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Launch-vehicle-to-spacecraft flight environments telemetry data processing requirement

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FOREWORD

The standard is translated from the Chinese version of Standard on GB/T 29077-2012 released by Standardization Administration of China (SAC) under the management of State General Administration of Quality Supervision and Inspection and Quarantine. TC 425 is responsible for the translation. In case of any doubt about the contents of English version, the Chinese original shall be considered authoritative.

This standard is drafted in accordance with rules given in GB/T 1.1-2009.

This standard is proposed by China Aerospace Science and Technology Corporation.

This standard is under the jurisdiction of National Technical Committee on Space Technology and Operation of Standardization Administration of China (SAC/TC 425).

INTRODUCTION

This standard belongs to the National Standard System of China Space. The National Standard System of China Space is applicable to the formulation, revision, and management of national standards in the field of space, covering three sectors of space management, space technology, and space application and services and serving as the basis for guiding spacecraft and launch vehicle project management, engineering, space launch services, and in-orbit satellite applications.

The spacecraft flight environment measurement is the most effective and directive method to obtain overload, vibration, shock, noise, temperature, heat flow, pressure and other mechanical and thermal environments during the flight process of launch vehicle as well as the foundation and basis of mechanical and thermal environment design verification. The environmental condition of payload interface is one of important spacecraft to launch vehicle interface conditions. the adequacy and effectiveness of spacecraft to launch vehicle interface flight environment measurement as well as the reasonableness and accuracy of data processing play an important role on analyzing the adaptability of spacecraft (in the ascending stage/launching stage) flight environment. That by specifying and unifying the measurement and data processing of flight telemetry parameters can ensure the validity and accuracy of flight measurement result, verify the reasonableness for developing environmental conditions, and play an important role especially for the launching and international corporation of Chinese commercial launch vehicle.

Launch-vehicle-to-spacecraft flight environments telemetry data processing requirement

1 Scope

This standard provides basic requirements for the measurement of the spacecraft flight environments generated by the launch vehicle, telemetry data processing and formats of analysis reports.

This standard is applicable to the interface of launch-vehicle-to-spacecraft (SC/LV) flight environment telemetry data processing and analysis.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 15862 Launch-vehicle-to-spacecraft flight environment telemetry data processing (SC/LV Flight environments telemetry data processing)

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 15862 apply.

4 Flight environments

4.1 Quasi-static load

Quasi-static load is the resultant of all external forces with the exception of gravity applied on the LV centre of gravity.

4.2 Low-frequency vibration

Low-frequency vibration is the structural response generated mainly by thrust variation of the LV engines at ignition and cut-off, by fluctuation of the pressure during the transonic phase, and by transient loads at stage separation(s).

4.3 High-frequency vibration

High-frequency vibration is the structural response generated mainly by the LV engine noise and by the aerodynamic noise. High-frequency vibration reaches the maximum during lift-off, ascent phase and transonic flight.

4.4 Acoustic noise

Acoustic noise is the sound pressure generated mainly by the LV engine noise and by aerodynamics. The maximum fairing internal noise occurs during lift-off, ascent phase and transonic flight.

4.5 Shock

Shock environment consists of the transient response generated by the LV fairing jettison, stage separation(s) and SC/LV separation(s).

4.6 Steady-state pressure

Steady-state pressure field consists of the instantaneous pressure of air outside the LV and inside the fairing. The fairing internal pressure of air decreases gradually during the LV ascent phase due to air escape.

Fairing internal pressure of air is related to the flight trajectory, the shape of the fairing and the vent configurations.

4.7 Thermal

Launch phase thermal environment is dependent on the fairing aerodynamic heating, the radiation of the sun and the earth, and the space conditions.

5 Measurement fields and measurement requirements

5.1 Measurement fields

Measurement fields shall be determined by common agreement between the LV service provider and the SC customer. Unless otherwise specified, the following measurement fields shall be planned and corresponding measurements shall be conducted:

a) steady-state acceleration;

b) low-frequency vibration;

c) high-frequency vibration;

d) acoustic noise;

e) shock acceleration;

f) steady-state pressure;

g) temperature.

5.2 Measurement requirements

5.2.1 Number and location of measurements

5.2.1.1 Steady-state acceleration

As a minimum, steady-state acceleration shall be measured at one location in the LV longitudinal axis and the two lateral orthogonal axes. The measurement location shall be close to the SC/LV interface.

5.2.1.2 Low-frequency vibration

As a minimum, low-frequency vibration shall be measured at one location in the LV longitudinal axis and the two lateral orthogonal axes. The measurement location shall be close to the SC/LV interface.

5.2.1.3 High-frequency vibration

As a minimum, high-frequency vibration shall be measured at one location in the LV longitudinal axis and the two lateral orthogonal axes. The measurement location shall be close to the SC/LV interface.

5.2.1.4 Acoustic noise

As a minimum, acoustic sound pressure shall be measured at two points. The measurement location shall be representative of the acoustic field inside the fairing.

5.2.1.5 Shock acceleration

As a minimum, shock acceleration shall be measured at one location in the LV longitudinal axis and in one orthogonal axis. The measurement location shall be close to the SC/LV interface.

5.2.1.6 Steady-state pressure

As a minimum, steady-state pressure shall be measured at one location. The measurement location shall be chosen inside the fairing to indicate the ambient pressure.

5.2.1.7 Temperature

As a minimum, temperature shall be measured at one location. The measurement location shall be chosen close to the SC/LV interface.

5.2.2 Measurement range selection

The measurement range shall be defined according to previous flight telemetry data or analysis results.

5.2.3 Frequency range and minimum sampling frequency

The requirements of frequency range and minimum sampling frequency are shown as follows:

a) Frequency ranges and minimum sampling frequency shall be selected to provide representative measurement results for flight environment characteristics evaluation;

b) Frequency ranges, corresponding measuring tool parameters and minimum sampling frequencies shall be selected to prevent frequency masking phenomena;

c) Frequency ranges and minimum sampling frequencies shall be established in technical specifications and/or in a statement of works by agreement between the SC and LV agencies.

6 Data processing and analysis

6.1 Data pre-processing procedure

6.1.1 Data quality examining

The time history of telemetry data shall be examined for data quality. If the signal time history is inconsistent with corresponding parameter physical nature, the signal shall be regarded as invalid. Telemetry malfunction segments shall be identified and excluded from further processing.

6.1.2 Steady-state acceleration, steady-state pressure and temperature

Because steady-state acceleration, steady-state pressure and temperature change slowly along with time, large and unexpected changes of signal for a very short duration shall be regarded as corrupted data points and shall be deleted or replaced with adjacent data points.

6.1.3 Low-frequency vibration, high-frequency vibration, acoustic noise and shock acceleration

6.1.3.1 Data quality identification

The time history shall be plotted and examined for data quality. The signal amplitude should be properly evaluated to determine whether the signal is regarded as valid or invalid.

6.1.3.2 Pseudo-signal identification

The pseudo-signal is identified as a random signal with a value significantly greater than the root mean square of the validated signal for a short period. Pseudo-signal shall be discarded.

6.1.3.3 Zero drift elimination

Low-frequency vibration, high-frequency vibration, acoustic noise and shock acceleration signals shall be processed to eliminate zero drift.

6.1.3.4 Mean value correction

Low-frequency vibration, high-frequency vibration, acoustic noise parameter shall be processed to correct for mean value error.

6.2 Data processing requirements

6.2.1 Steady-state acceleration

Steady-state acceleration shall include a time history plot covering the flight from lift-off to SC/LV separation(s).

6.2.2 Low-frequency acceleration

6.2.2.1 General

The low-frequency acceleration data shall include the time history curve from lift-off to launch-vehicle/spacecraft separation(s).

6.2.2.2 Processing method

Low-frequency vibration data shall be processed into a shock response spectrum (SRS). SRS shall be transformed to equivalent sinusoidal vibration levels.

6.2.2.3 Processing of discrete phases

The following discrete phases of the launch profile shall be processed: lift-off, transonic phase, maximum dynamic pressure phase, stage separation(s), fairing jettison, SC/LV separation(s), and any other large vibration phases.

6.2.3 High-frequency vibration

6.2.3.1 Processing method

The frequency spectrum analysis shall be carried out for high-frequency vibration signals. High-frequency vibration data shall be processed into power spectral density (PSD).

6.2.3.2 Processing of discrete phases

The following discrete phases of the launch profile shall be processed: lift-off, transonic phase, maximum dynamic pressure phase, and any other large vibration phases.

6.2.4 Acoustic noise

6.2.4.1 Processing method

The frequency spectrum analysis shall be carried out for acoustic noise signals. Acoustic noise data shall be processed into 1/3 octave or one octave sound pressure level (SPL).

6.2.4.2 Processing of discrete phases

The following discrete phases of the launch profile shall be processed: lift-off, transonic phase, and maximum dynamic pressure phase.

6.2.5 Shock acceleration

6.2.5.1 Processing method

The frequency spectrum analysis shall be carried out for shock signals. Shock data shall be processed into SRS, the damping ratio (ξ) is taken generally as ξ=0.05, namely the amplification is Q=10.

6.2.5.2 Processing of discrete phases

The following discrete phases of the launch profile shall be processed: LV stage separation(s), fairing jettison, and SC/LV separation phase(s).

6.2.5.3 Steady-state pressure

Steady-state pressure data shall include a time history plot covering the flight from lift-off to fairing jettison.

6.2.6 Temperature

Temperature data shall include a time history plot covering the flight from lift-off to fairing jettison.

6.3 Formats of delivered data

6.3.1 Delivery form

Delivered data may be in electronic format or in a hard copy.

6.3.2 Steady-state acceleration

As a minimum, steady-state acceleration shall be provided in tabular form indicating the maximum longitudinal and lateral steady-state acceleration seen by the SC for the discrete phases.

The LV agency shall deliver plots of processed time histories. The plot shall be displayed in linear scale. The abscissa is time, and its unit is second. The ordinate is steady-state acceleration, and its unit is meter per second squared.

6.3.3 Low-frequency vibration

As a minimum, low-frequency vibration shall be provided in tabular form indicating the maximum longitudinal and lateral levels seen by the SC for the discrete phases.

The LV agency may deliver plots of acceleration time histories for the discrete phases. The plot shall be displayed in linear scale. The abscissa is time, and its unit is second. The ordinate is acceleration, and its unit is meter per second squared.

The LV agency shall deliver a tabular presentation or plots of processed equivalent sinusoidal vibration levels for the discrete phases. The plot shall be displayed in linear or logarithmic scale. The abscissa is frequency, and its unit is hertz. The ordinate is vibration level, and its unit is metre per second squared.

6.3.4 High-frequency vibration

As a minimum, high-frequency vibration shall be provided in tabular form indicating the longitudinal and lateral envelopes of PSD and related RMS seen by the SC for the discrete phases.

The LV agency shall deliver plots of processed PSD and corresponding RMS. The plots shall be displayed in logarithmic scale. The abscissa is frequency, and its unit is hertz. The ordinate is PSD of acceleration, and its unit is meter squared per second to the fourth power per hertz.

6.3.5 Acoustic noise

As a minimum, acoustic noise shall be provided in tabular form indicating the SPLs seen by the SC for the discrete phases.

SPLs shall be presented as SPL, in decibels, versus the relevant octave bands, or 1/3 octave band.

6.3.6 Shock acceleration

As a minimum, shock acceleration shall be provided in tabular form indicating the maximum longitudinal and lateral levels seen by the SC for the discrete phases.

The LV agency shall provide processed SRS in tabular forms or in plots. The plot shall be displayed in logarithmic scale. The abscissa is frequency, and its unit is hertz. The ordinate is SRS, and its unit is meter per second squared. The interval shall be no greater than 1/6 octave.

6.3.7 Steady-state pressure

As a minimum, steady-state pressure shall be provided in tabular form indicating the maximum level and maximum pressure decay rates seen by the SC for the discrete phases.

The LV agency may deliver plots of processed time history. The plots shall be displayed in linear scale. The abscissa is time, and its unit is second. The ordinate is pressure, and its unit is pascal.

6.3.8 Temperature

As a minimum, temperature shall be provided in tabular form indicating the maximum and minimum levels seen by the SC for the discrete phases.

The LV agency may provide plots of processed time history. The plots shall be displayed in linear scale. The abscissa is time, and its unit is second. The ordinate is temperature, and its unit is degree celsius.

7 Analysis results reports of flight environments

7.1 General

The LV agency shall present tables and plots as described in 6.3.

7.2 Steady-state acceleration

The LV agency shall verify that the flight steady-state accelerations are within the specified values and shall provide the results of this analysis.

7.3 Low-frequency vibration

The LV agency shall verify that flight low-frequency vibration data are within the specified values and shall compare the flight data with the flight environment predictions and SC test conditions. The results of this analysis shall be provided.

7.4 High-frequency vibration

The LV agency shall verify that flight high-frequency vibration data are within the specified values and shall compare the flight data with the flight environment predictions and SC test conditions. The results of this analysis shall be provided.

7.5 Acoustic noise

The LV agency shall verify that the flight acoustic data are within the specified values. The results of this analysis shall be provided.

7.6 Shock acceleration

The LV agency shall verify that the flight shock acceleration data are within the specified values and shall compare the flight data with the flight environment predictions and SC test conditions. The results of this analysis shall be provided.

7.7 Steady-state pressure

The LV agency shall verify that the flight steady-state pressure data are within the specified values. The results of this analysis shall be provided.

7.8 Temperature

The LV agency shall verify that the flight temperature data are within the specified values. The results of this analysis shall be provided.