APPROVED

Head of department

S.V. Pavlova

"___" ___________2021

GRADUATION WORK

(EXPLANATORY NOTES)

FOR THE DEGREE OF MASTER

SPECIALITY 173 "AVIONICS"

Theme: Complex technology of flying processing analysis

Done by: student of the AV-209Ma group, Vladyslav Yuriiovich Shuhailo

(student, group, surname, name, patronymic)

Supervisor: ______PhD, H.A. Polozhevets____________________

(scientific degree, academic rank, surname, name, patronymic)

Consultant on 'Labor protection': ___________ Kovalenko V.V.

(signature) (surname, name, patronymic)

Consultant on 'Environmental protection': ___________ Dmytrukha T.I

(signature) (surname, name, patronymic)

Standard controller: ___________ Levkivskyi V.V.

(signature) (surname, name, patronymic)

Kyiv 2021

МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ
НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ
ФАКУЛЬТЕТ АЕРОНАВІГАЦІЇ, ЕЛЕКТРОНІКИ ТА ТЕЛЕКОМУНІКАЦІЙ
КАФЕДРА АВІОНІКИ

ДОПУСТИТИ ДО ЗАХИСТУ
Завідувач кафедри
___________С.В.Павлова
«__»_________2021 р.

Тема: Комплексна технологія аналізу льотної обробки

Виконав: студент групи АВ-209Ма, Шугайло Владислав Юрійович
(студент, група, прізвище, ім'я, по-батьвові)

Керівник: ______к.т.н, Положевець Г.А.____________________
(наукова ступінь, вчене звання, прізвище, ім'я, по-батькові)

Консультант розділу 'Охорона праці': ________ Коваленко В.В.
(підпис) (прізвище, ім'я, по-батькові)

Консультант розділу 'Охорона навколишнього середовища': ___________ Дмитруха Т.І
(підпис) (прізвище, ім'я, по-батькові)

Нормоконтролер: ___________ В.В. Левківський
(підпис) (прізвище, ім'я, по-батькові)

Київ 2021

NATIONAL AVIATION UNIVERSITY

Faculty of Air Navigation, Electronics and Telecommunications

Department of avionics

Specialty 173 ‘Avionics’

APPROVED

Head of department

S.V. Pavlova

“___” ___________2021

TASK

for execution graduation work

V. Y. Shuhailo

1. Theme of graduation work is the ‘Complex technology of flying processing analysis’, approved by order 1945/ст of the Rector of the National Aviation University of 22 September 2021.

2. Duration of which: 18 October 2021 to 31 December 2021.

3. Background to the work: algorithms of information processing

4. Content of explanatory notes: List of conditional terms and abbreviations; Introduction; Chapter1: Prospects for the development of on-board recorders; Chapter 2: Functional scheme of the complex analyser of flight technologies; Chapter 3: ; Chapter 4:; Conclusions; References;

5. The list of mandatory graphic material: Graphical presentation of the results of the study of the human factor under the part of aircraft maintenance in the form of a presentation.

6. Planned schedule

№	Task	Duration	Signature of supervisor
1.	Validate the rationale of graduate work theme	18.10.2021	
2.	Carry out a literature review	19.10.2021 – 25.10.2021	
3.	Develop the first chapter of diploma	26.10.2021 – 01.11.2021	
4.	Develop the second chapter of diploma	02.11.2021 – 10.11.2021	
5.	Develop the third and fourth chapter of diploma	11.11.2021 –9.12.2021	
6.	Tested for anti-plagiarism and obtaining a review of the diploma	10.12.2021	

7.Consultants individual chapters:

Chapter	Consultant (Position, surname, name, patronymic)	Date, signature	
		Task issued	Task accepted
Labor protection	Ph.D., Associate Professor Kovalenko V.V.		

Environmental protection	Ph.D., Associate Professor Dmytrukha T. I		

ABSTRACT

Explanatory note to the final work " Comprehensive analyzer of flight scanning technologies in promising flight recorders ": 99 pages, 41 figures, 28 tables, 12 sources used.

The object of research is a promising two-channel complex analyzer.

The purpose of the work is to create a functional diagram of a complex analyzer and substantiate its elements

Research method - collecting information on the latest (those being developed) registrars, control and calculation devices.

In the future, the integrated analyzer will automatically process the data coming from the flight recorders and control devices, compare them with the programmed control schemes of flight procedures in order to eliminate the violations on board that will appear.

Predictive assumptions about the development of the object of study - to ensure fewer errors during the flight of the crew, as well as reduction / complete elimination of the consequences of these errors, provided the use of the device considered in this work.

Content

LIST OF SYMBOLS, ABBREVIATIONS, TERMS

OBREE – on-board radio electronic equipment;

FICU– flight information collection unit;

ORD – on-board registration device;

POD – protected on-board drive;

SINS – small inertial integrated navigation system;

PC – personal computer;

GAE – general aircraft equipment;

UHF – ultrashort waves;

TFAP – technology of flight analysis processes.

Introduction

The peculiarity of the design of the proposed integrated analyzer is that the structure of the inputs and outputs of the analyzer must be worked out. The offered analyzer is two-channel:

1. Channel for testing (control) of standard operating procedures for flight operations manual. The possibility of such control arises because from paper RLE passed to electronic RLE. From 1995 Intensive developments were carried out by the Department of Avionics and the Scientific Center for Accounting the Technological Complexity of Flight Procedures. The technology of accounting for technological complexity is called TFAP (technology of flight analysis processes). The need to take into account the technological complexity arises due to the fact that the crew operates systems of complex complexity and complexes. Therefore the technological device of the account of peaks of technological complexity is required.
2. Output of the perspective onboard recorder with an onboard conclusion. Therefore, the diploma analyzes the development trend of on-board recorders and determines the possibility of on-board output in them.

The main purpose of the designed analyzer is on-board control of flight procedures in order to violate them by the crew. The principle of operation of the analyzer is to compare the standard operating procedures TFAP with the data of on-board recorders and further elimination of violations on board that will occur.

CHAPTER 1. PROSPECTS FOR THE DEVELOPMENT OF ON-BOARD RECORDERS

This chapter will consider a large number of on-board recorders of domestic and foreign production. The purpose is to select an on-board recorder that will later be used in the design, manufacture and operation of a comprehensive flight technology analyzer.

The flight recorder / recorder must meet the following requirements – have an on-board output for the transmission of parametric and voice information.

1.1. On-board recorders of domestic production and prospects of their development. Control devices for engines and other elements of the aircraft

Fig 1.1. Modernization of the registration system on "Mi" and "Ka" helicopters

The on-board registration device of the BUR-1-2 type includes:

- PU-25 control panel;
- flight information collection unit BMPI-4-2 series 2;
- protected onboard drive ZBN-1-1.

For Mi-8AMT, Mi-171, Mi-171E, Mi-171A helicopters according to the bulletins № АМТ3088-БУ-АБ, № АМТ3088-БУ-Г (“Replacement of the BUR-1-2 system with the BUR-1-2 system .2 and installation of the TBN-K-4 series 2 solid state drive), the BUR-1-2 system is being replaced with the BUR-1-2 system ser.2 (fig. 1.3). To expand the information capabilities to the unit BSPI-4-2 series 2 can be connected to the solid state on-board storage TBN-4-2 series 2, in which case the drive is introduced into the object.

Fig 1.2. Onboard recorders of the series with the connected solid state onboard operational drive

Fig 1.3. Control panel and flight information collection unit

For Ka-32A helicopters and its modifications in accordance with Act № 10 / 020-2007 of 05.04.2007, based on the results of BUR-1-2 series 2 tests on Ka-32A11VS № 98-01, 98-04 helicopters, approved by the Chief Designer OJSC "Kamov" Shiryaev L.P., is replacing the system BUR-1-2V system BUR-1-2 series 2. Installation and connection of the product BUR-1-2 series 2 on board helicopters is carried out in accordance with the adjusted design documentation, developed by KumAPP and approved by Kamov.

For Mi-8, Mi-8MTV, Mi-8AMT, Mi-171 helicopters and their modifications according to the bulletin BUR-1-1-BU / BE dated 03.09.2009 in the BUR-1-2Zh system (BUR-1-2) replacement of the protected onboard ZBN-1-1 drive on the protected onboard ZBN-1-3 series 3 series is carried out.

For the Mi-26T helicopter according to the bulletin BUR-1-1-BU / BE from 03.09.2009 in the BUR-1-2B system replacement of the protected onboard ZBN-1-1 drive on the protected onboard ZBN-1-3 series series is carried out 3.

Fig. 1.4. On-board registration devices

It is allowed to replace the units in the systems: PU-25 control panel with PU-25-1 control panel (see fig. 1.3),, BSPI-4-2 flight information collection unit with BSPI-4-2 series 2 flight information collection unit, protected ZBN-1- on-board drive 1 on the protected onboard ZBN-1-3 series 3.

For MI-8MTV-1 helicopters according to bulletins № T2835-BU-G ("Replacement of a product of SARPP-12D1M on a product of BUR-1-2") and № TM3046-BU-G (specifying) replacement of system of automatic registration of parameters of flight of SARPP is carried out -12D1M on the BUR-1-2 system. Given the heredity of the BUR-1 products, it is allowed to combine the performance of two bulletins (№ T2835-BU-G and AMT3088-BU-G) with the final modernization of the SARPP-12 system to the BUR-1-2 series 2 system.

Fig 1.5. SARPP-12 System of automatic registration of flight parameters

For Mi-8T and Mi-8MTV-1 helicopters, in accordance with the design documentation developed by CJSC SPARK, the automatic registration system SARPP-12 is replaced by the on-board registration device BUR-SL-1 series 9 together with the NEL-1 easily removable operational drive.

Autonomous storage of flight information

The autonomous storage of flight information (fig 1.6) is designed to record flight data coming from a small inertial integrated navigation system (MINS) KompaNav-2. MINS KompaNav-2 defines up to 30 parameters, including:

- orientation angles (roll, pitch);
- heading
- speed;
- location coordinates (latitude, longitude);
- height, barometric height;
- vertical speed;
- overload and acceleration on three axes;
- angular velocities along three axes.

The drive can store from 30 to 100 hours of continuous recording of data of several flights (depending on frequency).

Fig 1.6. Autonomous storage of flight information

New international air navigation requirements and means of ensuring them have been introduced to standardize and improve performance (table 1.1).

Table 1.1

New international air navigation requirements and means of ensuring

№	Requirements	Date of introduction	Airspace area
1	VHF radio frequency band 8.33 KHz	Entered	Europe
2	FM immunity system ILS, VOR, VHF	Entered	Europe, South America
3	Preventing aircraft collisions in the air	Entered	USA, Europe, India, Australia, Argentina, China
4	Vertical separation of 300 m at high altitudes (RVSM)	Entered	North Atlantic, Europe, North America, Russia
5	Emergency drive transmitter	Entered	Global requirement Annex 6
6	Early warning of dangerous approach to the ground	2003 - new aircraft, 2005 - all aircraft are more than 15 tons	Global requirement Annex 6
7	Basic zonal navigation (B-RNAV, RNP-5)	Entered	Europe
8	Precision zonal navigation (P-RNAV, RNP-1)	April 2003	Europe
9	Promising zonal navigation (RNP-RNAV)	2005–2006	Gradual introduction in all areas

The onboard generalized system of the built-in control and the warning of crew of the SCREEN-13M-3

The Ekran-13M-3 system is intended for:

● reception and logical processing of signals from the connected general aircraft equipment (ZLO), complexes of onboard radio electronic equipment (BREO);

● issuance of warning and notification information about the status of on-board systems and complexes in the on-board device for displaying text messages – block 2E-03;

● recording in flight on an easily removable flash cassette unit 2E-03 with a capacity of 1000 MB of information from the six systems SOK UBD, recorder type "Tester" and unit "BOD-88" series ZKM;

- processing the information accumulated on the flash cassette unit 2E-03, means PIP-27 or IBM-compatible PC;
- input of service information using the keyboard located on the front panel of the unit 2E-03. Installed on the MiG-29.

For a more detailed study, the following are the technical characteristics of the system "Screen-13M-3" (table 1.2).

Table 1.2

Specifications

Parameter name	Value
The amount of information processed in the form of: -one-time commands -serial code signals according to DSTU 19977-79	 144 2500
Number of control commands issued	23
Display the displayed information	LED indicator
Supply voltage	18-31 B
Consumer power	50 W.
Mass, no more	10 kg

Flight data analysis, flight analysis, flight tests, three-dimensional flight visualization, motion detection.

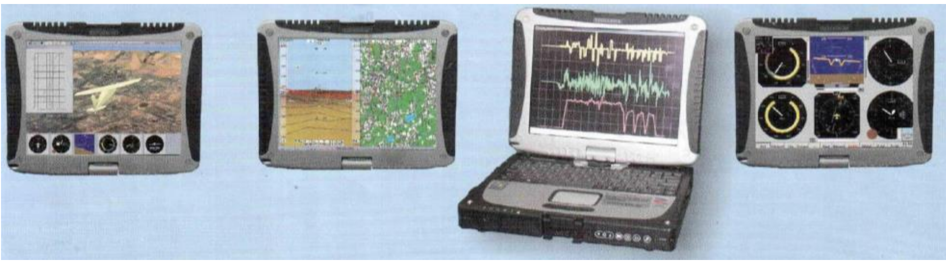


Fig 1.7. Devices for analysis, flight analysis, flight tests, three-dimensional flight visualization and motion detection

A review and review of drives, in table. 1.3 describes the characteristics of the drive, and in table. 1.4 Accurate characteristics of MINS KompaNav-2. The parameters are specified in the specification as the value of the root mean square error obtained in comparison with the reference meter based on the results of flight tests.

* – rectilinear flight is defined as the absence of intentional maneuvers on the course and pitch

** – roll and pitch angles do not exceed 45º

*** – roll and pitch angles in the range from 45º to 75º

**** – autonomous (without SNA) determination of the course is possible when compensating for magnetic deviations.

Table 1.3

Drive characteristics:

High-voltage	= 12… 30 V
Power	<2 W.
Operating temperature	-40… + 70ºC
Shock	10g
Weight	0.150 kg
Data recording frequency	50 Hz
Recording time	30-150 years
Operating ranges: Heel Pitch Course Acceleration	 ± 180º ± 90º ± 180º ± 10g

Table 1.4

Accurate characteristics of MINS KompaNav-2

	INS / SNA integrated mode	Autonomous inertial solution
Coordinates (complex solution)	6 m	500 m (5 minutes after GPS disappearance)
Road speed	0.2 m / s	5 m / s (5 minutes after GPS disappearance)
Vertical speed	0.25 m / s	0.3 m / s
Orientation angles		
Rectilinear flight *	0.2º… 0.3º	0.3º… 0.4º
Maneuvering **	0.3º… 0.5º	0.5º… 0.7º (unlimited time)
Highly maneuverable flight ***	1º	1.5º (unlimited time)
Resolution	0.05º	0.05º
Course (path angle) ****		
Precision	0.4º	2º
Resolution	0.1º	0.1º

3D FlightViz software

Software «3D FlightViz» provides visualization of flight data coming directly from Minsi KompaNav-2 or uploaded to the computer as a file with the store flight information. The software allows you to observe the flight in the form of the evolution of a 3-dimensional model of the aircraft with an indication of the main parameters on a standard toolbar.

In separate windows construction of the plan, the 3-dimensional image of a trajectory, sweep on height is possible.

In conjunction with the drive FIR Software «3D FlightViz» is an operational tool for reconstruction and analysis of the flight.

ZBN-GA on-board information registration system

The on-board information registration system ZBN-GA is designed for registration of audio / speech and digital parametric information as part of on-board control systems and flight information registration. The system provides rewriting of the registered flight information in the ground processing system KARAT-N-02, storage of the registered flight information in case of a flight accident.

Storage:

- protected onboard ZBN-MR drive;
- the control panel of the registrar of the language information PU RRI;
- device microphone dynamic UMD-3 (3 pcs.).

Specifications:

- Assigned system resource – 10000 hours;
- Power supply of the system on two independent inputs – + 27 V;
- Power consumed by the system, not more than 30 W;
- The presence of a built-in control system with a depth of 95%;
- No need for scheduled work;
- The presence of an acoustic water alarm.

The protected on-board drive ZBN-MR, which is a part of the ZBN-GA system, has been certified in the Aviation Register of the Interstate Aviation Committee. A certificate of suitability of SGKI № 161-163-3BN-MR was obtained. Approval № 214-023-1 for installation on the Tu-214 aircraft was obtained for the PU RRI remote control and the UMD-3 dynamic microphone device. ZBN-GA provides:

- reception and registration of digital parametric information coming from the system of collection and processing via the ARINC 717 communication line, with a transmission rate of

64, 128, 256, 512 or 1024 words / s for at least the last 25 hours of registration and in the mode " ring "at a speed of 256 words / s;

- reception of voice information on three narrowband 150-3500 Hz channels from the equipment of internal communication of LA and on one broadband 150-5000 Hz channel from open microphones of a cabin through the PU RRI panel, its processing and registration within not less than two last hours of registration and in "ring" mode;
- synchronization of all information received on signals from the single time system of the aircraft (chronometer of aviation electronic type HAE-85 M on ARINC 429 or ARINC 717 channels);
- erasure of the registered sound and speech information on the command arriving from the PU RRI panel;
- issuance of registered information on an external command on the channel ARINC 646 (Ethernet) for rewriting in the ground processing service Karat-H-02 for further processing and analysis;
- storage of the carrier and the information recorded on it, necessary for the investigation in the event of a flight accident in accordance with the requirements of TSO C124, ED-55 and OST 101080-95.

The on-board information registration system ZBN-GA can be used on board the aircraft as a secure recorder of speech (sound) information (dictaphone), secure recorder of digital parametric information or secure combined (combined) recorder of speech (sound) and digital parametric information.

On-board registration device BUR-1-2 series 3

On-board registration device BUR-1-2 series 3 (fig 1.8) is designed to collect and register in flight parametric and audio / speech information and save this information in the event of an accident. The state of efficiency of BUR-1-2 series 3 is displayed by means of the built-in control.

Fig 1.8. BUR-1-2 series 3

Primary processing of the accumulated parametric information is carried out on terrestrial complexes such as "PS-90", "Topaz-M" and similar equipped with a receiving port according to the standards RSMSIA-II primary processing of audio / speech information is carried out by terrestrial playback devices NUV-1 series 2. Delivery set (fig 1.9):

- flight information collection unit BSPI-4-2 series 3;
- the control panel with the removable PU-SN-10010 drive;
- system of collection and registration of sound / speech and registration of parametric information SZBN-1-11000140;
- frame Ra-37K-3.

Fig 1.9. Delivery set of on-board registration device

The main technical characteristics are described in table 1.5.

Table 1.5

Basic technical characteristics

Supply voltage	27 B (18-31) B
Consumer power	
-without heating	not more than 40 watts
-with heating	not more than 73 watts
Ready time for operation after switching on at ambient temperature:	
-from 60º to minus 40º	no more than 3 minutes
-from minus 40º to minus 60º	no more than 15 minutes
Number of parameters registered	
-analog signals	30
-analog-discrete (frequency) signals	5
-one-time commands	to 96
-serial codes	up to 16 channels
BUR-1-2 series 3 provides:	
-registration of the incoming signals arriving with registration frequency	0.5, 1, 2, 4, 8, 16 or 32 Hz
-time registration: hours, minutes, seconds	Six decimal places
Duration of storage of the information of the registered SZBN-1:	
-parametric information	not less than the last 760 hours
-language information	at least the last 7 hours of work on each language channel
-audio information	at least 3.5 hours on each audio channel
Duration of storage of information of the registered PU-SN	not less than the last 2600 hours of operation
Saving information in action	

-successful overloads	up to 33342 m / s ^{2} (3400 g) with a duration of 6.5 ms
-hitting a falling load	weighing 227 kg, falling from a height of 3 m, a diameter of 6.35 mm
-static compression	with a force of 2270 kgf, for 5 minutes on all axes
-ambient temperature	1100ºC for 1 hour, covering 100% of the surface
-ambient temperature	260ºC for 10 hours, with 100% surface coverage
-aviation fluids	for 200 hours
-sea water	at a depth of 6000 m for 30 days
Continuous operation time BUR-1-2 series 3	15 hours
Block BUR-1-2 ser. 3 is serviced	on technical condition

On-board registration device BUR-92A-05

The on-board registration device BUR-92A-05 is intended for registration of flight information and its storage in case of a flight accident. Modification of the registrar BUR-92A-05 is certified in the Aviation Register of the International Aviation Committee and has a Certificate of Fitness SGKI № 142-003-97 dated 04.04.1997. The main technical characteristics of the recorder are described in table 1.6. The composition of the registrar:

- information collection unit BSIP-92A-05 (1 pc.);
- solid-state flight data recorder ZBN-24MT-02 (1 pc.);
- operational drive EBN-92 (1 pc.);
- cassette BK-92 (2 pcs.):

Table 1.6

Basic technical characteristics

Parameter name	Value
Supply voltage, V	18-31
Consumer power, W.	not more than 100
0-6.3 V	52
0-40 V	16
0-0.05 V	6
-AC voltage 115 V 400 Hz	3
-frequency 400-16000 Hz	8
-sine-cosine transformers	15
-according to DSTU 18977-79	24
- discrete	150
Number of measurements in 1 s.	256
Time of storage of the registered information, hours	last 25
Saving information	ZBN-24MT-02, OST1 101080-95, TSO-C124
Weight, kg	not more than 20

Small-sized storage device MNS-29

MOE-29 is designed to record and store information from the system type "Screen-13M-3" and the upgraded system "Tester U3-L":

- the results of the last three modes of ground and flight control of the MiG-29 aircraft, conducted using the system type "Screen-13M-3";
- engine and aircraft parameters from the upgraded system "Tester 3-L" with "wrapping" of the record at the beginning.

MNS-29 is attached to the coverall of the pilot and is connected to the system type "Screen-13M-3" by means of a harness, which ends with a burst connector type RVN1. Disconnection force RVN1 - 1.5 kg.

Ground processing of information recorded in the MOE-29 should be carried out in the event of an accident or preconditions to it by means of IBM-compatible PC or PIP-29, which are connected to the MOE-29 using a cable included in the delivery of MOE-29 at the rate of 1 : 10, but not less than one at the point of operation. The cable is connected to the Mini-USB connector, which is located under the protective cover MHC-29. The main technical characteristics are given below (table 1.7).

Table 1.7

Basic technical characteristics

Name of parameters	Value
Supply voltage	5 V
Consumer power	not more than 1 watt
Recording time before "wrapping"	last 30 minutes flight
Ready time to work	no more than 1 minute
Overall dimensions	not more than 60x105x20 mm
Mass	not more than 0.2 kg

The BK-77M complexing block

The BK-77M (fig 1.10) complexing unit is installed on An-70 aircraft, the power plant of which consists of four engine units with D-27 engines and coaxial SV-27 fans. The BK-77M complexing unit is intended for:

- collection of information from the control bodies of engine installations;
- issuance of discrete signals on the signal board;
- management of preparation for start-up and coordination of work of engine installations on various flight modes;

● management of information interaction with electronic systems of the plane by means of program-controlled multiplex channels of information exchange.

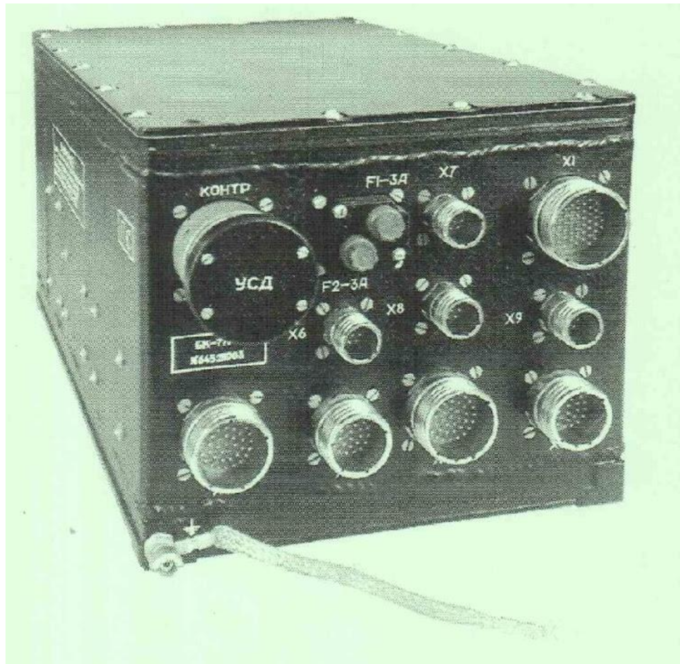


Fig 1.10. BK-77M – complexing block

Audio-video registration system SAVR-27

The SAVR-27 audio-video recording system is installed on the MiG-27 aircraft (fig 1.11), basic technical characteristics system are described in table 1.8. The SAVR-27 audio-video registration system is intended for:

● registration of visible information, which is displayed on the optical sighting head S-17VG from the set of sight ASP-17C and visible to the pilot cockpit space in real time;

● registration of audio information from the SPU about the negotiations of the crew in flight, time stamps and one-time team "BC";

● recording of registered information in the CEC removable storage;

● control of video output signals;

● display on the PC recorded in flight audio-video information, time stamps and one-time commands "BC";

- playback of registered information in AVI format by standard video players;

Fig 1.11. Audio-video registration system SAVR-27

Table 1.8

Basic technical characteristics

Name of parameters	Value
Supply voltage	18-31
Consumer power	35 W.
Removable storage capacity, not less	8 GB
Write information to a removable drive, no more	4 years
Mass, no more	8 kg

IPM-140 wing mechanization position indicator

The IMP-140-C (fig 1.12) indicator is designed to display the left and right flaps, as well as the position of the interceptors of each wing. Indicator IMP-140-C has been certified in the Aviation Register of the Interstate Aviation Committee and received a Certificate of Fitness № SKGI-031-49-IMP-140 dated 25.04.2000. And the main characteristics of the indicator are described in table 1.9.

Table 1.9

Basic technical characteristics

Parameter name	Value
Supply voltage	18-31 B
Brightness adjustment voltage	from 0 to 6.3 V, with a frequency of 400 Hz
Sensor supply voltage	5 ± 0.25
Input voltage from sensors	from 0.25 to (4.55-0.03) B
Display the position of the flaps	from 0º to 40º
Error displaying flap position	not more than ± 2.5º
One-time team	"Body-break"
Number of incoming one-time commands	8
Update information	0.5 s
Viewing angles:	
-horizontally	± 35
-vertically	from + 25º to minus 10º
Ready time to work:	

-from + 55ºC to minus 10ºC	no more than 3 minutes
-from minus 10ºC to minus 55ºC	no more than 5 minutes
Continuous operation time	not less than 8 hours
Mass	not more than 1 kg

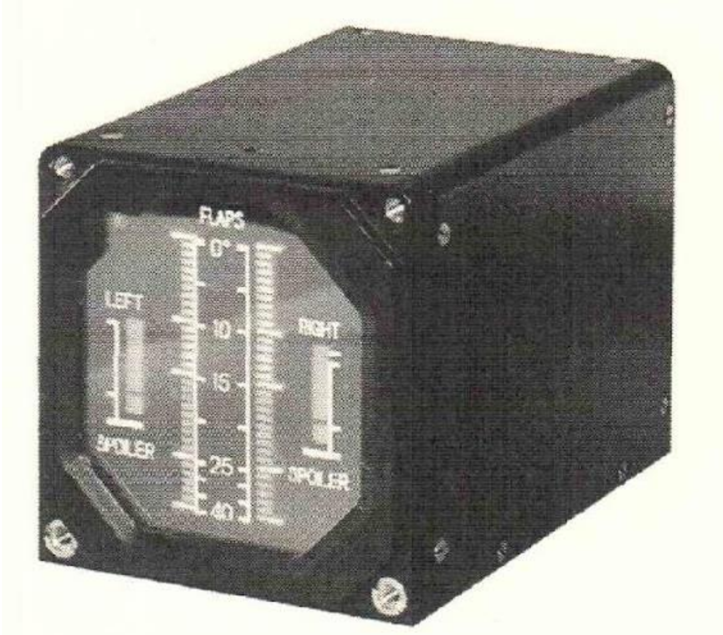


Fig 1.12. Indicator IMP-140-C

The modernized block of border commands of the MiG-29 aircraft with the RD-33 BPK-88 engine ZKM series

The BKK-88 ZKM (fig 1.13) series unit is intended for the automated control and registration on own electronic drive (EN) of parameters of the RD-33 engine and a box of KSA-2 aircraft units of the MiG-29 aircraft with issue of commands in engine control system, and also in TESTER and SCREEN systems, in the table. 1.10 describes the technical characteristics of BOD-88 series ZKM .

Table 1.10

Basic technical characteristics

Features	BOD-88 series ZKM
Supply voltage	109-121 V (400 ± 5%) Hz
	24-30 V
Number of information channels for reception:	
-signals of analog sensors	19
-32-bit words of the serial code according to DSTU 18977-79 and RTM 1495-75	2
The amount of information processed in the form:	
-one-time commands	45
-32-bit words of the serial code according to DSTU 18977-79 and RTM 1495-75	80
The number of information channels for the transmission of 32-bit words of the serial code in accordance with DSTU 18977-79 and RTM 1495-75	1
Number of commands issued	33
Duration of registration of parameters on EN	not less than 75 hours
Operating conditions:	
The value of temperature, ºC:	
-working increased	+ 60
-working reduced	minus 60
Consumer power	55 W.
Block mass	not more than 10.3 kg

Fig 1.13. Indicator IMP-140-C

Vibration control system of the D-18T engine of the An-124-100 SKVD 18 aircraft

SKVD-18 (fig 1.14) is intended for:

- control of vibration parameters of four D-18T engines;
- determination and issuance of signal signs of dangerous and increased vibration on each engine;
- monitoring the performance of the product, sensors and communication lines with them;
- continuous display of values of vibration displacement and vibration speed on the indicator BIPV 18-400 on four engines simultaneously.

The composition of the system

- Electronic vibrocontrol unit EBV-18USF1 (2pcs);
- Charge converter two-channel PZ-2k-04 (4pcs);
- KS-3 harness (4pcs);
- Vibration sensor for operating temperature up to 400 ºC (8pcs);
- High-temperature cable for operating temperature up to 400 ºC (4pcs);
- The unit for indicating the vibration parameters of D-18T engines on the An-124 aircraft;
- BIPV-18-400 (1pc).

Table 1.11

Основні технічні характеристики

Parameter name	Value
Supply voltage	18-31 В
Number of analog inputs:	
-for speed sensors	3
-for vibration sensors	4
The number of output channels on ARINC-429-15,16	2
Consumer power	not more than 40 watts
Continuous operation time	not less than 8 hours

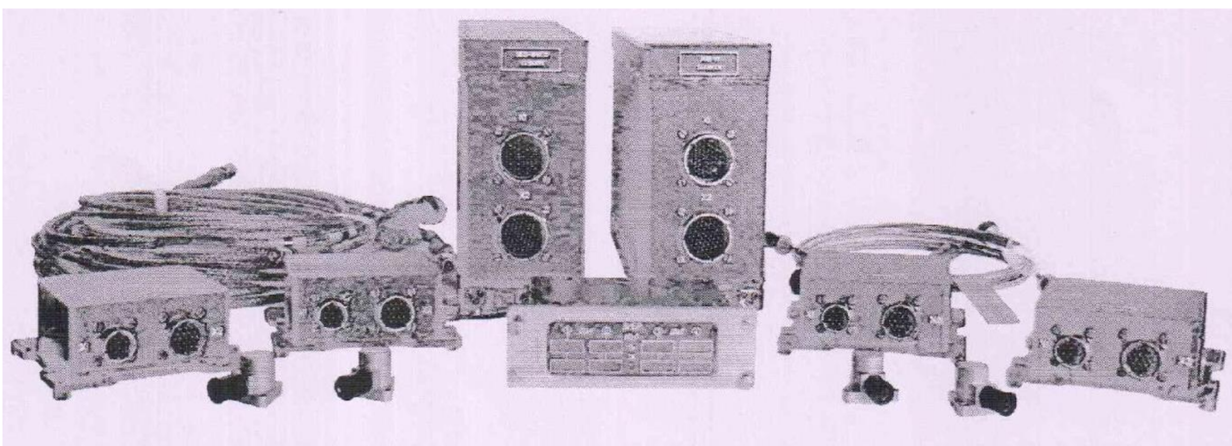


Fig 1.14. Vibration level control system of the D-18T engine of the An-124-100 SKVD 18 aircraft

Switching unit for starting the D-436-148 marching engine of the An-148 BKZ-148 aircraft

The BKZ-148, which is shown in the fig 1.15, unit is designed to switch the start of the D-436-148 propulsion engine, amplify low-current start control unit signals, generate unit control signals, issue signals to aircraft systems and turn on the crew alarm panel. The main characteristics are described in table. 1.12.

Table 1.12

Basic technical characteristics

Parameter name	Value
Supply voltage	18-31 B
Number of input signals:	
One-time team + 27 V	10
One-time command - 27 V (Housing)	15
One-time team + 27 V	37
One-time command - 27 V (Housing)	5
Current consumption (excluding the use of IM remote control)	not more than 2A
The mass of the block	not more than 2.2 kg
Continuous operation time	no more than 20 hours

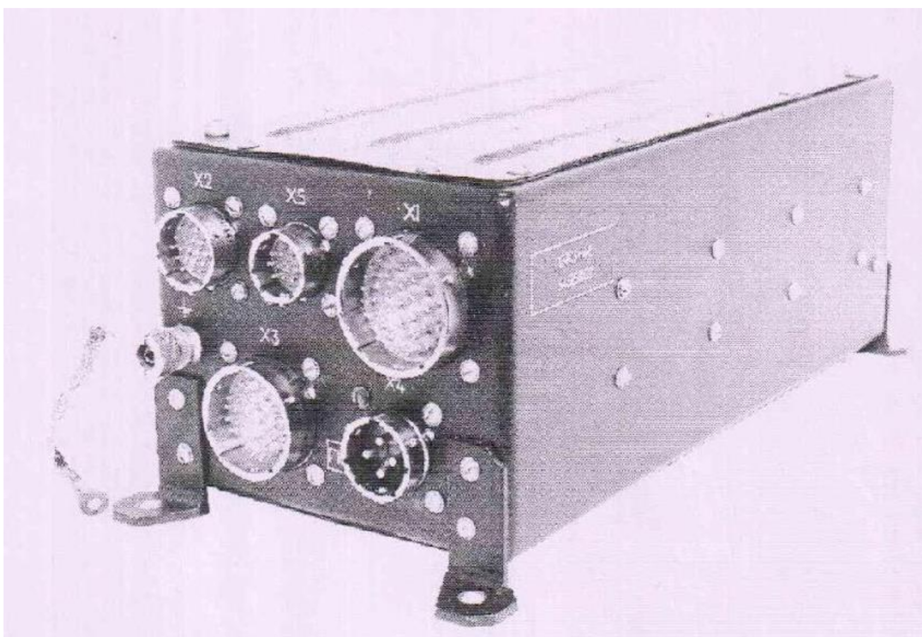


Fig 1.15. BKZ-148 aircraft

Switching and starting unit of the auxiliary gas turbine engine AI-450-MS on the An-148 aircraft, code: "BKZ-MS2"

Purpose of the block – unit is designed for installation on An-148, An-158 aircraft and their modifications, amplifies low-current start control units, generates control units, transmits signals to aircraft systems (control, power supply, parameter registration), and turns on the crew alarm panel.

The BKZ-MS2 (fig 1.16) unit performs the following functions:

- fire hydrant control (PC);
- air intake (software) control;
- control of the SSU heating damper;
- fuel pump (PN) control;
- management of restructuring and maintenance of the aircraft power system (EPS) in the mode of launching the SSU;
- amplification of starter control signals;
- amplification of control signals of the ignition unit;
- signal transmission to aircraft systems;
- inclusion of the alarm system of the board on the DSU start panel;
- power supply of control bodies and units of SSU.

Fig 1.16. The BKZ-MS2

Torque indicator and fuel lever of the IKMRT-140 engine

LED indicator type IKMRT-140-C (IKMRT-140-F-C), show on fig 1.17, is designed to display information about the value of the torque of the turbine shaft on the digitized scale and information about the position of the fuel supply lever on the 3-digit digital indicator.

Fig 1.17. LED indicator type IKMRT-140-C

Indicator IKMRT-140C was certified in the Aviation Register of the Interstate Aviation Committee and received a Certificate of Fitness № SGKI-77-42-IKMRT-140 dated 30.03.2000. Below are the technical characteristics of the indicator (table 1.13).

Table 1.13

Basic technical characteristics

Parameter name	Value
Supply voltage	18-31 B
Brightness adjustment voltage	from 0 to 6.3 V, with a frequency of 400 Hz
The number of input channels of the 32-bit serial code according to DSTU 18977-79 and RTM 1495-75	2
Torque (μr)	From 0 to 100%
Display error: -on the digital indicator -on a digitized scale	 not more than ± 1% not more than ± 2%
Position of the engine fuel lever (RUD)	from 0 to 100%

Display error: -on the digital indicator	 not more than ± 1%
Update information	0.5 s
Viewing angles: -horizontally -vertically	 ± 50º from + 30º to minus 10º
Ready time to work: -from + 55ºC to minus 10ºC -from minus 10ºC to minus 55ºC	 no more than 20 seconds no more than 3 minutes
Continuous operation time	not less than 8 hours
Mass	not more than 0.8 kg

Indicator of temperature of exhaust gases of the engine like ITZh-1

The LED indicator ITZh-1-C, show on fig 1.18, (ITZh-1-FC, ITZh-1A-C, ITZh-1A-FC) is intended for display of information on values of temperature of exhaust gases of the engine on the digitized scale and the 3-digit digital indicator, and also formation and issuance of signals on the board SAS-Tg BEFORE reaching the temperature limit.

Fig 1.18. LED indicator ITZh-1-C

The indicator of type ITZh-1-C has passed certification in the Aviation register of the Interstate Aviation Committee and has received the Certificate of suitability № SGKI-77-41-ITZh-1 from 30.03.2000. Below are the technical characteristics of the indicator (table 1.14).

Table 1.14

Basic technical characteristics ITZh-1-C

Parameter name	Value
Supply voltage	18-31 B
Brightness adjustment voltage	from 0 to 6.3 V, with a frequency of 400 Hz
Input voltage	from 0 to 6.0 V
The temperature that is displayed	from 0ºC to 1000ºC
Display error: -on the digital indicator -on a digitized scale	 not more than ± 1.5% not more than ± 1 segment
Update information	0.5 s
Viewing angles: -horizontally -vertically	 ± 50º from + 30º to minus 10º
Ready time to work: -from + 55ºC to minus 10ºC -from minus 10ºC to minus 55ºC	 no more than 20 seconds no more than 3 minutes
Continuous operation time	not less than 8 hours
Mass	not more than 0.8 kg

Engine speed indicator type IChZh-1

LED indicator IChZh-1TK-S, see fig 1.19 (IChZh-1TK-F-C, IChZh-1-VV-S, IChZh-1-VV-F-C, IChZh-1ST-S, IChZh-1 ST-F-C, IChZh-1A-C, IChZh-1A-F-C) is designed to display information about the value of the engine shaft speed on a digitized scale and 3-digit digital indicator, as well as the formation and output of signals on the board SAS-PRED PARAMETER when reaching the frequency limit.

Fig 1.19. LED indicator IChZh-1TK-S

The indicator of type IChZh-1C has passed certification in the Aviation register of the Interstate Aviation Committee and has received the Certificate of suitability № SGKI-77-41-IChZh-1 from 30.03.2000. Technical characteristics of the indicator are given below in table 1.15.

Table 1.15

The main technical characteristics of ICH-1TK-S

Parameter name	Value
Supply voltage	18-31 B
Brightness adjustment voltage	from 0 to 6.3 V, with a frequency of 400 Hz
Input voltage from the sensor	from 0.5 to 15 V.
Displayed frequency: -on the digital indicator -on a digitized scale	 from 0 to 110% from 20 to 110%
Display error: -on the digitized indicator -on a digitized scale	 not more than ± 0.5% not more than ± 2%

Update information	0.5 s
BEFORE PARAMETER for: ICZH-1 ST-S, ICZH-1 VV-S ICZH-1 TK-S ICZH-1 AS	 - 101% - 106% - 108%
Viewing angles: -horizontally -vertically	 ± 50º from + 30º to minus 10º
Ready time to work: -from + 55ºC to minus 10ºC -from minus 10ºC to minus 55ºC	 no more than 20 seconds no more than 3 minutes
Continuous operation time	not less than 8 hours
Mass	not more than 0.8 kg

The control and monitoring unit of the propulsion engine installations of the An-148 BUK-148 aircraft

The BUK-148 unit is designed to control and monitor the D-436-148 propulsion engines of the An-148 aircraft, as well as to ensure interaction according to the serial code DSTU 18977-79 and RTM 1496-75 changes. 3 with digital units and systems that ensure engine performance, exact technical characteristics are given in table 1.16.

Table 1.16

Basic technical characteristics

Parameter name	Value
Supply voltage	18-31 V
Number of input signals "Single command + 27 V"	16
Number of input signals "Single command - housing"	1
Number of output signals "Single command + 27 V"	5

The number of channels of serial 32-bit code according to DSTU 18977-79 and RTM 1496-75 with changes. 3: -receiving information -issuance of information	 21 6
Consumer power	not more than 45 watts
Continuous operation time	not less than 20 hours
The mass of the block	not more than 8.1 kg
Overall dimensions	319x191x194 мм

The block of switching and management of reverse of draft of the D-436-148 engine of the An-148 BKR-436 plane

The BKR-436 (fig 1.20) block is intended for management and control of system of reverse of draft of the D-436-148 engine of the An-148 plane. Interactions with digital blocks ESU-436 and BUK-148 according to DSTU 18977-79 and RTM 1495-75 on changes. 3 Technical characteristics are given in table. 1.17.

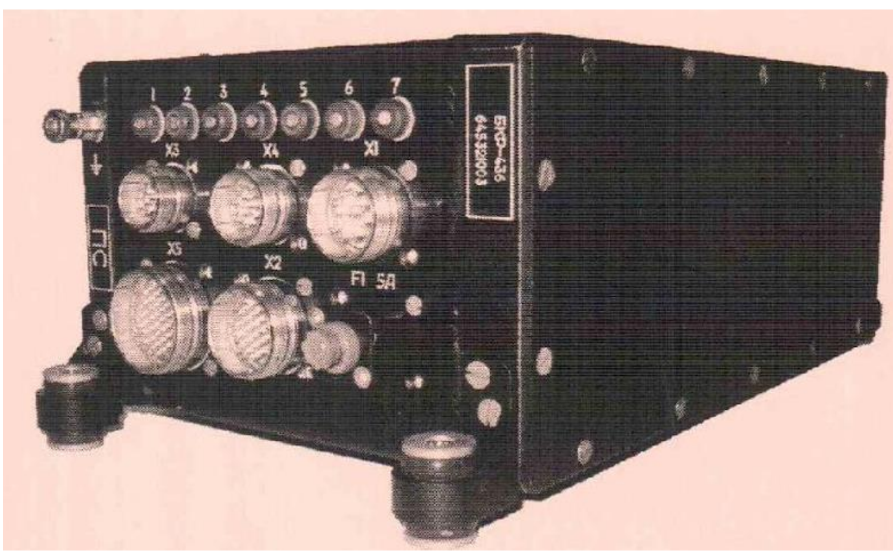


Fig 1.20 The block of switching and management of reverse of draft

Table 1.17

Basic technical characteristics BKR-436

Parameter name	Value
Supply voltage	18-31 B
Number of input signals "Single command + 27 V"	11
Number of input signals "Single command - housing"	2
Number of output signals "Single command + 27 V"	5
Number of output signals "Single command - housing"	5
The number of channels of serial 32-bit code according to DSTU 18977-79 and RTM 1496-75 with changes. 3: -receiving information -issuance of information	 2 2
Current consumption	not more than 2 A
Continuous operation time	not less than 20 hours
The mass of the block	not more than 5.5 kg
Overall dimensions	319x124x160 мм

The block of system of control and vibration of the D436-148 engine of the An-148 plane BSKV-436

The BKSV-436 (fig 1.21) block is intended for providing control and diagnostics of a vibrostand of the D-436-148 engine of the An-148 plane. The main functions performed:

- collection of analog parameters and one-time (binary) signals from sensors and alarms of the engine and their conversion into digital form; interconnection with digital units of the aircraft according to DSTU 18977-79 with RTM 1495 changes. 3;
- control and diagnostics of the engine according to engineering algorithms; storage of engine characteristics (control values of rotor run-out time, data on engine life and other variables and adjustable values);
- control of the vibration state of the engine simultaneously from two vibration sensors.

Fig 1.21 BKSV-436

Table 1.18

The main technical characteristics of BKSV-436

Parameter name	Value
Supply voltage	18-31 B
Number of input discrete commands (housing / break and 27V / break)	16
Number of output discrete commands	
Input analog channels for measuring signals from: -pressure sensors -thermoresistive sensors -rotary speed sensors -chip detectors -vibration sensors	 6 3 3 4 2
The number of channels of serial 32-bit code according to DSTU 18977-79 and RTM1496-75 with changes.3: -receiving information -issuance of information	 4 1
Current consumption	not more than 0.5 A
The mass of the block	not more than 4 kg

Overall dimensions, mm	1K
Continuous operation time	not less than 15 hours

Fuel measuring system for the An-158 TIS-158 aircraft

The TIS-158 (fig 1.22), the main technical characteristics on table 1.19 fuel gauge system is intended for regular placement on the An-158 aircraft and the solution of the following tasks:

- measuring the amount of fuel in each tank in flight and on the ground;
- calculation of the total amount of fuel in the tanks of the aircraft in flight and on the ground;
- generating a signal about the reserve fuel balance on the aircraft through the fuel metering channels;
- formation of a signal about the beginning of fuel production from the consumption compartment;
- formation and issuance of a signal of fuel imbalance;
- control of fuel taps of gas station and drain of fuel from the panel of PKU and PKUZ;
- indication of the amount of fuel for each engine on the TCU;
- formation and issuance of control signals for pumps and taps;
- ensuring system control and issuing warning signals;
- reception and issuance of information on airplane systems.

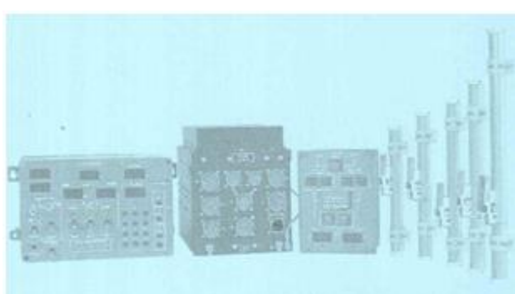


Fig 1.22. Fuel measuring system TIS-158

System composition:

- The fuel gauge unit is measuring and computing BTI-158 (1 pcs);
- Fuel gauge sensor DT (18 pcs);
- The sensor – fuel gauge with the compensator DTK (7 pcs);
- The sensor – fuel gauge with the alarm system DTS (5 pcs);
- Sensor-alarm DS (2 pcs);
- Free water sensor DSV (6 pcs);
- Control and management panel PKU-158 (1 pcs);
- Control panel and gas station control PKUZ-158 (1 pcs).

Table 1.19

Basic technical characteristics

Parameter name	Value
Supply voltage, V	+27
Consumer power, W, no more - when refueling / in flight	40/30
Measured fuel mass, kg	0 - 8900
The error in measuring the amount of fuel is total and in each tank, %	± 2
Error measuring the amount of fuel in flight, %	± 2.5
Fuel temperature measurement, ºC	-50 - +60
Time of continuous operation of the system, hours, not less	15
Time of readiness of system for work, with, no more	30
System weight, kg, no more	29.5

Control and monitoring unit of the auxiliary gas turbine engine AI-450-MS, code "BUK-MS2"

The unit is designed for installation on the An-148, An-158 aircraft and their modifications, for control and monitoring of the auxiliary gas turbine engine – AI-450 MS (VGTD).

The composition of the control and monitoring unit of the auxiliary gas turbine engine (fig 1.23):

- filtration devices (UV);
- power supply devices (UP-MS2);
- central computing devices (UCV-MS2);
- control devices of the dosing pump (UU-ND);
- information collection and processing devices (USO MC2);
- gas temperature amplifier (UTg-2);
- switching devices (UK-MS2);
- devices of automatic protection of a free turbine (AZST-MS2);
- information storage devices.

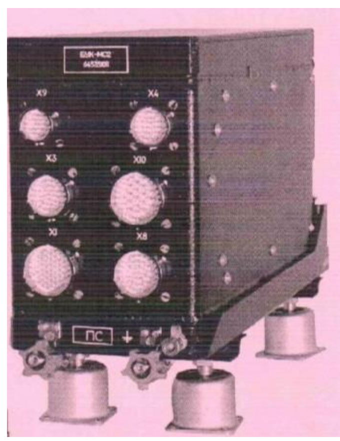


Fig 1.23. Auxiliary gas turbine engine control and monitoring unit

BUK-MS2 performs the following functions of management and control of VGTD AI-450-MS:

- control of readiness for launch, CP, LP and conservation;
- formation of management teams to ensure the launch, CP, drugs and conservation;
- manual and automatic stop of execution of cyclograms of start, HP, LZ and preservation;
- regular and automatic stop;
- control of fuel supply at the height, transient and stat. modes;
- measurement of engine operation parameters;

- control of executive mechanisms, KPV, ZOV, VNA, the service compressor and information boards;
- automatic protection of the power turbine;
- accumulation and counters of starts and time of work of VGTD on an operating mode;
- control of the state of SSU;
- formation of signs of failures of fuel consumption control channels and service compressor;
- control of efficiency of devices of the block, sensors and communication lines;
- issuance of data to aircraft systems on the serial communication channel in accordance with the requirements of DSTU-18977-79 and RTM-1495-75 with changes.3;
- implementation of algorithms of starts, work and stop of VGTD AI-450-MS is carried out through the block of switching and control of start of BKZ-MS2.

BUK-500-14. The control and monitoring unit of the turbocharged gas turbine engine MS-14 and its modifications

BUK-500-14 (fig 1.24) The unit provides the following engine control functions:

- reception and processing of signals from sensors and signaling devices of the engine;
- formation of the cyclogram of start, cold scrolling, preservation and wrong start of the engine;
- control of fuel consumption in the combustion chamber of the engine at start, reception, reset and in the steady-state modes;
- limiting the limit parameters of the engine;
- control of engine geometry (compressor guides and air bypass valves);
- protection of the engine from promotion of the power turbine at destruction of its kinematic communication with a reducer;
- engine surge protection;
- automatic restoration of the operating mode at spontaneous extinguishing of the combustion chamber;

- engine stop (emergency or regular) control of the electric stopcock;
- formation of the team REFUSAL YUK-MS14, for the transition to a backup hydromechanical control system.

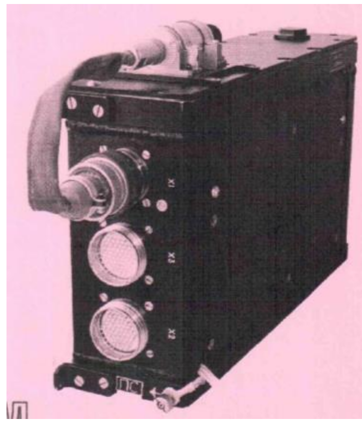


Fig 1.24. The control and monitoring unit of the turbocharged gas turbine engine

The unit performs the following functions to control the engine:

- control of serviceability of sensors and signaling devices of engine parameters;
- control of serviceability of executive mechanisms;
- control of integrity of circles of communication lines with sensors;
- control of the vibrostate of the engine during work at the established modes;
- formation and transfer to the system of registration and indication of the object of information about the parameters and condition of the engine and its units;
- formation and storage of information about the engine operating time in physical clocks and cycles and resource development;
- identification of engine operating modes;
- control of serviceability of internal devices of the block;
- receiving and transmitting information to the control and verification equipment (KPA) to display control parameters, control control laws and simulate commands and signals.

BUK-500 (BUK-500-1) The control and monitoring unit of the MS-500V gas turbine engine and its modifications. Universal FADEC for control of gas turbine engine with a capacity of 500… 3000 hp

The characteristics of the unit BUK-500 are listed in table 1.20. The control and monitoring unit of the MS-500V gas turbine engine is designed for:

- control of executive mechanisms of the MS-500 engine for ensuring start, cold scrolling, preservation, wrong start;
- regulation of fuel consumption in all modes of operation of the engine to maintain optimal operating parameters at all stages of flight, with the transfer of control in case of failure of the unit – the hydromechanical part;
- synchronization of engine operation with the current mode of operation of the neighboring engine of the object;
- engine vibration control;
- protection against exceeding the limit parameters in all operating modes;
- control of serviceability of a communication line with sensors and executive mechanisms, control of efficiency of sensors and IM;
- issuance of information to interacting systems (secure on-board drive, system for indicating the parameters of the object, etc.) through information exchange channels.

Table 1.20

Characteristics of the BUK-500 unit collection system

Pressure sensors	5 inputs of the APT type transmitter (Kulite)
Thermoresistive channels	3 inputs from sensors like P-98AM, P117M
Speed sensors	8 inputs from sensors like DTA-15, DCHV-4
Chip alarms	2 inputs from sensors like TSS-450
Position sensors	2 inputs from sensors like DBSKT-650
	2 inputs from sensors like DLDT-615

Vibration sensors	2 inputs from sensors type CA281, CA139, pre-amplified through the module PZ-2K
Incoming discrete commands	38 inputs type Housing / Break or 27V / Break, provided 1 input = 50 mA, for each input
Output discrete commands	up to 12 outputs, I_{RAB} not more than 1A
Output analog commands	2 outputs for PS-7-2 with $I_{RAB} = \pm 35$ mA
	2 outputs for stepper motor control
Block volume	not more than the standard size of 1,5K (according to DSTU 26765.16-87)
Mass	not more than 6 kg
The block resource is assigned	For serial samples - not less than 30,000 hours
	For researchers - not less than 10,000 hours
Pressure sensors	5 inputs of the APT type transmitter (Kulite)

The indicator of parameters of work of auxiliary power unit of SP VSU-148

The indicator of AP VSU-148 (fig 1.25) is intended for measurement of continuous display of temperature of exhaust gases of temperature of oil of the engine of VSU of the An-148 plane on two 3-digit digital indicators. Interactive system - block BUK-MS2. The main technical characteristics are described in table 1.21.

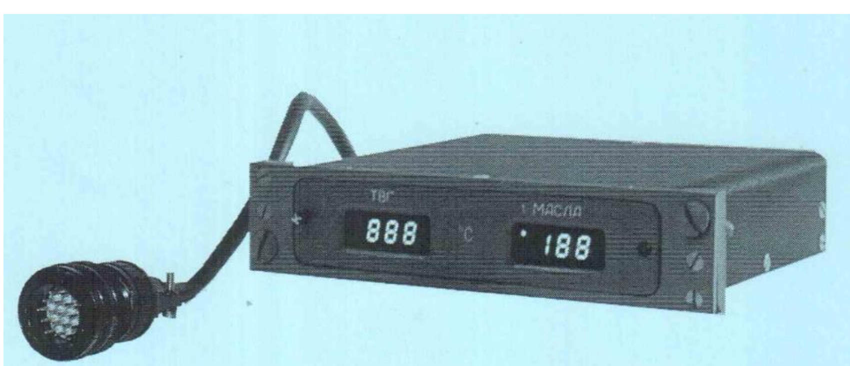


Fig 1.25. Indicator SP APU-148

Table 1.21

Basic technical characteristics

The name of the parameter	Value
Input signal: serial digital code in accordance with DSTU 18977-79 and RTM 1495-75 as amended. 3	
-number of inputs	1
Display range:	
-the temperature of the exhaust gases	from 0 to 999 ° C
-ink temperature	from - 50 to +199 ° C
Display error	not more than 1 ° C
Update information	0.5 s
Continuous operation time	not less than 5 hours
Supply voltage	18-33 B
Power consumption	not more than 25 watts
Mass	not more than 0.4 kg
Overall dimensions	146x130x32 mm

BCD-1 Data storage unit code: "BCD-1"

Modifications of the unit are intended for installation on various types of engines: BCD-1-MS-500V engine; BHD-1-14-MS-14 engine; BCD-2-18-D-18 series 3 engine; BHD-2-136 - D-136 engine; BCD-2-450-AI-450-C engine. The unit itself (fig 1.26) is designed to perform the following functions:

- reception and storage of information received on one or more channels of sequential exchange, in accordance with the requirements of DSTU 18977-79 and RTM 1495-75 (as amended № 3);
- - storage in the internal memory of individual engine settings and controller coefficients.

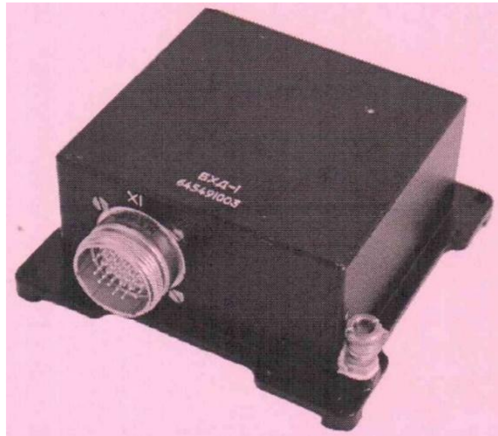


Fig 1.26. BCD-1 Data storage unit

The block provides the account and preservation of operational characteristics of the engine in counters of operating time on modes, in counters of trends, in counters of events.

- Number of operating meters in modes - 16;
- Capacity of counters - seconds, from 0 to 232;
- Account error 1 s at each inclusion / exclusion of counters;

Hours - incremental, ie when the engine goes to a given mode, the calculation of time starts from the stored value for each meter.

- Number of trend counters - 16;
- Capacity of counters - seconds, from 0 to 232;
- Account error 1 s at each inclusion and exclusion of counters;

Rose counters start counting the engine run time in a given mode with "O", storing in memory the final value. No more than the last 10 final values should be stored in memory.

- Number of event counters - 16;
- Capacity of counters - the maximum saved value, not less than 65000;
- Error of account 1 at each inclusion and exclusion of counters;

Event counters increase their value by "1" when specified events occur. The counters are switched on / off when the state of the information bits in the yag stream received from the control and monitoring unit changes from lot. "0" per lot. "1".

- The unit stores the individual motor settings and the coefficients of the controller and issue them to the control and monitoring unit of the motor at its request.
- Number of saved parameters - not less than 1000;
- The bit size of each parameter is not more than 16-bit.

The indicator of parameters of work of the IPSU-148 power plant

The IPSU-148 indicator is intended for continuous measurement and indication of values of parameters of work of power plant - speed of rotation of a rotor of the fan, frequency of rotation of a rotor of the high pressure compressor, temperature of exhaust gases behind the turbine of low pressure and the alarm system -148 on six 3-digit digital indicators. The main technical parameters are given in table 1.22.

Table 1.22

The main technical characteristics of the IPSU-148 indicator

The name of the parameter	Value
Input analog signals:	
Fan rotor speed	
-number of signals	2
-frequency	from 0 to 9 kHz
-High-voltage	from 0.15 to 10 V.
Frequency of rotation of a rotor of a high pressure compressor:	
-number of signals	2
-frequency	from 0 to 18 kHz

-High-voltage	from 0.15 to 10 V.
The temperature of the exhaust gases behind the low pressure turbine:	
-number of signals	2
-High-voltage	from 0 to 4.95 V
Display range:	
-fan rotor speed	from 0 to 120%
-the speed of rotation of the rotor of the high pressure compressor	from 0 to 120%
-tempo. exhaust gases behind a low pressure turbine	from 0 to 999 C
Display error:	
-fan rotor speed	not more than 0.6%
-the speed of rotation of the rotor of the high pressure compressor	not more than 0.6%
-tempo. exhaust gases behind a low pressure turbine	not more than 10 C
Update information	0.5s
Continuous operation time	not less than 20 hours
Supply voltage	18-33 B
Power consumption	not more than 25 watts

Mass	not more than 1.0 kg
Overall dimensions	205.5 x146x64 mm

1.2. Onboard recorders of Western production and prospects for their development

Until the 1930s, tests of aircraft were limited to observations of visual instruments. Recording of instrument readings in flight requires certain skills from the pilot, and the use of a special observer on single cars is impossible. With this method of recording the readings of the devices there is no one of the mandatory conditions of properly conducted tests – objectivity. In laboratory conditions, the errors of the observer depend on his attentiveness, experience, etc., individual qualities.

Therefore, when conducting flight tests in research organizations are beginning to be widely used various kinds of special devices that must objectively record the readings of the entire dashboard. For these purposes, compact film equipment was used, which photographed the dashboard on photographic film. This method is used quite often today. At the same time, eliminating the errors of the observer, experts faced shortcomings that are associated with strong vibration of the arrows of the devices, which led to large scatter readings, the number of films and accuracy of measurements, which was limited by the accuracy of visual instruments. And for a number of tests such accuracy became insufficient.

In flight tests of aircraft have been used special equipment, recorders. These devices, recorders using mechanical principle of recording device in Germany called mikrozapisyu. Mikrozapis published if scratched with a diamond rotating glass drum. In the US, as the storage medium used smoked glass. In some other countries widely used steel post pin on celluloid film. France used optical recording.

It was found that the recording of flight data provides valuable information not only during flight tests, but also for the investigation of AP. Therefore, the issue of installing on-board recorders on aircraft not only for testing but also for mass operation was brought up for discussion by ICAO. Specialists investigating the AP, at the second session of ICAO, held in February 1947, came to an agreement on the feasibility of developing and using on-board recording devices (BUR).

The first country to prepare materials and develop requirements for the mandatory installation of BUR on aircraft is the United States. In September 1957, the United States passed a decree stipulating the mandatory installation of BUR on aircraft with gas turbine engines with a maximum takeoff weight of more than 5700 kg, and on all aircraft with reciprocating engines of the same weight, but operated at altitudes of more than 7625 m.

Installed on aircraft BUR must record throughout the flight the following parameters:

- time;
- height;
- air (instrument) speed;
- vertical acceleration;
- course.

The resolution defined the requirements for the safety of registered information at AP TSO (Technical Standards Order) C-51. In the table 1.23 shows the requirements of TSO C-51.

Таблица 1.23

TSO C-51 requirements

Influencing factor	Requirements
Fire	The flame at a temperature of 1100 ° C, covering 50% of the area of the recorder for 30 minutes
Impact of impact	100 g
Being in sea water	36 hours

Three types of registrars were defined in MSW:

- Type I: Invincible registrar, unlimited location.
- Type II: the inescapable recorder, which can withstand fire for 15 minutes at 50% surface coverage, should not be installed in the wings and near fuel tanks.

- Type III: save the recorder, which can withstand fire for at least 1.5 minutes, unlimited location.

The first recorder, installed on board the aircraft, was with the mechanical principle of recording. Such a recorder is called a recorder.

Recorder – a device for automatic registration in the form of various physical quantities that change over time. The simplest recorder is a measuring device, the moving part of which has a writing instrument (pen, pencil, etc.), which leaves a mark on the moving paper tape.

The most widely used recorders were two companies: Lockheed Aircraft Service Co. and United Data Control. Flight recorder company Lockheed Aircraft Service Co. – LAS Model 109C (fig 1.27) records by scratching the five parameters on a metal foil. Metal foil width of 56.9 mm made of steel or aluminum. Number foil enables register 200 hours.

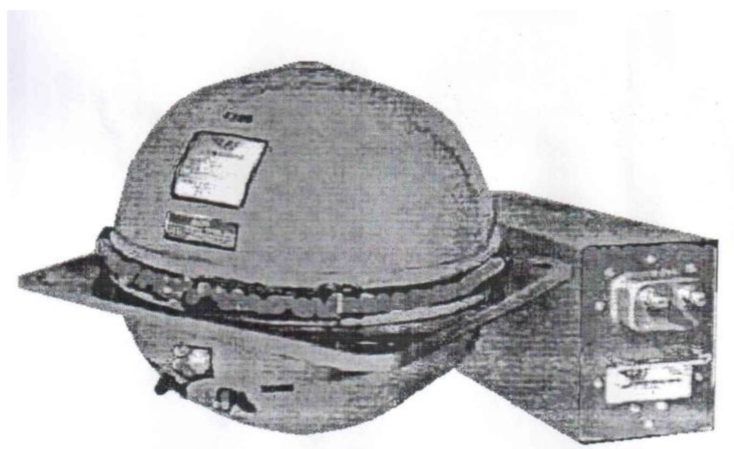


Fig 1.27. Onboard LAS recorder model I09C (left), model 109D (right)

The tape mechanism with the information carrier is enclosed in the case of the spherical form consisting of two sections. The sections are attached to each other with a snap ring. For mounting on board the aircraft there is a mounting flange located in the central part. The LAS recorder model 109D on the operational functions is basically similar to model 109C. The main differences are as follows: the components of the recorder mechanism of the model 109D are enclosed in a rectangular body (fig 1.28), which greatly facilitates its location on the aircraft. A microscope is used to read the information.

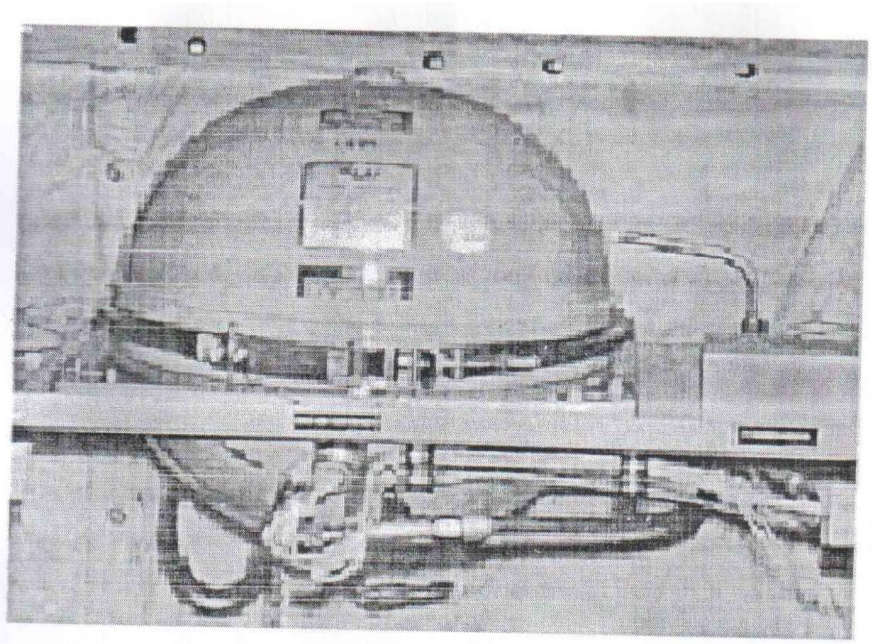


Fig 1.28. Placement of the LAS recorder model I09C on board the aircraft

Onboard recorders firm United Data Control Model F-542 (fig 1.29) provides five registration required parameters. Recorder produces oscillographic record by deleting lines on a metal foil with a high nickel content. Foil strip width is 12.3 cm, capable of withstanding high temperature fire at the AP without thermal protection.

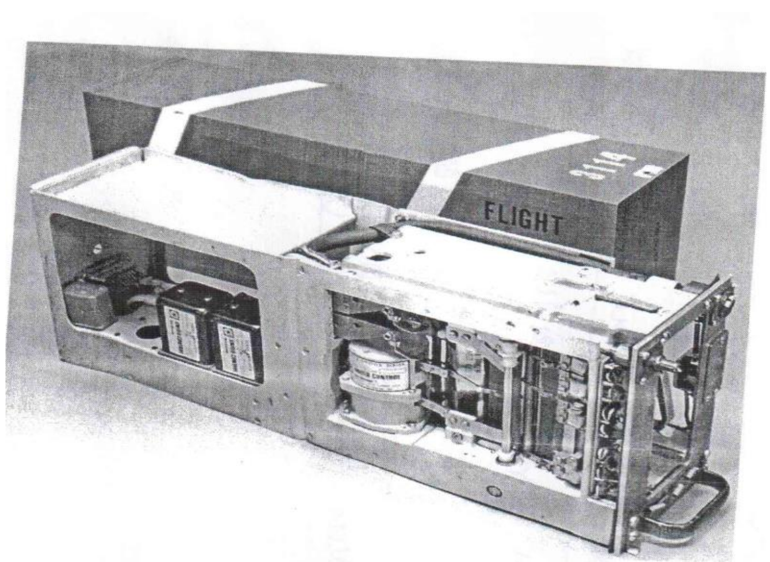


Рис. 1.29. Onboard recorder model F-542

While recorders were used in the United States, magnetic recorders were used in the United Kingdom. Wire was used as a storage medium. Information was recorded by digital method – pulse-width modulation.

In France, recorders with the optical principle of recording were used. The recorder is a light-beam magnetoelectric oscilloscope. The parameters were registered on photographic film or photographic paper.

Instead of mechanical recorders come recorders recording principle of magnetic recording principle. In the late 1960s, there were negotiations recorders in cockpit CVR (Cockpit Voice Recorder) and the beginning of the 1970s were developed parametric recorders DFDR (Digital Flight Data Recorder). Data recording made on magnetic tape. The registrar of the most widely used magnetic tape based on mylar (Polyethyleneterephthalates), kapton (polyamide film) and metallic. Recording information is a closed endless loop. CVR registers provides a record of the last 30 minutes of talks, a DFDR – 25 hours of flight. The record flight parameters on magnetic tape made consistent digital code, fig 1.30 shows the recorder DFDR.

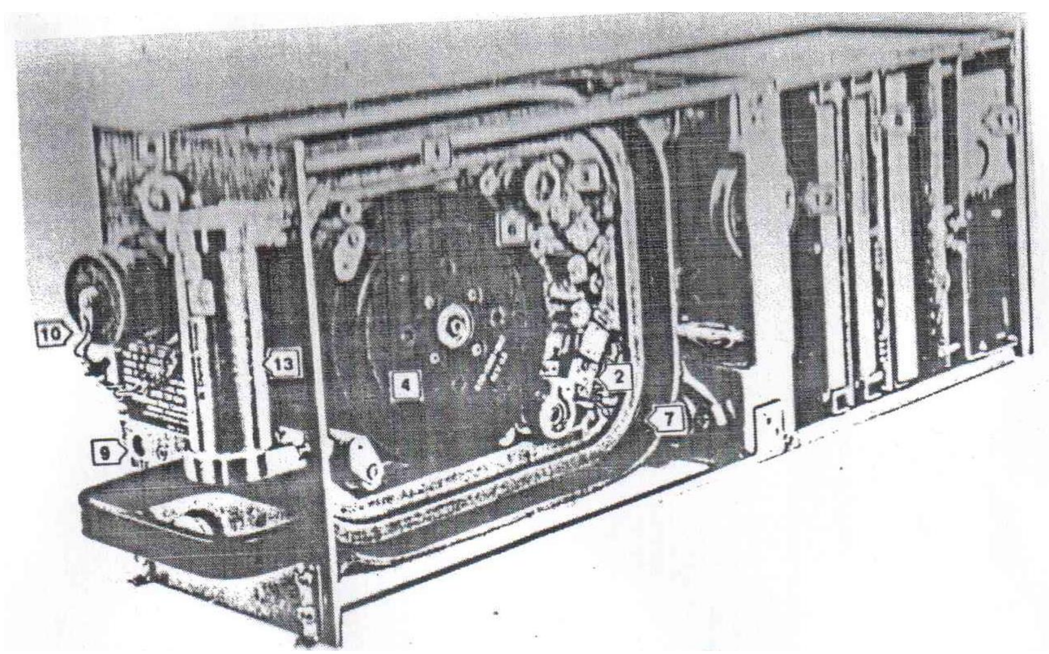


Рис. 1.30. Recorder DFDR

US aviation authority FAA issued guidelines for the use of CVR all AC and TSO C-84, which approved the rules of the factors that must withstand the registrar for the AP. AP investigative experience using parametric recorders showed that the requirements for the storage of information TSO C-51 do not meet on data protection. FAA aviation authorities have issued rule changes that determined Positioning registrar rear fuselage and upgraded standard TSO C-51A.

In the 1980s of the last century, a new type of semiconductor memory devices - flash memory, which has brought significant progress in the development of storms. Began production of the solid state of emergency recorders (integral) data carrier with an electronic recording principle (solid-state CVR and solid-state DFDR). The data recorders compared with the registrars of magnetic recording principle have: increased reliability and speed informative. For solid state registers of data carrier requirements were designed to preserve information TSO-C123a and TSO-C124a. Standard TSO-C123a for SSCVR, a standard TSO-C124 for SSFDR.

In these standards are unfavorable external influences that must withstand protected onboard storage device for storing registered information, fire resistance, temperature 1100 °C for 60 minutes at 100% coverage of the area with a heat output of 14,650 watts of water calorimeter; thermal stability: temperature 260 °C for 10 hours; 3400g shock overload pulse duration of 6.5 ms; penetrating strike a mass of 227 kg with a height of 3 m tip diameter of 6.35 mm; static load of 22.25 kN added for 5 minutes; sea water at a depth of 6,000 meters 30 days; corrosive liquids 48 hours; liquid extinguishing 8 hours. Improving recorders made on several fronts:

- Receiving information not only through its autonomous collection network, but also through the ND data collection network;
- Inclusion of a microprocessor in the system for pre-screening of redundant information (data compression);
- Development of normative portable devices for rapid analysis of data recorded in flight.

After analyzing the development of BUR, a modern classification of foreign registrars according to the principle of recording information was proposed. Taking into account the classification in table. 3 shows the data on the aircraft and the main types of registered information. In world aviation, it was decided to replace traditional tape recorders with solid-state recorders on flash memory chips, which have significant advantages over tape recorders in terms of reliability, speed, cost of storing bits of information, weight and dimensions.

Ways to improve BUR and ways to improve recording methods

Improvement of registrars is carried out in several directions:

- Receiving information not only through its autonomous network of collection, but also through the network of data collection and processing of flight information;
- Replacement of tape magnetic recorders with more perfect solid-state recorders;
- Inclusion of a microprocessor recorder in the system for pre-screening of redundant information (data compression).
- Development of normative portable devices for rapid analysis of data recorded in flight.
- Meanwhile, in addition to the reliability of operation, increasingly important requirements in flight information collection systems are functionality, ease of installation and maintenance, adaptability to specific conditions, compliance with generally accepted standards.

The development of microprocessor technology contributed to the transition to arhytek round of distributed systems, automation and control functions have been increasingly implemented outside the central processor unit-in sensors, actuators and units.

"Intellectual" peripheral board equipment and the emergence of digital interfaces have created the need for new forms of communication – they put on the agenda the creation of a local network on board the aircraft, operating at a lower level of automation and control in processes directly in hardware. Network equipment onboard differ determination behavior pidderzhkoyu features real-time, high reliability data transmission in environments with high levels of electromagnetic interference, the presence protected from exposure to environmental connectors.

Interest in the unification of onboard information networks and the creation of heterogeneous network environments based on products from different manufacturers is very high, and the idea of building a single information infrastructure of the aircraft, which ensures the joint work of software and hardware onboard systems, looks very attractive.

Development of on-board registration facilities abroad in 1960-2010

Таблиця 1.24

Development of on-board registration facilities

Type of PS	Graduation year	Type FDR	Number of parameters	FDR data capacity
Boeing 707	1958	Analog	5	Mechanical parameters200 hours
Boeing 747	1969	Digital (magnetic tape)	24 ... 70	64 words per second (serial code)
Airbus 330	1993	Digital (chips flash memory or magnetic tape) Address and reporting system	280	128 words per second (serial code)
Embraer 170	2004	Digital combined recorder (flash memory chips)	774	256 words per second (serial code)

Airbus 380	2007	Digital combined recorder (flash memory chips)	> 1000	1024 words per second (serial code)
Boeing 787	2007	Digital combined recorder (flash memory chips)	> 1000	Ethernet system

Ethernet is the most popular network technology. With the help of Sun developers seeking to create a single-board communication infrastructure and expand on-board systems such benefits Ethernet, ease of integration as the Internet, the possibility of including a variety of network devices and centralized management. Large market support Ethernet devices and components, mass production of these products ensures their relatively low cost. Unification Ethernet as the single network technology leads to cost reductions, including for training specialists and service systems. Implementation at Ethernet onboard systems allow the system to transmit information collected at the level of the onboard system for collecting flight data for use in various applications.

The introduction of Ethernet BUR are quickly read the recorded information for surface processing. Table 1.24 shows the main characteristics of modern foreign onboard devices of registration. These are emergency BUR registrars and have special protection storage medium from outside influences that occur when the AP.

Table 1.24

The main characteristics of modern foreign on-board registration devices

Developer company	L-3 Communications				
The name of the registrar	FA 2500 APR	FA2100 CVDR	FA2100 SSCVR	FA2100 SSFDR	FA 2200/2300 MADRAS
Recorder type	Compatible	Compatible	Compatible	Compatible	Compatible
Media type	flash memory chips	flash memory chips	flash memory chips	flash memory chips	flash memory chips
Method of registration and reading	MIL-STD-1553B ARINC 429 Ethernet	MIL-STD-1553 ARINC 573/717/747 (data) ARINC 557 and 757 sound ARINC 429	ARINC 557 and 757 ATC data-link, OMS and ARINC 429	MIL-STD-1553 ARINC 573/717	ARINC 747
Recording time: sound-number of channels /	2-4 / 25	2-4 / 25	2-4 / -	- / 25	2-4 / 25

flight parameters (hour)					
Recording speed (ppm)	64/128/256 / 512	64/128/256 / 512		64/128/256/512 / 1024	256/512
Possibility of integration into the control system	So	So	So	So	So
Autonomy of reading information	IS	IS	IS	IS	IS
Information storage standards	ED-55 ED-56a TSO-C123a TSO-C124a	ED-55 ED-112 ED-56a TSO-C123a TSO-C124a	ED-56a, TSO-C123a	ED-55, TSO-C124a	ED-55 ED-56a TSO-C123a TSO-C124a
Supply voltages: AC - AC, DC-DC	DC-27 V	AC-115 V, 400 Hz & DC-27V	AC-115V, 400Hz & DC -27V	AC-115 V, 400 Hz & DC-27V	AC-115V, 400Hz & DC -27V

Table 1.25

The main characteristics of modern foreign on-board registration devices

Developer company	Honeywell			
The name of the registrar	SSFDR 4X 980-4700-04X	SSCVR	AR-Series System	SSDVDR
Recorder type	Parametric	Audio	Compatible	Compatible
Media type	flash memory chips	flash memory chips	flash memory chips	flash memory chips
Method of registration and reading	ARINC 573/717/747	ARINC 429	ARINC 573/717 ARINC 429	ARINC 573/717 ARINC 429 PCMSIA
Recording time: sound-number of channels / flight parameters (hour)	- / 25-50-100	24	0.5-4.2-4 / 25	2-4 / 25
Recording speed for recording (words per second)	256/128/64		64/128/256	64/128/256
Data recording speeds (ppm)	256/128/64		64/128/256	64/128/256
Possibility of integration into the control system	So	So	So	So

Autonomy of reading information	IS	IS	IS	IS
Information storage standards	TSO-C124a	ED-56a TSO-C123a	ED-55 ED-56a TSO-C123a TSO-C124a	ED-55 ED-56a TSO-C123a TSO-C124a
Supply voltages: AC - AC, DC-DC	AC-115V, 400Hz & DC - 27V	AC-115V, 400Hz & DC - 27V	AC-115V, 400Hz & DC - 27V	AC-115 V, 400 Hz & DC-27V

Table 1.26

The main characteristics of modern foreign on-board registration devices

Developer company	CURTISS WRIGHT Controls, Inc.		
The name of the registrar	MPFR	DAFR	EMPFR
Recorder type	Compatible	Compatible	Compatible
Media type	flash memory chips	flash memory chips	flash memory chips
Method of registration and reading	ARINC 573/717 Ethernet	ARINC 757	ARINC 573/717 TCO-C177 Ethernet
Recording time: sound-number of channels / flight parameters (hour)	2-4 / 25	2-4 / 25	2-4 / 25

Recording speed for recording (words per second)	512	1024	512
Data recording speeds (ppm)	64/128/256/5 12 / 1024	64/128/256/5 12 / 1024	64/128/256/512 / 1024/2048
Possibility of integration into the control system	So	So	So
Autonomy of reading information	IS	IS	IS
Information storage standards	ED-112 TSO-C123a TSO-C124a	ED-112 TSO-C123a TSO-C124a	ED-112 TSO-C123a TSO-C124a
Supply voltages: AC - AC, DC-DC	DC - 27 V	DC - 27 V	DC -27B

Table 1.27

The main characteristics of modern foreign on-board registration devices

Developer company	APIBOX	GE-Aviation	Universal Avionics Systems Corporation	
The name of the registrar	APIBOX System	EAFR	SSCVR	CVFDR
Recorder type	Compatible	Compatible	Audio	Compatible
Media type	flash memory chips	flash memory chips	flash memory chips	flash memory chips

Method of registration and reading	ARINC 429/717, Ethernet	ARINC 557 and 757 PBX datalink, OMS and ARINC 429	ARINC 557 and 757	ARINC 757 and 717
Recording time: sound-number of channels / flight parameters (hour)		2-4 / 25	21 -	2/25
Recording speed for recording (words per second)	512	512		512
Data recording speeds (ppm)	64/128/256/51 21 1024/2048	64/128/256/51 21 1024		64/128/256/5 12 / 1024
Possibility of integration into the control system	So	So	So	So
Autonomy of reading information	There is either data transfer via GSM / Sat	IS	IS	IS
Information storage standards	ED-55 ED-56a TSO-C123a TSO-C124a	ED-55 ED-56a TSO-C123a TSO-C124a	ED-56a TSO-C123a	TSO-C123b TSO-C124b TSO-C155 TSO-C177 ED-112

Supply voltages: AC - AC, DC-DC	DC -27B	DC -27B	AC-115V, 400Hz & DC - 27V	AC-115V, 400Hz & DC - 27V

The analysis shows that there is a tendency to combine in one registration drives and parametric audio information. Again or development drives have a wide range of input interfaces (ARINC 429, ARINC 573, ARINC 747, ARINC 717, ATS datalink, OMS, M1L-STU-1553V, PCMCIA, Ethernet) in the future, protected storage is recorded information from a video camera in the cockpit. There is a tendency to increased requirements for the storage of information. On-board device registration processing tends to recorded information in real time with the issuance of warning signals crew. Recording information complies with current ICAO standards. On-board devices registered to secure board storage provides for rewriting information on a portable device processing.

The advantages of BUR with solid state storage devices in comparison with traditional recorders with a magnetic tape are:

- Significant increase in reliability;
- Reduction of weight and overall dimensions of the information storage device (weight will decrease by 25%, and overall dimensions approximately in 3);
- Elimination of the need for periodic maintenance and increase the possibility of self-control;
- Simplification of design and improvement of characteristics of terrestrial devices of processing of the registered information.

The following types of devices are used to read the registered information from the on-board registration devices with a solid-state storage device:

- Pocket portable device;
- PC card (PCMCIA);
- Data transmission via satellite phone of GSM \ SAT standard;
- Ground processing device on a tablet computer;

- Hardware and software complex.

The PI device (Portable Interface) fig 1.31. The device was developed by L-3 Communications and is designed to search and overwrite data from recorders type FA2100. User interface, seven-button auxiliary keyboard and display with eight lines.

Fig 1.31. PI device (Portable Interface)

Features of modern cartography of foreign BUR

The PCMCIA is designed to store multiple flights of aircraft. PC card (fig 1.32) refers to easily removable storage devices.

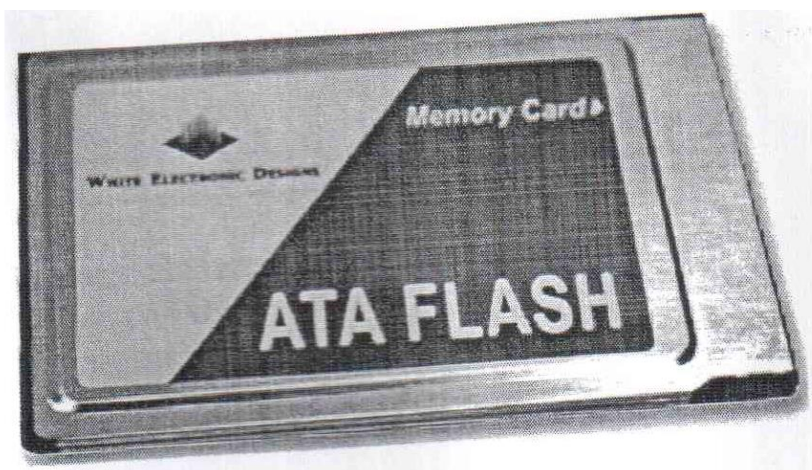


Fig 1.32. PC card (PCMCIA)

The system of monitoring of the registered parameters of BUR is developed on the basis of a satellite communication network of the GSM \ SAT standard. This system is designed to quickly transfer registered information from the aircraft. A tablet computer is a type of laptop that is equipped with a touch screen and allows you to work with a stylus or fingers, both with and without the use of a keyboard and mouse.

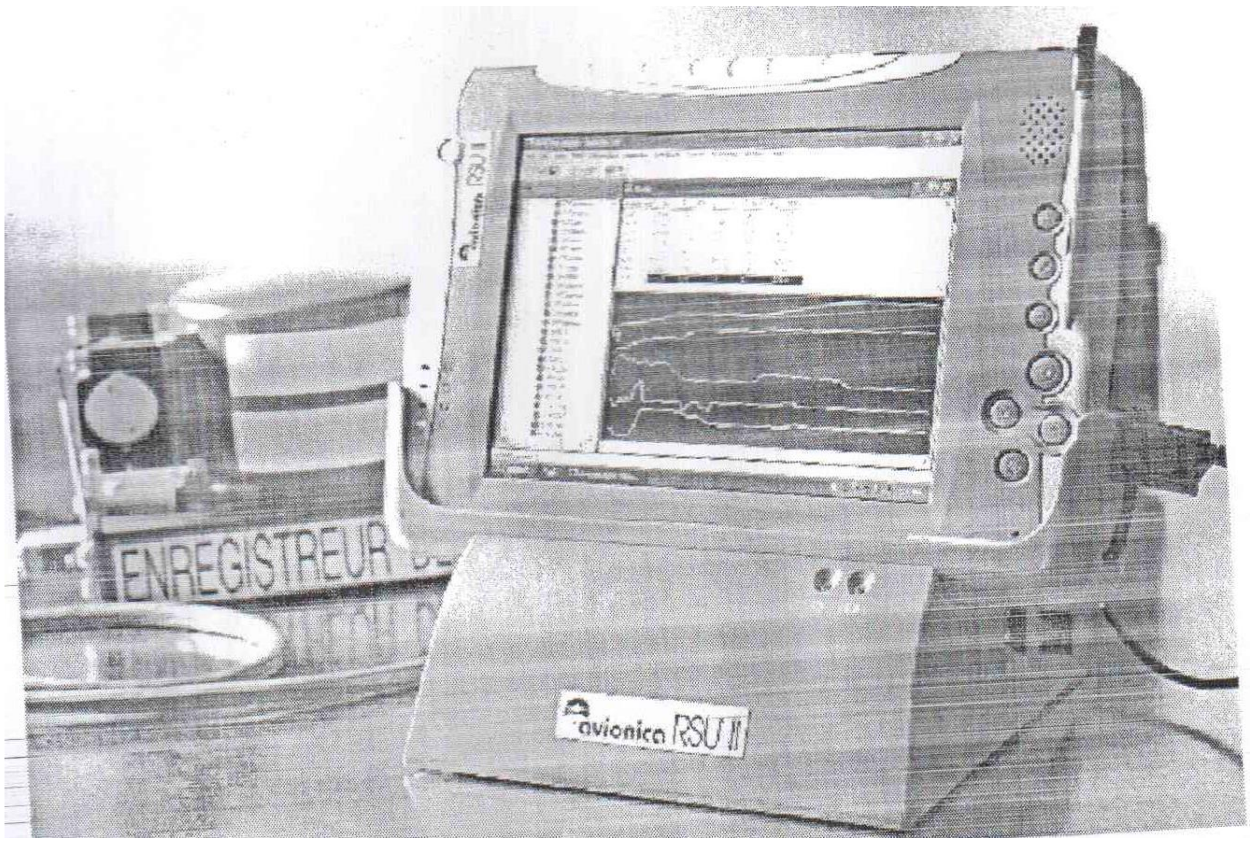


Fig 1.33. Ground processing device RSU II tablet type

The RSU II system is made on a powerful, durable and weather-resistant tablet platform with an 8.5 "color LCD display. The RSU II system is equipped with Ethernet and USB 2.0 ports. The hardware and software complex is a system, which includes hardware and software, jointly used to solve problems related to the processing of flight information, registered by BUR. is an Automated Workstation (AWP) for processing flight information BUR. AWP - for processing includes hardware in the following composition:

● Stationary place of processing on the basis of the personal computer with a set of cables for connection of various BUR that includes full software and methodical maintenance of the workstation. In fig. 10 shows the ROSE / RI workstation for processing L-3 Communications type registrars;

● Mobile workstation for processing flight information on the basis of "Notebooke", designed for pre-processing and analysis of information obtained as a result of the flight of the aircraft.

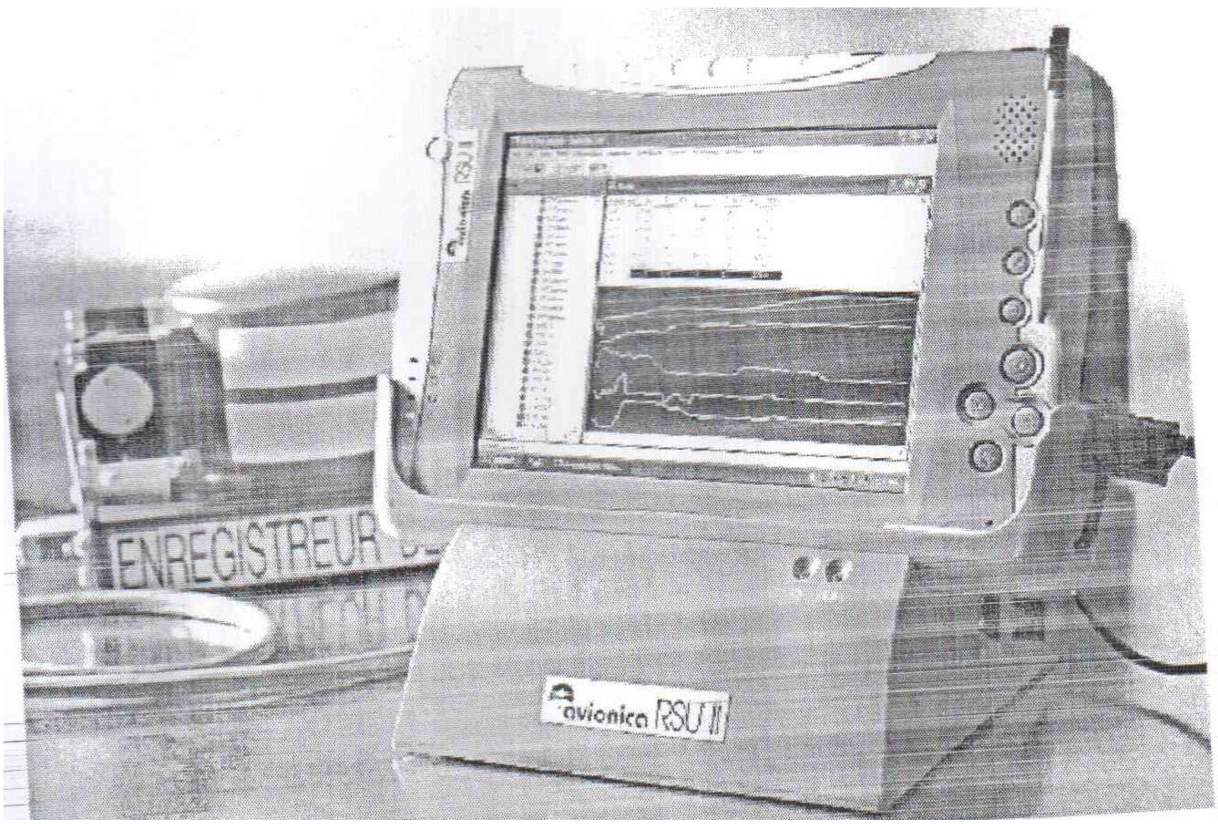


Fig 1.34. Ground processing device RSU II tablet type

The software of the hardware and software complex is a software component that implements various algorithms for solving problems of flight information processing. A characteristic feature of the software is the ability to choose the modes of processing flight information depending on the task.

Flight information analysis programs allow you to view the entire amount of registered information in order to detect abnormal events in flight (express analysis program). Systematic analysis of flight information allows timely detection and prevention of aircraft failures, to detect errors and deviations in the operation of aircraft in flight.

When building a risk management system in civil aviation, great importance is attached to flight information, the analysis of which allows to identify hazard factors and assess them. The processing of registered flight information is aimed at the risk management system to address the following tasks:

- Identification and quantification of existing operational risks;
- Identify and quantify changes in operational risks;
- Formal risk assessment to determine their unacceptability;
- To adjust activities for unacceptable risks;
- Measuring the effectiveness of actions and risk monitoring.

Features of AGC when using BUR

Since 1960, England has been instructed to process flight information to assess the suitability of aircraft for flight. Flight information processing programs solve the following tasks:

- Environmental impact and operational use of the Armed Forces;
- How the aircraft is operated within its characteristics;
- Detection of unusual cases caused by the environment;
- Detection of failures and malfunctions in the work of ND systems.

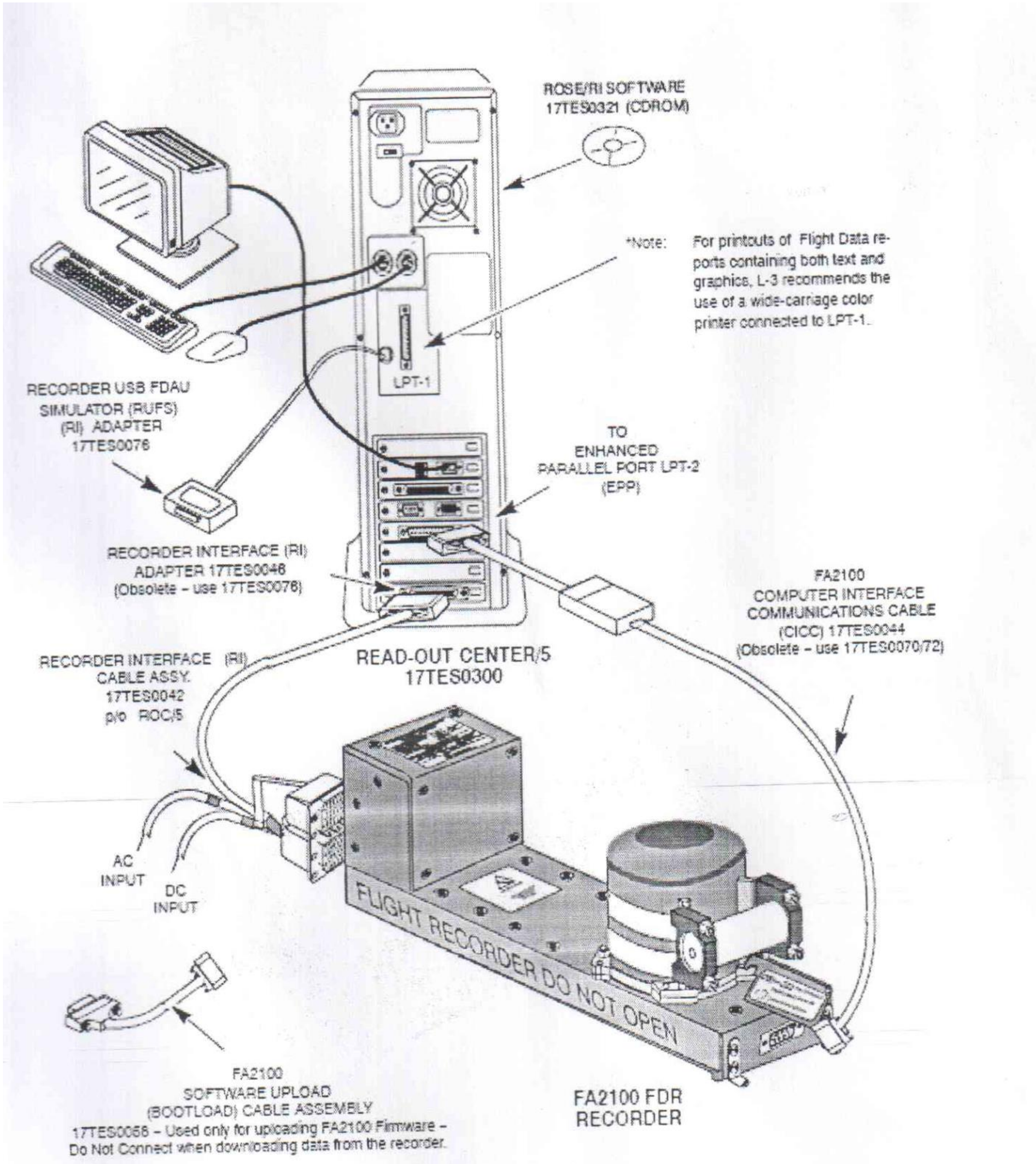


Fig 1.35. ROSE / RI automated workstation

The concept of complex control systems and registration of flight technical parameters of AIDS (Airborne Integrated Data Systems) began to be used to control the efficiency of onboard systems at the ND developed in the 1970s. In fig. 13 shows the AIDS scheme.

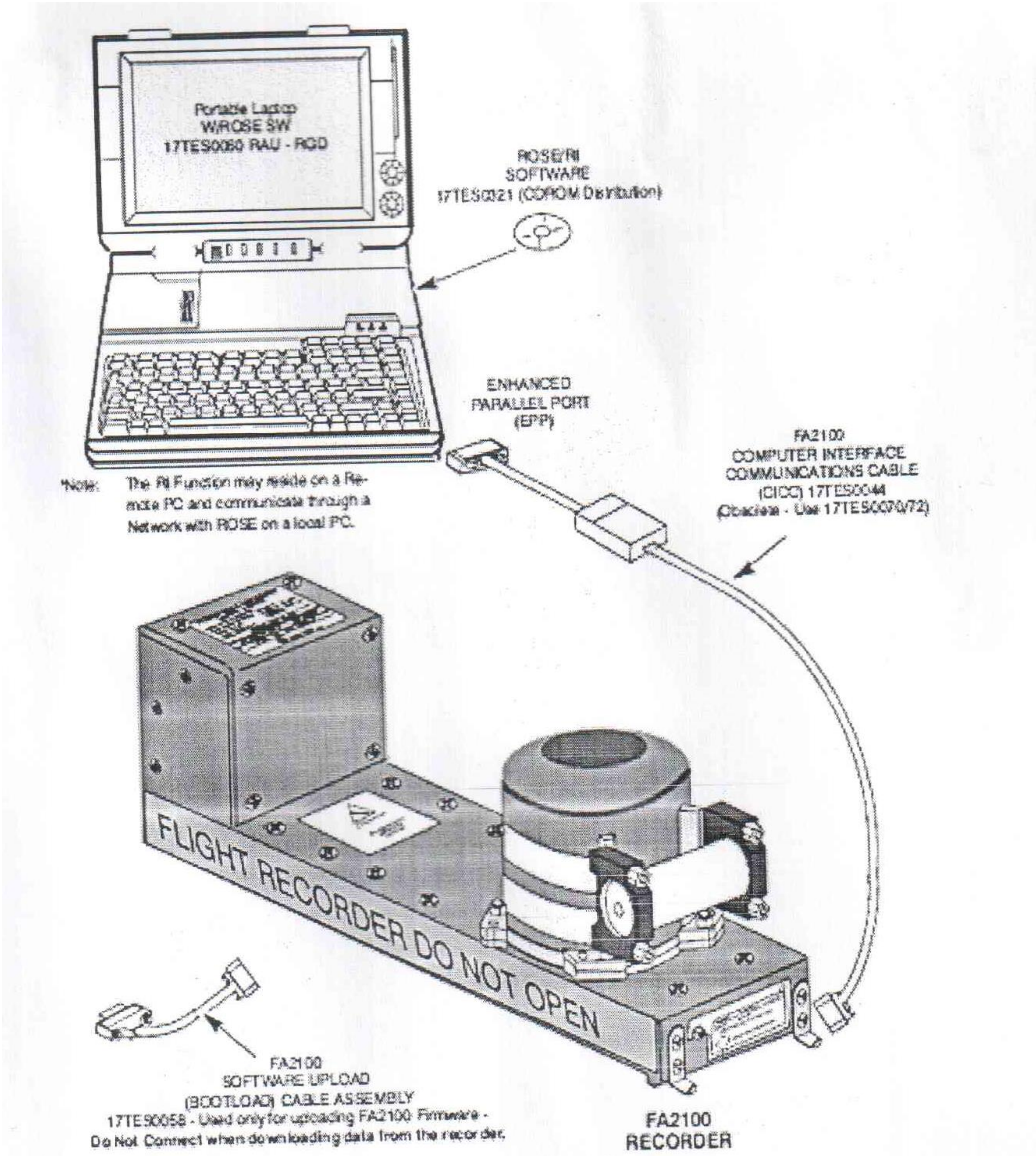


Fig 1.36. Mobile workstation for registrars of the company type L-3 Communications

The list of functions of systems such as AIDS includes, on the one hand, the collection and storage of values of flight parameters in accordance with the requirements of regulatory documents to the BUR, and on the other hand - data processing for maintenance purposes. The system includes a unit for conversion and processing of flight data, engine parameters and aircraft systems. For systems such as AIDS is characterized by the fact that with their help you can detect the pre-failure state of the object of control, because they use the principle of functional control. In this regard, AIDS systems are an effective tool for the operation of aircraft.

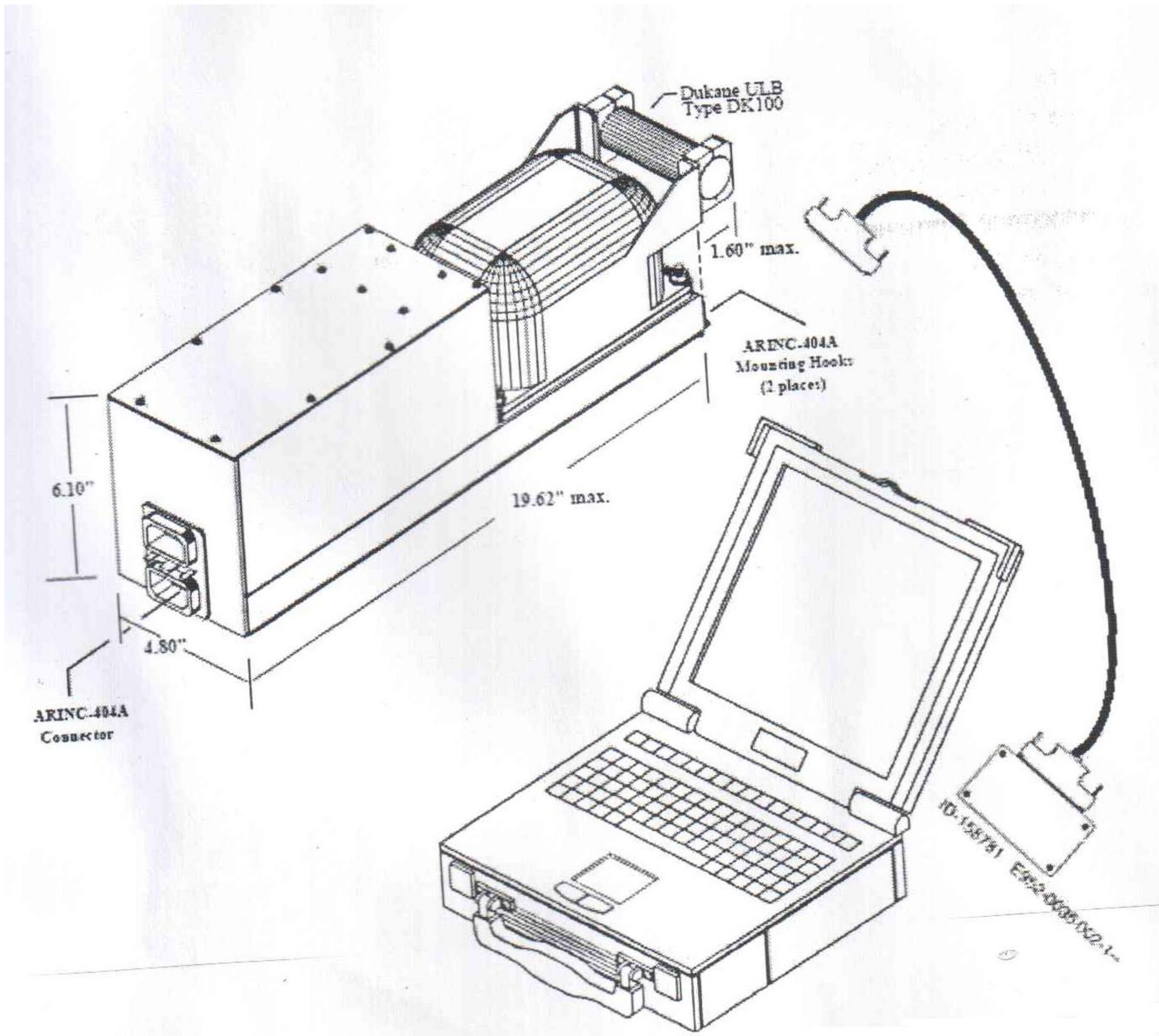


Fig 1.37. Mobile workstation for Honeywell registrars

Location of BUR on the western ND

The AIDS system (fig 1.38) includes registrars to store information for operational control and investigation of AP. Flash memory integrated circuits are used as data carriers in these recorders. Rapid development and improvement of computer technology, development and mass production of large and ultra-large integrated circuits and microprocessors (MP) have provided the possibility of widespread use of computers in onboard systems and functional devices.

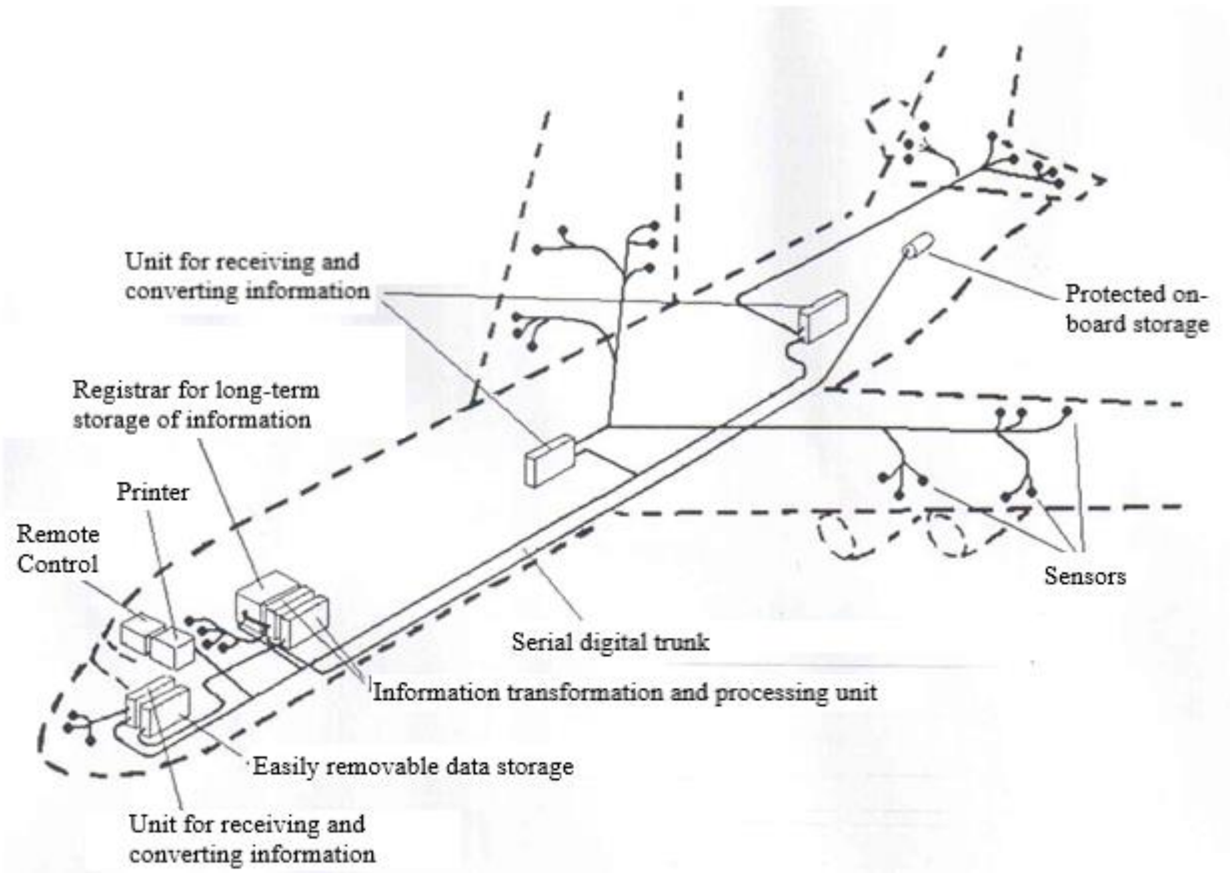


Fig 1.38. AIDS scheme

The development of general principles and technical solutions ensured the integration of computers into a single information and computing system (ITT). One of the most important components of ITT, determining its main properties, is a standard bus (bus) data transmission between system elements. The trunk-modular principle of ITT construction provides allocation of the general universal channel – the trunk of communication between elements of system – modules and definition of the general rules of interaction. In the center of ITT – the central processor (CPU). It manages the information communication between devices. Peripherals (PU) and memory are connected to the bus. Information communication between computer devices is carried out through the information bus (another name – the common bus). A trunk is a cable that consists of many wires. One group of wires (data bus) transmits the processed information, the other (address bus) – the addresses of memory or external devices to which the processor accesses. There is a third part of the highway – the control bus, it transmits control signals (for example, the signal of readiness of the device to work, the signal to start the device, etc.).

Characteristics of this bus, as well as electrical characteristics of signals, word formats, message formats, electrical characteristics (parameters) of signal transmission lines that provide electrical and logical compatibility of ITT elements that define the document / USA MIL - STO - 1553A /. Simplified ITT of the aircraft, which is a hierarchical multilevel trunk-modular structure in which individual microprocessors (microcomputers) connected by a common bus can process data from one or more sensors.

Distributed systems with a trunk-modular structure are the most common. In them connection of local technological stations (LTS) and mini-computers to the highway is carried out through the network adapter (CA). All connected devices can operate in data transfer and reception mode. To carry out data transmission, the subsystem captures a bus operating in time division mode. Data transmission is performed by frames, which include control information, data and cyclic code used to control the transmitted data. The frames transmitted to the backbone are available to all devices, and the reception is based on the selection of the station to which they are addressed. Access to the highway is provided by three main methods: random, deterministic and combined. In the case of random access, each device determines the channel for transmitting the frame at any time. With deterministic access, permission to transfer data is carried out in turn. Combined access uses random and deterministic access in different phases of data transmission. In trunk distributed systems, random access with collision checking is most commonly used. In this case, the station starts the transmission at any time. If at the same time several data stations start transmitting data, then there is a collision of frames and due to the overlap of signals, the data is distorted. The collision is detected by each station receiving the frame transmitted by it and comparing the cyclic frame code. When distortion is detected, the station stops transmitting the frame and repeats it after a random time.

The presence of collisions in the highway leads to a decrease in channel capacity. To achieve the required bandwidth and reliable transmission, the data length of the bus and the number of connected stations to the bus are limited. Increasing the length of the highway and the number of devices to be connected is achieved by using repeaters that provide recovery of electrical signals. Possibilities of expansion of the distributed ITT by means of repeaters are limited by time of propagation of a signal between the most remote LTS. The main advantages of this ITT configuration are: the simplicity of the system due to the flexible connection to the monochannel of additional stations and the simplicity of data transmission control methods.

The common standard bus provides access to this data of all other microcomputers or LTS. The main advantages of the main-modular ITT are as follows:

- Ability to arbitrarily complete the standard components of ITT (board systems) in a single system;
- Ability to autonomously refine any of the onboard systems, replace it with another system, increase ITT by including other components;
- The possibility of more efficient resources of the computer system, the survivability of the system;
- Unity (universality) of mathematical software and reducing the cost of program development;
- Reduction of costs for the future and refinement of programs during operation;
- Reduction of the required number of spare components (- 50%);
- Reducing the cost of training staff;
- Reduction of weight of wires (on the passenger liner ~ 95%);
- Improving the survivability and reliability of the Armed Forces by reducing the number of wires and their duplication.

One of the most important consequences of the creation and development of trunk-modular ITT is the integration of BUR.

This construction of the ITT opens access to information flows circulating on the universal bus and contains the values of all or at least most of the controlled parameters and flight parameters (emergency parameters). This eliminates from AIDS an autonomous data collection network (sensors, wires, matching devices, switches, analog-to-digital converters). AIDS is an integral part of ITT.

AIDS can maintain its autonomous position if the methods of control of power elements and components of the ND load integrators are developed.

If for aircraft the main control and registration system is AIDS, then for helicopters it has become the HUMS (Health and Usage Monitoring System). HUMS allows you to monitor the technical condition of the helicopter in real time. The creation of this system became possible after solving the problems:

- Diagnosis of the gearbox and transmission - detection of faults at an early stage of their occurrence;
- Control of position of blades and check of balancing of the bearing system of the helicopter;
- Engine diagnostics - "determination of gas pollution".

Currently, the software and hardware of on-board systems for collecting and processing flight information is undergoing significant changes.

In 2008, Annex 6 to the ICAO Chicago Convention was amended to address the safety management system. All airlines must conduct Flight Data Monitoring (FDM) and parameter analysis. Flight Data Analysis - FDA. The following recommendations were made in Annex 6:

3.3.6. - An operator of a certified take-off mass before 20,000 kg should establish and maintain flight data analysis programs as part of its SAFETY MANAGEMENT SYSTEM.

3.3.7. An aircraft operator with a maximum certificated take-off mass over 27,000 kg must establish and maintain flight data analysis programs as part of its safety management system. The operator may contract the operation of the flight data analysis program on the other party while maintaining overall responsibility for the content of such program.

3.3.7. The flight data analysis program should not be punitive and contain sufficient guarantees to increase the reliability of the aircraft. These actions are aimed at reducing disasters and incidents. Flight data monitoring is by its nature a process of quality improvement, which consists in the analysis of flight parameters. It is currently used to inform and correct emerging non-standard provisions in a number of areas of the airline's operations.

Offering the ability to track and assess trends in flight, identify risks and take appropriate action to correct them. Flight data monitoring helps to increase flight quality and operational efficiency by:

- Providing data to prevent incidents and accidents. Fewer APs will not only reduce material losses and insurance costs, but will also maintain high passenger confidence.
- The results of operational analysis allow to identify potential risks and modify training programs accordingly.
- Control fuel consumption: Monitoring flight data makes it possible to detect high fuel consumption.
- Reduce maintenance and repair work: flight data monitoring reduces maintenance costs and increases the fleet of aircraft used.
- Improving airport accommodation: in some cases, airport management may use monitoring data to change air traffic and airport management procedures.
- Reduction of the number of reports via digital communication channels (Aircraft Communications, Addressing and Reporting System - ACARS): non-critical data (for example: take-off report, stable course report) are not sent through ACARS, but are recorded and transmitted through flight monitoring equipment .
- Reduction of registered data of flight recorders: the flight of data monitoring can transmit automatically via the Internet and be analyzed without delays.
- Compliance with noise restrictions: Flight data monitoring allows airlines to demonstrate a commitment to noise control. The data make it possible to verify and deny violations, and thus avoid any fines.
- Improved exposure monitoring to various flight radiation: Monitoring flight data can help track radiation exposure.
- Flight data monitoring programs are a powerful tool in identifying in-flight hazards.

The aircraft's information and computing system still uses several different protocols, but the trend in recent years has been the widespread use of Ethernet technologies, which allow more flexible integration of services provided on a single platform.

CHAPTER 2. FUNCTIONAL SCHEME OF THE COMPLEX ANALYZER OF FLIGHT TECHNOLOGIES

2.1 Flight technologies - TFAP, features of their structure and use in the intellectual property market

The principle of operation of the complex analyzer TFAP is that to combine a variety of onboard information (information on electronic RLE, information from BUR, information from control systems, information from security systems, etc.) into a single integrated information flow that provides complete extrapolation flight safety with sending information to a single console.

At present, the information from BUR, as you know, is not related to the information of the RLE, with the information of control and security systems, which complicates the decision of the crew.

Functionally KATPAP is built on the use of the latest technological elements such as OICS - on-board integrated computer system, PPC - digital and analog signal conversion device, integrated control panel, etc.

Programmable power supply of Exar PowerXR

Exar PowerXR integrated circuits combine all the best of the digital and analog worlds - the cheapness and flexibility of digital control with high allowable power and excellent performance of high-quality analog switching sources. PowerXR products reduce development time from a few weeks to several hours, giving system developers a significant advantage in terms of market entry.

The easy-to-use software development environment Exar PowerArchitect ™ allows engineers to develop complex circuits for sequentially turning on / off buses, power systems, and changing voltage, current, or other parameters in seconds.

The PowerXR family consists of six step- down DC / DC converters with PWM, equipped with a built-in low-voltage stabilizer (LDO) for standby mode and GPIO lines. In the latest novelty of this family, XPP7724, the function of frequency-pulse modulation (PIM) for mobile systems is implemented.

These devices are a complete solution for power management within a single IC and are fully programmable through a serial interface I 2 C. Independent channels of digital pulse-width modulator (DPWM) provide stabilization of output voltages and all necessary protection functions, such as current limitation and protection against voltage overload.

XPP7724: the world's first digital PWM controller for mobile systems

Digital PWM controller HRP7724 has a wide range of input (4.75 ... 25 V) and output voltages (0.6 ... 5.1 V), has the ability to set the sequence of on / off channels, equipped with built-in PT drivers and up to six GPIO lines. This IC contains a patented digital pulse width modulator (DPFM). It also includes a low voltage drop stabilizer - the fifth voltage source that can be used as a power source when starting the system or in standby mode. The Exar PowerArchitect software development environment allows designers to effectively adjust parameters such as power supply voltages and threshold currents, fault monitoring and response, soft start and active shutdown parameters, channel on / off sequence, phase shift control, and feedback loop response. 'language. This IC uses a digital PID control algorithm that provides digital feedback control with a conversion frequency of up to 1.2 MHz.

Interactive electronic technical manuals - IETR

IETR is a set of interconnected technical data on products that meet the international standards ISO 8879, ISO 10179, AESMA SPEC 1000D. The IETR complex includes information on the use of products and consists of logically related elements that allow the user to quickly access data, including in the interactive mode to generate reference data on maintenance and repair procedures. IETR is a hierarchically structured electronic documentation that includes textual, tabular and graphical information. At the request of the customer, audio and video data can be included in the IETR. It is possible to access sources of information through computer networks. IETR provides:

- exchange of data in electronic form between the user and the manufacturer of products;
- information support of reference materials on the device and principles of operation of the product;
- reduction of training and qualification training of operating personnel;
- planning and accounting of routine and repair work;
- automated ordering of materials and spare parts;
- diagnostics and troubleshooting based on the analysis of signs of malfunctions and application of procedures to clarify the diagnosis, c. Therefore, remotely via computer networks.

Complex panel of radio engineering means KPRTZ-95M-1

The KPRTZ-95M-1 panel is intended for control in a manual mode of radio engineering means of navigation, landing and communication, and also for reception, processing and transfer of control signals of radio engineering means from VSS.

Functions performed, that the KPRTZ-95M-1 remote control controls the following radio means of navigation, landing and communication:

- radio navigation system for short-range navigation and landing of the meter wave range - VOR (2 sets);
- radio landing system of meter wave range - ILS (3 sets);
- short-range radio navigation system and landing of the decimeter wave range - RSBN (2 sets);
- automatic radio compass - ARC (2 sets);
- aircraft rangefinder - DME (2 sets);

- microwave landing system - MLS (3 sets);
- MB communication system - waveband (3 sets);
- DKMV communication system - wave range (2 sets).

The KPRTZ-95M-1 panel controls radio means of navigation, landing and communication in a manual mode by a set of control parameters on the front panel of the panel and issue of control signals in the form of digital words and one-time commands.

The KPRTZ-95M-1 panel controls radio means of navigation, landing and communication in the automatic mode by reception, processing and transfer of control signals of radio means from VSS.

The KPRTZ-95M-1 panel is a monoblock with a front panel, which includes a computer system with a micro 80C167 manufactured by SIEMENS.

MAIN CHARACTERISTICS OF THE PANEL:

- the number of output channels of the serial code – 4;
- the number of input channels of the serial code – 4;
- number of outgoing one-time commands – 20;
- number of incoming one-time commands – 12;
- indication on 6 matrix indicators on 8 acquaintances everyone;
- indication on 13 signaling devices which are provided with 23 buttons, 2 double setters of parameters on 30 values for one turn and the galet switch on 3 positions;
- permanent program memory (RAM) – flash memory of 512 KB;
- external program memory (RAM) of 64 KB;
- frequency of operation of the microcontroller – 20 MHz;
- main power supply – 115V 400Hz;
- consumption on the network 115V 400Hz – 20VA;
- backup power supply RAM – +27 V DC (consumption 1W);
- overall dimensions 146x 192x 170 (without controls and connectors);
- weight not more than 2.5 kg;

- code of external influences on ENLG-C BIII, zone A1, soil-U 1-VUL-DRSH-T1-VL1-TMH-ROH-PPH-RS-PGS-VDH-ASHH KT-160D category R, code M;
- operating conditions in accordance with the requirements of the qualification base for AP-25 for passenger aircraft.

FEATURES KPRTZ-95M-1

- When using two KPRTZ-95M-1 consoles the inter-console exchange of information, adjustment of all RTS and PC by any of two KPRTZ-95M-1 is provided;
- Tool for setting up PC radio communication systems (MB, DKMV) with the ability to work with the frequency grid of 25 KHz and 8.33 KHz;
- Option of manual adjustment of navigation RTS (ARC, RSBN, ILS, VOR, MLS, DME with provision of work on VOR, MLS and TACAN channels);
- Ensuring automatic adjustment of the RTS from the BCC through KPRTZ;
- Configuration management (type and number of RTS and PC);
- Blocking the tuning of radio systems and radio stations;
- In-depth control of own working capacity with a possibility of autonomous control and indication of results and time of working;
- Reliable reading of information displayed by indicators in direct, sunlight.

Secondary power sources. Single-channel DC-DC converter with an output power of 10 W.

Description and application: power supplies CT10 DC / DC converters with a capacity of 10W (WFP), designed to supply stabilized DC voltage of analog and digital equipment for special purposes, as well as for import substitution of power supplies in the format of a standard circuit board 2 "x 1". Runways have a sealed metal housing, as well as a set of protections: short circuit, excess output current, lower input voltage and excess input voltage. Runways are designed for harsh operating conditions.

Main characteristics:

- Extended operating temperature range from -60 ° C to +100 ° C;

- Technological deviation of the output voltage is not more than 1%;
- Temperature instability of output voltage no more than 2%;
- Instability of output voltage at smooth change of input voltage no more than 0,3%;
- Temporary instability of the output voltage is not more than 0.3%;
- Instability of output voltage at change of output current from 0,1 to 1nom no more than 1%;
- Total instability not more than 3%;
- Insulation resistance not less than 20 MO at a voltage of 500 V;
- Weight 65 g.

Table 2.1

<table>
<tr><th>U_{in}, V</th><th>P_{max}, W.</th><th>U_{out}, V</th><th>I_{out}, nom, A</th><th>Efficiency, %</th><th>Output voltage ripple, mV</th><th>Name</th></tr>
<tr><td rowspan="3">27 (16-36)</td><td rowspan="3">10</td><td>3.3</td><td>2</td><td>70</td><td rowspan="3">50</td><td>ST10-A0ZZEV</td></tr>
<tr><td>5</td><td>2</td><td>72</td><td>ST10-A050EV</td></tr>
<tr><td>12</td><td>0.83</td><td>76</td><td>ST10-A120EV</td></tr>
</table>

BTSO-R digital processing unit

BCO-R is an improved analogue of BCO-M, BCO-P blocks. The design is a metal housing with removable modules. Technical characteristics of BCO-R (with the MSRP module) fully meet the technical requirements for the BCO-M, BCO-P units, which are an integral part of the low-frequency receiver H019-03.

The unit implements algorithms for digital Doppler filtering and detection of reflected signals in standard radar modes (MSRP module). In the future, it is also planned to install an air situation assessment module (AIR) and a digital radar aperture synthesis module (MCRSA). The block is made on a modern element base. BCO-R provides the possibility of flexible reconfiguration of the system and changes in signal processing algorithms to implement the new features of the modernized RLPK. Resistant to a wide range of mechanical and climatic factors.

Specifications:

- input signal frequency, MHz – 28.0, 84.0;
- sampling frequency, MHz – 210;
- width of Doppler filters, Hz – 2-220 (programmable);
- number of parallel channels – 48;
- dimensions, mm – 350x225x110;
- power consumption, W – 65.

Areas of application of cyclography sorting

When organizing flight work:

- accounting for restrictions on the Black Sea Fleet (crew) when planning flight work;
- application in theoretical training in flight units;
- formation of crews taking into account the ability to remove the peaks of deployment;
- special admission of flight crew to flights with engineering-psychological reservation;
- preliminary and pre-flight training of crews on deployment cyclography;
- testing knowledge of deployment peaks and technological complexities of flight upon admission to flights;
- demonstration of cyclography deployment data. tables and process diagrams on flight analysis;
- flight control by process analysis;
- analysis of flight work taking into account the results of process analysis;
- in the development of methodological documents;
- implementation of regulatory documents.

When providing flights:

- taking into account the fact that a normal flight is an extremely complex process;
- increasing the activity of the flight crew;

- in the development of measures for engineering and psychological support of flights;
- when collecting information about the production process;
- when analyzing the causes of deviations from the flight plan and violations of technological schedules;
- in the prognosis or prevention of AL;
- when taking into account the duration of working hours;
- at increase of professional skill in difficult conditions;
- when calculating the coefficients of payment for flight work.

In compliance with the rules of flight and flight performance:

- taking into account the engineering and psychological limitations (minimums and maximums for loading operations) for the Black Sea Fleet (crew);
- when working out the instructions for interaction;
- when testing the technology of the crew;
- taking into account the technological features of the flight stages;
- when considering the technological difficulties of the busiest stages of the Black Sea Fleet;
- in conditions when it is difficult to make decisions on KLE;
- in terms of information-factor overlay and special cases in flight to relieve stress.

Basic cyclographies of deployment on the plane

Information-analytical analysis on the cyclography of the scan: cyclogram of normal flight sorting; deployment cyclograms by functional systems; diagram of technological difficulty of aircraft systems; histogram of normal flight sorting; sort histograms of your choice; generalized histogram of the scan; estimation of normal flight; assessment of aircraft systems and equipment complexes; assessment of the technological difficulty of operation in general.

In the analysis of flight processes, new analytical and information technologies of process analysis of flights (TPAP) were developed. The TPAP classification consists of three groups.

Scanning technology:

- sweep cyclograms;
- scan histograms;
- transition scan diagrams;
- graphics and maps, etc.

Ring technologies:

- ring analytics;
- "circle of circles" technology;
- spiral technologies;
- zone technologies;
- indefinite technologies;
- technologies of "antipults", etc.

Factor technologies:

- factor list technology;
- factor transition technology;
- ZUBKF technology;
- factor resonance technologies;
- technologies of adeitivity and multiplication
- information factor analysis (ELISA) technology, etc.

Deployment technologies involve the compilation of technological maps of the flight process – deployment cyclograms, as well as the construction of deployment histograms and various deployment diagrams.

Currently created and used in flight practice reference books on the cyclography of the deployment of aircraft IL-96-300, TU-204, IL-76, AN-124-100 and for aircraft "Boeing". Ring technologies are used in the analysis of the flows of comments of aviation specialists, the analysis of factor lists, taking into account the concepts of causality of aviation events.

Factor technologies are a set of technologies for accounting for a set of factors, factor transitions, factor resonance phenomena and other multifactor processes. The most familiar to aviation specialists in factor technologies TPAP is the technology of accounting for "factor overlays". Method of analysis of factor overlays (so-called effects of factor multiplication). Deployment cyclography is a new priority technology - process analysis technology, designed to reduce accidents on (Human factors) human factor.

Deployment cyclography allows to assess the technological complexities of aircraft operation and take into account technological maxima in flight operation in order to reduce the negative effects of information-factor load under the influence of multifactor and a complex of simultaneously interacting factors.

Cyclogram scan IL-76 TD: Aircraft control. Initial data – 31

Sort operation:

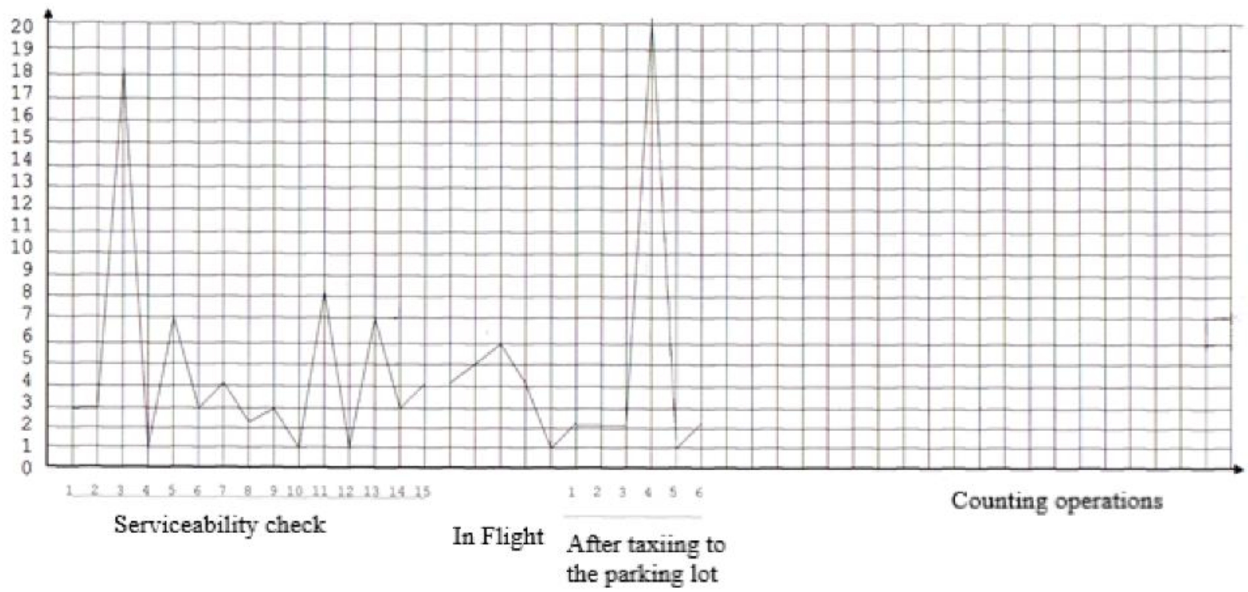


Fig 2.1. Cyclogram of the deployment of IL-76 TD: Flight

Scan operations

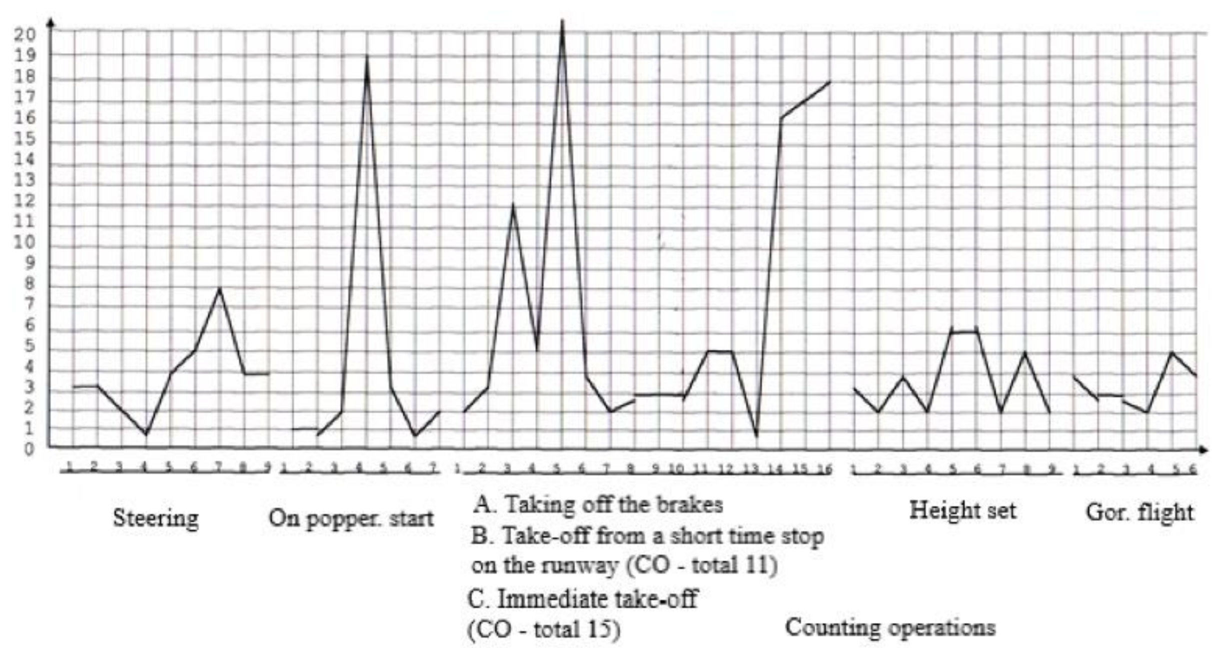
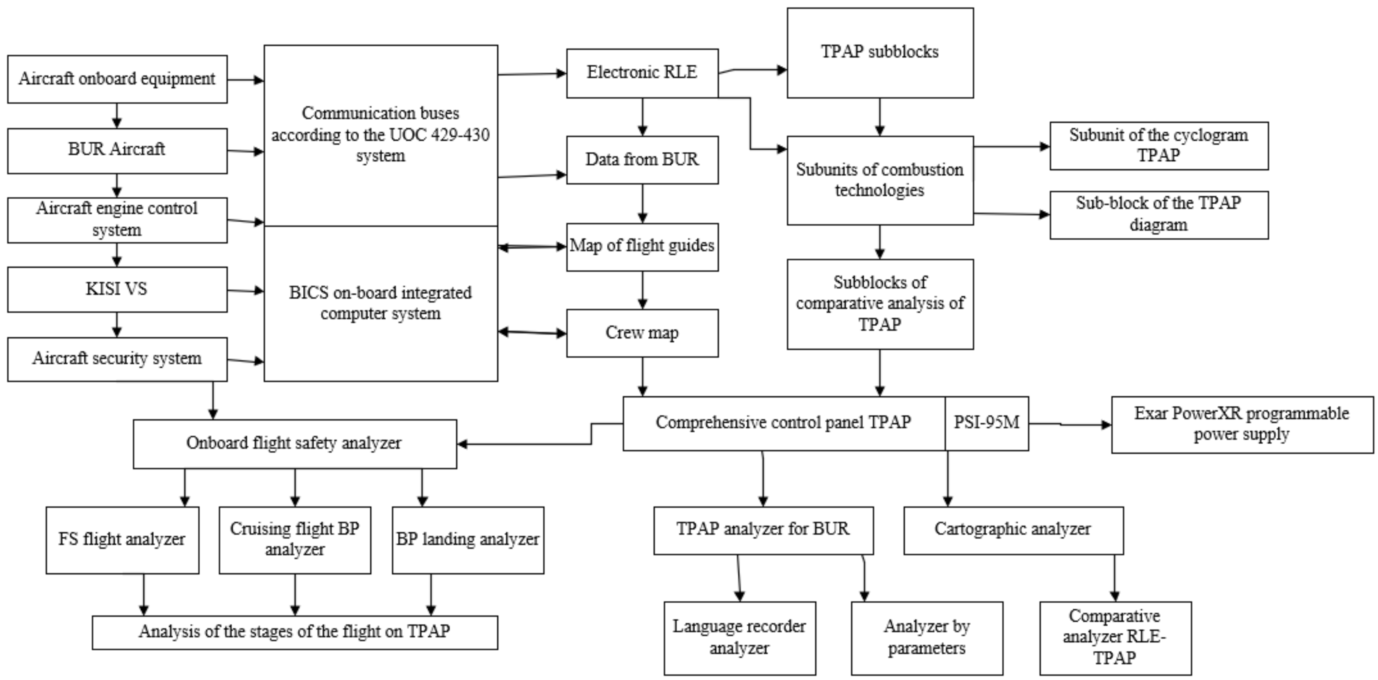


Fig 2.2. Cyclogram of the deployment

2.2 Functional diagram of the complex analyzer TPAP



Chapter 3 Labor protection

3.1 Introducing

Completion of this diploma work requires educational environment and PC, which can cause harmful affect shown in this chapter.

Dangerous and harmful factors occur at the PC user's workplace: increased noise level, unfavorable microclimatic conditions, insufficient light level, harmful substances, increased level of electromagnetic radiation of radio frequencies, high mains voltage , static electricity and others. Working with a PC is also accompanied by an increased degree of intensity of the labor process. Chemically hazardous factors that constantly affect the PC user include the occurrence of active particles as a result of air ionization during computer operation. There are no biologically harmful production factors in this room.

Improper organization of the workplace contributes to the general and local tension of the muscles of the neck, torso, upper extremities, curvature of the spine and the development of osteochondrosis.

3.2 Room description

A room with the following geometric parameters was selected for the computer laboratory: width – 4 m, length – 6.25 m, area – 25 m 2, ceiling height – 3.2 m. The building and premises are constructed in accordance with the requirements [10]. Room computer lab equipped with four working places for engineers.

Volume producing facilities for engineers, operators of video terminal devices on one employee is 19.5 m 3, area of premises – 6 m 2 with a view of maximizing the number of workers in one shift.

The plan of the computer laboratory is shown in Fig. 4.1.

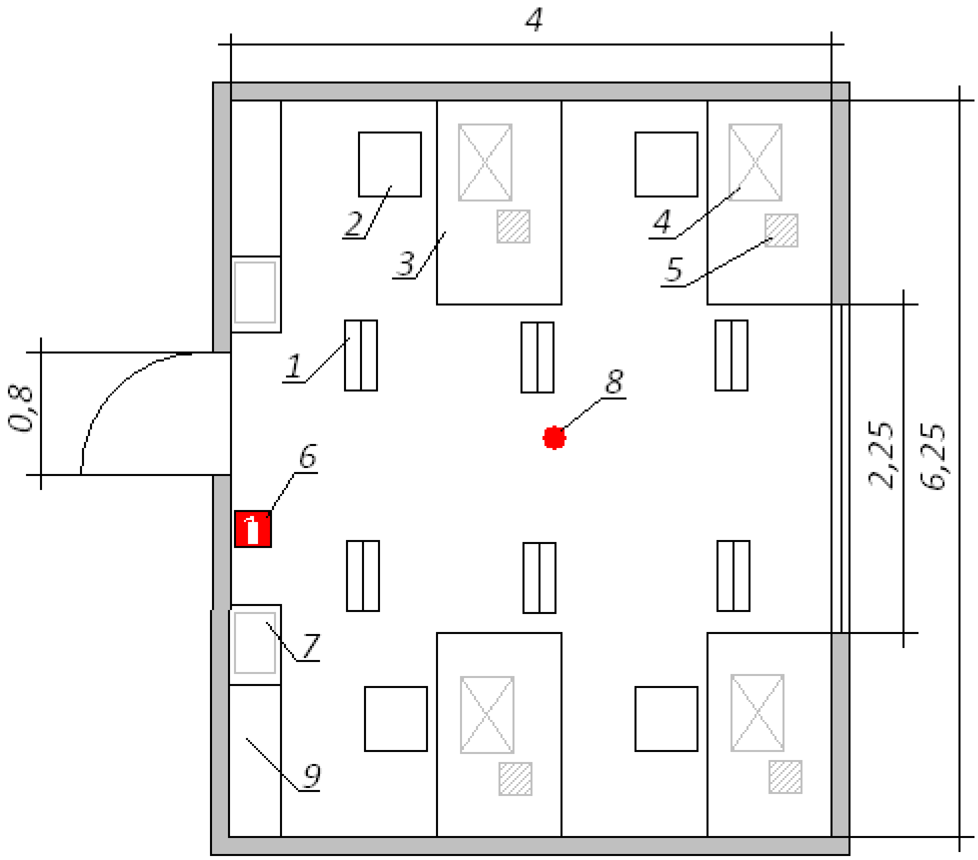


Figure 4.1 - Plan of the computer laboratory: 1 - lamp; 2 - chair; 3 - table; 4 - personal computer (PC); 5 - telephone - fax; 6 - fire extinguisher; 7 - multi-function product/printer/peripheral (MFP); 8 - fire sensors; 9 - closet

The main production process is the development of algorithms, technical documentation and analyzing that requires the use of computers. There are four workstations in the computer lab. They all equipped with a liquid crystal display, and each location is connected to a local area network. A fax machine is additionally installed on the table. There are two MFPs in the laboratory. Six lamps are used for lighting. Each lamp contains two fluorescent lamps type LB-40-1. The windows of the computer lab are quite old. There is no special ventilation and sound insulation in the room. All the equipment located in the computer lab connected to the source of supply during voltage to 220 V.

3.2 Room description

The work of an engineer is associated with a significant visual load, which requires proper lighting. In this room, the level of natural light is sufficient, and the level of artificial - reduced. An engineer works with computers and other office equipment, which is a source of danger of electric shock. The work is associated with a constant stay indoors, so for comfortable working conditions it is necessary to create a proper microclimate in the computer lab.

According to the normative documents [11] and [12], the following harmful production factors can be identified that affect the employee of this computer laboratory:

1. Insufficient level of artificial lighting.
2. Microclimate of the working area: temperature, relative humidity, air velocity.
3. The increased level of noise in the workplace.
4. Dangerous voltage in the electrical circuit.
5. Elevated levels of vibration.

Next, we will analyze the first three harmful and dangerous factors of production that operate in the computer lab on the engineer. Perform quality and quantitative analysis of these factors. Also, we will develop labor protection measures for these three harmful production factors that improve working conditions for the engineers in the computer lab.

4.3.1 Level of artificial lighting

The main document that regulates lighting standards is [13]. In the computer laboratory there are six lamps with two fluorescent lamps LB40-1 in each. The power supply of the lighting is a 220 V supply circuit.

The actual value of the illumination of the working space is only E = 210-220 lux. The category of work performed by the engineer refers to high-precision work with the assignment of the III category. Therefore, the standard value of the general lighting of the working space should be E = 300-500 lux. Therefore, it is necessary to take measures to increase the lighting of the room.

The lighting in engineer's workplace should be such that the employee can do his job without eyestrain. The calculation of the illumination of the workplace is reduced to the choice of lighting system, determining the required number of lamps, their type and location.

According to the selected category of visual works, the allowable value of the illumination of the work surface is taken E = 400 lux. To improve the lighting of the computer lab will be used LED lamps, namely LITWELL LED-T8S-120 luminous flux which Fl = 1500lm. The calculation for the improved level of artificial lighting will be described in clause 3.3.4.

4.3.2 Microclimate of the working area: temperature, relative humidity, air velocity

Table 3.1

Optimal and acceptable microclimate parameters

Season	Microclimate parameter	Value		
		Optimal	Admissible	In fact
Cold	Temperature air in indoors	21.0-23.4 °C	23.5-25.4 °C	16.1-18.0°C
	Relative humidity	40- 60%	75%	35%
	Speed of movement of air	0.1 m / s	up to 0.1 m / s	0.1 m / s
Warm	Temperature air in indoors	21.0-23.4 ° C	23.5-25.4 °C	26.7-27.4 °C
	Relative humidity	40- 60%	55%	55%
	Speed of movement of air	0.1 m / s	0.2-0.1 m / s	0.1 m / s

According to [12], the work of a engineer by difficulty refers to the light physical work of category Ia.

The main document that regulates the microclimate of the work area is [14].

Computers and office equipment are a source of significant heat, which can lead to higher temperatures and lower relative humidity in the room. Certain microclimate parameters must be observed in rooms where computers are installed. Sanitary norms set the values of microclimate parameters that create comfortable conditions. (see Table 3.1). Values of parameters of optimal and admissible parameters of microclimate according to [14] for premises, and actual parameters are presented in table 4.1.

To ensure comfortable conditions used as organizational methods (rational organization of work, depending on the time of year and day, alternation of work and rest), and technical means (ventilation, air conditioning, heating system). The value of the actual humidity in the room in the cold period - 35%, does not fall into the range of permissible values. Therefore, in the cold season in the room you need to use humidifiers, and to increase the temperature you need to install additional heating.

In the warm season, you need to install air conditioning to lower the temperature.

4.3.3 The level of noise in the workplace

The increased noise level in the computer lab is caused by four PCs, two multifunction devices, as well as the hum of the starter relay. The actual value of the noise level is 88-92 dB, when the allowable sound level is ≤ GDR, namely 50 db. Methods of measuring noise and permissible sound pressure levels in octave frequency bands, equivalent sound levels at the workplace are regulated [15].

Noise worsens working conditions by having a harmful effect on the human body. Working in conditions of prolonged noise test steps irritability, headaches, dizziness, memory loss, fatigue, decrease in appetite, pain in the ears etc. Such violations in the work of several organs and systems of the human body can cause negative changes in the emotional state of man and stressful situations. Under the influence of noise, the concentration of attention decreases, physiological functions are disturbed, fatigue appears due to increased energy expenditure and mental stress, speech switching deteriorates. All this reduces a person's ability to work and his productivity, quality, and safety.

Additional sound insulation is required to reduce the noise level. As sound-insulating materials used in the construction of floors to reduce the transmission of structural (impact) sound are mainly used mats and plates of glass and mineral fiber, soft boards of wood chips, cardboard, rubber, insulated linoleum, as well as replacing windows with soundproofing.

4.3.4 Calculation to improve the level of artificial lighting

To improve the lighting of the computer lab will be used LED lamps, namely LITWELL LED-T8S-120 luminous flux which Fl = 1500lm. According to the selected category of visual works, the allowable value of the illumination of the work surface is taken E = 400 lux.

To calculate the illumination of the CL, we use the method of light flux. To determine the number of lamps determine the luminous flux incident on the surface by formula 4.1:

$$F = \frac{ElSZ}{} \quad (4.1)$$

where F is the luminous flux, Lm;

E - normalized optimal illuminance, Lk, E = 400 Lk;

S - area of the illuminated room (in our case S = 25 m 2);

Z- is the coefficient of minimum illumination, which characterizes the unevenness of illumination. It is accepted at the most favorable arrangement of illuminators when the light stream is used for illumination of a working zone most rationally, (Z = 1.1);

k- is the stock factor, which takes into account the reduction of the luminous flux of the lamp as a result of contamination of lamps during operation (its value is determined by the table of stock ratios for different rooms and in our case k = 1.2);

η - coefficient using global flux of a lamp that shows what part of the light flux lamp reaches the illuminated surface, including due to the reflection light flux from the walls, ceiling and work surface.

To determine the coefficient η you need to calculate the index of the room i by formula 4.2:

$$i = \frac{S}{h(A+B)} \qquad (4.2)$$

where S is the area of the room, S = 25 m2 ;

h is the height of the suspension of lamps above the work surface, m ; A - width of the room, A = 4 m ;

B - length of the room, B = 6.25 m . The height of the suspension is found by formula 4.3:

$$h = H - h_{св} - h_{р} \qquad (4.3)$$

where H is the geometric height of the CL, H = 3 m ;

$$3,2 - 0,3 - 0,9 = 2 \text{ м}$$

$$i = \frac{25}{2,9(4 + 6,25)} = 0,84$$

According to the room index and luminous flux coefficients from the floor - 10% (0.1),

$$F = \frac{400 \cdot 1.2 \cdot 25 \cdot 1.1}{0.51} = 25882 \text{ Лм}$$

from the walls - 30% (0.3) and from the ceiling - 50% (0.5), we determine the value for the LED lamp LITWELL LED-T8S-120 luminous flux utilization factor η = 0.51. Substitute all the values in formula 5.1 to determine the luminous flux:

$$F = \frac{400 \cdot 1.2 \cdot 25 \cdot 1.1}{0.51} = 25882 \text{ Лм}$$

Calculate the required number of lamps according to formula 4.4:

$$N = \frac{F}{F_л} \qquad (4.4)$$

where N is the number of lamps.

F - luminous flux, F = 25882 Lm;

$$N = \frac{25882}{1500} = 18\ шт.$$

Fl - luminous flux of the lamp, Fl = 1500 Lm.

So, we use 6 lamps for lighting, each lamp is equipped with 3 lamps. Luminaires are placed in two rows, three in each row. According to [13], this room does not belong to those that need emergency lighting.

3.5 Fire protection

Flammable substances are placed in the auditorium (Table 3.2). The source of ignition may be a short circuit and mains failure.

Table 3.2

Type of fire	Characteristic
Class A	burning of solids
Class E	combustion of electrical installations, under voltage up to 1000 V
Subclass A	combustion is accompanied by decay
Class B	explosive

To prevent fire in the classroom should take the following fire safety measures listed in table. 3.3

Table 3.3

Type of protection	Means of preventing danger
Technica l	In the corridor, opposite the office, there is a fire hydrant and a hose, OU-5 fire extinguisher
Organizational	Fire safety instruction and periodic control of knowledge of fire safety rules. Fire evacuation plan. Free access to the power switch.

3.6 Conclusions

The analysis of working conditions in the considered workplace showed that the working conditions with a PC meet the requirements, as the area and volume are not less than the normative values, noise, vibration and gas levels do not exceed the normative limits.

The proposed LED lamps have a service life of 50 thousand hours, which is much better than fluorescent lamps, where the service life is 10 - 20 thousand hours, and also depends on the number of switches. On the other hand, luminaires are 44 % more economical (LED lamp 20 +/- 1 W, fluorescent 36 +/- 1 W), more impact resistant, does not contain toxic substances and has no special requirements for disposal. These lamps create optimal conditions for the visual work of a software engineer, and the relatively low heating temperature increases the level of fire safety.

The value of the actual humidity in the room in the cold period - 35%, does not fall into the range of permissible values. Therefore, in the cold season in the room you need to use humidifiers, and to increase the temperature you need to install additional heating.

To lower the temperature in the warm season, you need to install air conditioning.

REFERENCES

10. DBN B.2.2-28: 2010. [Electronic resource]: DBN B.2.2-28: 2010. Access mode: http://document.ua/budinki-i-sporudi.-budinki-administrativnogo-ta-pobutovogop-nor19583.html Access date: 10.04.2015.

11. About the minimum safety requirements when working with display equipment [Electronic resource]: 90/270 / EEC. - Valid from 1990-05-29. - Brussels.: Council of the European Communities, 1990. - URL: http://docs.pravo.ru/document/view/32704903/. - (Directive; International Document) "Hygienic classification of labor according to the indicators of harmfulness and danger of factors of the production environment, the difficulty and intensity of the labor process." Order of the Ministry of Health of Ukraine of April 8, 2014 N 248–. [Electronic resource] : - Access mode : http://golovbukh.ua/regulations/2340/2592/2593/332659/ - Access date: 20.04.2015.

12."Hygienic classification of labor according to the indicators of harmfulness and danger of factors of the production environment, the difficulty and intensity of the labor process." Order of the Ministry of Health of Ukraine of April 8, 2014 N 248–. [Electronic resource] : - Access mode : http://golovbukh.ua/regulations/2340/2592/2593/332659/ -Access date: 20.04.2015.

13."State building codes. Natural and artificial lighting ". DBN B 2.5.28- 2006. [Electronic resource]: DBN B 2.5.28-2006. - Access mode: http://www.info-build.com.ua/normativ/detail.php?ID=45079 . - Access date: 25.04.2015.

14."State sanitary norms of microclimate of industrial premises". LTO 3.3.6.042-99. [Electronic resource]: LTO 3.3.6.042-99.– Access mode: http://mozdocs.kiev.ua/view.php?id=1972 . - Access date: 1.05.2015.

15.“Sanitary norms production noise, ultrasound and infrasound. LTO 3.3.6.037-99. [Electronic resource]: LTO 3.3.6.037-99. - Mode of access : http://document.ua/sanitarni-normi-virobnichogo-shumu-ultrazvuku-ta-infrazvuku- nor4878.html - Date of access: 7.05.201

CHAPTER 4. IMPACT OF AVIATION ON THE ENVIRONMENT AND MITIGATION MEASURES

Introduction

Land transport is one of the most active sources of air pollution. Although today aircraft significantly (approximately a 15 times) inferior road transport of the recoiling number of pollutants in the air, it affects the daily ecology upper troposphere and lower stratosphere. Unlike other types of transport aircraft covers a huge distance, effecting on air quality in the local, regional, and global scope. In this case, the impact of aviation on the atmosphere can be divided into acoustic and chemical.

In 1972, at the United Nations Conference on the Environment in Stockholm, the position of the International Civil Aviation Organization (ICAO) was stated as follows: "In fulfilling its role, ICAO is aware of the harmful effects on the environment that can be related to the operation of aircraft, as well as their duties and responsibilities of the ICAO Member States to achieve maximum compatibility between the safe and orderly development of civil aviation and the quality of the human environment ". Following this position, CAEP (Committee on Aviation Environmental Protection) was created in 1983.

The technical committee of the ICAO Council for the protection of the environment from the impact of aviation. The Committee shall assist the Council to formulate poly-tick and take new corresponding documents ICAO – "Standards and Recommended Practices" (SARPs) related to aircraft noise, aircraft engine emissions and the broader environmental impact of aviation. Basically, these documents are drawn up in the form of Appendix 16 "Environmental Protection" to the Convention on International Civil Aviation.

Acoustic pollution of the atmosphere

Aircraft noise is the most important factor in the negative attitude towards aviation among the population in the areas adjacent to the airport. It affects a relatively large number of people living in the vicinity, as well as airport workers and passengers. Aircraft noise adversely affects human health (most often it is hearing impairment, stressful conditions, problems associated with concentration). The ICAO Aircraft Noise Policy calls for the development of measures to mitigate acoustic pollution: introduction of noise abatement technologies, ground planning (for example, night flight bans), tightening noise standards for the existing aircraft fleet and development of standards for new aircraft models.

Aircraft noise standards and recommended practices are set out in the first volume of Annex 16. Here the permissible noise levels and the method of their measurement for aircraft of various categories are formulated (considering the year of manufacture, the number of engines and their type, the values of the maximum certified take-off weight of the aircraft).

For the development of noise reduction technologies, a group of independent experts created by CAEP formulated medium-term (until 2020) and long-term (until 2030) technology goals. They represent the standards that will be mandatory for four categories of aircraft in 2030 (Table 4.1). The targets are shown in the form of noise reduction values relative to the limiting parameters of the nominal and maximum take-off weight. Noise level is measured in units of db - effectively perceived noise level in decibels. Considering that in 2014 year [4] these levels, depending on the type of aircraft, amounted to 89 106 db, it becomes obvious how radically ICAO is going to fight against acoustic pollution of the atmosphere.

The quality of air in airports

Interest to the pollution of air in airports started to rise since the beginning of the 1970s, when the sharply intensified the commercial transportation using turboprop aircraft. Chemical air pollution at airports is represented by such aviation emissions as carbon oxides (CO, CO_2), nitrogen (NO_x), sulfur (SO_x), hydrocarbons (HC) and particulate matter generated by engines and combustion. aviation fuel.

Table 4.1.

Estimated long-term prospects for aircraft noise reduction by 2030 [8]

Category of aircraft	Long-term goals, db
Regional jet aircraft 40 t (nominal)	21.5 ± 4
50 t (maximum)	17 ± 4
Short / medium- range two-engine aircraft	
Turbofan:	
78 t (nominal)	30 ± 4
98 t (maximum)	26.5 ± 4
With birotating turbofan engines	
78 t (nominal)	13.5 + 2 / - 6
98 t (maximum)	10.5 + 2 / - 6
Two-engine main aircraft	
230 t (nominal)	28 ± 4
290 t (maximum)	24.5 ± 4
Four-engine mainline aircraft	
440 t (nominal)	27 ± 4
550 t (maximum)	20.5 ± 4

Sources of emissions from aviation can spread and degrade air quality in nearby communities. These emissions pose a potential risk to public health and the environment since they can cause an increase in the concentration of ground-level ozone and lead to acid rain. National and international air quality monitoring programs continually require authorized aviation and government agencies to monitor air quality near airports. Special attention is also paid to the impact of aviation on the surrounding environment, associated with water quality, waste disposal, energy consumption, and the impact on the local ecology near airports (prevention of fuel leaks is especially important).

Over the past few decades, significant progress has been achieved in reducing emissions due to the improvement of the environmental friendliness of aviation fuels (partial replacement of kerosene with liquefied natural gas or biofuels) and technical improvements of aircraft engines (increasing their thrust efficiency, implying a decrease in fuel consumption). However, this progress may be offset in the future by an increase in air traffic.

To assess air quality at the airport, back in 2007, the "Guidance material on charges for aviation emissions related to local air quality" was developed, which implied the introduction of duties levied by the state, specifically designed and applied to prevent or reduce environmental impact on local air quality during the operation of civil aircraft. The methodology for estimating aircraft engine emissions was outlined in the subsequently developed Document 9889 "Guidelines for Air Quality in Airports". It formulated methods for estimating aircraft engine emissions at an airport based on three parameters.

EI emission (weight substances released during the combustion of a unit mass of fuel) and the third fuel consumption. In [5] it is stipulated that in order to certify aircraft engines, the following types of emissions are regulated: smoke, unburned hydrocarbons (HC), carbon monoxide (CO), nitrogen oxides (NO_x).

The ICAO Engine Emission Bank (EEDB ICAO Engine Emission Bank) contains information on the EI values for certified engines (in grams of pollutant per kilogram of fuel for NO_x, CO and HC), as well as the consumption of special fuels (in kilograms in second) for different operating modes of different types of engines. In addition, here indicated number opacity   dimensionless parameter, which is calculated on a 10-point scale and characterizing the emission of smoke as the "opacity" of the exhaust stream. Emission indices for the PW4074D engine, which, for example, the A330 aerobuses are equipped with, are presented in table 4.2.

Table 4.2

Emissions figures for the PW4074D engine from the ICAO emissions database [13]

Operational mode	Engine power, %	Time, min	Fuel consumption, kg / s	Fuel emission index, g / kg			Number dymno- STI
				HC	CO	NO x	
Takeoff	100	0.7	3.042	0.02	0.3	42.46	4.22
Climb	85	2.2	2.471	0.02	0.35	32.71	2.36
Descend	thirty	4.0	0.869	0.04	0.96	11.35	0.65
Small gas	7	26.0	0.305	3.12	26.34	3.8	0.33
Fuel (kg) and emissions (g) for HCV			1138	1502	12885	20269	-

Aircraft engine emissions

Most aviation fuel is burned not in the ground layer near airports, but in the higher layers of the atmosphere. Experts believe that the annually increasing emissions of carbon dioxide, water and methane from commercial aircraft engines change the chemical and radiation balance of the atmosphere, which, along with the emission of soot sulphate aerosols, can affect the climate. Components such as carbon dioxide and nitrogen oxides are of particular importance. Nitrogen oxides take part in the chemistry of ozone (its increase can lead to heating of the upper troposphere) and an increase in the amount of hydroxyl radicals (OH), the main atmospheric oxidant. An increase in OH leads to a reduction in the lifetime of CH_4 methane, which can result in cooling, and in parallel - on a scale of decades - a decrease in tropospheric ozone. Sulfur oxides and soot lead to the formation of aerosols. Aerosols and their precursors (soot and sulfates) increase cloudiness in the form of linear contrails (condensation trails) and cirrus clouds. Depending on the state of the surrounding atmosphere, these tracks can sometimes exist for several minutes, and sometimes for hours, spreading over several kilometers in width and resembling cirrus or altocumulus clouds.

A very significant impact on the radiation balance should be expected because of emissions of soot particles solid-state products of incomplete combustion of fuel, which play the role of condensation nuclei. In the upper troposphere, soot aerosols have a size of 0.1 0.5 μm and consist of agglomerates of primary particles with a diameter of 20 40 nm. Their average concentration varies from 0.004 to 0.5 cm^{-3}. Earlier, in assessing the climatic consequences of the emission of soot aerosols, the main attention was paid to changes in the composition of the atmosphere caused by the occurrence of heterogeneous chemical reactions on the surface of soot particles. However, no noticeable effect of the emission of these particles on the gas composition of the atmosphere has yet been found [6, 7]. At present time it is believed that the effect of the emission of soot particles on climate due principally way the formation of long-lived capacitor satsionnyh traces (direct effect) and initiating formation of grained clouds (secondary effect).

It is extremely difficult to estimate the radiation effect from such clouds - even the sign of this influence is not determined with certainty. The model estimates the global effect of aviation soot on radiation balance (the effect of large cirrus formation in which the particles of carbon black playing the role of nuclear condensation), made with the use of chemical co-transport models for different assumptions and parametrization tions, found differences from -110 to + 260 mW / m^2.

Indeed, the lack of a detailed description of the processes in the models and the completeness of observational data limits confidence in the quantitative assessment of the contribution of radiation forcing. According to calculations, the total radiative forcing of the expense of air emissions (excluding induced cirrus clouds) in 2005 was ~ 55mVt / m 2, in view of cirrus clouds ~ 78 mW / m 2.

Greenhouse gases, whose emissions can contribute to the process of global warming, occupy a special attention among the combustion products of aviation fuel. Airlines have essentially only two options to reduce them. The first is an increase in the growth of fuel efficiency (that is, specific fuel consumption). The second is the use of alternative fuels: synthetic fuels from coal, natural gas, or biomass. Natural fuels do not contain sulfur and aromatic hydrocarbons, which significantly reduces emissions of volatile aerosols and cloud condensation nuclei, thus weakening the effect on the radiation balance.

Conclusion

Even though aviation is a relatively “clean” mode of transport compared to others, its impact on the climate and the environment can become noticeable over time due to the constantly increasing air traffic, leading to an increase in pollution in the upper layers of the troposphere. Although estimates of such impacts are currently highly uncertain, the International Civil Aviation Organization is taking steps to reduce the negative environmental impacts of aviation. To this end, new standards are being developed that tighten the requirements for aircraft in operation in terms of aircraft noise and emissions, as well as the list of aviation emissions for which certification of aircraft engines is carried out is expanding. The main instrument adjusting the negative impact of aviation on the atmosphere of the ICAO Committee on the Protection of the surrounding environment offers a mechanism for the Global market measures. While not all ICAO members support this idea, there is a clear need for new technologies in the aviation industry to reduce the environmental burden of air transport.

List of sources used

1. Andreev In A. Solobozov B. Fuel for aircraft of the XXI century // Science and life. 2001. No. 3. S. 23-25.

2. Guidance material on aircraft emissions related to local air quality. Doc. 9884.

3. ICAO, 1st edition, 2007.

4. Nikiforov O. Golod as an alternative to biofuel. h ttp: //www.ng.ru/ng_ energiya / 2012-09-11 / 15_hunger.html

5. Protection of the environment. Volume 1. Aircraft Noise: Appendix 16 to the Convention on International Civil Aviation. ICAO Edition 3 July 2008

6. Protection of the environment. Volume 2. Aircraft engine emissions: Appendix 16 to the Convention on International Civil Aviation. ICAO Edition 5 July 2014

7. Popovicheva O.B., Old man A.M. Aviation soot aerosols: physicochemical properties and consequences of emission into the atmosphere // Izvestiya RAN. FAO. 2007. T 43, No. 2. S. 147-164.

8. Popovicheva O.B., Persiantseva N.M., Zubareva N.A., Shonia N.K., Starik A.M., Savelyev A.M. Soot aerosols in the upper troposphere: properties and consequences of aviation emissions. SINP MSU, 2005, 83 p.

9. Developments in civil aviation and the environment: working document of the 38th session of the ICAO Assembly - at www.icao.int.

10. Old man A.M., Favorsky A.N. Aviation and atmospheric processes // Actual problems of aviation and aerospace systems. 2015.Vol. 20, No. 1 (40). S. 1-20.

11. Khaletskiy Yu.D. ICAO: a new standard for the noise of civil aircraft // Engines. 2014. No. 2 (92). S. 8-11.

12. Airport Air Quality Manual. Doc9889. ICAO, First edition, 2011.

13. EU states tread warily on naming and shaming aircraft operators that have failed to comply with EU ETS rules. http://www.greenaironline.com/news.php?vi ewStory = 2021

14. ICAO Aircraft engine emission Databank. November 2016.

15. https: // www. easa.e uropa.eu/document- library / icao-aircraft-engine-emissions- databank

16. Lee D., Fahey D.W., Forster P.M. et al. Aviation and global climate change in 21 st cen- tury // Atm. Environ. 2009. Vol. 43. R. 3520- 3537.

17. Liu X., Penner J.E., Wang M. Influence of antropogenic and black carbon on upper tropospheric clouds in the NCAR CAM3 model coupled to the IMPACT global aeroso l model // J. Geophys. Res. 2009. Vol. 114. D03204.

18. doi: 10.1029 / 2009JD010492.

19. Olsen S.C., Brasseur G.P., Wuebbles DJ, Barret S.RH et al. Comparison of mod el estimates of the effects of aviation emissions on atmospheric ozone and methane // Geophys. Res. Let. 2013. Vol. 40. P. 6004-6009. doi: 10.1002 / 2013GL057660.

20. On Board. A sustainable future. En- vironmental Report. - ICAO, 2016.

21. The EU Emission Traiding System (EU ETS). - European Union, 2016.

22. Unger N . Global climate impact of civil aviation for standard and desulfurized jet fuel // Geoph. Res. Lett. 2011. Vol. 38. L20803. doi: 10.1029 / 2011GL049289.

Conclusions:

6. The complication of the structure of avionics and onboard equipment of modern aircraft, the transition to electronic flight manuals, the emergence of new TPAP - technical process analysis of flights, the emergence of a set of onboard safety systems led to a number of integrations of control panels to unload the flight crew.

7. There is a need for prompt use on board the aircraft means of control - language flight recorders, flight recorders flight data. There is a need to compare the production of onboard recorders of eastern and western production.

8. TPAP 's allowed to combine data on the parameters of piloting techniques by indication with modern on-board security systems, by introducing integrated electronic analyzers.

9. For the first time, one of the variants of new complex analyzers is proposed in the work, in which TPAP data and data of on-board recorders are operatively used (during the flight) for the crew.

10. The work is promising, because in the coming years communication with the Armed Forces will be digital (ICAO requirements)

References

- 1. Хохлов Є.М. Процесна концепція безпеки польотів // ВИНИТИ, Проблеми безпеки польотів,- Москва.- 1999.-№ 1. - С. 9-23.
- 2. Хохлов Є.М. Процесна концепція безпеки польотів, як формула світового наукового пріоритету і методологія захисту легкого експлуатанта // Проблеми безпеки польотів,- Москва: ВИНИТИ. - 1994. -№ 12. - С. 3-12.
- 3. Аль-Амморі Алі. Інформаційно-факторний спосіб розпізнавання небезпечних польотних ситуацій / Ин-т кібернетики ім. В.М.Глушкова. - Київ, 1997.-53 с.
- 4. Хохлов Є.М., Аль-Амморі Алі. Авторський процес ний підхід (авторський погляд на перше десятиріччя впровадження процесного підходу у глобальному масштабі 1995-2005 рр..). - Київ, 2006. - 174 с. - (авторське свідотство № 16117).
- 5. Хохлов Є.М. Пріорітетна науково-методологічна програма виходу на нульовий рівень аварійності по людському фактору (екіпажу) в глобальному авіатранспортному процесі. - Проблеми безпеки польотів.- Москва: ВИНИТИ. - 2000. -№ 1. - С. 16-26.
- 6. Хохлов Є.М., Аль-Амморі Алі, Грищенко Ю.В., Шкурко Е.П. Процесна концепція виробництва польотів і її фундаментальне значення для розвитку авіації СНГ. - Проблеми безпеки польотів,- Москва: ВИНИТИ. - 2001. -№ 6. - С. 6-9.
- 7. Аль-Амморі Алі. Передумови розвитку інформаційно-факторного аналізу при експлуатацеї нової техніки // Засоби управління охороною праці і навколишньої середи на підприємствах ГА. - Київ: КИИГА, 1991. - С. 21-27.
- 8. Аль-Амморі Алі. Інформаційно-факторний аналіз появи перших моментів небезпечних польотних ситуацій по даним перспективних бортових сигналізаторів // Проблеми безпеки польотів. - Москва: ВИНИТИ. -2006. - № 9. - с.39-50.
- 9. Настанова по виробництву польотів у цивільній авіації СРСР (НПП ГА -85). - Москва.: Повітряний транспорт, 1985.- 254 с.

- 10. DBN B.2.2-28: 2010. [Electronic resource]: DBN B.2.2-28: 2010. Access mode: http://document.ua/budinki-i-sporudi.-budinki-administrativnogo-ta-pobutovogop- nor19583.html Access date: 10.04.2015.
- 11. About the minimum safety requirements when working with display equipment [Electronic resource]: 90/270 / EEC. - Valid from 1990-05-29. - Brussels.: Council of the European Communities, 1990. - URL: http://docs.pravo.ru/document/view/32704903/. - (Directive; International Document) "Hygienic classification of labor according to the indicators of harmfulness and danger of factors of the production environment, the difficulty and intensity of the labor process." Order of the Ministry of Health of Ukraine of April 8, 2014 N 248– . [Electronic resource] : - Access mode : http://golovbukh.ua/regulations/2340/2592/2593/332659/ - Access date: 20.04.2015.
- 12."Hygienic classification of labor according to the indicators of harmfulness and danger of factors of the production environment, the difficulty and intensity of the labor process." Order of the Ministry of Health of Ukraine of April 8, 2014 N 248– . [Electronic resource] : - Access mode : http://golovbukh.ua/regulations/2340/2592/2593/332659/ -Access date: 20.04.2015.
- 13."State building codes. Natural and artificial lighting ". DBN B 2.5.28- 2006. [Electronic resource]: DBN B 2.5.28-2006. - Access mode: http://www.info-build.com.ua/normativ/detail.php?ID=45079 . - Access date: 25.04.2015.
- 14."State sanitary norms of microclimate of industrial premises". LTO 3.3.6.042-99. [Electronic resource]: LTO 3.3.6.042-99.– Access mode: http://mozdocs.kiev.ua/view.php?id=1972 . - Access date: 1.05.2015.
- 15.“Sanitary norms production noise, ultrasound and infrasound. LTO 3.3.6.037-99. [Electronic resource]: LTO 3.3.6.037-99. - Mode

of access : http://document.ua/sanitarni-normi-virobnichogo-shumu-ultrazvuku-ta-infrazvuku- nor4878.html - Date of access: 7.05.201

- 16. Керівництво по управлінню безпеки польотів (ІКАО), 2006. Doc 9859 AN/460, 364