these methods criteria of chi-square and Kolmogorov-Smirnov are used (fig. 1).

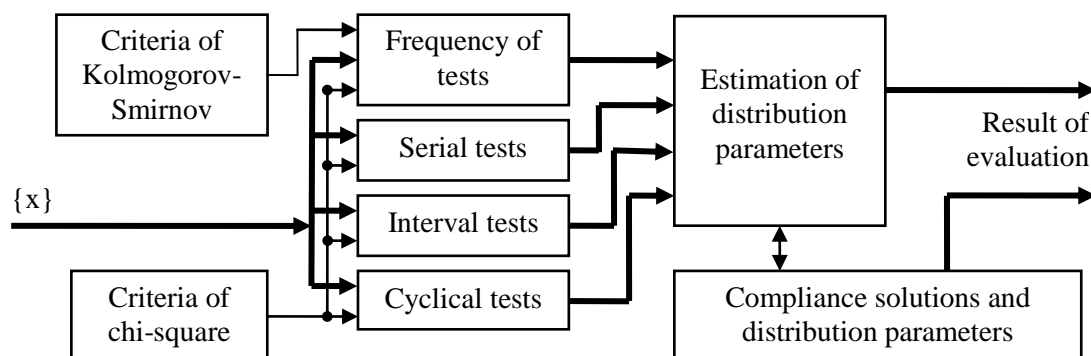


Fig. 1 Structure of software statistical tests random sequence

In the method of the frequency tests to compare the proximity of pseudo-random numbers obtained set distribution for the uniform law the chi-square criterion or the criterion of Kolmogorov-Smirnov is used. In the method of the serial test frequencies of occurrence of all possible combinations of the numbers 2, 3, 4, ... n are fixed, in the method of the interval test the calculation of laws is done that appear between repetitions of any numbers and in cyclic testing method the number of cycles above and below the expectation value is verified.



Then, the obtained result is compared with the expected in accordance to chi-square criterion.

In the work development of algorithms and realization of methods in the form of software modules that are integrated into the set of tests are done. Programming was carried out in the language of Delphi XE3 under Embarcadero RAD Studio XE3.

Application of the developed software modules allows you to perform statistical tests of sequences of random variables to determine the proximity of their behavior to the accident one that improves the quality of the simulation.

### **Bohoslavets R., Gavrylenko V., Bondarenko O. DESIGNING OF THE CAMERA STABILIZING SYSTEM**

Nowadays technologies allow us to make significant rise in producing of technical devices. A plenty of technologies from military industry have spread around the world, becoming more simple and useful for civil applying. Stabilizing systems are ones of such kind of devices.

This paper deals with designing of the stabilizing system for the camera, which can obtain the information about targeting from operator.

In a result of a cinema operator's survey and analyzing of given information were determined next desirable features of stabilizing system:

1. Time of stabilization must be up to 30 minutes. There is no need to increase stabilizing time, because operator has to change memory card and replace battery. It depends on the filming quality, because good quality requires more memory and charge resources.

2. Possibility of targeting from operator on a determined direction.

3. Low weight of gimbal and sensors. In some cases weight of camera and optical lens can be up to 2 kilos, thus it is a little hard for operator to hold the whole system in his hands.

Also it is required high accuracy and easy interface of stabilizing system.

After the survey was determined next problems, that modern systems have:

1. Wrong using of sensors (like accelerometer to determine the angle, while system accelerates in linear direction)

2. Instability of system is also considerable problem.

In the article were conducted theoretical calculation in order to design stabilizing system with given requirements (according to the survey). There were determined and analyzed possible variants of constructing. In order to satisfy the need of low weight, as angular velocity sensor was chosen



micromechanical gyroscope. But such type of sensor cannot provide required level of accuracy. Thus, was decided to create a complex system that uses accelerometers too.

As a result was created a mathematical model of stabilizing system, were synthesized and determined requirements to the sensors - micromechanical gyroscopes and accelerometers. Mathematical model was applied to emulate the work of a model of stabilization system in Matlab Simulink that has demonstrated reactions on input values. Also was created the algorithm of stabilizing of the camera.

**Bydim A., Nechyporenko O.**

### **THE METHOD OF ANALYSIS OF RELIABILITY OF FREQUENCY PRESSURE SENSOR FOR SYSTEMS OF AIR SIGNALS OF AIRCRAFT**

Frequency static (barometric) pressure sensor with a cylindrical resonator, which is part of the system of air signals (SAS) of the aircraft, is a self-oscillating system for which it is important to define the limits of sustainability. When designing the oscillating circuit of a frequency-dependent system of "mechanical resonator – excitation oscillation system" of a frequency sensor and its reliability analysis we may use proposed in parametric reliability criterion of robust stable automatic control systems, considering as a determining parameter the frequency of natural oscillations of the cylinder of mechanical resonator and using a linear probability model of physical change in the wall thickness over time due to its physical degradation.

Development of a method of analysis of reliability of the systems of air signals (SAS) of the aircraft is relevant in terms of improving the reliability and quality of technical objects and systems.

Scientific novelty lies in the use of parametric failure criterion of robust stable systems, which combines classic indicators of reliability of technical systems and stability criteria for calculating the reliability of the frequency-dependent automatic control systems, including pressure sensors with mechanical resonators. This criterion will also enable to take into account the physical processes of physical degradation of system during its operation at timing of its consequent subregulation (duration of turnaround time).

Using parametric failure criterion of robust stable systems will allow to develop the reliability analysis method of static pressure sensor of aircraft SAS.

This criterion also enables to take into account the physical degradation processes of self-oscillating system during its operation at the normalization time of the following subregulation (duration of turnaround time).



The method of analysis of reliability oscillating system according to reliability parametric criterion of stable nonlinear ACS is the following:

- 1) the conditions of self-oscillations in the system;
- 2) determination of parameters of self-oscillations (amplitude  $a_0$  and frequency  $\omega_0$  of its own oscillations);
- 3) evaluation of the stability of self-oscillatory regime, calculation of the stability limits  $|\omega_0| \ll \omega_{cr}$ ;
- 4) determining the time of ADP to reach these limits of stability  $\omega_{th}$  using a linear model (1) of physical degradation of mechanical resonator;
- 5) determination of the operating time of the system to failure.

Practical application: while analyzing the reliability of self-oscillating circuit of frequency-dependent system of “mechanical resonator – excitation oscillation system” of frequency pressure sensor of aircraft SAS, we propose to use the proposed criterion, considering as a determining parameter own cylinder oscillation frequency of mechanical resonator. This parameter is always regulated as in each resonant system because the process of setting electronic board of oscillating circuit is carried out during the manufacture and checkout procedures.

**Burym Y.**

### **INVESTIGATION OF NAVIGATIONAL ACCELEROMETERS BIAS STABILITY OF VARIOUS ACCURACY CLASSES BY THE ALLAN VARIANCE METHOD**

The famous classical method investigation of accelerometers bias stability does not allow possibility to find all basic components of bias stability errors in launching for one experiment.

The considered method of investigation bias stability consists in using the Allan variance method for researching bias stability of group of different accuracy accelerometers classes and determining their time errors in-run.

To conduct research was accepted a general mathematical model of the input signal, which includes the conversion factor, bias and timing errors of bias.

On the special stand was held a set of runs from which received data processed according to the Allan variance method and classical method. As a result of researches were received the numerical values of time errors for each accelerometer, that was investigated. Thus were obtained for each accelerometer the following drift factors by the Allan variance method and classical method: for ADXL202 -  $2.61 \cdot 10^{-8}$  g/sec and  $1.83 \cdot 10^{-8}$  g/sec; for S1500S -  $2.4 \cdot 10^{-8}$  g/sec and  $1.68 \cdot 10^{-8}$  g/sec; for ДЖУММ-3 -  $3.36 \cdot 10^{-8}$  g/sec and  $1.3 \cdot 10^{-8}$  g/sec; for

ДЛЮММ-30 -  $4.2 \cdot 10^{-7}$  g/sec and  $1.5 \cdot 10^{-7}$  g/sec; for A30 -  $1.3 \cdot 10^{-8}$  g/sec and  $7.8 \cdot 10^{-9}$  g/sec; for AL-15 -  $8.9 \cdot 10^{-9}$  g/sec and  $7.9 \cdot 10^{-9}$  g/sec in accordance. Also were obtained for each accelerometer errors from low-frequency fluctuations by the Allan variance method and classical method: for ADXL202 -  $8.12 \cdot 10^{-5}$  g and  $1.6 \cdot 10^{-4}$  g; for S1500S -  $9.7 \cdot 10^{-5}$  g and  $2.24 \cdot 10^{-4}$  g; for ДЛЮММ-3 -  $8.43 \cdot 10^{-5}$  g and  $1.73 \cdot 10^{-4}$  g; for accelerometer ДЛЮММ-30 -  $7.2 \cdot 10^{-4}$  g and  $1.48 \cdot 10^{-3}$  g; for A30  $4.1 \cdot 10^{-5}$  g and  $8.3 \cdot 10^{-5}$  g; for AL-15 -  $1.2 \cdot 10^{-5}$  g and  $5.1 \cdot 10^{-5}$  g in accordance. The difference between the results of investigations may be due to the fact that for the Allan variance method with increasing averaging time increases estimation error.

Besides the time errors were obtained thresholds of sensitivity during researches, for each accelerometer by the Allan variance method and classical method, which are equal: for ADXL202 -  $2.5 \cdot 10^{-3}$  g and  $2.44 \cdot 10^{-3}$  g; for S1500S -  $4.33 \cdot 10^{-3}$  g and  $4.41 \cdot 10^{-3}$  g; for ДЛЮММ-3 -  $2.87 \cdot 10^{-3}$  g and  $2.92 \cdot 10^{-3}$  g; for accelerometer ДЛЮММ-30 -  $1.74 \cdot 10^{-2}$  g and  $1.81 \cdot 10^{-2}$  g; for A30  $2.68 \cdot 10^{-3}$  g and  $2.72 \cdot 10^{-3}$  g; for AL-15 -  $7.71 \cdot 10^{-4}$  g and  $8.23 \cdot 10^{-4}$  g in accordance.

Conducted investigations show the possibility of using the Allan variance method for investigations groups of different accuracy accelerometers classes to determine the coefficients of random error components of output signal during one experiment. The obtained results allow to conduct the comparative investigations of various accelerometers to determine possibilities of their use in strapdown navigational systems.

**Chmykh V., Marynoshenko O.**

## **INVESTIGATION OF SCREENING ON THE SURFACE CHARACTERISTICS OF THE UAV**

The ground (screen) effect produces a sharp increase of lift and affects to other aerodynamic characteristics of an aircraft in flight near screen surface (water, land, etc.). Ground effect gives an opportunity to reduce the speed at landing and thereby to improve safety.

The purpose of this study is to determine input screen effect to lift, drag and the most advantageous altitude above the screen for UAV, which weight is 8 kg, designed by "flying wing" aerodynamic scheme.

A model of UAV was made by Pansym program using coordinate method to achieve the goal. It was blown at different distances from the screen  $h$  (10-400mm) to determine the most advantageous altitude on which will be the largest coefficient of lift. Further analysis of the results showed that the best altitude for UAV's flight is 80 mm with  $C_L$  is 0.45. Further calculations were





made at a constant altitude  $h$  above the screen at different angles of attack and were made a comparative analysis which shows increase of lift near the screen from 0.01 to 0.13 at the angles from -15 to 26 degrees. Also, the calculations show that the flight over the screening surface decreases the drag coefficient of the aircraft, and it is closer

,  $C_D \text{ scr.} = 0.003$  and  
 $C_D \text{ without scr.} = -0.552$ ).

We can see a beneficial effect on the screen plane. For this conclusion had been counted values of the

. Considering the difference in lifting force  $C_L$  between screen and without we can observe that input of screen to lift force of the aircraft is 1 kg for UAV weighing 8 kg, which is an increase by 12.5%.

With these results we can calculate how possible to reduce landing speed. For this purpose were carried out similar calculations as with lift. The rate may be reduced for 5 m/s.

The received data can be used at this UAV, and the method of calculation and output may be used for any aircraft designed by "flying wing" scheme.

**Danyluk D., Virchenko G.**

## **INTEGRATED AIDED DESIGN ELEMENTS AIRPLANE**

At design widely used various means of computer information technology.

Computer-aided design (CAD) is the use of computer systems to assist in the creation, modification, analysis, or optimization of a design. CAD software is used to increase the productivity of the designer, improve the quality of design, improve communications through documentation, and to create a database for manufacturing. CAD output is often in the form of electronic files for print, machining, or other manufacturing operations.

CAE - computer-aided design, using special software for engineering analysis and other technical strength of the components made in computer-aided design. Applications aided design allow for dynamic simulation, verification and optimization of products and means of production.

CAM - automated production. The term used to refer to software whose main purpose is to create programs to control machines with CNC (numerical control). Input data CAM- system is a geometric model of the product, developed in computer-aided design.



The main purpose of the automated design of complex technical objects is to achieve comprehensive, multi ie, optimal results, part of which is the creation of computer-aided design techniques.

Conducted research generated new techniques integrated computer modeling construction elements airframe, demonstrated their practical application in the design example plumage. Completed a comprehensive analysis of the study in terms of durability, design and production of the unit.

The technique, which allows you to significantly reduce the volume of work involved in the design of the aircraft tail, and characterized by a certain universality, and not only provides greater productivity, but also for its effective use in various enterprises aviation industry.

The main advantages of the developed computer modeling techniques conditioned ease of use, implementation of a comprehensive analysis to determine the best compromise design options not only elements of individual units, but also the entire aircraft in general.

The practical significance of the proposed technique integrated computer-aided design elements of the design of the aircraft is to provide further quality improvements created aviation technology, accelerate the design process while increasing the number of options considered configurations and lower economic cost to this, and holding a large number of required calculations.

**Dovbnia Y., Vorobiov M., Khavin S.**

### **THERMAL-HYDRAULIC EFFICIENCY OF HIGH-TEMPERATURE RECUPERATOR WITH SECONDARY EMITTERS**

The use of secondary emitters in channels of recuperative heat exchanger is an effective technique of intensification of heat exchange.

The aim of researches was comparing basic characteristics among ourselves: heat transfer and thermal, hydraulic and thermal-hydraulic – recuperative sections in the form of long loops.

Experimental investigations were conducted on the computerized firing stand, designed and built in Gas Institute of National Academy of Sciences of Ukraine. The methodology of researches consisted in simultaneous investigations of recuperative two sections, each consisting of three parallel U-shaped loops. For investigations were chosen following constructions of tubular loop recuperators:

- 1) smooth pipe (without inserts) design (*BD*);
- 2) design with spiral inserts - *SP* with relative pitch helices  $\sigma = s/d = 4,0$ ;
- 3) design with flexible cruciform inserts - secondary emitters - design

*MD.*

For estimation of heat exchangers perfection was used complex – thermal-hydraulic characteristic  $e$ , which connects the change in the transmitted heat flow and head loss of blowing. In the present work used the next transformation dependency that provides the definition of the auxiliary thermal-hydraulic properties:

$$e = E_{mod} \approx (T_{a,ex} - T_{a,en}) / \Delta p_a. \quad (1)$$

Researches have shown that the value of thermal-hydraulic characteristics is increased for heat exchanger design with inserts - secondary emitters *MD* compared to *SP*, but the biggest value is of course related to the design smooth pipe *BD*. Change thermal-hydraulic characteristic  $e$  of research recuperator sections depending on the temperature in the combustion chamber  $T_{fl}$  shown in Fig. 1.

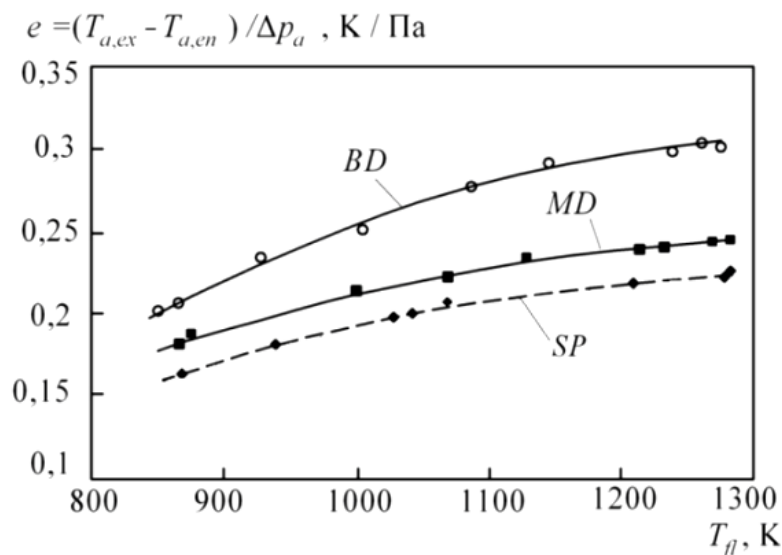


Fig. 1 Dependence of thermal-hydraulic efficiency of the temperature in the combustion chamber  $T_{fl}$  for research recuperator sections of different designs.

These advantages allow recommend secondary emitters the proposed design as more effective as compared with spiral inserts for tubular high-temperature recuperators.



**Franovska T., Shantyr S.**

## **DIGITAL MEASURING TRANSFORMER OF PLATINUM RESISTANCE THERMOMETER**

For control of temperature of babbitt plain bearings large rotary machines the platinum thermometers of resistance are used. In every support of bearing eight thermometers are set as TRP-309, that have a working range of measureable temperatures from  $-200^{\circ}\text{C}$  to  $+850^{\circ}\text{C}$ . At the use of platinum thermometer in measuring chains there is a task of linearizing of his description with the set error.

An aim of work is development of 8-channel digital measuring transformer of platinum to the thermometer resistance for the monitor of temperature condition of bearings.

Dependence of resistance of platinum on a temperature in area of  $-200^{\circ}\text{C} \dots +0^{\circ}\text{C}$  described by expression (1)

$$R_{\text{Pl}} = R_0[1 + AT_C + BT_C^2 + C(T_C - 100^{\circ}\text{C})T_C^3], \quad (1)$$

and in area of  $0^{\circ}\text{C} \dots +850^{\circ}\text{C}$  - by expression (2)

$$R_{\text{Pl}} = R_0(1 + AT_C + BT_C^2), \quad (2)$$

$R_0$  - resistance of thermometer is at temperature  $0^{\circ}\text{C}$  accordance with marking;  $R_{\text{Pl}}$  - resistance of thermometer is at temperature  $T^{\circ}\text{C}$ ;  $A$ ,  $B$  and  $C$  - constants that matter  $A = 3,9690 \times 10^{-3} \text{ }^{\circ}\text{C}^{-1}$ ,  $B = -5,841 \times 10^{-7} \text{ }^{\circ}\text{C}^{-2}$  and  $C = -4,330 \times 10^{-12} \text{ }^{\circ}\text{C}^{-4}$  in accordance with standards or determined at a graduation.

A method and algorithm of linearizing of description of transformation platinum to the thermometer are in-process worked out, built model and the design of procedure of linearizing is conducted in the complex of computer mathematics of MathCAD Prime 2.0.

According to the simulation results developed digital measuring converter platinum thermometer, adapted to use in the 8-channel temperature monitor babbitt plain bearings. The converter performs linearization characteristics platinum resistance thermometer for constants that are defined in the individual calibration of each thermometer and stored in nonvolatile memory monitor. Using linearization algorithm characteristics thermometer provides for the monitor sample temperature values for each of the eight channels with a period of 0,1 s, linearization characteristics thermometers all channels in real-time and accuracy of temperature measurement up  $\pm 0,05\%$ . The performance of the algorithm makes it possible to monitor the processor, in addition to the basic functions of measurement and control, serve as an emergency condition for



determining the temperature settings object, function well and diagnosing the performance of the signaling system of higher level.

Designed digital measuring converter platinum resistance thermometer is designed to monitor the temperature of the bearing assembly machines and can be used in multi-information and measurement systems to control temperature condition of objects in real time.

**Ganem S.**

### **MEASURING PARAMETERS OF TRANSLATORY MOTION OF AN AIRCRAFT USING GYRO-FREE INERTIAL MEASURING UNIT**

There are lots of approaches to constructing inertial measurement units (IMU), based on "only accelerometers" principle. However, the main drawback is that these solutions have much higher calculating error of basic navigation parameters (coordinates and angular orientation) than errors of traditional IMU based on gyroscopes. This greatly limits the scope of gyro-free IMU in the actual development. Therefore, the construction of cheap gyro-free IMU whose accuracy characteristics are comparable with the accuracy characteristics of traditional IMU is an urgent task.

A compact design solution of triaxial gyro-free IMU for the control system of the aircraft is designed. This gyro-free IMU has three pairs of accelerometers mounted on a platform that vibrates relative to its axis perpendicular to its base. Accelerometers mounted on special installation surfaces evenly on the platform: in pairs, at the fixed angle to the platform and its axis.

In order to achieve a mathematical model of gyro-free IMU a projection of measured absolute acceleration of each accelerometer's axis is designed. Accelerometer signals of linear acceleration and angular velocity have different order of magnitude therefore for their separation accelerometers' signals previously deducted and added together. Afterwards separated signals are fed to the low-pass filter (LPF) and integrator. The output of the LPF receives a signal containing information about linear acceleration, and the output of the integrator - a signal that consist the information about the angular velocity of the object. By submitting these signals in special assessing blocks of angular velocity and linear acceleration, which also eliminate the errors, a separate evaluation of the measured linear acceleration and angular velocity are received.

Setting the different angles between the accelerometer and the platform a particular sensitivity axis linear acceleration and angular velocity can be



obtained. With an equal sensitivity through the measurement of angular velocity, inclination axis accelerometer sensitivity to the platform is 60 degrees.

Based on the results of mathematical modeling of IMU, special requirements for the accelerometers and actuator are developed and presented. Consider with the results of the requirements, the usage of average accuracy compensation type of accelerometer AK-5 is recommended.

**Golovchenko I., Dveirin A.**

### **SYNTHESIS OF THE AIRCRAFT COMPOSITE UNITS' RATIONAL CONSTRUCTIVE-BEARING SCHEMES**

The engineering of the composite materials passed a way from euphoria concerning real opportunities of the solution of metals' problems to understanding of need and expansion of systematic researches in the field of composites, including components' properties; mechanic, strength analysis, design and manufacturing of structures from composites, etc.

Despite the reached considerable volumes of composite materials application in design of transport and passenger aircrafts, and also on high rates of drop of weight, ruggedness, durability, increase of corrosion resistance and drop of labor input of production, still there are reserves of further application of composites in the high-loaded plane designs.

Composite materials application is the most effective in designs with determined nature of load application of their elements, when high specific strength and rigidity along fibers are realized in full.

Basic principle of designing discrete simply supported aircraft units' rational constructive-bearing schemes was substantiated and formulated by authors at previous time. It guarantees minimal mass of aggregate considering the required load-carrying ability within operational spectrums of external loads.

According to what has been said implementation of a design technique of the aircraft composite units' considering the main features of composites and technology of their processing and providing is an actual problem and it's solving at Antonov Company.

The process of design and selection of the aircraft units' constructive-bearing scheme was considered by authors in detail. The expediency of the considering several constructive-bearing schemes was demonstrated by example of the cargo hatch main components of the transport aircraft, what kind of aircraft is the main product of Antonov Company. Two different constructive-bearing schemes of aggregates were reviewed and analyzed, proving efficiency of principle of designing.





It should be noted that realization of these fundamental principles allowed engineers, who designs composite aircraft units, to develop new rational constructive-bearing schemes, analyzed and modified constructions, which are already designed and being in operation.

Universality of a method confirms the fact that discrete simply supported units are inherent not only designs of aircrafts, but also are widely used in space branch, automotive industry, etc., in which also composites occupy a considerable share among the applied materials.

**Kizitskiy A., Zbrutsky O.**

### **THE AUTOMATIC CONTROL SYSTEM OF THE QUADROPTER**

Modern control systems, which are represented on the market, make it easy to realize a small quadrocopter. Each of them has its advantages and disadvantages, so the creation of a new and improved automatic control system (ACS) is an urgent task.

A mathematical model of aircraft with four rotors, also known as quadrocopter, that consider its main structural and dynamic features has been developed in this work. The optimum automatic control system of aircraft's angular motion has been synthesized to compensate the effect of perturbations. This model has been simulated with MATLAB and shows that automatic control system holds an appropriate position of aerial vehicle.

For experimental adjusting of the quadrocopter's automatic control system the experimental model has been established. The electronic part of the control system consists of the AVR family microcontroller - Atmega328pa. The micromechanical gyroscope L3G4200D, accelerometer and magnetometer LSM303DLHC are sensors of kinematic parameters of aerial vehicle. Global positioning system (GPS) NEO6 helps to refund position, height and velocity of the quadrocopter. Barometer BP180 helps find the height above the sea level, when GPS doesn't work. Control system retrieves the distance to the ground from the ultrasonic sonar for a "soft" landing. But landing-control function can work only with distance to the ground less than 4 m. If a rangefinder with measurement distance range more than 4 m is used, landing control function can be used on height more than 4 m. The 9-channel remote controller Turnigy 9X provides control of the aircraft's movement. In case of signal losing automatic control system keeps control for safety purposes and keeps hovering of aerial vehicle at constant altitude until the signal comes back. If the signal is lost, quadrocopter will reach the take off position. Mechanical part consists of four



980 KV rotors (maximal angular speed 11000 rpm). With such rotors payload mass is 1.5 kg.

To expand the range of problems being solved such as flight coordinates, recognition of images, survey-comparative navigation, scientific tasks to be performed at the instant height, you can connect the on-board computer with dual core processor Allwinner A20 and Linux OS. Current version of OS on-board computer provides soft real time. For better response hard real-time operating systems are preferred.

Experimental researches have performed for the effectiveness of the developed automatic control system. The system may have a number of different applications such as silent surveillance, cartography, navigation, aerial photo, and just for entertainment. The system also has military applications especially for intelligence and fast and short assaults.

### **Kryvokhatko I.**

#### **LATERAL STABILITY DETERMINATION FOR TANDEM-SCHEME AIRCRAFT SUBJECT TO WING INTERFERENCE**

Tandem-wing scheme has become quite widespread among micro-UAV (with mass less than 5 kg) because of the possibility of span decreasing. Nevertheless aerodynamic optimization of tandem-scheme UAV is complicated as analytical methods of aerodynamic characteristics determination are imperfect. Even more there is no analytical method for lateral characteristics determination subject to interference between forward and rear wings.

The task of the present work is to develop the roll static stability and yaw static stability determination method.

First the positioning of forward wing tip vortices was defined by analytical and empirical formulae. Then the forward wing downwash through rear wing span was defined with help of Bio-Savare formula and geometric considerations. Lift and rolling moment of every rear wing element under downwash was defined and reduced to moment coefficient corresponding to total area and averaged span of two wings. Finally we integrated moment coefficient through rear wing span and got wing interference correction of aircraft rolling moment.

This correction was added to rolling moment of isolated wing as in method for traditional scheme aircraft.

Meanwhile interference creates different lift coefficients on left and right rear wings. So induced drag coefficients are slightly different but calculation



showed that this yawing moment correction is negligible compared to other yawing moment components including vertical-tail one.

The calculation was performed for different wing spans and relative position of wings.

Calculation results analysis brings us to the conclusions:

- 1) interference rolling moment has maximum if wingspan is almost equal;
- 2) interference rolling moment is gaining if stagger (horizontal distance between wings) increases and height (vertical distance) decreases;
- 3) interference yawing moment practically doesn't depend on stagger;
- 4) performed calculation proves significant effect of interference on roll moment comparable with wings and fin moments. So for practical estimation of roll moment characteristics we should take into account the wing interference.

Analytical predictions show good agreement with wind tunnel experiment results.

Method is applicable for low Mach number (under 0.5), arbitrary Reynolds number and can be used for tandem-scheme UAV and aircraft design.

### **Laptiychuk K.**

#### **MEASURING TRANSDUCER SHAFT SPEED ROTATION MONITOR IN ROTARY MACHINE**

The value of the shaft rotation speed is one of the main mechanic parameters of the rotary machine that is used for building and influences immensely the quality characteristics of the security monitoring system, diagnostics and technical state prediction. The development of the new and the improvement of the already existent technical approaches aiming at accuracy increase in rotary speed measurements are topical nowadays.

Purpose of the work is the elaboration and research of the scheme electrical of measuring transducer shaft speed rotation monitor in rotary machine.

At the heart of the measuring transducer construction is the effect of the whirlwind current appearance in a metal of the rotor machine during the cooperation with the electromagnetic field of generator coil on a frequency of 1...2 MHz. The functional mechanization consists of the induced coil, high-frequency oscillations generator, generator work stabilizer and feed circuit, as it is shown on fig. 1.

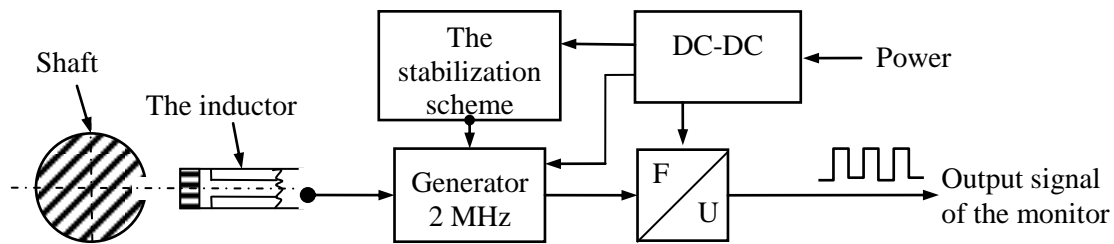


Fig. 1 Functional circuit of measuring transducer

The scheme electrical of measuring transducer was developed. The model of the electrical circuit of the measuring transducer for PC against universal among Multisim 11.0 was constructed. A research was conducted on the characteristics of the scheme measuring transducer of the developed model. Based on the results of the simulation model vortex currents measuring transducer was created and tested.

Designed whirlwind overcurrent measuring transducer differs from analogues with its low voltage and current supply (12 V, 20 mA), and the presence of a stabilization scheme. The converter has chains to ensure self-diagnosed efficiency and compliance to the metrological characteristics of a passport in working conditions, without decommissioning while connected to the monitor.

Measuring transducer is used as a primary source of information for measuring the speed of rotation of the shaft monitor machines. In primary purpose, the converter can be used to convert the distance between the face of the coil and the object into a proportional electrical signal.

**Matusevych R., Prohorchuk O.**

### **ROBUST REGULATOR SYNTESIS FOR THE CONTROL SYSTEM OF COMPACT UNMANNED AERIAL VECHICLE WITCH IS UNDER THE INFLUENCE OF WIND DISTURBANCES**

In recent years, unmanned aerial vehicles (UAVs) are used not only for solving a wide class of problems of a military character, but for purely civilian tasks such as monitoring of pipelines and power lines, agriculture, aerial photography and so on. Creating an UAV to solve such problems requires detailed studying of the structure, payloads, navigation, control and guidance systems. The development of automatic control systems would meet the demands placed on modern UAV in the most urgent problem today



Automatic control system, in most cases, is operating under partial uncertainty in the presence of external disturbances such as wind loads, vortexes, and thermal flows.

This paper is studying and exploring robust controller, which ensures the operation of a UAV in uncertainty conditions. Using controller like this in automatic control systems of UAVs allows to increase the accuracy of spatial motion control of UAV in terms of random disturbances, particularly in small UAV flight in the range of thermal disturbances that occur as a result of heating of the Earth's surface heterogeneity.

This paper describes synthesizing of a robust controller for small UAV, with thinking about both parametric uncertainty of mathematical model of UAV and random wind disturbance. The simulation of a system in Matlab Simulink environment was done and was shown that the synthesized system with using of a robust controller by the method  $H_\infty$  has higher accuracy in comparison to control system synthesized by the method of  $H_2$ , but it has worst performance. Therefore, the application of an approach to the synthesis of automatic control system should thinking about the operating conditions and instrumental composition of UAV systems, such as on-board performance calculator.

**Maystrovoy V.**

## **THE ALGORITHM OF SQUARING IS BASED ON THE PRINCIPLES OF COMBINATIONAL CIRCUITS**

It needs to resolve issues related to processing digital signal in real time during designing a computerized equipment of measuring technic. This requires during processing of measurement information applying some specialized digital transducers. Structures of such converters have to meet the follow criteria - uniformity of structure, small memory footprint, large dynamic range, working in real time scale and simplicity of implementation.

Purpose of the work is research and development of functional characteristics of the converter with a quadratic function on principles of digital combinational circuits for microprocessor-based measuring devices.

Basis of the algorithm of functional converter is supposed piecewise-linear approximation of function  $Y = x^2$  on the interval  $x \in [0, 1)$ , with a followed repeatedly simultaneously correction of the difference between the initial function and its approximation. Corrective function  $\xi$  is obtained after

the  $m$  step of the correction, after that resulting transformation equation takes the form

$$Y = \varphi + \sum_{i=1}^m \psi_i + \xi$$

The algorithm of calculating the square contains an argument register RG, a unit switches MUX1...MUX $m+1$ , DS decoder, the memory module M correction coefficients, a group of logic elements AND & 1...& $m$  and an additional group of logic elements And & D, two adder SUM1 and SUM2, as shown in fig. 1.

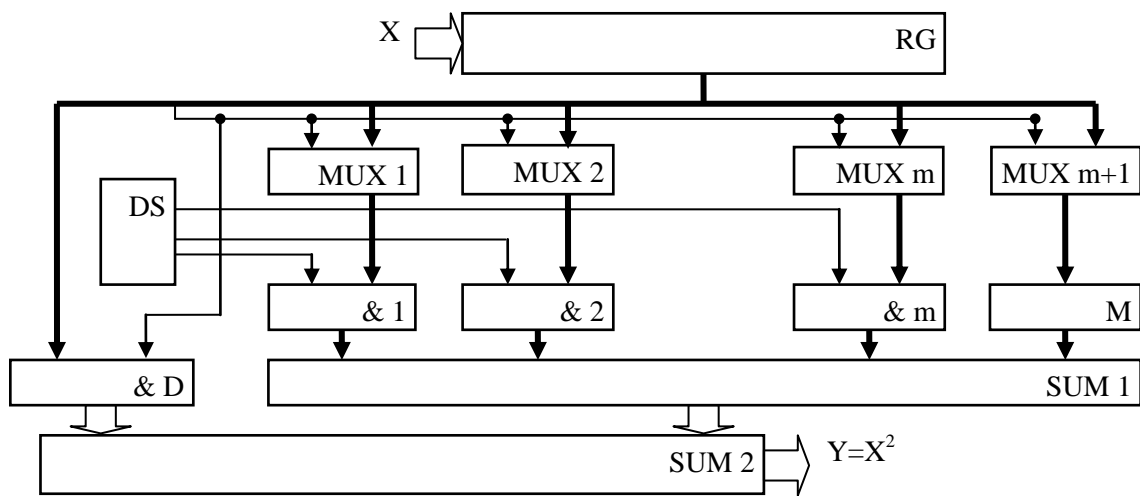


Fig. 1 Algorithm squaring

Modeling algorithm of digital converter with a function of squaring is done on the principles of construction combinational schemes in LabVIEW environment.

Application of the developed algorithm allows increasing a range of the processed number and changes them in real time. The principle of construction of digital combinational circuits, formed the basis of the algorithm allows its effective use in microprocessor-based transducers.

**Mikhailyuk O.**

**ALGORITHM FOR DETERMINING THE PEAK VALUE OF THE SIGNAL**

Multimeter-logger refers to specialized instrumentation system with specific functions that are performed in real-time operational service facilities.

Among the specific functions logger function is related to the definition signal parameters such as mean values, peak values, etc., as well as their deviation from the values given technological process maps or exceeding their critical values. Modern digital technologies allow to implement features such as tool-logger for industrial use, but algorithms should be developed taking into account the most significant constraints associated with the digital net, free memory, performance computing facilities.

Purpose of the work is researching and development of the algorithm for determining the peak value of the measuring signal in real time microprocessor multimeter-logger.

The paper presents a recursive algorithm for determining the peak value of the measuring signal

$$X_n^{\text{Peak}} = X_n^{\text{PD}} + (1 - \alpha)X_{n-k}^{\text{Peak}},$$

where:

$$X_n^{\text{PD}} = \begin{cases} |X_n| - (1 - \alpha)X_{n-k}^{\text{Peak}} & , \text{ when } |X_n| - (1 - \alpha)X_{n-k}^{\text{Peak}} > X_{n-1}^{\text{PD}} \\ X_{n-1}^{\text{PD}} & , \text{ when } |X_n| - (1 - \alpha)X_{n-k}^{\text{Peak}} < X_{n-1}^{\text{PD}} \end{cases}$$

According to the algorithm developed software unit converter peak signal functional diagram of which is shown in Fig. 1. The circuit includes transducer absolute value of the signal at the input, adding two devices and device multiplication, peak detector and delay line.

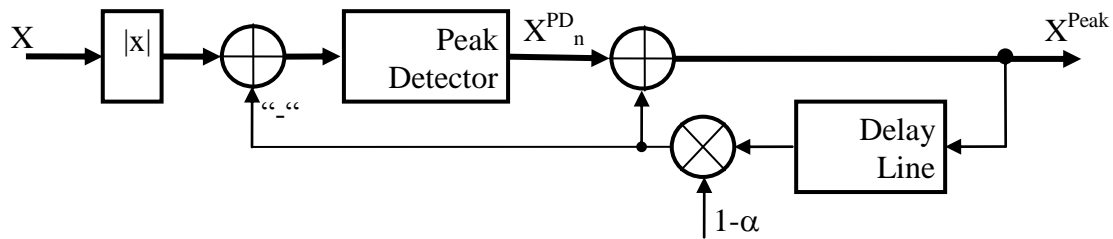


Fig. 1 Tool to determine peak measuring signal

Conversion options defined intervals and damping rate imposed by the delay line delay and coefficient  $1 - \alpha$ .

Experimental study of the characteristics of the converter has confirmed its effectiveness when used in digital measuring under tight restriction of the use of memory word length limitations and performance microcontroller.

Experimental results can be used for the algorithm for determining the peak value of the measuring signal converter peak developed for industrial digital multimeter system-logger, which implements the transfer function in real time.



**Momot B., Gavrilenko V.**  
**VARIABLE-SWEEP WING**

The aim of this work is analyzing the characteristics of a wing with variable sweep, determining its strengths, weaknesses and feasibility of use in a particular aircraft.

Variable sweep wing is a wing (in flight) which can change the sweep angle on the front or back edge. The sweep angle is an angle relative to the perpendicular of the longitudinal axis of the aircraft. This is done to change the aerodynamic characteristics of the aircraft. Most often this wing type is used on aircraft which have to fly at different speeds: transonic (subsonic), supersonic.

Also, this type of wing improves landing characteristics of the aircraft which reduces its take-off and landing runlength. When set to minimum sweep angle is greatly reduced landing speed of the aircraft, this can simplify aircraft landing and prevent accidents. If sweep angle of the plane is maximum it decreases drag, which is useful at high speeds.

The disadvantage of this wing is the increased weight of the aircraft, due to the installation of hydraulic systems (servos) which provides the change of the sweep angle. This greatly complicates the design and increases the cost of the aircraft maintenance. The complication for pilots is the instability of the flight with the direct change of sweep angle, and breakdowns in flight due to a complex structure.

Despite all the advantages, the weakness of this wing type, it is not used for passenger transport and sport aircraft.

But it is used on less evasive large supersonic bombers (for example, B 1 B Lancer, Tu-160, Tu-22 m).

But for a small maneuverable fighter aircraft this type of wing has failed (for example, MiG-23, MiG 27).

The variable sweep wing is replaced by a more versatile trapezoidal wing used for all ranges of speeds.

In conclusion, we can say that a wing with variable sweep have fewer advantages than disadvantages. In the most aircraft you can replace it with the other types of wings.



**Okhotnikova O.**

## **STRAPDOWN NAVIGATING SYSTEM SIMULATING**

Currently it is actual to create strapdown inertial system (SINS), with the advent and development of gyroscopic sensors on new physical principles – LG, FOG, MMG; the system is characterized by high reliability and performance. Such systems are widely used in submarines, ships, ground vehicles, aircraft, missiles and spacecraft. Relatively low cost and high information content (determining the current values of the parameters of spatial movement in any coordinate system) lead to increased demand for them.

The project aims to create strapdown micromechanical systems for determining the parameters of navigation using the matrix of quaternion. This method is widely used because it speeds up the algorithm, and has positive impact on system reliability.

The scheme of SINS includes three gyroscopes and accelerometers 3 and board computer, which form together the inertial-measurement module. System determines the coordinates, speed, altitude and other parameters of navigation and orientation.

For simulating was selected measuring module ADIS16364, developed by Analog Devices. The company offers inertial sensors based on MEMS-technology. This ensures coordination of signals to optimize the dynamic characteristics. This sensor is designed for use in navigation, tracking movements, stabilization and tool control. ADIS 16364 is a simple and cost effective to determine the accuracy inertial sensitivity in industrial systems, especially when compared to the complexity and cost associated with the same design. These compact modules provide a flexible connector that allows several options for mounting orientation.

The result of the work is block diagram and the algorithm of SINS on micromechanical sensors. Quaternion matrix increases the system performance, and it is necessary for small highly maneuverable unmanned tactical use. Modes of motion of the object (pitching) were asked in the geographic coordinate system to meet these challenges. Were estimated the errors of angles of orientation and of navigation parameters for errors gyroscopes and accelerometers. Also were created special software that allows exploring the dynamics and behavior of SINS on different modes of motion of the aircraft.





**Ortamevzi Gurkan, Zinchenko D.**

## **THE ASSESSMENT OF THE EFFECTIVENESS WING WITH SOFT SKIN**

It is shown that in article analysis is performed design aircraft carrier with a soft surface, considered especially their aerodynamics, defined scientific novelty research, the goals and objectives of the work. Based on the analysis of deformable wing aerodynamics, performed the assessment method applicability computational aerodynamics to the task.

The purpose of this research is to increase operating capacity of aircrafts, that is confirmed by the fact development of experimental aircraft with the soft wings. Potential soft surface attracted the attention of leading aviation specialists for the realization of the specific qualities projected aircraft.

The main goal of the research is to develop a common methodology aerodynamic design of the aircraft with a soft deformable wing. To do this, you must solve the following problem :

- Aerodynamic analysis and synthesis of the aircraft wing with soft surfaces. Analysis of the aerodynamic features of the aircraft with a soft deforming wing. Selection and justification of the study parameters layout, the limits of applicability of forming the applicability criteria of design solutions of the aircraft with a soft deforming wing.
- Development of algorithmic evaluation of the aerodynamic characteristics of the aircraft with a soft deforming wing that takes into account the influence of the deformable wing using numerical methods. Selection and justification of the methods with using computational aerodynamics. Planning computational experiment, the development of computational models. Analysis and generalization of the results.
- Assessment of changes in the aerodynamic characteristics of the aircraft with a soft deformable wing in a full-scale experiment on the flying model. Selection and justification of the prototype aircraft. Design and production of experimental flying model. Definition of instrumentation, methods of conducting flight tests and analyzing the results of the experiment.
- Development of a common algorithm formation of aerodynamic configuration of the aircraft with a soft deformable wing based on the results of computational and physical experiment.

For the experiment we made four wing models with nonsymmetrical profiles. Material of the models - balsa, plywood and windproof (parachute) cloth. Via plastic tubes air intakes mounted to inflate the soft part of the wing. Each model has a different ratio of rigid and soft parts of the overall wing chord  $b$ , namely:





- The first model completely rigid;
- The second model: the rigid part - 70% b, soft part - 30% b;
- The third model: the rigid part - 50% b, soft part - 50% b;
- The fourth model: the rigid part - 30% b, soft part - 70% b;

Experimental results can be used for designing folding portable aircrafts and for optimizing weight and aerodynamic performance.

**Osintseva M.**

### **DDS CONVERTER FOR CALBRATOR PHASE SHIFT**

The main functional element of modern digital calibrator phase shifts, which determines its quality are functional digital-to-analog converter. The existing DAC can only perform a linear transformation of species. However, to implement the functions of the calibrator phase shifts necessary to accurately reproduce the nonlinear functional relationships. Play nonlinear functional relationships and their modeling with linear DAC to present implemented in several ways - tabular formation, direct calculation, piecewise linear approximation or approximation POWER series. The problem of choice of playing nonlinear functional relationship tested in multi-phase displacement calibrator needs to be addressed in terms of technical constraints for a given implementation fidelity.

Purpose of the work is researching and development characteristics of nonlinear functional relationships converter multichannel microprocessor calibrator phase shifts.

This paper has explored playback nonlinear functional relationships tabular method, the method of calculation for recurrent formulas way piecewise linear approximation method and Taylor series approximation POWER. When given constraints calibrator technical implementation phase shifts - the number of channels to 128, the frequency range up to 20000 Hz, setting the range of phase shifts  $0^{\circ} \dots 360^{\circ}$  and installation phase shift error  $0,01^{\circ}$  by simulation results and performance indicators chosen method of direct digital synthesis (DDS) for recurrent formulas. Block diagram of the developed module DDS-converter for multi-calibrator phase shifts shown in Fig. 1. Play the harmonic oscillations with given parameters and external system clock to create a common test wave pattern, executed by the microcontroller digitally. Further conversion to analog form performed linear DAC.

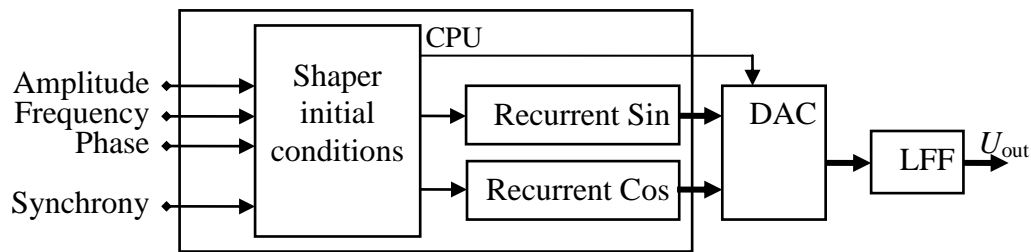


Fig. 1 DDS-transformer calibrator phase shift

Using DDS converter designed to improve performance and functionality generator unit for a given fidelity nonlinear functional relationship and create multi-calibrating microprocessor testing phase shift hydro acoustic stations.

**Pokhilenko O., Prokhorchuk O.**

## **MULTY-ANTENNA SATELLITE NAVIGATION AND ORIENTATION SYSTEM**

A satellite navigation system (SNS) is a comprehensive electronic and technology system, which consists of a set of ground and space equipment designed to determine the location and movement parameters (speed and direction) of land, water and air facilities, as well as the exact time. At the same time, the question of determining the orientation of moving objects using single or multi-antenna receivers SNS remains open both in terms of hardware implementation and in terms of algorithmic and software of such systems.

The principle of satellite navigation systems operation based on measuring the distance from the antenna on the object (whose coordinates must be obtained) to satellites, whose position is known with great precision.

Work is devoted to the issue of increasing the accuracy of the coordinates and angular orientation of moving objects using SNS multi-antenna receiver.

In the work was analyzed the main factors that affect the accuracy of the orientation of moving objects using SNS multi-antenna receiver and proposed measures to reduce the errors of the system. The algorithm of the system determines the moving objects' orientation based on the algorithm of Kalman's type observer.

A semi simulation of operation of the satellite orientation and navigation system was done, errors determined the orientation of moving objects, depending on the length of the antenna base location and determined the coordinates relative error vectors were obtained. The results suggest that using

of dual-frequency SNS receivers and modern methods of information processing can ensure the accuracy of the orientation of the moving objects within  $0.05 - 0.1^\circ$ .

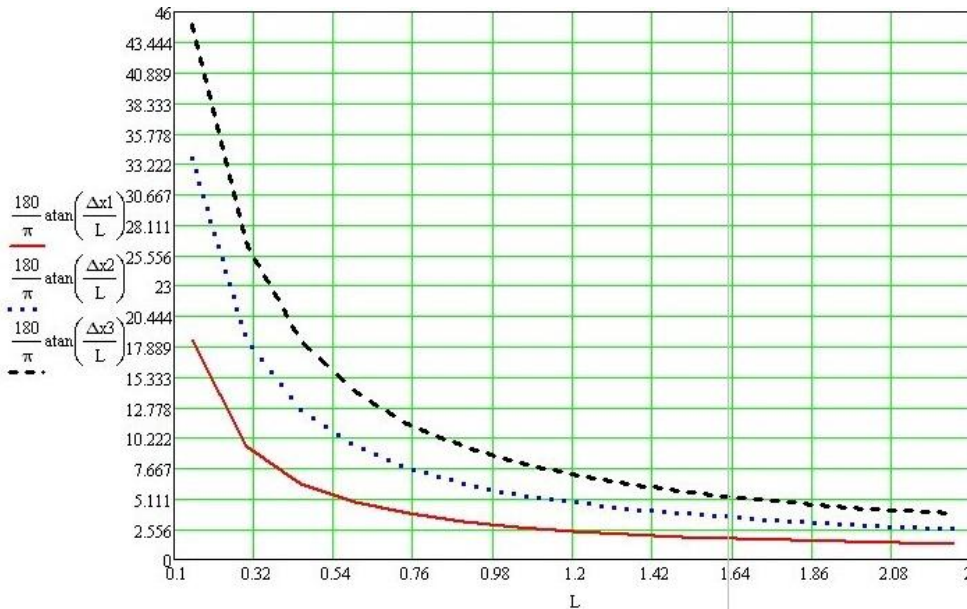


Fig. 1 Dependence of Determination of the course angle error from the SNS receiver error

**Sednevets A., Zinchenko D.**

### **DETERMINATION OF THE FINEST GEOMETRICAL PARAMETERS FOR AGRICULTURAL UAVS IN UNSTEADY FLOW**

Available air crash statistics of civil utility aircrafts shows that in most cases the cause of accidents is the contact with the ground objects. Such statistics caused by piloting complexity of such type of aircrafts compared with transport or passenger aircrafts, and the construction of these aircraft are not always designed for such piloting.

Among all existing aerodynamic configurations the most effective for air chemical spraying is biplane scheme, which has better maneuverability characteristics in comparison with others schemes.

The purpose of work is estimation of unsteady flow influence on the aerodynamic characteristics of the aircraft with several lifting surfaces and determination of the finest geometrical parameters for minimizing the influence of unsteady flow.

The work presents characteristic features of specialized agricultural aircraft operation based on the specifics of modern agriculture. The most



significant affecting factors on the efficiency of agricultural aircraft were identified.

The features of a non-stationary aerodynamics for agricultural aircraft with several supporting surfaces were viewed and the calculation results of aerodynamic characteristics, which depend on the basic parameters of the lifting surfaces, were shown. The mutual influence of lifting surfaces on the aerodynamic characteristics of the aircraft was estimated.

To take into account the impact of interference between the bearing surfaces, such as adverse effects of shading one bearing surface by another, used computer panel-symmetric vortex flow modeling method because the nature of pull unsteady flow dissemination around a wing is very similar to the case pull steady flow.

For a finding of system parameters, which could provide the best value for the aerodynamic qualities of a multiple bearing surfaces have been used all sorts of variations of these parameters, and then made their linear interpolation.

The main parameters, which were considered in this research, of a multi-carrier surfaces system were vertical and horizontal distances between surfaces with forward removal one by one of each wing.

The results show, which range of input geometrical parameters of multiple bearing surfaces system has the best aerodynamic efficiency.

The research was used to reduce the influence of unsteady flow on the aerodynamic characteristics of the aircraft with several lifting surfaces during design of the UAV to perform aviation chemical works.

**Toporivskiy B., Gagarin O.**

### **AUTOMATE THE PROCESS OF SELECTING THE CANDIDATES APPROPRIATE FRAMEWORK COMPETENCE**

The current stage of development of the labor market makes high demands on the process of selection of employees, due to the specifics of performance and objective constraints on decision-making by management personnel, leading to the need to improve procedures for recruitment and selection of staff using modern methods of data mining.

At a time when workers need to select the most competent among a large number of applicants for the job, there may be considerable difficulty because the process of assessing the competence of each candidate is quite intensive process. To solve this problem are encouraged to develop a system that automates the selection of candidates and applicants will be rated. Initial data for calculation rating - your application form.

Analysis of the statement must determine "the competence" of a particular candidate that highlights his acquired skills in this area. To determine competency in statement, carried them search the Knowledge Base predetermined criteria values. To find all lexicographically similar words, different substitutions, insertions and omissions characters advisable to implement a search algorithm using fuzzy search that will get rid of the necessity to observe complete identity between compared objects. In this paper we propose to use Lowenstein algorithm. In this method, a measure of differences between the two strings is calculated as the minimum number of operations insert, delete, and change needed to transform one sequence to another.

Purpose of work is researching the existing building intelligent systems specialist competence framework and develops an algorithm that provides automatic selection of the candidates and forms them into a list in order of relevance to their competence.

Construction jobs criteria to match the scope of competence of the applicant to be the same way. This method of peer review indicates priority for each criterion.

The selection of the most competent candidates performed by multi analysis based on analytic hierarchy process (Analytic Hierarchy Process) and with multi-criteria decision analysis method ELECTRE.

Improved method of using the algorithm thresholds incomparability by using the analytic hierarchy process to determine the final priority alternatives that have the same priority led to increased accuracy of search. Further developed to use technological means to obtain a decision on the selection of quality staff.

The proposed algorithm implements matching skills with the requirements of job applicant and the employer establishes a comprehensive assessment of the applicant pursuant to the vacancy.

Automation staff selection for the company to significantly reduce the time in the selection of candidates for vacant positions, improve treatment results of psychological techniques to create a database of candidates. In DB worker can search candidates using appropriate introductions restrictions, thereby selecting employees for a job more efficiently, given their psychological characteristics and necessary social data.



**Trunov V., Zbrutsky O.**

## **ACCURACY OF STABILIZATION SYSTEMS ON MICROMECHANICAL SENSORS INCREASING**

The current level of science and technology has led to the widespread use of micromechanical gyros (MMG) as key elements sensitive control systems, navigation and orientation of moving objects.

One of the most significant is the random error MMG caused by the presence of low-frequency output signal harmonics.

Experimental studies revealed nature of random low frequency components of the output signal MMG type ADXRS401, which parameters (frequency, amplitude) are changing in the process and form start to start.

Using MMG sensor in orientation and navigation systems is associated with the use of algorithms integrating of the output signal, because white noise component leads to increase integrated signal time variance. The observed regularity of change the angle of rotation measurement error MMG and its proposed model is suitable for identification parameters and subsequent compensation.

To compensate the low-frequency output signal rejection filter with a special configuration has been developed.

MMG is applied for building control systems and stabilization. Single-axis stabilization system of the angle of rotation of the object to be stabilized under the influence of the disturbance was synthesized.

To measure the rotation angle of the stabilizer integration output signal of the MMG was applied. In the presence of low-frequency component in the output signal of the MMG stabilization system has a strongly growing time error, which limits its use for long periods of time. The application of the developed low frequency components filtering algorithm of the output MMG signal can significantly improve the accuracy of the stabilization system and make it workable for a long time interval. The features of random low-frequency component MMG output signal have studied experimentally. An algorithm for its compensation is proposed.

The possibilities of increasing the accuracy of the stabilization system by MMG errors compensation with the designed filter were shown. This opens the possibility of designing stabilization and navigation systems with long – time high accuracy on low-cost micromechanical sensors.



Vasilevska N.

**FILTER WITH FREQUENCY DECIMATION FOR FREQUENCY ANALYZER**

Most common in acoustic measurements are time domain analyzers based on bandpass filters. Analyzer input is discrete time domain signal  $x(nT)$  with sampling period  $T$  that processed by discrete bandpass filter with transfer function  $H(z)$ , where  $z = \exp(i\omega T)$ , and impulse response  $h_l = h(lT)$ ,  $l = 0,1,2,\dots,n$  Output signal of bandpass filter has the form

$$Y(\omega) = X(\omega)H(\omega).$$

Bandpass filter characteristics are determined by a standard and forms octave frequency spectrum.

Purpose – filter with multiple digital signal decimation development for octave spectrum analyzer for acoustic measurements in real time.

In accordance with the time domain analyzer equivalent schema, the system of bandpass filters can be represented as discrete system with signal multiple decimation. Block of filters of signals octave spectrum analyzer as discrete system with multiple signal decimation and decimation factor  $m=2$  shown at Fig. 1.

Discrete time domain signal  $x(nT)$  with sampling period  $T$  is processed by discrete bandpass filter with transfer function  $H(z)$ . On the filter output installed compressor of sampling rate, which reduces filter signal sample rate in  $m$  times. Resulting discrete signal is formed with a new sample rate  $y(nT/m)$ . Each channel has integrator; its output is mean square value of the signal in each octave frequency band.

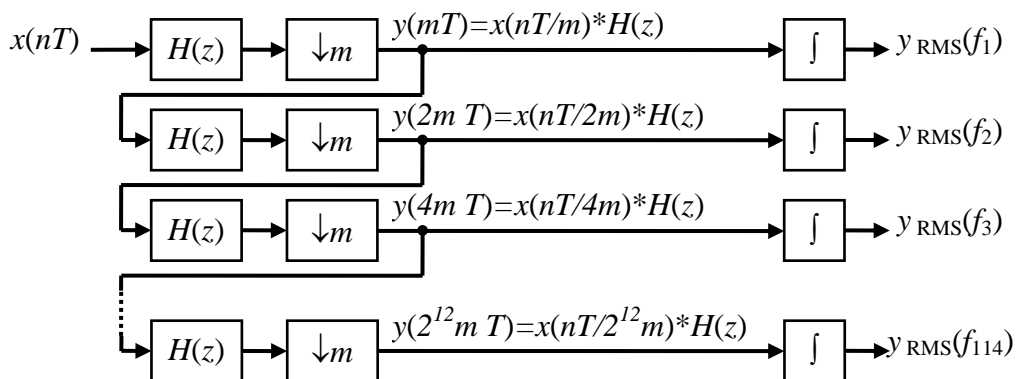


Fig. 1 The equivalent schema of the filter for octave spectrum analyzer



Digital filter coefficients for Remez algorithm calculated. The model of filter created and tested as part of acoustic noise measuring system.

Application of this filter with multiple signal decimation to acoustic noise frequency analyzer in the frequency range up to 20 KHz allows decrease requirements to RAM and provide measurement in real time.

**Vasilevskiy I., Dveirin A., Sementsov V.**

## **EXPERIMENTAL PROVISION OF MECHANICAL JOINTS STRENGTH CALCULATION OF THE COMPOSITE AVIATION STRUCTURES**

Permanent increase of amount and responsibility of polymeric composite materials (PCM) details in aircraft (including cargo aircraft) units provides essential decrease of their weight because of high specific performances of strength, rigidity and controlled anisotropy of properties. However in irregular zones PCM concede on strength and endurance to structural metals, particularly in widespread mechanical joints with discrete fixing elements.

Practice of the mechanical joints designing has shown, that the existing experiments system has limited application because it does not consider to the full feature of composite details in joints.

The experimental provision system of mechanical joints strength calculation of polymeric units details is presented.

The system of the experimental definition of composite details bearing strength in the mechanical joints, including straightness variation fixing on the "loading- displacement" diagram, as well as the special composite round octagonal shaped sample, fixed in the designed test device with self-balancing holders that compensate deviations and automatically regulate holders pressing effort to the sample is developed. The system allows to decrease tested materials consumption in 6,2 times and experiment labor content in 3,8 times for basic carbon-filled plastic based on ЭЛТР-0,08П tape and 5-211-БН binder. By results of experiments engineer dependence of bearing strength forecasting for wide PCM structures amount and fixing elements diameters - 3,4,5,6 and 8 mm is synthesized.

Based on the modified techniques and new designs the combination of ways, samples and devices for shearing strength definition of joint elements and interlaminar shear definition are synthesized. Detail edge cut implementation conditions and cutting effort direction according to the composite reinforcing scheme is determined. The approximate dependence for shearing strength forecasting of laminar reinforced composites is synthesized.





Stress concentration near the hole of the composite was explored theoretically, experimentally and using FEM, and determined that it essentially depends on load level of fixing elements.

Techniques and samples for experimental definition of compliance coefficient of mechanical joint are modified. Various joint sensitivity areas to accuracy of its elements parameters estimation are determined.

Results of research and work realization are introduced into Antonov facilities.

**Vidiakina K.**

## **HELMET MOUNTED SIGHTS**

One of the newly modernized fighter cockpit designs is the Helmet Mounted Sight (HMS) or Display (HMD). Directing heat seeking missiles was initial systems in the arena which were developed within seventies of the last century. Today, implementation of the HMS and HMDs became the system next generation in the category. The purpose of work is to investigate this device, its structure and operational principles.

HMS in conjunction with head tracker system provides beneficial means for the operator to indicate an object. The target indication carries out simply following pilot head moving, while pilot uses helmet sight aiming cross. The necessity to turn the whole aircraft is changed to easiest way and it leads to earlier missile launching.

The device could establish visual navigation system "marks" by means of defining known landmarks and features. Furthermore it doesn't require the pilot to fly over them.

Usually the HMS display source consists of LED matrix array. The display image is produced via compact optical prism by reflecting the image from the visor into the pilot's eye. The prism surfaces have different shapes: spherical or cylindrical, so they have different curvature. This is lead to correct optical errors.

HMS has practical application in navigation issues resolving which emphasizes its actuality and worth. Such devices were producing and developing by many manufacturers. For example, the ELBIT DASH series, the derived VSI/Kaiser JHMCS, and designs by Pilkington Optronics for the Eurofighter, and Sextant Avionique for the Rafale. The Russian HMS design is employed by such users as Flanker and Fulcrum.



Firstly the pointing a missile seeker seems to be very simple, but implementation is not the case. To achieve this goal number of issues should be decided as rising the reliability and delivering the required performance.



Для нотаток / Application



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