THE DYNAMIC TEST EQUIPMENT FOR THE STAR TRACKERS PROCESSING

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ABSTRACT

The Space Research Institute of the Russian Academy of Sciences has been developing the star trackers for the spacecraft attitude determination during the last 20 years. The sensors abbreviated to BOKZ and BOKZ-M, have operated onto the various spacecrafts and satellites.

To carry out the star trackers tests in laboratory environment the testing facilities is demanded. Of course, the star trackers processing can be fulfilled at real environment by using the starry sky, but this way has a lot of inconveniences, for example, in this case we depend on the weather conditions, etc. Efficiency improvement of onground testing procedures can be achieved by creating of special test facilities. This kind of facilities should simulate the base factors of space, which can influence on the star trackers' functioning. The specialists of the Space Research Institute have developed the Dynamic Test Equipment (DTE) – the laboratory complex for the onground star trackers processing.

The DTE's structure and principles of operation are considered in this paper.

1. INTRODUCTION

The DTE is a laboratory hardware designed to simulate the light and optics conditions similar to the star tracker's operation conditions in space. The main tasks solved using the equipment are onground star tracker processing, including performance check and the software debugging.

The Dynamic Test Equipment allows carrying out the tests of star trackers with a circular field of view capable to register stars with a magnitude of up to +8 within the spectral band of 0.5–0.8 μm.

During the last 4 years the star trackers BOKZ were processing onto the DTE. A comparison of the data, obtained from the sensors tested on the DTE and the data, collected from the star trackers, which operated in space, and from the star trackers processed on real starry sky during their onground tests have shown their good correlation. That let us carry out the most of the star trackers's debug procedures by using the DTE and fulfill the star trackers' processing on real starry sky for acceptance tests only.

2. THE DTE's CONFIGURATION

The DTE (fig. 1) consists of the following parts: an LCD monitor, a light protection casing, a collimator, a rail with riders, a bench, a personal computer with the special software, an adapter for fastening the tested star tracker.

The Dynamic Test Equipment provides orientation parameters determination for the axes of the star tracker's coordinate system relative to the axes of the inertial coordinate system simulated on the LCD monitor. For the star trackers processing the DTE simulates quasi-real conditions of their operation in space. To achieve that the DTE imitates *brightness characteristics of stars and the background* as well as *the celestial geometry*.

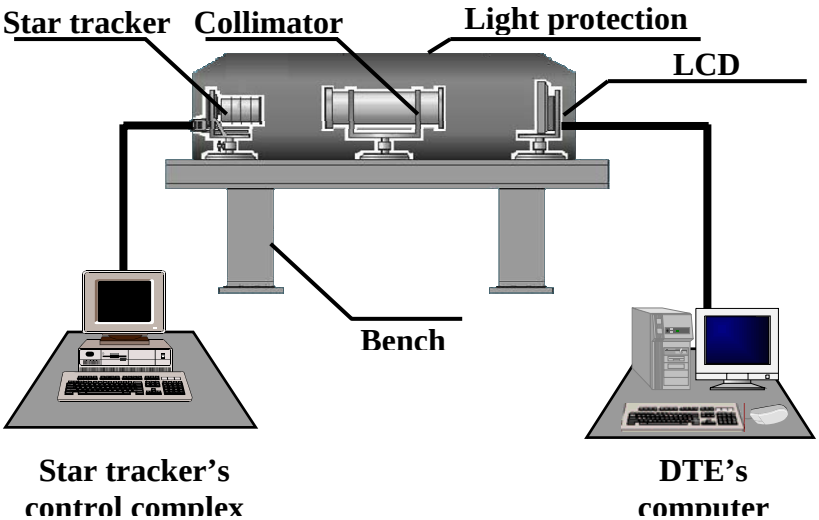

Fig.1

The starry sky brightness characteristics are retrieved by the introduction of a coding technique for various star magnitudes of the celestial sky's stars.

The stars' angular dimensions and their mutual position determine the geometry of the starry sky's segment image. Mutual positioning of the stars in an image is fulfilled using the star catalog of all celestial sphere stored in the DTE's computer memory. The star catalog contains three parameters for each star, including its spherical coordinates (declination and direct ascension) and the star magnitude.

The collimator simulates a real imaging geometry in space since an optical image of the celestial sphere is distanced to infinity. The collimator is fastened to the rail and positioned between the LCD monitor and the star tracker in such a way that the LCD monitor is in its focal plane. At the collimator's output a parallel light beam is built. Light filters included in the collimator cut the background component in the observed by the star tracker images displayed on the LCD monitor.

The light protection casing provides for the required illumination and optical conditions thus enabling tests under any level of the ambient illumination.

3. DESCRIPTION OF THE DTE

The Dynamic Test Equipment provides simulation of the following:

– *motion dynamics of the being tested star tracker* defined by the star tracker's motion together with the spacecraft in orbit as well as the spacecraft wobbles caused by the control system operation; and

– the *environmental disturbances*.

These options make it possible to improve the authenticity of simulation of the real conditions defining operation of star trackers in space.

When simulating the orbital motion the stars' spherical coordinates on the celestial sphere are re-calculated into the rectangular coordinates of the stars' projections onto the LCD monitor's plane. After this an image is reconstructed and displayed on the monitor's screen. This cycle repetition at a given image-refreshing rate allows to imitate a transfer of the celestial sphere's segment over the entire monitor's screen within the field of view of the fastened star instrument. Due to the LCD monitor's crystal structure coordinates of star images change discretely. In order to imitate a smooth process of a star position change within the instrument's field of view the stars' coordinates should be recalculated and displayed at the given frequency.

In addition to the simulation of the field of view shift due to the orbital motion the Dynamic Test Equipment allows to imitate the s/c control system dynamics. For this it is supposed that the spacecraft is equipped with the being tested star tracker. Thus the velocity vector has an addition component of the angular velocity**.** This mode is implemented due to the simulation of the sawtooth sweep for the instrument's field of view motion relative to the velocity vector in the given direction.

In order to imitate *the charged particles influence* on the star tracker resulting in registration of star-like objects (so-called "false stars") the noise objects are being added to the image displayed on the LCD monitor. The speckled objects imitate the charged particles' front incoming onto the star tracker. The elongated noise tracks simulate the impact of the charged particles penetrating the instrument at large incident angles towards its optical axis. The software generates this noise based on the initial data on the proton fluxes specified in the options of the DTE software.

In space because of the light coming from the Sun, the Moon, the Earth or reflected from the mirror-like structure of the spacecraft the star tracker can register a nonuniform background. The DTE software allows imitating this situation due to *the field of view nonuniform illumination*. In practice this is achieved by adding a background component to the image displayed on the digital monitor.

Fig. 2 gives a general scenario according to which the operation on the Dynamic Test Equipment is conducted.

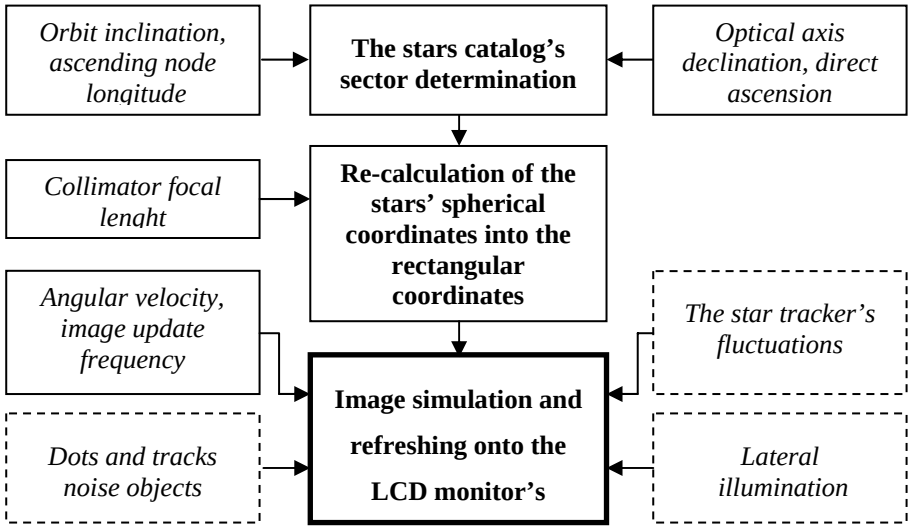

Fig.2

Of course, there are some restrictions on simulation of the conditions on the DTE in comparison of the conditions of star tracker's operation in space. At the same time the data, obtained from testing different instruments, proof that the DTE simulates the celestial sphere's parameters with a sufficient degree of authenticity in order to conduct such works as onground processing of the star trackers.

4. THE DTE's SOFTWARE

The DTE's software and the star catalogue are stored in the DTE's computer memory. The main DTE program are called "Sky Viewer". It operates in according to the flow-chart given in the fig. 2 and makes it possible to simulate a starry sky segment on the LCD monitor, to simulate additional components of the angular velocity concerning the roll, yaw and pitch components, to imitate the influence of the charged particles onto the CCD-array of the being tested instrument and to simulate a non-uniform illumination of the field of view.

The main window of the Sky Viewer package (see fig. 3) contains instruments needed for making choice of the initial simulating parameters.

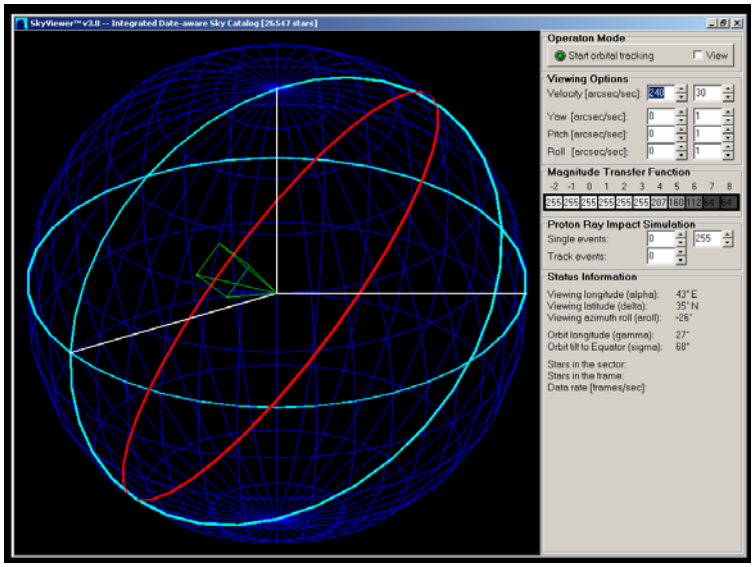

Fig. 3

After a procedure of parameters' choice is fulfilled and an orbital tracking mode is being started, the software calculates the starry sky images' parameters in accordance with the algorithm given in the fig. 2 and displays these images onto the LCD monitor screen.

5. CONCLUSION

The Dynamic Test Equipment has proven to be a very efficient tool to provide onground star trackers processing. An opportunity of changing the LCD monitor and collimator allows to carry out a test of different type of the star trackers on the DTE.

Nowadays, all types of the star trackers, developed in the Space Research Institute are being tested on the DTE. At the same time, as development of new star trackers is

impossible without development of new modifications of DTE we constantly continue to improve the DTE's performances.

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