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Space systems — Launch-vehicle-to-spacecraft flight environments telemetry data processing

Systèmes spatiaux — Traitement des données télémétriques des environnements de vol entre le lanceur spatial et le véhicule spatial

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Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
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Foreword

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ISO 15862 was prepared by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 14, *Space systems and operations*.

Introduction

This International Standard addresses flight environment measurements, data processing and analysis, and reports of analysis results. If launch vehicle (LV) environmental specifications are exceeded, the LV and spacecraft (SC) agencies can perform an analysis to determine the cause of the problem.

Flight environments describe different types of flight mechanical and thermal environments. Measurement fields include parameters characterizing such environments as loads, vibration, shock, acoustics, steady-state pressure and temperature. Requirements include number, location, range and frequency of measurement devices.

Data processing and analysis include data pre-processing, data processing and formats of delivered data.

Flight measurement plan formats are provided.

The report on flight environment analysis results records all the above information.

Space systems — Launch-vehicle-to-spacecraft flight environments telemetry data processing

1 Scope

This International 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 International Standard defines the field and number of measurement parameters, the principles of data processing, the format of delivered data and the content and the form of the flight environment analysis report.

Flight telemetry data are used to verify if flight environment conditions exceed pre-flight analyses and environmental test results. In the event of a launch failure, adequate flight environment data can assist in investigating and analysing failure causes.

This International Standard is applicable to commercial launch vehicles and related ground processing, no matter which launch vehicle agencies are selected.

2 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

2.1
cut-off
load case when the engine thrust begins to decrease from current value to zero

2.2
ground transportation
spacecraft transportation at launch site

2.3
lift-off
launch vehicle motion when the vehicle's contact is terminated with launch pad or other support devices

NOTE This is commonly called “first motion” of the vehicle. Possible abnormal cut-off is also included.

2.4
load case
event in spacecraft service life during which essential mechanical environments are expected

2.5
maximum dynamic pressure phase
flight phase when dynamic pressure reaches its maximum value

2.6
minimum sampling frequency
minimum number of data points of measurement fields collected per second

2.7
spacecraft-to-launch-vehicle interface
SC/LV interface
mechanical interface that connects spacecraft (or spacecraft-provided adapter) to launch-vehicle-provided adapter

2.8
separation
separations of launch vehicle stages, boosters and other structural elements (e.g. fairing jettison)

2.9
steady-state acceleration
constant acceleration that generates static loads.

2.10
transonic phase
flight phase when the Mach number is in the range of 0,8 to 1,2

3 Abbreviated terms

LV launch vehicle

PSD power spectral density

SC spacecraft

SPL sound pressure level

SRS shock response spectrum

RMS root mean square

4 Flight environments, measurement fields and measurement requirements

4.1 Flight environments

4.1.1 General

Different types of mechanical environments and thermal environments are described in 4.1.2 to 4.1.8 below.

4.1.2 Quasi-static load

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

4.1.3 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).

4.1.4 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.

4.1.5 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.

4.1.6 Shock

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

4.1.7 Steady-state pressure

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

4.1.8 Thermal

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

4.2 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:

— steady-state acceleration,

— low-frequency vibration,

— high-frequency vibration,

— acoustic noise,

— shock acceleration,

— steady-state pressure, and

— temperature.

4.3 Measurement requirements

4.3.1 Number and location of measurements

4.3.1.1 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.

NOTE In general, this practice is recommended for developmental flights, but is often not required for operational systems.

4.3.1.2 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.

4.3.1.3 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.

NOTE In general, this practice is recommended for developmental flights, but is often not required for operational systems.

4.3.1.4 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.

4.3.1.5 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.

NOTE In general, this practice is recommended for developmental flights, but is often not required for operational systems.

4.3.1.6 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.

NOTE In general, this practice is recommended for developmental flights, but is often not required for operational systems.

4.3.1.7 Temperature

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

4.3.2 Measurement range selection

The range of measurement shall be properly defined by the LV agency.

4.3.3 Frequency range and minimum sampling frequency

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

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

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.

4.4 Flight measurement plan

The flight measurement plan shall be properly defined by the LV agency and shall be agreed by the SC customer. It shall include the list, type, location, orientation, characteristics of the measurement sensors, ranges of frequencies, sequence of measurement, as well as the minimal sampling frequency of sensors needed to fulfil the measurement requirements.

For each measurement sensor, the following are examples to be described in the plan:

- identification code,
- type,
- location,
- direction (if applicable),
- units,
- measurement range,
- frequency range,
- sampling rate,
- sensitivity, and
- accuracy.

5 Data processing and analysis

5.1 Data pre-processing procedure

5.1.1 General

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.

5.1.2 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.

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

5.1.3.1 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.

5.1.3.2 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.

5.1.3.3 Zero drift elimination

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

5.1.3.4 Mean value correction

Low-frequency vibration signals shall be processed to correct for mean value error.

5.2 Data processing requirements

5.2.1 Steady-state acceleration

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

5.2.2 Low-frequency vibration

5.2.2.1 Processing method

Low-frequency vibration data shall be processed into a shock response spectrum (SRS). SRS shall be transformed to equivalent sinusoidal vibration levels. The value of damping ratios shall be defined in agreement between the SC and LV agencies.

5.2.2.2 Processing of discrete phases

The following discrete phases of the launch profile shall be processed:

— ground transportation (if applicable),

— lift-off,

— transonic phase,

— maximum dynamic pressure phase,

— stage separation(s),

— fairing jettison,

— SC/LV separation(s), and

— any other large vibration phases.

5.2.3 High-frequency vibration

5.2.3.1 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).

5.2.3.2 Processing of discrete phases

The following discrete phases of the launch profile shall be processed:

— ground transportation (if applicable),

— lift-off,

— transonic phase,

— maximum dynamic pressure phase, and

— any other large vibration phases.

5.2.4 Acoustic noise

5.2.4.1 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).

5.2.4.2 Processing of discrete phases

The following discrete phases of the launch profile shall be processed:

— lift-off,

— transonic phase, and

— maximum dynamic pressure phase.

5.2.5 Shock acceleration

5.2.5.1 Processing method

The frequency spectrum analysis shall be carried out for shock signals. Shock data shall be processed into SRS, and the value of damping ratios shall be defined in agreement between the SC and LV agencies.

5.2.5.2 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).

5.2.6 Steady-state pressure

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

5.2.7 Temperature

Temperature data shall include a time history plot covering ground transportation (if applicable) and the flight from lift-off to fairing jettison.