Using calculated-logical systems (CLS) to raise the effectiveness of the remote control of automatic space vehicles (SV)

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Abstract: **-** In this article is investigating a problem of CLS building application of it during taking decision process during the remote control of SV (space vehicle). CLS is based on the periodic accumulation of knowledge about flight information of SV and on elements using of intellectual searching.

There are following principles in the base of CLS projecting:

- The apportionment of hierarchical stages of TMP to make the operative diagnostics of onboard systems′ capacity for work;
- The working out of logical connections between control influences and the prognosis of SV onboard systems′ condition;
- The automated working out recommendations of taking decisions to take SV in different conditions.

CLS functions in two conditions: the tuning condition using during the preparing stage of SV for control and the operative condition using during control process.

Using of CLS allows making the monitoring of onboard systems, to make prognosis onboard systems′ capacity for work for the following period of time and to work out future control programs.

There are described examples of CLS using during the operative control process of SV. Given the inference about the existence of a big reserve of reliability and energy in getting things done during the remote control when an irregular situation is string up.

Key – words: - Taking decision, operative control, irregular situations, calculated-logical systems (CLS) and accumulation of knowledge.

1. Introduction.

The most important problem during the remote control of SV (space vehicle) is making both of exact and operative decision to have an influence on onboard systems, especially when an unregular situation is spring up. A wrong decision or a delayed decision may disrupt the mission plan or in certain causes it can be more serious negative consequences.

To make a correct decision the controlling personnel must operatively estimate onboard systems condition, which include grate number of telemetry parameters (TMP). Also the controlling personnel have to define exact sequence of commanding influence on SV and make sure, that the commands have been fulfilled during communication session. This problem is sufficient difficult because of rigid temporal limitations.

During taking a decision it seems to be very prospective to use elements of an intellectual searching and to create CLS which are based themselves upon periodic knowledge accumulation of the SV′s flight information.

In this work we discuss the example CLS using during the remote control of the SV when an unregular situation is string up.

2. Principles of CLS construction.

The main purpose of CLS is organization of automatized cycle of giving recommendations do make solutions during the remote control of SV. On the basis of analysis of telemetry parameters’ values it should secure the active decision of following questions:

- There is a logical interpretation of data it means that the sense of TMP gotten is defined;
- The diagnostics of systems condition is done it means that there is established availability (absence) of onboard systems' elements which were out of order;
- The systems are monitored it means that previous questions are decided in real time;
- The prognosis of onboard systems is done for the next period of time;
- The SV's onboard systems controlling is planed for the next period of time.

Let's describe the sequence of CLS stages making.

At the first stage the data base of CLS is formed on the basis of documentation worked out. Names of TMP, TMP's logical sense, rated values, permissible upper and lower limits are carried in data base of CLS. It makes possible to carry out automatized interpretation and diagnostics of SV's onboard systems in a time fixed. It should be noted that the normal condition of onboard systems is characterized by different sets of TMP's values for different rates of the SV working which are defined by temporal programs of control (TPC). So the set of nominal limited values of TMP depending on all of possible sets of the SV's work is put in to the CLS data base (DB) to estimate the SV's work. On the basis of TPC U(t) it makes possible to define the dependence of normal TMP's values by the time and to make the monitoring of onboard systems by the way of these dependences comparing against the real telemetry data. On the basis of monitor's results forming recommendations in the DB fro the control operator to give (not to give) orders to make correcting outward influences.

The next stage of CLS's DB building is consisting in logical accordance forming between command influences given and conditions of onboard systems. It makes possible to choose recommendations for the control operator to give SV correcting outward if it needs them to put onboard systems in a normal condition when the unregular situation is string up.

So CLS functions in two rates:

1. The turning rate is used during the stage of SV preparing for control. On the basis of TPC U(t) given to the SV it defines dependences of all TMP CLS DB and their permissible values from the time. These dependences TMP*s*(t) are standard and define normal condition of capacity for work of onboard systems.
2. The efficient rate is used in the control process of SV. Standard dependences gotten should be compared with real data TMP*r*(t) gotten from the SV. There are messages about availability (absence) of convergences between standard and real dependences. On the basis of this recommendations for outward influences are forked out.

3. Forming hierarchical groups of TMP gotten.

Let's pick out main five hierarchical groups of TMP analyzed.

These groups are classified by the next situations when TMP are out of permissible limits.

1. The condition of onboard systems can not derange the mission plan. For example some rise or fall temperature in some blocks. Double TMP are bearing on this group too it means that the system condition can be tested without taking into account values of these parameters. For example condition of some units can be tasted by values of current, tension and capacity. We can judge by one of these TMP about availability of the signal in the unit.
2. Separate fragments flight program don't work. But it doesn't bring whole program to disruption of work. For example we are going to conduct redundant fulfillment rates "Time check" during connection with SV to estimate accordance between surface and onboard scales of the time. If two or three of five rates are done then we can consider that the information gotten is enough to get reliable estimate.
3. Faultinesses of some units lead to lowering of onboard systems' work effectiveness but not to disruption of mission plan. For example when the come out capacity of the transmitter is coming down the purpose

information may have low of quality in a condition of partial distortions.

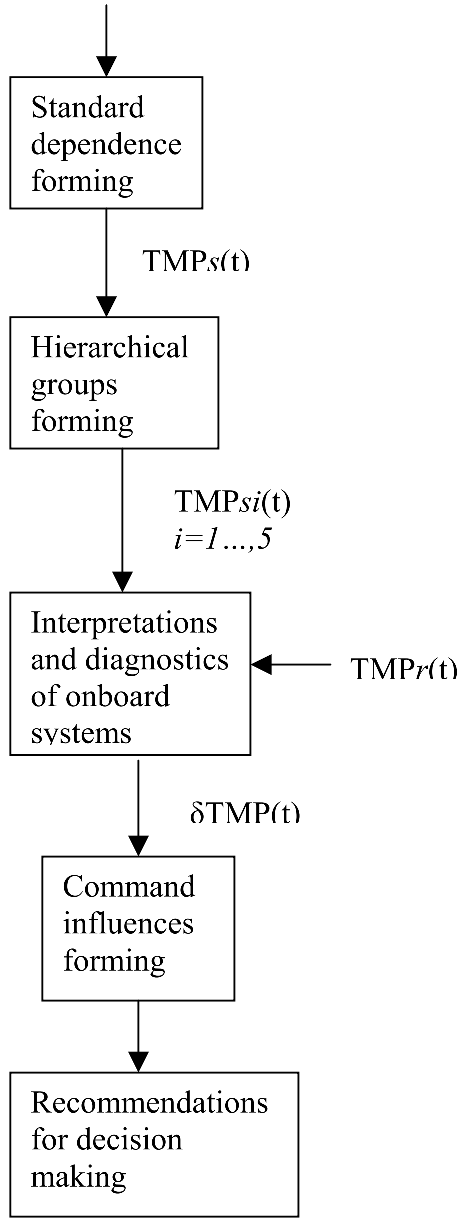
4. Faultinesses gotten lead to disruption of some systems but not to disruption of SV's work. For example disruption of meteorological system can't lead to disruption of other systems.

5. The faultiness of systems can lead to disruption of flight program and to partial or total disruption of the SV's capacity for work. For example loosing orientation of SV, discharge of the chemical battery and another.

In tab. 1 we can see the main descriptions of every of TMP groups and recommendations for the control operator:

№	The interpretation of the situation	The essence of the TMP analysis	Recommendations for the control operator
1	TMP with low information	Statistics setting, appropriateness searching	It doesn't need any orders
2	Diagnostics of some onboard systems' units work	Statistics setting, causes of disrepair searching	To give orders to SV if it needs to
3	Diagnostics of the quality of program implementation	Checking up the correctness of the control program forming	Correcting the remote control program, changing system's complete sets
4	Diagnostics of all onboard systems	Causes of disrepair efficient searching	It needs to make a decision during the connection with SV
5	Diagnostics of SV systems	Causes of disrepair efficient searching, making decision immediately	It needs to make a decision of single command giving

So there is the scheme of CLS functioning:



4. CLS using during the remote control when an unregular situation is string up.

At the preparing stage of SV's flight it's forming CLS on the basis of regular documentations and using CLS in identify conditions of SV control. At the same time using CLS can give a good effect during the removal of unregular situations. These situations should be analyzed in detail for it; to make an identification of just gotten conditions of SV; to work out new logical algorithms which tie together these conditions with necessary corrective control influences. Then new algorithms of the identification, diagnostics of the SV condition and

recommendations to form correcting orders are added in to CLS.
So the information of CLS is growing new logical functions are appearing and CLS's possibility during the remote control of the SV is becoming wider.

For example during the controlling process of Russian – Uralian SV "Ocean – O" the regular scheme of engine – flywheel relieving in the pitch channel found oneself ineffective during a magnetic storm arising. The atmospheric density is changed in these cases and there was a large disturbing moment in a pitch channel. There was made kinetic moment of opposite token with the help of engine – flywheel rotation for the disturbing moment compensation. However, in connection with bad effecting of magnetic unloading contour work, kinetic moment has a maximum value and then didn't cancel the disturbing moment. This might be lost both of orientation SV and flight program.

Was offered a new scheme of engine – flywheel unloading for orientation of the "Ocean – O". It's basic on periodic corrections of solar batteries (SB) for creation an aerodynamic and a gravitational moments combinations on a pitch channel, which compensatory a disturbing moment. It was required both of really and fast calculation of necessary attitude angle SB value and the programs of their improvement and the command formations and their uplink in communication sessions which duration is not more then 10 minutes. This problem was very difficult even for the very good experts. For its creating there was make an automated work cycle of decision making in multivariate problem. The content of this objects function are:

1. Maintenance of SV orientation;
2. Maintenance of a required power balance;
3. Fulfillments of the given mission plan;

The solution of these problems has a very compromise character. So, the fulfillment of the third problem is making on the necessary energy consumption mode, that possible on some SB values angle rotate. However, for some values these angles are impossible to make the necessary attitude of the SV. Then the first problem must be decided with corrections of the mission plan.
To organize the logical cycle of decision making to remove unregular situations the next algorithm was worked out. There was picked out TMP using in this algorithm which are in group 5 (see tab. 1):

- V*z* is value of a kinetic moment in a pitch channel (limiting value Vz is ± 20 Hms)
- APP is angle pitch of the panel of SB. It's counted down against clock pointer from the condition of air flow parallel running. So if APP = 0 then aerodynamical moment in a pitch channel is min. but if APP = 90º then aerodynamical moment in a pitch channel is max.

In every connection seance analyzing value of V*z* and quality of it's changing in the period from last turn *n* to current tern *m*.:

$$\Delta Vz = \frac{Vz_n - Vz_m}{n-m};$$

The delivery of recommendations about SB's turn was made with implementation of next conditions:

- Rotation of the engine-flywheel in a pitch channel grown up relative to rated condition:

$|Vz| \geq 0{,}6$Hms;

- Velocity of the rotation changing is high:

$\Delta Vz \geq 0.8$ Hms/orb;

There is the formula to do the calculation of angle changing of SB:
ΔAPP = 20 sing (ΔV*z*);
There is a time of the SB's turn:
$\Delta t = \frac{\Delta APP}{V}$, where V is a velocity of the SB's turn.

With this CLS forms recommendation to give single command (SC) to make left or right turn of SB but in a time Δt to give SC to stop SB's movements.

This recommendation is successful if SV has enough power to implement the flying mission:
W*rec*(p) < W*real* (APP, T∑), (1)
Where W*rec* is required power for SV which includes the work *i* of onboard systems during the time the time *ti*; W*real* is the quantity of

power when the angle of the SB's pitch = APP during all the time of the flight mission.

W*rec* and W*real* are calculated on the basis of the documentation of the General constructor. If W*rec* > W*real* then the program of flight mission changes to the side power giving diminution till the condition (1) is done.

There is the functional scheme of the recommendation delivery cycle to make decisions (fig. 2).

Using of foregoing algorithm allowed to secure the competent flight of SV "Ocean-O" to implement successfully the program of scientific experiments during 2,5 years.

5. Inference

The practice of the remote control of SV ("Ocean-O", "Meteor-3M") showed high effectiveness of CLS using both in regular and in irregular situation. Inculcation of additional algorithms allows to increase the information knowledge base of CLS and to raise energy in getting things done and the reliability of irregular situation removal. Later on we are going to use CLS during the remote control of any automatic SV if it's elaborated with taking into account the specific of onboard systems' work.

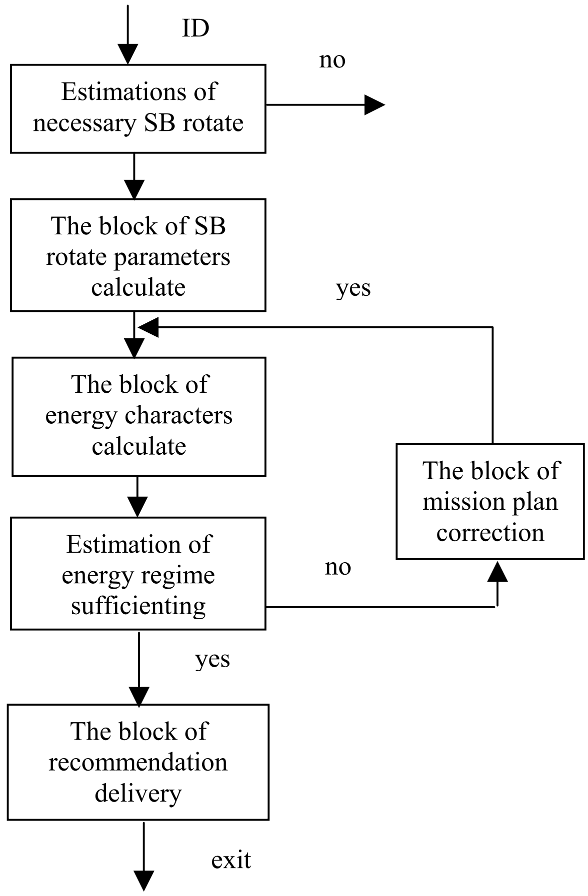


Fig.2.
The functional scheme of the technological cycle.

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