METHODS AND FACILITIES TO BE USED TO EVALUATE THE AIRCRAFT FLIGHT AND NAVIGATION EQUIPMENT IN FLIGHT TESTS

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Abstract

The Flight Vehicle (FV) flight tests costs are the major part of all capital expenditures to create it. They are possible to be reduced due to transfer of data, based on which the decision-making may be made for engineering performance definition, tested aircraft to declared requirements conformity, from the flight tests to the mathematical and HIL (Hardware-in-the-Loop) simulating estimation. When taking in consideration that the pilot aircraft batch manufacture costs constitute the major part of tests costs, the number of items in pilot aircraft batch depends, in its turn, upon the number of flight tests, conditioned by the given flight tests termination date the part of the tasks redistribution from flight tests to ground investigation allows reducing the number of flight tests and increasing the flight tests safety. The airborne equipment flight development tests are to be considered as the most hang-the-expense and unreasonable. The installation of under debugged equipment samples in test aircraft is not capable to provide the required flight tests approval and safety.

1 Methods and means

The technology of flight researches and tests of systems and complexes flight and navigation equipment (FNE) is under construction on modern tests facilities created in FRI of M.M.Gromov, on the basis of information, satellite and computer technologies: onboard trajectory measurement complex (OTMC) and its component - mobile base control station (MBCS), a stend-modelling complex, the local computer network of post processing and the analysis of materials of flight tests with use of unique program complexes of complex processing of the information, the statistical and spectral analysis of processes of measurements and errors of measurements, calculations of correlation functions, laws of distribution, frequency characteristics, identifications of measurements errors mathematical models.
Program complexes provide the analysis of navigation systems errors characteristics – inertial, Doppler, radio engineering near and far navigation, satellite, etc.; formation and delivery of the valid values of co-ordinates of a site, components of speed (in any system of co-ordinates), a course, a list and angle of attack:

- On all extent of flight from launch till landing,
- At any evolutions of object,
- Irrespective of meteoconditions,
- Without delay and dynamic errors.

1.1 OTMC – registration and definition facility of trajectory parameters in flight tests.

The onboard trajectory measurement complex is the multipurpose device intended for an

estimation of flying vehicles (FV) characteristics and their equipment during flight tests by definition of reference values of trajectory parameters of movement, synchronization of these parameters in rate of flight with estimated parameters and estimations of flight vehicle and onboard equipment characteristics.
OTMC forms trajectory measurements system in a combination with land control correcting station of satellite navigating systems GLONASS and GPS.
Complex OTMC includes: the onboard easily removable block (OERB) with the aerial and cable SNS, the control and management block (CMB) on the basis of portable notebook, land equipment (base control-correcting station (BCCS) or MBCS), program-mathematical maintenance (PMM).
Trajectory parameters in OTMC are formed on the basis of differential mode SNS and complex processing of SNS and INS information. Accuracy characteristics OTMC: in a code mode on co-ordinates 3-5м, to speeds of 0.1 km/s, a course 5 angl.min. with synchronization of parameters 0.003c, in a phase mode on co-ordinates 0.7м, to speeds 0.005m/with, a course 5 angl.min. with synchronization 0.001c.
OTMC is widely introduced in practice of flight tests of modern skilled flying vehicles and their flight and navigation equipment [1].
At carrying out of flight tests in a zone of test airdrome the base control-correcting station (BCCS) which aerial of receiver SNS takes place in a point with known geodetic co-ordinates is established. In post flight processing under the data which has been saved up in flight in OTMC from built in payment SNS, and data of BCCS high-precision values of parameters of differential mode SNS on code and phase measurements [2] are formed. The values of trajectory parameters accepted at estimation of onboard flight-navigating systems for valid, are calculated also with demanded frequency by means of complex processing of the information of SNS differential mode and onboard INS which information is registered in OTMC. The scheme of application of equipment OTMC in flight tests is presented on fig. 1.
Thus MBCS as the mobile stand is also used for checking of the flying vehicles onboard equipment in land conditions [3].
Specialized methodical and program-mathematical maintenance is developed for estimation of each system. The results of processing on each system arrive from experts workplaces on the server, are discussed with the head of works and after the statement are brought in accounting documents. The general scheme of processing of materials of FNE flight tests of flying vehicles is presented on fig. 2.

1.2 Mathematical modeling

For modeling introduction creation of mathematical models with high degree of reliability is necessary, leaning on which it would be possible to state an estimation to a complex of the flight-navigating equipment as a whole. First of all it is necessary to create adequate models of gauges of the primary physical information since further in system purely mathematical operations within the limits of FNE software are made. Such approach will allow to have already before the beginning of flight tests the almost necessary information on FNE work, and each flight experiment will be spent only with a view of specification of already available data. The optimum combination of modeling and flight experiment allows to pass to essentially new kinds of FNE tests, namely digital-natural.

1.3 Technologies of FNE flight tests with application of OTMC

It is possible to present the general structure of technology of FNE tests in the form of the scheme where the order of operations and their maintenance for an estimation of FNE characteristics is set. According to this scheme process of characteristics estimation includes a number of operations:

- Methodical preparation.
- Land tests.
- Preflight modeling.
- The factorial analysis.
- Flight tests.

- Primary and secondary processing of the flight information.
- Formation of entrance signals models.
- Post flight modeling.
- Statistical modelling.
- Estimation of FNE characteristics distribution density parameters
- Interpolation of FNE characteristics distribution density parameters estimations.
- Estimation of reliability of modeling results.
- Definition of conformity of the received estimations of FNE characteristics to requirements.

Thus, the work cycle of tests and checking of FV flight-navigating equipment with application of OTMC can be presented as on fig. 3.
Such technique of tests allows essentially (in 5... 10 times) reduce the number of flight tests at preservation of results reliability as statistical estimation of TTC can be received in one flight and even for one calling. Thus, FNE digit-natural test method allows to provide demanded increase in efficiency of tests, decrease in number of flight tests, terms and cost of tests at simultaneous increase in reliability of FNE efficiency estimations.

2. Results of FNE research

As an example of the developed methods, means and technologies of FNE flight tests efficiency the assessment of the inertial channel of platform less inertial small-sized system BIMS works is resulted at performance of plane flight IL-96-300 on a route Moscow - Petropavlovsk-Kamchatsky a Fig. 4. In the course of flight tests all the necessary parameters for the analysis of FNE characteristics have been registered, defined reference trajectory parameters on all line of flight. All information is synchronized on time with accuracy not more low 3мс. Complex processing of the information of various systems FNE, the statistical analysis of processes of measurements are executed. By results of the executed researches for BIMS errors of measurements have been divided into components, their estimations are received and the occurrence reasons are established. The received results characterizes system BIMS as exact enough navigating system for its application on modern FV, apparently from fig. 4. All cycle of researches is executed in a current 24h after flight.

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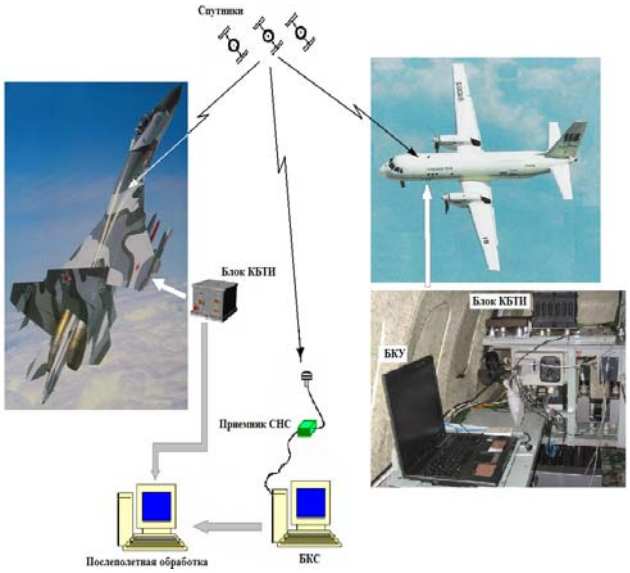

Fig. 1. The scheme of application of equipment КБТИ in flight tests. БКУ – the control and management block executed on the basis of the laptop.

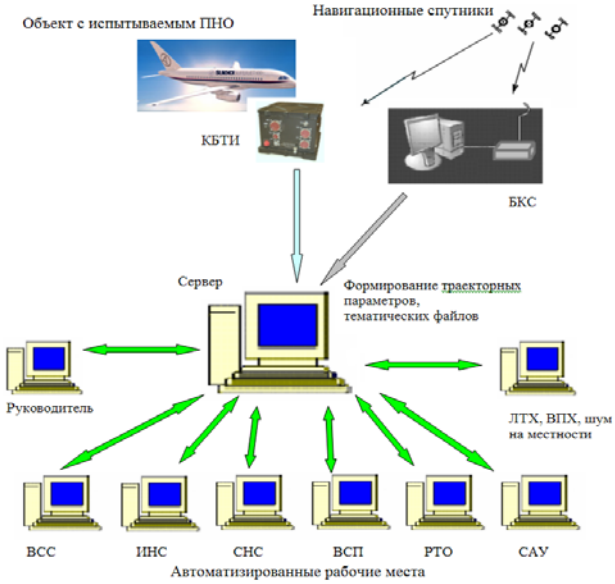

Fig. 2 Scheme послеполетной processings of materials of tests.
ЛТХ – flight-technical characteristics;
ВПХ – runway characteristics;
ВСС – the computing system самолетовождения;
ВСП – air-speed parameters;
РТО – the radio-technical equipment;
САУ – automatic control system

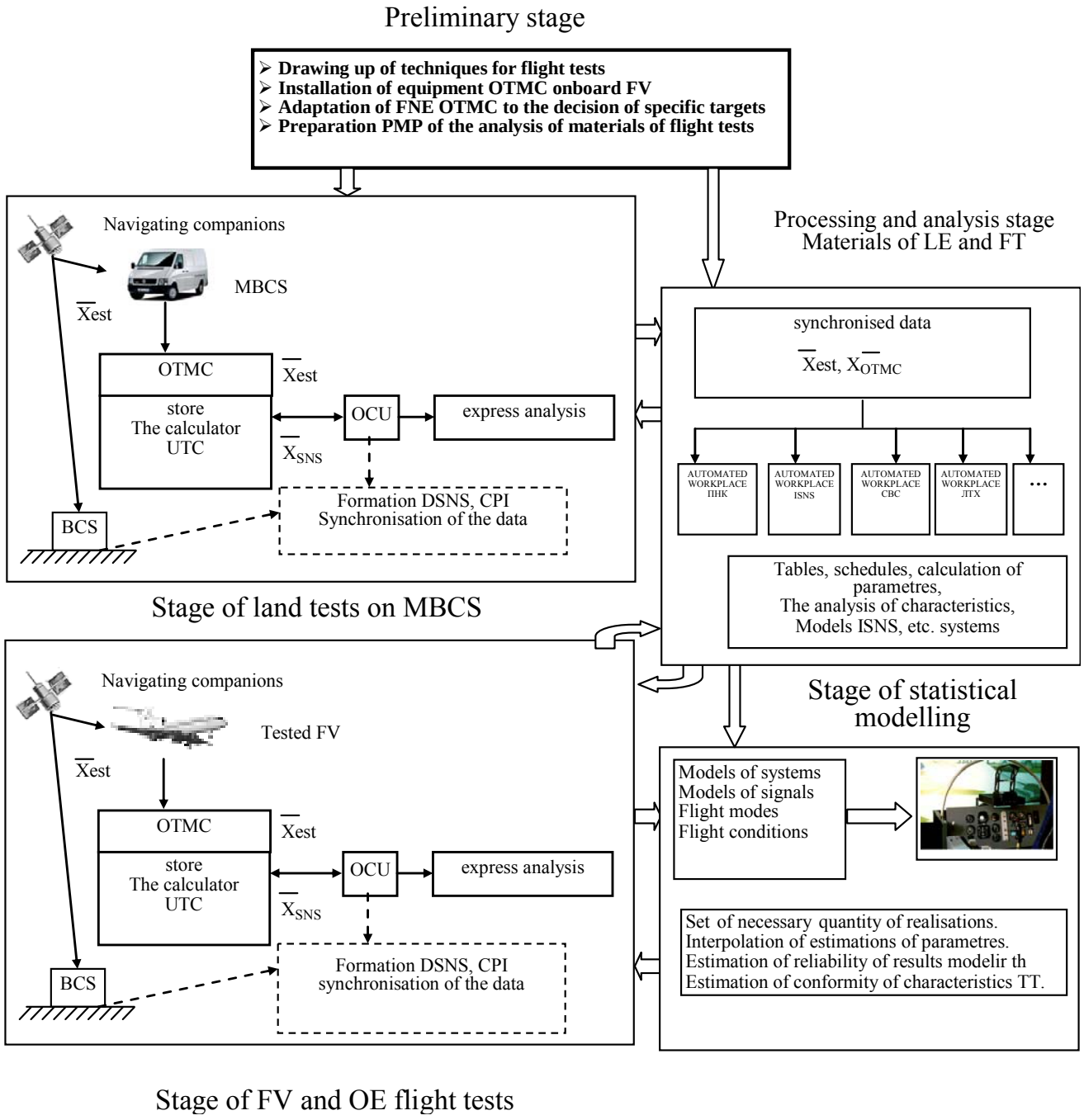

Fig. 3. The Work cycle of FNE tests and checking with application of OTMC.

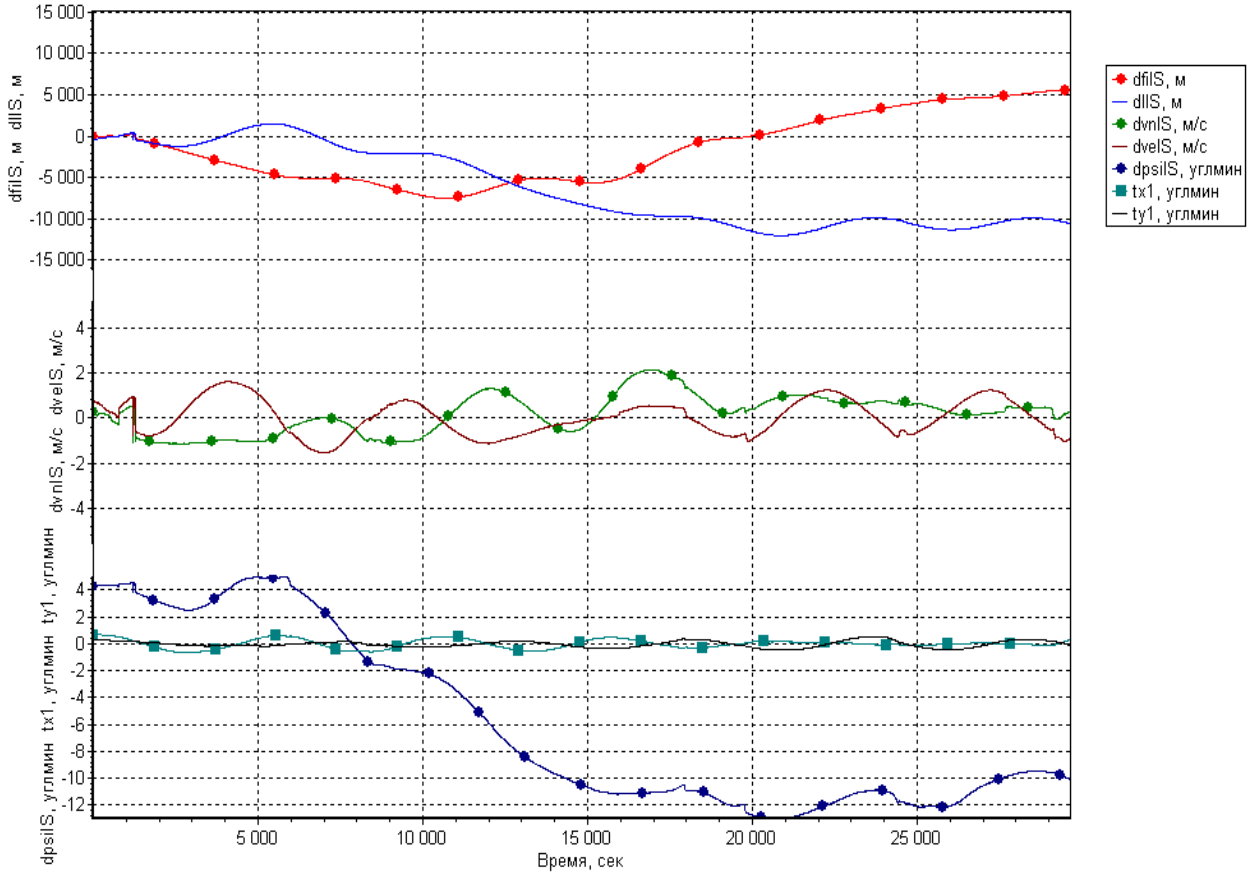

Fig. 4. System BIMS. IL-96-300. Moscow - Petropavlovsk-Kamchatsky weeds
Errors on co-ordinates (dfi, dla), to components of speed (dvn, dve), to a true course (dpsi), verticals (tx1, ty1)