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Space systems — Relative motion analysis elements after LV/SC separation

Systèmes spatiaux — Éléments d'analyse de mouvement relatif après séparation du LV/SC

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Foreword

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The committee responsible for this document is ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 14, *Space systems and operations*.

Introduction

Relative motion analysis predicts the relative distance after launch vehicle (LV) and spacecraft (SC) separation. The analysis result offers support to the mission design and operation.

This International Standard provides LV and SC operators and manufacturers with specific elements and procedures for performing relative motion analysis after LV and SC separation. The intent is to regulate a common basis and offer a direction.

Space systems — Relative motion analysis elements after LV/SC separation

1 Scope

This International Standard provides relative motion analysis elements after LV/SC separation, including analysis input, analysis principle, analysis method and analysis output. It is applicable to the mission design and verification for the prediction of relative motion after LV/SC separation.

This International Standard focuses on the relative motion between the objects involved in one launch mission. It does not cover the issues about the collision avoidance between newly launched objects and on-orbit ones.

2 Normative reference

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

ISO 14303, *Space systems — Launch-vehicle-to-spacecraft interfaces*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 14303 and the following apply.

3.1
LV/SC separation
event of disconnection between LV/SC under the control of LV

3.2
relative motion analysis
analysis to predict the relative distance of spacecraft(s) to objects (end stage of LV and others generated during the separation) after the LV/SC separation

3.3
separation velocity
relative speed to LV when separation is completed instantly

4 Abbreviated terms

LV launch vehicle

SC spacecraft

ICD interface control document

RMS root mean square

5 Input for analysis

The following information shall be included as analysis input.

a) Theoretical velocity, position, attitude of LV and (each) spacecraft at the separation moment, which shall be presented in pre-determined coordinate system. Velocity and position vectors shall be offered in the format as Vx, Vy, Vz, X, Y, Z. The potential reference frames are offered in Annex C.

b) Separation velocity, mass and inertia characteristics of separation bodies.

c) Deviations of LV and separation parts [mass, thrust, impulse, moment-inertial characteristics (optional), tailed-effect, etc.].

d) Manoeuvres or other operations which shall affect LV end-stage orbit, related parameters and sequences.

e) Manoeuvres or other operations which shall affect SC orbit, related parameters and sequences (optional).

6 General process

In actual flight, relative motion after LV/SC separation is affected by many factors, including certain operations, deviations, mission profile, etc. on both sides. However, in order to simplify collaborations in applications of launch services, LV and SC parties shall perform the following processes:

a) LV conducts relative motion analysis without taking into account SC manoeuvre, attitude control, etc. into account,

b) SC evaluates it does not collide with LV orbital stage or other SC (for multi-SC launch mission) after separation due to its manoeuvre, attitude control, etc., based on the result of LV relative motion analysis.

The general process is described in Figure 1, where Party A represents LV and Party B represents SC.

The final safety evaluation should be performed based upon LV's and SC's analysis. If necessary input can be offered, the aforementioned processes a) and b) can be incorporated.

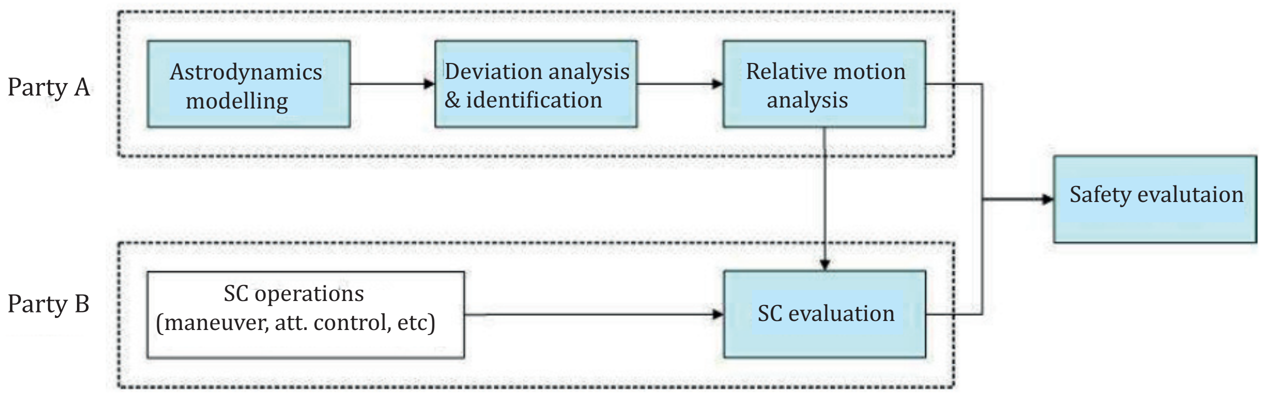

Figure 1 — Flow for relative motion analysis after LV/SC separation

7 Analysis principle

In the analysis principle, safety deserves priority. The analysis shall be in accordance with general principles for trajectory/orbit analysis (perturbations, astrodynamics, etc.) and shall cover deviations status.

8 Analysis method

8.1 General

The following content shall be included for relative motion analysis:

— astrodynamics modelling;

— deviation analysis and identification;

— relative motion simulation;

— safety evaluation.

8.2 Astrodynamics modelling

The astrodynamics modelling can be achieved in different coordinate systems. One alternative centroid motion model in an Earth-fixed coordinate system is offered in Annex A for information. Motion analysis of different objects should be conducted in the same coordinate system.

Gravity, atmosphere force models and related parameters shall be dealt in accordance with the trajectory/orbit calculation.

8.3 Deviation analysis and identification

Theoretical parameters shall be applied in normal analysis while deviation status shall be considered to cover the deviations existing in actual flight. The possible deviations have to be included and necessary items have to be identified for the relative motion analysis.

Typical deviations for LV shall include the following:

— separation velocity;

— separation attitude (pitch, yaw);

— mass of orbital stage;

— other factors, de-orbit thrust, de-orbit attitude control precision, etc.

8.4 Relative motion simulation

8.4.1 Relative motion analysis period

Relative motion analysis period should be a period of time agreed upon with the SC contractor. It should be no less than one orbit period.

8.4.2 Deviation

Deviation trajectory calculations are performed to support the analysis on minimum relative distance between orbital stage and spacecraft. Generally, deviations can be generated in 3 typical manners:

— margin status,

— typical combination of deviations, (note that Annex B offers a combination matrix for information) and

— combination of deviations generated by random sampling method.