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METHODS OF PROCESSING ANALOG PARAMETERS OF AIRCRAFT FLIGHT INFORMATION (REVIEW)

Introduction

Modern systems of aircraft objective control make it possible to accumulate and analyze masses of information acquired during a certain cycle of operation, which makes it possible to increase the flight safety. An important component is the control parameters definition, their physical content and methods of processing the information obtained.

Throughout its existence, mankind has been monitoring environmental phenomena in order to anticipate adaptation to its expected changes, that is, forecasting and planning life cycles. Examples of such cycles:

– daily (morning, afternoon, evening, night);

– lunar (phase change of the type of the moon's disk – new, growing, full, aging);

– annual or seasonal (spring, summer, autumn, winter).

Long-term observations founded the primary science – Philosophy. Then it stratified into different areas (fields of research), such as Astronomy, Geography, Physics, History, Mathematics, and others. The history in this list is not accidental, since its phenomena also change phase-by-phase and cyclically: the birth of nations (peoples), development, greatness, confusion, destruction, decay ... Examples of this: the civilizations of Egypt, Greece, the Roman Empire and others.

From the above mentioned, one can form the primary condition for scientific research: the presence of cycles and periods is the basis for formulating patterns that mean the recurrence of certain phenomena or properties under the influence of external conditions independent of people (objective), or artificially created conditions. Distinguish ones are now Fundamental and Applied sciences. The fundamental direction studies Phenomena, and the applied direction studies Technological Processes of Obtaining Some Properties.

Thus, it is known a priori that it is practically impossible to create a new material by uniformly mixing the components in their solid state (an exception may be some technologies of powder metallurgy). But such a mixture can be made in any proportions, bringing the components to a liquid state.

Publications Review

Usually science requires confirmation of such repeatability, and very often this is achieved by the sameness of the values of the sets of features that characterize the state or phenomenon. Hence, for comparisons, there is a need for the availability of sets of measuring systems.

In the world's civil aviation, the Standards and Recommended Practices are used given in the Annexes to the Convention of the ICAO (International Civil Aviation Organization) [1] and [2].

The second document recommends lists of information for types of aircraft (airplanes, rotorcraft, general purpose, others), the names and quantities of parameters that it is desirable to display on the dashboards of crews under different flight conditions or record their values in the storage of registration systems. These conditions require some explanation.

When performing various types of activities, both insufficiency and excess of information to be analyzed can be harmful. The first contributes to the so-called "missing the target", since in some cases difficult or dangerous situations are not recognized (signals not provided or absent). Excessive information, including its duplication or human interference in the processes of obtaining data, greatly complicates the analysis of the current situation, sometimes “false signals” appear. This can lead to serious consequences caused by incorrect recognition.

Thus, from the point of view of optimality, the concept of Minimum Sufficiency is considered more acceptable.

Mentioned in papers [3–5] is that the effective use of information obtained with the help of on-board automated devices (systems) of registration and control and ground means of flight data processing during all types of objective control and preparation for flights will allow: to increase the flight safety of by preventing the departure of faulty aircraft, to conduct analysis of the aircraft functioning with the purpose of ensuring deeper control over its technical state during the scheduled period of operation, after performing scheduled work, as well as assessing the post flight performance of aircraft.

The purpose of the article is the review of the analog parameters of flight data and modern methods of their processing.

Analog parameters of flight data

Information arrays are divided into two main groups:

– analog parameters, the values of which change depending on the influencing conditions (for example, the engine operation modes set by the crew, flight altitude, air temperature, etc.).

– binary signals or one-time commands confirming the presence or absence of a phenomenon/state for some time (the system is on or off, the landing gear is retracted or released, the value of some parameter has reached a critical value, etc.).

In both cases, we are talking about values described by numbers. Somewhere over 2,500 years ago, the mathematician Pythagoras, still known to everyone, declared: “Numbers rule the world.” This phrase has been understood and actively implemented by the society only recently. We are all witnesses of the intensive process of the so-called "digitization" of photographs, films, sound, etc. This direction has become possible thanks to technical and technological advances in the field of computer technology and informatics.

As an anachronism in a purely physical sense, the criterion "Volume" of memory is now perceived. With modern micron sizes or Nano-Technology of the constituent elements of memory blocks, the concept of "Quantity" would be more accurate. But the use of such a term, in turn, also requires an understanding of Memory itself.

“Almost all controversy would be removed from among Philosophers, if they were always to agree as to the meaning of words,” said the French philosopher, physicist and mathematician Rene Descartes [6]. In other words, he proposed not to waste time on disputes, but to agree on scientific designations. So, let’s get back to the concept of "Analogue Parameters".

First, these are time-varying quantitative quantities that describe processes by numbers.

Secondly, for different parameters, measurement ranges are selected, divided into fractional values – scales.

Thirdly, the scales are assigned with physical quantities characteristic of a given parameter.

Thus, the parameter is always being read as a scale mark with an agreed physical name attached.

By the way, about "degrees": they are units of measurement of geometric angles, magnetic or other directions, positions of aircraft controls and engine modes, temperatures, coordinates of the earth's surface, and, as some people say, even the strength of alcoholic beverages.

The mark of the scale can be: the position of the arrow on the dial, the height of some column, the value converted into a numerical form, something else.

The initial part of physics – Mechanics, in the metric system of measurements, offers an initial set of basic quantities: mass, size, time. Most of the subsequent units are derivatives of the primary ones. Immediately, we notice different interpretations (standards) among different peoples:

– weight: gram, pound, liter, gallon, pood, carat (for precious metals and stones) other;

– size: meter, inch, foot, yard, mile, nautical mile, step (step), arshin, verst, and others;

– time: second, hour, day, calendar month (variable), lunar month, etc.

Even at the initial stage, differences are noticeable not only in the names, but also in the values, according to which some estimates, comparisons, analyzes, conclusions, etc., etc. are carried out. At a minimum, such actions require recalculations, or the presence of several indication scales.

At the same time, the question of the constancy of values arises when such conditions are repeated. This means the need to have means of comparison with something of their values: to have standard étalon - reference object for comparison, the properties of which are repeated under certain conditions.

Let's start with mass. The definition of mass refers to the amount of a substance that depends on the constituents of the material, its state (solid, liquid, gaseous), external conditions (pressure, temperature, etc.). It is known that figures that are absolutely identical in shape with minimal differences in size, but made of different materials, have different weights. This is easy to check on a lever-type balance. Such a check gives only a comparison: harder-lighter. So, the mass is determined not only by the volume of the figure, but also by the property of the material, called density. For quantitative characteristics, it is necessary to introduce rational concepts of weight and the force that equalizes it. In a general sense, force is a physical phenomenon capable of holding objects raised above the surface motionless. In this case, the force is equal to the weight, and with the help of spring scales, you can calibrate their scales based on the initially selected standard étalon. Sometimes the force is measured using strain gauge elements that change their electrical characteristics under the influence of loads. But, having agreed on the standard of mass, we find that it is affected by centrifugal force due to the rotation of the globe. At the same time, it is known that it is possible to create conditions of lack of weight or significant overloads by moving along special trajectories. That is, weighing the standard on a spring scale during movements will show different values. On the Moon, for example, it will be about six times smaller due to gravitational laws, etc. In this case, the mass, dimensions and density of the object do not change. Some compensation for discrepancies between mass and weight is introduced by taking into account accelerations under the influence of gravitational forces (“kgf”, “dyne”, “newton”, etc.).

A little about the dimension. Another question arises: is it possible to consider an object with variable properties as a standard étalon, for example, under the influence of temperatures? After all, it is known about the ability of materials to change their dimensions in different ways. Water can serve as an example: when cooled, it goes through several stages (vapor-liquid-ice) with a decrease in volume and, moreover, it begins to increase during subsequent cooling.

It looks like they found a material with minimal linear thermal expansions. From it they made the world standard étalon of length – a meter. During comparisons, the specified reference temperature is maintained. But other "meters" (standards of countries that have almost no difference in comparison with the world in given conditions), when they change, strictly speaking, cannot be considered as reference.

There are several theories about the definition of time. On the one hand, it always goes in one direction – months, years, centuries go irreversibly ... On the other hand, there are cyclical nature of natural phenomena depending on the positions in the sky of the Sun, Moon, constellations, etc., constantly moving along the tracks of their trajectories – regularities. This allows you to introduce hourly cycles and reference scales. On the third hand, the “world mill theory” states that all galaxies, including our solar one, rotate around the world axis at different speeds and a complete repetition of mutual positions in outer space occurs cyclically approximately every 24,000 years on the scale of the solar galaxy. And finally, the "theory of relativity" says that the dimension of time depends on its reference systems.

In this "cyclical disorder" humanity introduces adjustments to the time scales, for example, adding one day every four years (leap year), every century, etc. and Gregorian calendars. So, there is still no concept of time accuracy. By agreement, some standard is assigned and the permissible accuracy is accepted within the selected period, according to which clocks of different types are adjusted.

Physical phenomena called "heat" and "temperature" also do not have established explanations for the processes of their appearance, transmission, distribution. Like the concepts of mass, units called "calories" are introduced, the amount of heat is estimated (by analogy with weight) by the change in temperature during the transfer of this heat. But it is noted that temperature increases depend on the characteristics of the sources (combustion of carbohydrates, endo- and exothermic chemical reactions, nuclear decays, friction of surfaces, concentration of sunlight at one point, etc.) as well as on organized research processes:

– isobaric (at constant pressure),
– isochoric (without volume change),
– isothermal (without temperature change),
– adiabatic (without heat exchange with the environment),
– polytropic (with a change of all factors).

In addition, the amount of heat must be calculated using the also reliably unknown criterion "calorific value per unit volume of the source" (by analogy with the density of a substance).

Based on the scientific requirements for the repeatability of values under certain conditions, ranges and characteristics of experiments are selected for temperatures when confirming regularity or patterns.

It is revealed that the characteristics of temperature indications are rectilinear. This allows you to base on only two fixed points - the beginning and the end of the selected measurement range. For the Celsius scale, for example, these are: the melting temperature of ice (≈0ºC) and the boiling point of water (≈100ºC). It is understood that these points can be reproduced at any time. Realistically, this is not true.

It is known that the concentrations of ordinary salt or other impurities shift the primary conditions; at low atmospheric pressures in the mountains, boiling occurs at much lower temperatures.

A few words about temperature measurement technologies. They are usually based on known properties. Some main ones:

– change in the volume of liquid (including mercury) under the influence of temperature,

– change in linear dimensions, mainly – length, including – bimetallic tapes,

– variability of electrical characteristics (resistance or induction),

– the ability of contacts of different materials (thermocouples) when placed in different temperature environments to generate electrical potentials, called "thermo-motive forces".

– comparison of the color of the heated material with sets of spectra, and so on.

The search for standards of heat and temperature is just as fruitless as for mass with weight, although they are also evaluated on scales. It is practically impossible to manufacture thermometers with the same temperature readings of the same medium. A lot of factors affect the accuracy: the volume of the heated liquid, its properties (mass, density, expansion capacity, dimensions of the attached glass column into which the liquid is displaced, the relative positions of the elements with the liquid and the scale. And this is only for the simplest liquid measurement scheme.

In most cases, the units of temperature scales are degrees. The scales themselves are different. Better known now are the following: Celsius, Fahrenheit, Kelvin, Réaumur... Standard étalon of temperature, as well as time, in its classical philosophical understanding is unknown.

Summarizing the above said, we can state:

– due to the complex versatile factors of natural processes and their mutual influence, one cannot be sure of absolute repeatability when checking properties,

– the appearance of unknown factors that can lead to measurement errors is not excluded,

– the possibility of errors in setting the criteria for measuring instruments taken as reference ones is not excluded.

The obvious lack of stability even at the level of standards of the simplest physical phenomena from the point of view of science means the practical impossibility of repeating the conditions of experiments and, as a result, proving patterns. The way out lies in the recognition and implementation of measurement error systems.

After the initial review of the main physical quantities, let's turn to Derivative Parameters.

The Area in the simplest case is determined by multiplying the dimensions. Therefore, its dimensions are usually referred to as "size squared" (mm^2, cm^2, m^2, km^2, etc.). For complex surface shapes, formulas are used in area calculations, but the overall dimension is preserved in all cases, although we are already familiar with the disadvantages of measuring dimensions. Errors for "oblique and curved surfaces" increase, both due to multiplications and due to inaccuracies in the formulas for describing these surfaces.

In some countries, national units of area are used, for example: “are”, “acre”, “hectare” ...

Volume refers to spatial forms, dimensions in the metric system are referred to as "size cubed" (mm^3, cm^3, m^3, etc.). Errors in values increase for reasons similar to area calculations.

Speed usually refers to the ability of an object to move a certain distance in a certain amount of time (size/time). But for flows of gases or liquids, the concepts of volumetric (m^3/h) or mass (kg/s) velocities can be applied. We are already familiar with the difference in the designations of these concepts and their shortcomings.

According to the methods of receiving and assigning, special names of speeds are introduced:

– aerodynamic, track, sound, decision making, relative to the ground, and others, as well as restrictive (mostly for transport);

– minimum or maximum allowable, stalling, etc.

In aviation, flight speeds are often compared with the speed of sound ($M = V/a$), where "M" is a dimensionless "Mach number". In water transport, a specific unit is used "knot", meaning "miles per hour".

The rate of speed change (that reflects the essence of the phenomenon) is called acceleration. According to the laws of physics, it depends on the force applied to the object (forward) and its mass (inversely). Most of the considered parameters to assess the state using the criteria given in the first part of physics, can be, at least, seen visually, to touch something, to compare Heights, etc., in our usual way.

Everything becomes much more complicated in the transition to the concepts of electrics. Suggested criteria such as "Coulomb", "Volt", "Ampere", "Ohm", "Watt", etc. are not measured directly.

Quantitative assessments are carried out by calculations according to the formulas of the identified relationships. Standards (in the strict sense of immutability of properties) are unknown. Measurement conformity is periodically checked using recognized technologies, after which:

– reconfiguration of measuring instruments is carried out,

– the accuracy classes of the equipment are determined,

– decisions are made on the recognition of measurement results.

Superficially convinced of the proposal of Rene Descartes on the need for agreements on the terminology of measurement designations and in Pythagoras's statement about the importance of numbers in people's lives, let's move on to the concept of "objective information".

Flight data processing methods

Let's start with a simplified scheme for moving information arrays using aviation as an example (Fig. 1).

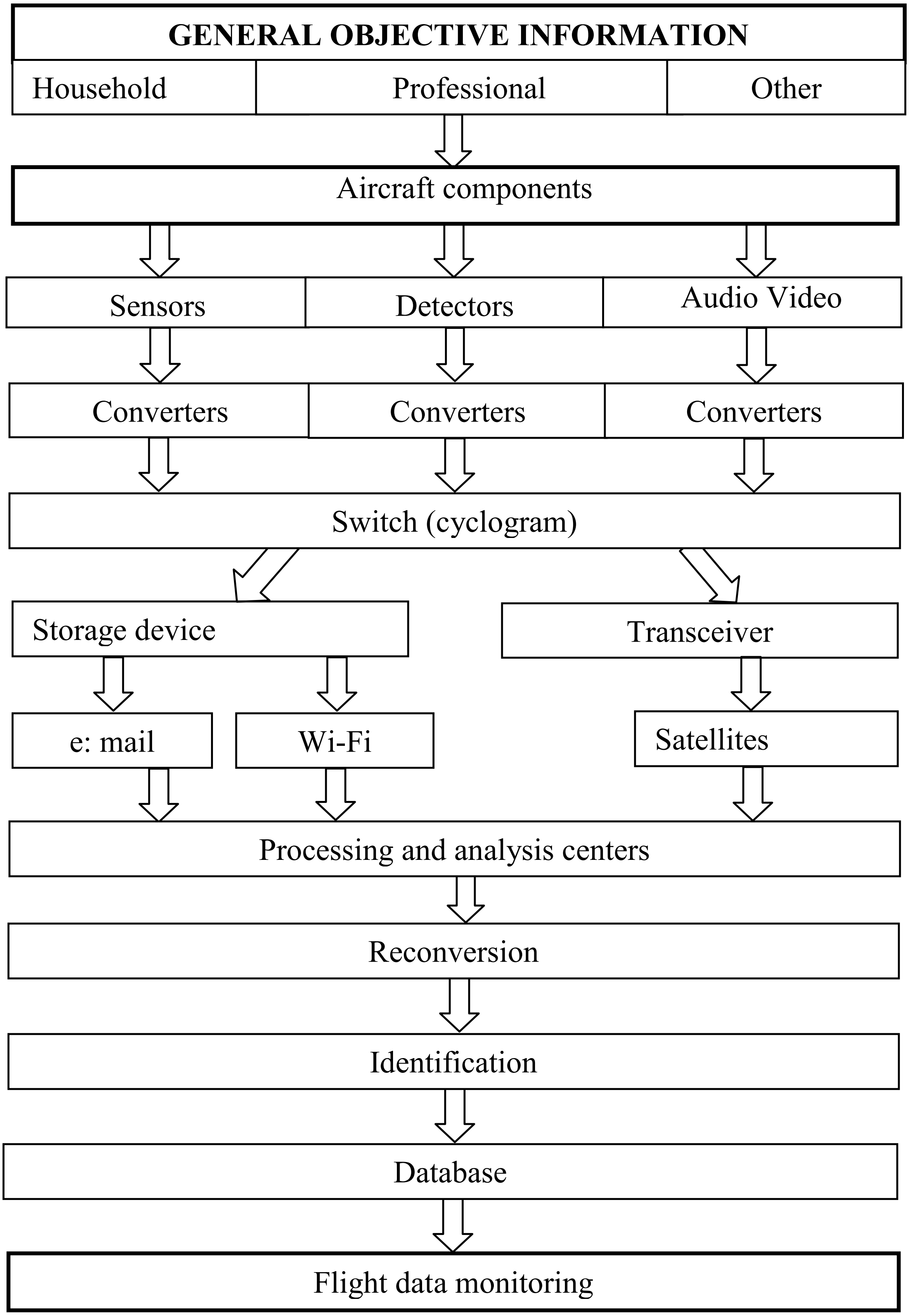

Fig. 1. Obtaining and applying information

Such a structure almost excludes people (subjects) to interfere in the process, and therefore, with some assumptions, information can be considered objective at all stages. At first glance, this is true, since there are practically no random errors in the received data (we should not forget about possible one-time failures due to technical or design flaws). But there are always system errors due to:

– design features of devices for generating parameter values;

– inconsistencies of parameters with approved measurement standards, as mentioned above;

– insufficiently accurate calibrations;

– incorrect information conversions in converters;

– data distribution failures in switches;

– systemic and random errors in the movement of information flows;

– deficiencies in aircraft identification algorithms, and so on and so forth.

As one can see, there are many options for distorting parameter values, on the basis of which further decisions on airworthiness are made.

Without a clear understanding of the physical properties, methods of their measurement, independent and unchanging standard étalon for comparisons and calibrations when obtaining the values of analog (time-variable) parameters, the questions arise: what is being measured and what for?

There is a need arising for the concept of Sufficient Measurement Accuracy.

Let's take a look at some navigation options as an example.

HEIGHTS Several technologies and height designations are used:

– relative to sea level; the reading is from the set pressure of the atmosphere, taken as standard (760 mm Hg or other); settings are set on all aircraft after takeoff at the so-called Transition Height. The standardized tolerances for each of the altitudes are called Flight Level and minimize the chance of collisions at the same altitude;

– relative to the runway; at an altitude called Transition Level, the barometric altimeters are adjusted to the atmospheric pressure of the touchdown airfield; this simplifies descent operations in low visibility conditions;

– relative to the ground; the radio altimeter fairly accurately counts the distance from the contact point or touchdown point, simplifies the actions of the crew at the final stages of landing (roundout, flare phase, touchdown);

– course-glide path indicator; in ILS (Instrument landing system) the localizer (108 to 112 MHz frequency) provides horizontal guidance, and the glideslope transmitter (329.15 to 335 MHz frequency) for vertical guidance, installed at the beginning of the runway, serving to refine the landing trajectory.

As you can see, with different instrument readings and their meanings, they all have the same dimensions: meters or feet.

COURSES. In a general sense, courses are the angles between the directions to the magnetic pole and the direction of flight. There are non-coinciding astronomical and magnetic poles. On the astronomical pole (its position practically does not change over time) in the Northern Hemisphere familiar to us, with a slight error, indicates the direction to the North Star in the constellation Ursa Minor. Yet, the magnetic poles are not fixed, and with sufficiently large areas of entry-exit fields, depending on the specifics of the local area, the directions to them "float" relatively to the astronomical poles.

– magnetic compass; shows the deviation of the course from the Earth's magnetic pole; possible reading errors in the areas of the so-called Magnetic Anomalies; local magnetic conjugations (Deviations) for airfield territories are taken into account, and constructive ones are corrected using special technologies (“written off”).

– radio compass; the frequencies of the radio stations located along the flight path are pre-tuned, the arrows of the device track the directions on them, using the intersections of the directions they specify their coordinates.

– heading-glideslope indicator; the course drive is located on the continuation of the line of the runway axis, the device reacts to the deviation from the equisignal: it determines the exact course. With different indications and their meanings, most devices give one dimension: angular degrees.

SPEEDS. Brief information about these parameters is given above. In most cases, the aerodynamic measurement principle is used, based on the difference between the total and static air pressures: $V^2 \approx 2(P^* - p)/d$, where:

– V – air flow velocity at the measurement point (assumed to be equal to the flight speed),

– P^* – dynamic (total) flow pressure);

– p – static air pressure;

– d – air density at flight altitude.

The probability of errors is quite high, and depends on the position of the sensors on the aircraft, flight modes and conditions (aircraft mass and angle of attack, pressure, temperature and air humidity). It is known that:

– in places of narrowing, for example – by aerodynamic profiles, the flow velocity increases;

– at speeds close to sound, local "pressure jumps" appear – the so-called "barriers", which sharply worsens aerodynamics. Flying at low speeds or at too high altitudes is dangerous because it can lead to a "stall" mode.

Regardless of the measurement systems and their meanings, most instruments give one dimension: km/h or miles/h.

Modern means of navigation are connected with satellite networks, which somewhat simplifies and refines the navigation parameters considered.

The vast majority of measurement systems is based on the conversion of any processes into electrical quantities by sensors that change instrument readings, or in converted ("digitized") types stored in aircraft storage devices or ground computers.

Even a superficial review of estimates and definitions of physical phenomena reveals a large number of doubts. Let's consider some unexpected concepts familiar to us.

1. Why is the measured static pressure (<kgf/cm^2>) called flight altitude (<m>)? Fluctuations in the temperature of the atmosphere, for example – in the Pamirs, even if you do not move, change the readings of the barometric altimeter by hundreds of meters during the day. It turns out that aircraft can be at different heights with the same instrument readings?

No: All aircraft's altimeters react the same way to ambient temperature and automatically reset. Some minor discrepancies in the readings are due to the peculiarities of their designs.

2. Why is the difference between the total and static pressures of air flows (both – <kgf/cm^2>) called the flight speed (<km/h>?

3. Why is the dimension <kgf m> assigned to different phenomena: torque and work, and with the multiplier <75> it is called “horsepower”?

4. Why is the power of engines in some cases called torque, (<kgf m>) and the dimension is determined by pressure in the system of its measurement (<kgf cm^2>)?

5. Why are the engine modes set by changing the mass consumption of fuel (<kg/h>), and the mode indicator has a scale in <angular degrees>?

6. Why are some ranges of engine modes, indicated in angular degrees, given the names: <ground idle>, <flight idle>, <cruising>, <nominal>, <maximum>, <take-off>, <emergency>?

7. What parameters determine the <maximum range> and <maximum duration> modes? Which of them is dangerous in aviation?

8. Why are parameters such as <pressure> and <temperature> sometimes given the designation <stagnant flow>? If the flow is "stagnant ", then can it be called a "flow"?

9. One of the definitions of the speed of rotation of the rotors <RPM> (which is understandable) is sometimes called <rotational speed>, or simply <revolutions> with assignment of other dimensions: <radians sec> and even <%>.

There can be many more such questions, and not only in aviation. Therefore, such reference devices are not defined that do not change their properties under the influence of various factors. Setting up measurement systems in accordance with the characteristics of the standard étalon being determined can be quite expensive and not always justified, therefore, measurement accuracy criteria are being accepted. Based on this, measures to obtain objective parameters only slightly reduce the deviations that always exist from the actually unknown physical characteristics and state of the research object. Data obtained in any way (objective or subjective) alone cannot guarantee their quality. The formation of groups of diagnostic parameters accumulates errors in the values of each of them. With the uncertainty and inaccuracy of measurements, questions arise about their needs, complexities, values and their subsequent use. One of the directions for ensuring flight safety is the transition to the use of a mechanism for continuous monitoring of flight data [7]. Some organizational recommendations are given in [8, 9]. This requires the development and implementation of a range of hardware, software and process standards based on the principles of Minimum Sufficiency and Sufficient Accuracy, for example:

1. Set the necessary nomenclature of objective information.

2. Decide on the frequency of data sampling and the accuracy of measurement channels.

3. Develop technologies for data acquisition hardware, data ordering and data exchange.

4. Include criteria and algorithms for automated tracking of trends, assessment and prediction of changes in the state of objects of observation in the software systems.

5. Keep tracking the remaining restrictive resources.

6. Perform statistical analysis of sample groups of data to develop algorithms (Fig. 2).

No matter how precise components make up the measurement system, the readings of the parameter values will always differ from the average. Some of the influences we may not be aware of. Thus, guided by inaccurate information, analyzes are performed and responsible decisions are made.

The next problem is the multivariance of values (Fig. 3) depending on the operating conditions (modes set by the crew, air density at different altitudes, at different temperatures, etc.).

And this is with objectively obtained data. Let's add to the imagination the individual features of sets of objects, different accuracies, system errors and one-time failures of measurement systems. Under such conditions, it is clear that increasing the accuracy of the obtained objective parameters is not always advisable. Taking into account measurement inaccuracies, as noted, and an increase in the nomenclature (Fig. 4), complex analysis becomes much more complicated.

The diagram combines the averaged values of only four statistically obtained parameters when changing two conditions: modes and flight altitudes.

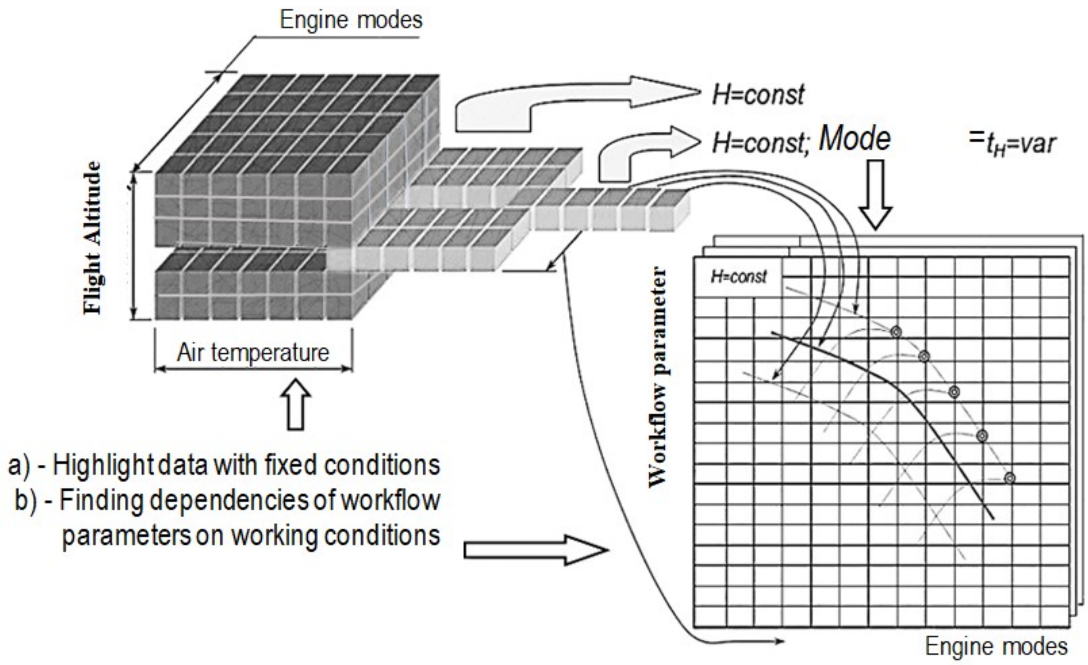

Fig. 2. Technology of statistical information processing

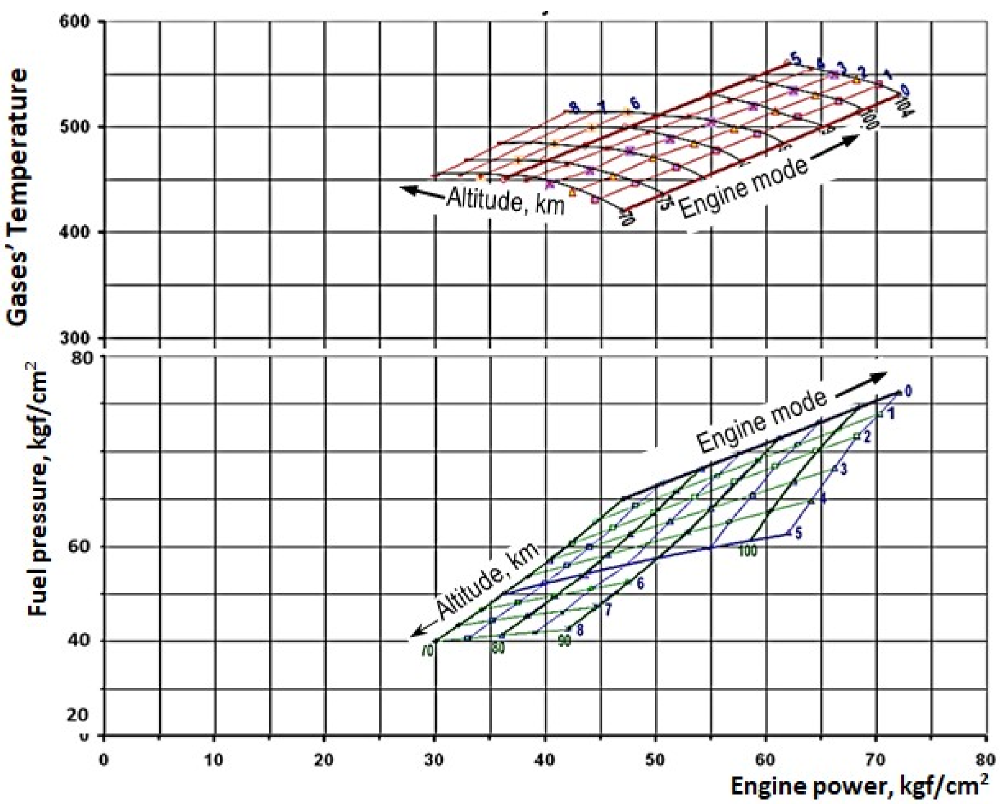

Fig. 3. Dependence of parameters on working conditions

The main tasks – determining the state and forecasting the prospects for its further change CANNOT be identified by the most accurate values of instantly obtained quantities (one point of the processes). It is known from geometry that many lines (straight lines and curves) can be drawn through one point, only one straight line through two points, and only one flat plane or one circle through three points. This coincides with the MINIMUM Sufficiency approach.

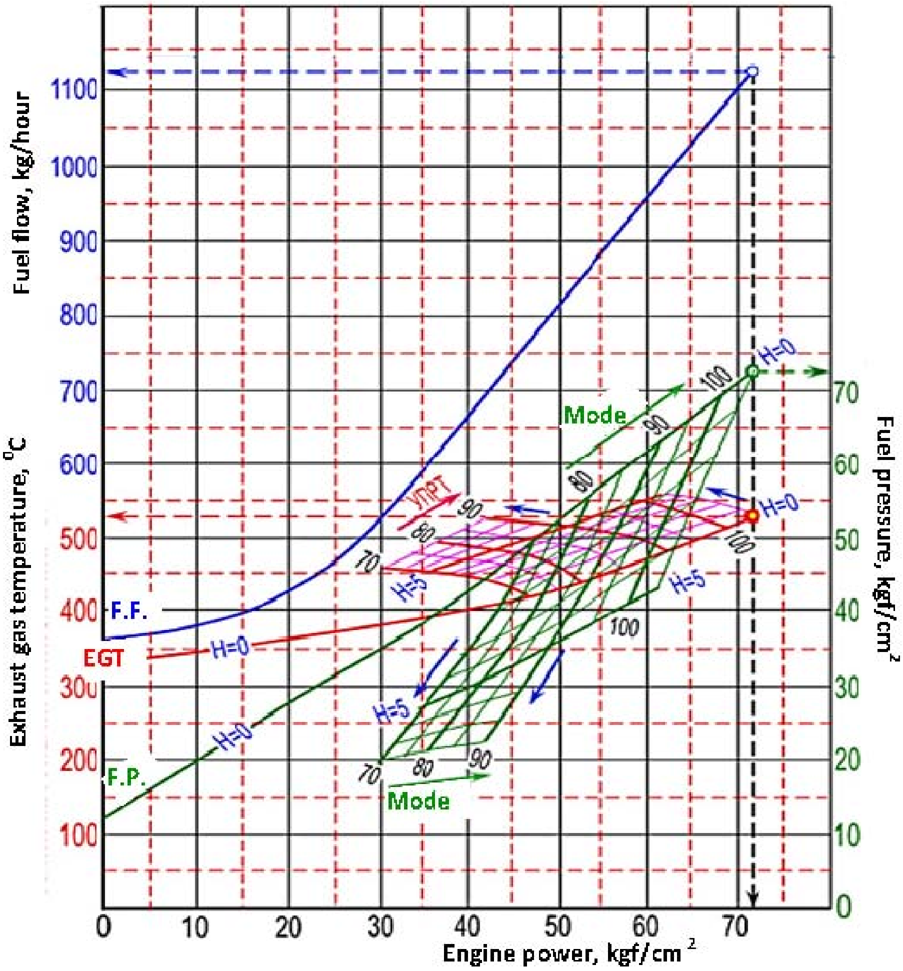

Fig. 4. Aggregate diagram of engine parameters

Deviation from recognized patterns is considered a sign of a change in condition and requires a more thorough investigation of the causes. The appearance of successive points is analyzed for compliance with one or another regularity (line, surface) or refinement of a recognized regularity. The appearance of successive points is analyzed for compliance with one or another pattern (lines, surfaces) or refinement of a recognized pattern. Diagnostics is based on this approach. The ultimate goal of diagnosing is to localize (find the cause of state changes) in order to take measures to stabilize or restore the state or limit further life regimes. Diagnostic algorithms are created for certain social needs: medicine, technology, veterinary medicine, etc.

The general definition can be: Diagnosis is a complex of signs which is named.

There are many diagnostic methods. But they all structurally solve the same tasks:

1. The generally accepted concept of a CORRECT (“healthy”) state of “families” of OBJECTS (SUBJECTS) of observation is established).

"Families" are understood as groups of people, animals, mechanisms, devices, etc. with similar properties.

2. Lists of signs of the state selected as serviceable are determined.

3. The factors influencing the magnitude of signs and the degree of these influences are clarified.

4. Algorithms for excluding variable influencing factors are being developed.

5. Technologies for determining changes in states and the causes of these changes are being refined.

The set of these actions is the so-called "diagnostic model".

Taking into account the above disadvantages inherent in information arrays, let’s consider the typical steps of data processing in order to extract the factors affecting the circumstances of the work (Fig. 5).

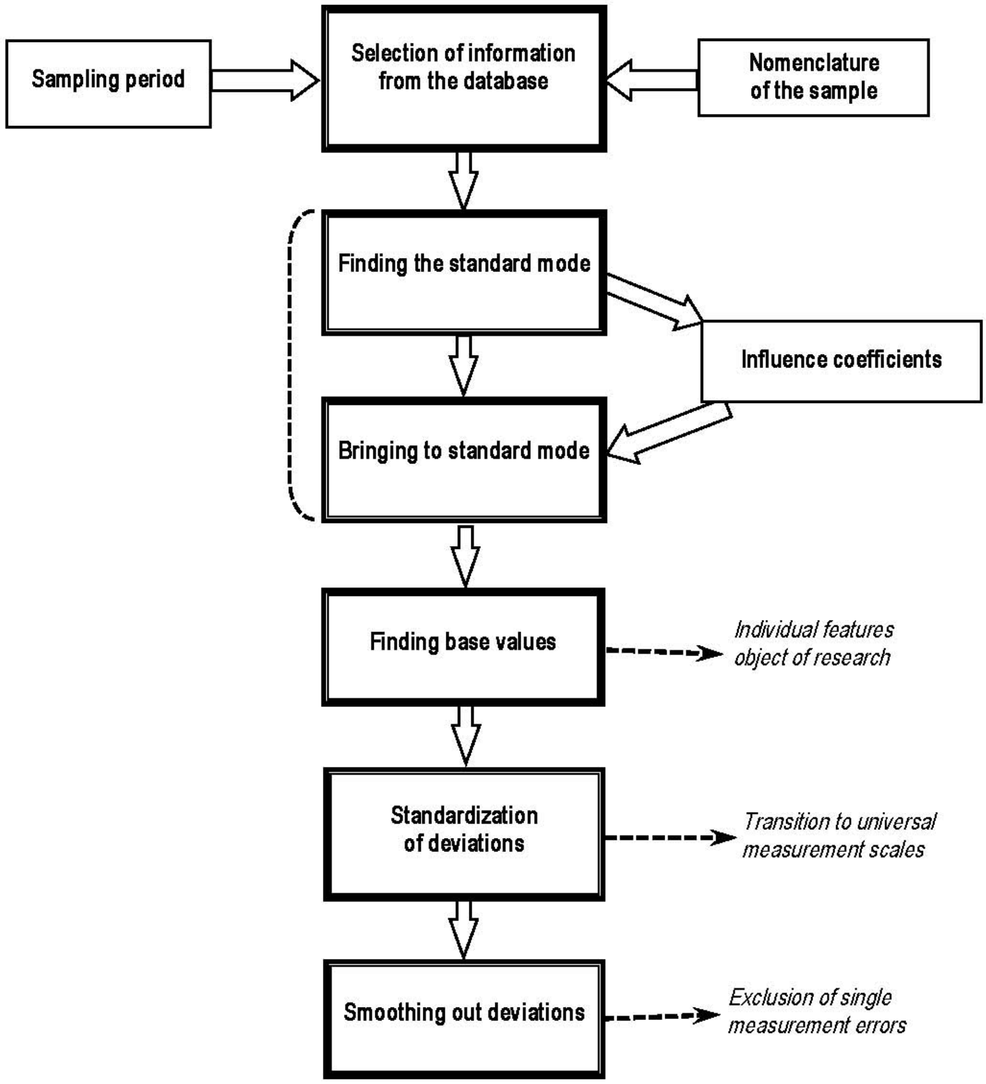

Fig. 5. Obtaining state signs

In the absence of standards and measurement inaccuracies, the standard mode is found as averaged values of parameters from a reliable sample (period and nomenclature) of a fleet of serviceable products (or theoretically). This also applies to the values of operating modes, and factors affecting the measurement values.

Influence coefficients are essentially the tangents of the slope angles of the trend lines of the current parameters relative to the horizontal line of the standardized parameter value. Thus, the values obtained are recalculated to the values that they would have under the operating conditions accepted as standard.

The recalculation process is called Standardizing.

Similarly, under certain examination conditions, criteria and tolerances for signs of healthy people (temperature, pulse, pressure range in the circulatory system, etc.) are established. Changes in conditions always distort the magnitude of features. For example, in a lifter, the signs of the state always differ from the values measured without loads.

So, firstly, everything is compared taking into account the influence of extraneous factors. But it is known that societies (human, technical, etc.) include various communities (groups) with features inherent in each of them. For example: hypo- and hypertensive patients, deaf, blind, color blind ...

For each of these groups, special rules, requirements, restrictions, etc. are established that allow joint operation.

Therefore, studies of objects begin with assigning them to a certain group (a car is not able to reach the speeds inherent in an airplane, a train cannot swim). Based on the foregoing, in order to determine critical changes in the state, it is necessary to set the initial parameters characterizing a healthy state. These can be values averaged over some initial period, called Basic Values. They are subsequently compared with the current values given. This process is called Monitoring.

It is clear that it is very inconvenient to work with a large number of "diverse" parameters having different dimensions. It is desirable to reduce the information to a form that makes it possible to simplify the analysis by rejecting dimensions. One option is to Rate Permissible Changes during life cycles.

In the absence of the possibility of updating the characteristics (treatment, repair, replacement of components), the cycles do not multiply. Such norms are established on the basis of research, theoretical calculations, experience or other considerations. They are set for each parameter and apply to the entire population.

Rationing is a comparison of the differences between the given and basic values with fixed norms: (Pi pr – Pbaz) / N. The obtained values are dimensionless: Part of the Allowed Rate. Deviations relative to the basic values can be in different directions (more or less), so the norms have different signs and, in addition, sometimes asymmetric values. For example: the values of permitted positive overloads for aircraft may be greater than negative ones. This approach simplifies the algorithms for automated recognition of the states of the observed object.

One more problem remains: random errors at different stages of working with objective information.

One-time failures of values obtained at different times for different parameters can create unnecessary "noise" with the need to spend time on analysis, searching for causes, etc. If there is no statistical evidence to interfere with system designs or processing algorithms, a Smoothing process is performed. Algorithmically, the difference between the current and previous values of the parameters processed according to the given technologies is reduced using the given coefficients: K (Pi pr – P i-1 pr).

A positive factor of such an action is a decrease in the level of one-time error of signals (“noise”), and a negative factor is a slow reaction to spasmodic changes.

The values of coefficients *K* and norms *N* regulate the sensitivity of recognition.

Properly selected and executed information processing procedures:

– reduce the spread of the initial measured values of the parameters by about an order of magnitude,

– eliminate the influence of time-variable factors of working conditions,

– take into account individual characteristics,

– make it possible to automate recognition processes by highlighting zones of a healthy or dangerous state of objects of observation.

Conclusions

1. No matter how we get the parameters (including objective ones), they will always be inaccurate, their dimensions and values are determined by some agreements. Based on this, the requirements for measurement accuracy are reduced.

2. The sufficiency of accuracy, in turn, is established by agreements.

3. The parameters, in their understanding, always change their values over time under the influence of various factors, creating a general picture of "white noise".

4. Isolation of useful signals ("signs of state") from the general "noise" requires the recognition of some kind of standard for groups of objects (subjects) under study.

5. The number of "features" in the process of processing is negotiated according to the principle of sufficiency, with the wishes of "minimum".

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МЕТОДИ ОБРОБКИ АНАЛОГОВИХ ПАРАМЕТРІВ ПОЛЬОТНОЇ ІНФОРМАЦІЇ ПОВІТРЯНИХ СУДЕН (ОГЛЯД)

Сучасні системи об'єктивного контролю повітряних суден дають можливість накопичення цілого масиву інформації, отриманої впродовж певного циклу експлуатації, що дозволяє підвищити безпеку польотів. Важливим є визначення основних параметрів контролю та методів обробки отриманої інформації. В статті розглянуто основні аналогові параметри для об'єктивного контролю польотів та сучасні методи їх обробки. Розглянуто інформаційну технологію статистичної обробки інформації, яка передбачає визначення необхідних номенклатур об'єктивної інформації, визначення частоти збору інформації та точності каналів вимірювання, технологію апаратного отримання, обміну та зберігання даних, виконання статистичної обробки даних та прогнозування стану об'єкту контролю. Відзначається, що точність вимірюваних параметрів завжди є суб'єктивною, і відповідає встановленим допускам. Параметри завжди змінюють свої значення протягом деякого часу під впливом різноманітних чинників, створюючи загальну картину «білого шуму». Виділення корисних сигналів («ознаки стану») із загального «шуму» вимагає визнання якогось стандарту для груп досліджуваних об'єктів (суб'єктів). Кількість «ознак», що обробляються, обумовлюється за принципом достатності, з побажаннями «мінімальності». З метою виконання вимог ICAO та інтеграції в єдину систему контролю безпеки польотів, з угодою про спільний авіаційний простір з ЄС (програма—відкрите небо), необхідно створення (вдосконалення) сучасної системи контролю польотів на нових фізичних цифрових принципах обробки польотної інформації з використанням високошвидкісних технологій її передачі.

Ключові слова: польотна інформація, аналогові параметри, обробка, літальні апарати.

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METHODS OF PROCESSING ANALOG PARAMETERS OF AIRCRAFT FLIGHT DATA (REVIEW)

Modern systems of aircraft objective control make it possible to accumulate a whole mass of information obtained during a certain cycle of operation, which makes it possible to increase the flight safety. It is important to determine the main control parameters and methods of processing the data obtained. The article discusses the main analog parameters for objective flight control and modern methods of their processing. The information technology of statistical data processing is considered, which involves determining the necessary nomenclature of objective information, determining the frequency of data collection and the accuracy of measurement channels, the technology of hardware acquisition, exchange and storage of data, performing statistical data processing and forecasting the state of the control object. It is noted that the accuracy of the measured parameters is always subjective and corresponds to the established tolerances. Parameters always change their values over time under the influence of various factors, creating a general picture of "white noise". Isolation of useful signals ("state signs") from general "noise" requires the recognition of some standard for groups of researched objects (subjects). The number of processed "signs" is determined by the principle of sufficiency, with the desire for "minimalism". In order to fulfill the requirements of ICAO and integration into a unified flight safety control system, with the agreement on common airspace with the EU (Open Skies Program), it is necessary to create (improve) a modern flight control system based on new physical and digital principles of flight data processing using high-speed transmission technologies.

Keywords: flight data, analog parameters, processing, aircraft.

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