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Method of automated telecommand based on condition modules

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Abstract

Command is a key part of spacecraft TT&C(Tracking, Telemetry and Command)and management and its main task is control of spacecraft operation or platform management. This paper presents an automated command method for reliable command operation based on condition modules , establishes the process of command route to minimize risks of errors in implementation of command operation for in-orbit management of spacecraft. The method effectively lowers management risks and increases spacecraft TT&C implementation efficiency and automation level. The technical approach is of high significance to increase of automated and refined spacecraft management.

Keywords

Tracking, Telemetry and Command; condition modules; automated telecommand; safety operation strategy.

1. Introduction

After the satellite successfully enters the orbit, the ground control system and application system need to continuously measure, monitor, and control it until the satellite completes its scheduled mission or runs to the end of its life. In the various satellite monitoring and control management activities, remote control is an effective method for the ground control system to implement platform and load management[1]. With the vigorous development of the aerospace, the application of satellites in our country has evolved from a single model and single mission to a multi-model, multi-mission, and large-scale direction. The number of satellites in orbit is increasing, the number of uplink measurement and control events is more frequent. Relatively concentrated situation, which makes management more difficult. In order to scientifically avoid the risk of uplink remote control, improve the efficiency of satellite measurement and control, it is a necessary and significant work to design a method to realize the automatic, safe and reliable operation of uplink tasks during the long-term management period[2].

At present, in the long-term management stage, the shortcomings of the remote-control operations on satellites are mainly manifested in: 1) Low degree of automation. The entire task implementation process requires manual participation, which resulting in poor remote control uplink security. This not only greatly reduces management efficiency, but also increased operational risks; 2) Lack of mission performance evaluation information. It is difficulty to adapt to the remote-control requirements of large-scale on-orbit satellite management. In order to solve the above problems and meet the requirements of automatic remote control for cross-platform multi-satellite management, this paper proposes an implementation method for the automatic safe and reliable operation of remote-control operations based on the characteristics of satellite uplink tasks.

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2. Uplink command characteristics

The satellite's orbital characteristics determine the complexity of its uplink remote control, so there are correspondingly more requirements for the design of remote-control operations[3][4]. The main features of the uplink mission are specifically manifested in:

1) Uplink command is frequent and restrictive conditions are complicated.

Among the many uplink measurement and control events, the more common ones are: orbit data injection in attitude control, satellite transponder on/off schedule injection, payload on/off data injection for payload management type users, satellite clock correction data injection, data management type of regular command chain for entry/exit, and handling of abnormal satellites, etc. In addition, due to different satellite manufacturing departments, each platform satellite has different designs in terms of structure, data management, etc., and it is impossible to enumerate all the various uplink measurement and control events that need to be carried out during the orbit management.

Uplink remote control restrictive conditions are complicated, mainly in that there are restrictive conditions and different when certain commands are sent or data injected, and even different types of satellites have different restrictions to the same type of data. For example, some satellites require that orbit data cannot be injected during side swing; some require that certain types of data or instructions cannot be sent when the payload is working; some require that certain values appear before the inbound/outbound instruction chain is sent. The measurement and control require that if the obscuration angle and high elevation angle are over the top, the uplink remote control should be avoided, because the antenna has a blind zone, and so on. These restrictions bring great risks to the implementation of remote uplink operations[5].

2) The time and content of the uplink command event are not fixed.

According to the management requirements of the platform and payload, satellite uplink control events are often unable to be fixed in time, which leads to different uplink events scheduled for each lap in the orbit management. Such as: periodic reset operation, memory data download, delayed telemetry data playback, satellite time management, and the other uplink events.

3) The measurable control time is short.

The measurable and controllable arc of a low-orbit satellite is relatively short, generally about 10 min. Therefore, after the uplink remote control command conditions are met, it is necessary to complete the transmission of various uplink remote control data and the outbound command chain. At the same time, if the established remote-control task cannot be completed, the outbound command chain must be sent in time..

3. Automatic operation of satellite remote control operations

3.1. Planning order mode

Through the automatic process of scheduled commanding operation in the flight control operation platform, the command sequence can be automatically generated, checked, and replaced. It can realize command sending, execution result comparison. When the command sequence needs to be replaced, the flight control operation schedule is automatically complete the inspection and replacement of the sequence. This process has a human-computer interaction interface, and manual intervention can be carried out if necessary. The specific process is as follows:

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First, the implementation-level planning system generates various plans based on flight control requirements and control conditions, clarifying related elements such as the command name, the command time, and the command direction.

Secondly, the flight control job dispatcher reads the control network tracking plan, command plan, etc., and the dispatch the control platform automatically generates the command sequence and completes the sequence check.

Finally, the remote control platform automatically completes the sequence transmission according to the command order, and completes the comparison and judgment of the command result..

3.2. Manual command mode

The manual command mode is the process in which the operator sends instructions (chain) to the target spacecraft through the control operating platform according to the dispatch password. The manual command can be a single command or injected data, or a series of commands (injected data) with a fixed sequence and logical relationship. By establishing a characteristic point time constraint with the first command, after the first manual command is issued, the time compliance instruction is automatically executed in accordance with the time constraint relationship with the manual instruction. The manual command mode has the following characteristics:

(1) Real-time performance, and it is generally used when supplementary issuance, temporary issuance, and the emergency disposal are required.

(2) Priority is higher than other commanding modes. If it conflicts with other commanding modes, the central commanding software will give priority to the commands issued manually.

(3) The ordering route can be manually specified, and the priority is higher than the auto-optimizing ordering route.

4. Analysis of remote operation function modules based on modularization ideas

4.1. Judging whether there is an uplink data function module

After the remote control operation is started, the required parameters and variables are initialized, and then it is automatically judged whether there is uplink data for the current measurement and control circle. If there is, all the injected data types and commands must be covered and prompted; if not, the operation will automatically exit.

4.2. Judging the on-board transponder lock state function module.

Automatically judge the lock state of the on-board transponder. Only when the transponder is locked properly can the follow-up work be started. This is a prerequisite for ensuring the uplink work; otherwise, the operation cycle judges whether the transponder is locked. If it is still not locked after a period of time, it will start to alarm to indicate that no target has been found, so as to remind the management staff to know whether such a situation really occurs or to handle abnormalities in time.

4.3. Judging satellite health status function module

Automatically judge the operating status of the satellite's key sub-systems. Only when the key parameters of the key sub-systems are normal and the satellite is in good health can continue to operate; otherwise, it will prompt the satellite to operate abnormally and enter the relevant abnormal handling stage (such as authorized fault handling).

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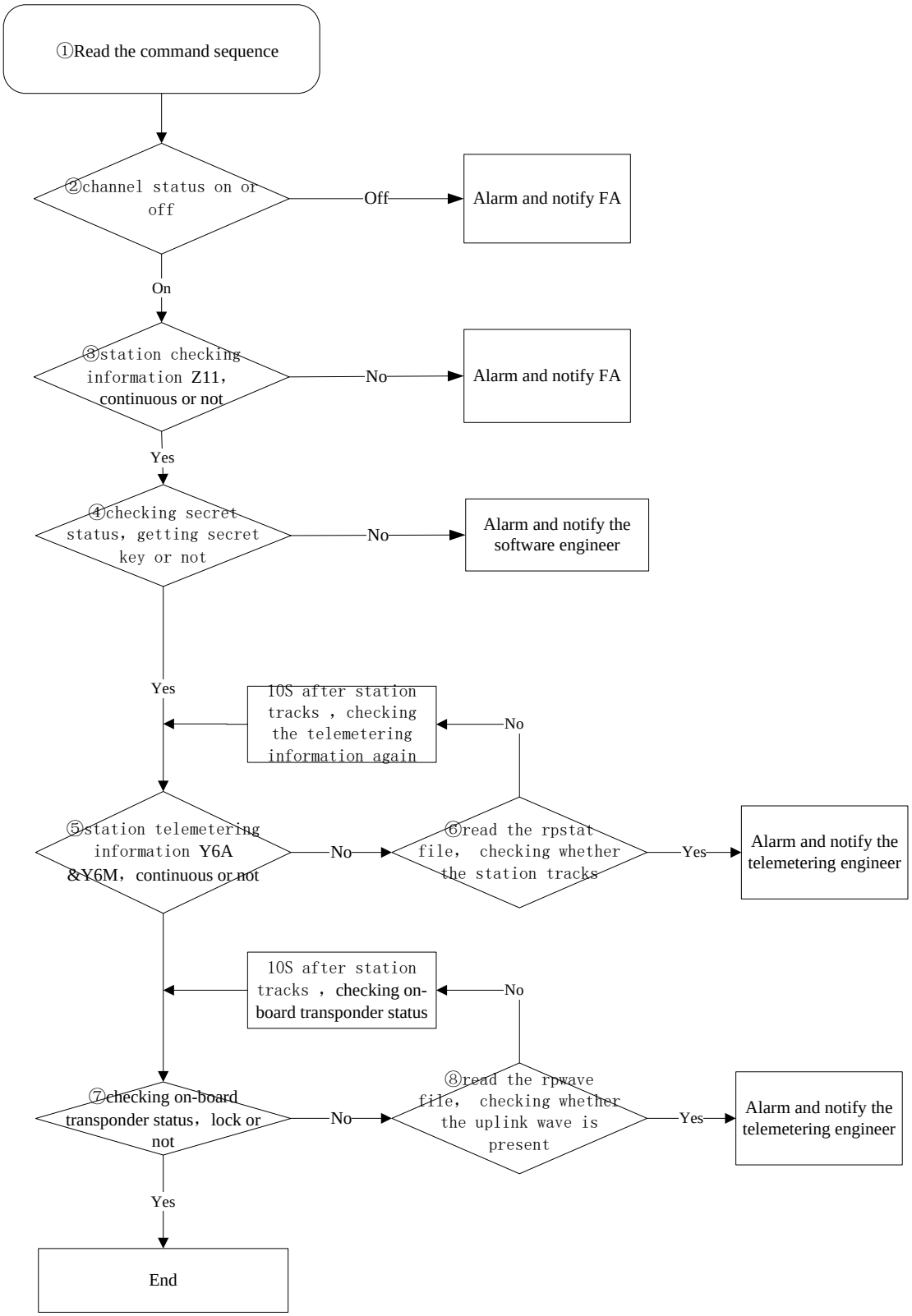

Figure 1: Process of automated uplink control inspection

4.4. Judging satellite command secret state function module

Taking into account the different importance of satellite applications, some satellite remote control does not require encryption, while some satellite remote control requires encryption. This function module automatically judges the secret state of the satellite command according to the telemetry information, and sets the state of whether the remote control is encrypted or

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not. The basic module implementation only needs to modify the telemetry parameters adaptively and assign a value to the remote control encryption flag.

4.5. Judging the remote control start condition function module

Automatically determine whether the measurement and control equipment is sending angle measurement data or whether the angle measurement data is valid. If there is no elevation angle data, the remote control operation cannot run smoothly. At this time, a voice alarm prompt will be issued. To ensure that the two-way capture is completed and the remote measurement is stable, the remote uplink must be in the ascending section and the elevation angle is greater than 5° (if elevation angle of the station is greater than 5°, the masking angle value will be automatically assigned), and in the descent section the elevation angle is less than at 5° (If the elevation angle out of the station is greater than 5°, the shielding angle value will be automatically assigned). The remote uplink must be stopped; in addition, the remote uplink must also consider the antenna high elevation angle over the top to ensure the safe, reliable and normal execution of uplink remote control data or instructions.

4.6. Judging of non-refillable data function module

The function module of command injection and result judgment has added judgment on non-refillable data blocks. In the actual measurement and control process, when the station is tracking satellites, the transponder will occasionally lock up due to interference from various factors, or there will be telemetry flashing, error codes, etc. due to transmission problems, which will lead to data injection failures. The telemetry criterion shows that the data has not been implemented. For some satellite require that the data block is not allowed to be refilled, the operation will be automatically judged and processed.

The automated uplink control inspection process is shown in Figure 1.

5. Conclusion

The satellite automatic command operation can quickly and efficiently complete the satellite control task, effectively solving the complicated uplink remote control restrictive conditions in daily management, the unfixed time and content of the uplink control event, and the execution effect cannot be evaluated. The problems that require manual interpretation and processing are greatly reduced. The labor intensity of the on-duty personnel relieves the pressure on the on-duty personnel; reduces the risk of uplink remote control operations and ensures the safe and reliable operation of satellites in orbit; and lays a solid foundation for long-term spacecraft management.

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