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Space systems — Design guidelines for multi-geo spacecraft collocation

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Foreword

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

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

With the wide application of geostationary orbit in spacecraft navigation, spacecraft communication and remote sensing, there comes a dramatic increase in the number of geostationary spacecraft while the orbit position of geostationary spacecraft is limited. In order to solve this problem, it is often necessary for spacecraft operators to collocate their spacecraft with spacecraft operated by other agencies in order to deliver their services.

Space systems — Design guidelines for multi-geo spacecraft collocation

1 Scope

This document addresses the design process of a collocation and the basic contents of collocation design process which include considerations, initial collocation strategy design, simulation evaluation of collocation strategy, optimal collocation strategy selection and collocation agreement.

This document gives guidelines for multi-geo spacecraft collocation, and it applies in particular to multi-geo constellation.

2 Normative references

There are no normative references in this document.

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

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

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1.1
orbit maintenance
orbit control for maintaining the spacecraft's orbit in certain prediction error around the nominal orbit

3.1.2
inclination vector
vector which points to the ascending node and which is measured from the vernal equinox

Note 1 to entry: The *x* and *y* components of the vector can be expressed as Formulae (1) and (2).

$$i_x = \sin i \cos(\Omega) \quad (1)$$

$$i_y = \sin i \sin(\Omega) \quad (2)$$

where

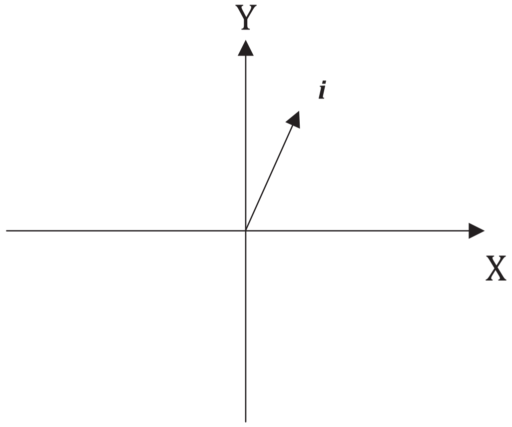
i is the magnitude of the inclination vector;

Ω is the raan in J2000 *geocentric equatorial coordinate system* (3.1.5);

i_x is the *x* component of the inclination vector coordinate;

i_y is the *y* component of the inclination vector coordinate.

Note 2 to entry: Figure 1 shows the definition of the inclination vector.



Key

i inclination vector which points to the ascending node

X direction of vernal equinox

Figure 1 — Inclination vector

3.1.3
eccentricity vector
vector which points to the orbit perigee and which is measured from the vernal equinox

Note 1 to entry: The *x* and y components of the vector can be expressed as Formulae (3) and (4).

$$e_x = e\cos(\Omega + \omega) \quad (3)$$

$$e_y = e\sin(\Omega + \omega) \quad (4)$$

where

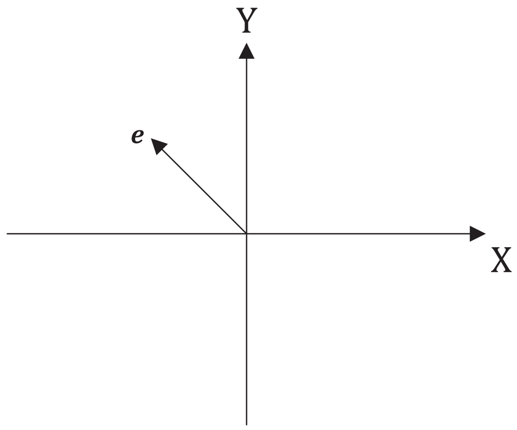
e is the magnitude of the eccentricity vector;

e_x is the *x* component of the eccentricity vector coordinate;

e_y is the y component of the eccentricity vector coordinate;

ω is the argument of perigee.

Note 2 to entry: Figure 2 shows the definition of the eccentricity vector.



Key

e eccentricity vector which points to the orbit perigee

X direction of the vernal equinox

Figure 2 — Eccentricity vector

3.1.4
mean longitude
l
sum of the right ascension of the ascending node, the augment of perigee and the mean anomaly

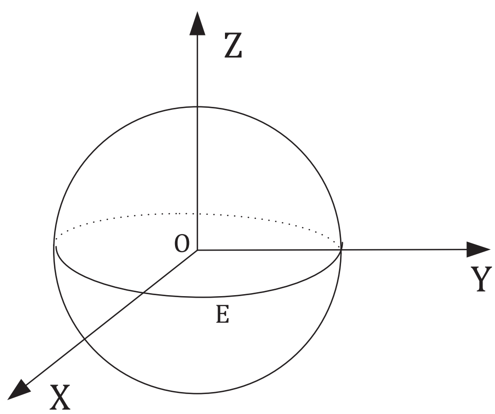
Note 1 to entry: It can further be interpreted as the approximate right ascension of the near-circular orbits with small inclination.

3.1.5
J2000 geocentric equatorial coordinate system
coordinate system with origin at the Earth's centre

Note 1 to entry: The positive x-axis points in the direction of the mean vernal equinox of Earth at J2000 epoch. The positive z-axis points in the direction of the normal direction of the mean equator at J2000 epoch. The y-axis is orthogonal to both the x-axis and the z-axis and completes a right-handed frame.

Note 2 to entry: J2000 epoch: JD=2451545,0, which is 1 Jan 2000 12:00:00 TDB.

Note 3 to entry: Figure 3 shows this coordinate system.



Key

E earth equator plane

Figure 3 — J2000 geocentric equatorial coordinate system

3.1.6
spacecraft coordinate system of geo spacecraft
RTN
coordinate system with origin at the centre of the geo spacecraft's positioned point

Note 1 to entry: The R axis is outward along radial. The N axis points in the direction of the normal direction of J2000 mean equator. The T axis is constructed as N×R.

Note 2 to entry: Figure 4 shows this coordinate system.

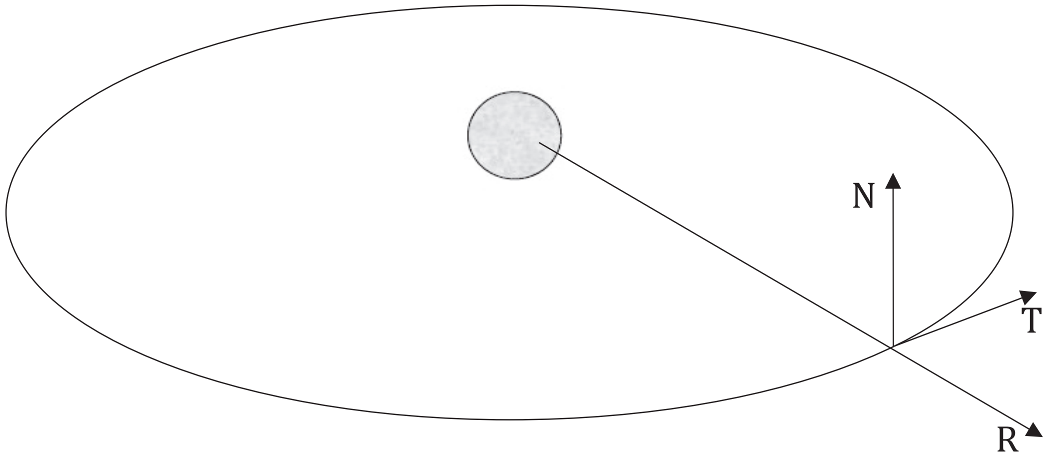


Figure 4 — Spacecraft coordinate system of geo spacecraft (RTN)

3.2 Abbreviated terms

E/W east/west

geo geostationary earth orbit

raan right ascension of the ascending node (the angle between the vernal equinox and the orbit ascending node)

OD orbit determination

4 Collocation design process

Design process of a collocation includes considerations, initial collocation strategy design, simulation evaluation of collocation strategy, initial selection of collocation strategy, optimal collocation strategy selection and collocation agreement.

The collocation design process is basically carried out according to the following steps, which are represented in the collocation working flow (see Figure 5).

a) Delegations of different spacecraft operators with diversity needs hold an orbit safety consultation meeting. Commonly, the operator of spacecraft that has to collocate with other spacecraft that is already located at the position brings forward the consultation meeting, negotiates and organizes the meeting.

b) In the consultation meeting, each operator presents the operation status, operational issue and then brings forward and confirms the considerations of collocation design.

c) The initial collocation strategy is designed according to the considerations. Each collocation spacecraft operator selects and proposes the preferred collocation strategy. The collocation strategy includes the strategy during mission period and the initial phase strategy to move a spacecraft into position of collocation configuration and the deorbit strategy.

d) Simulation is carried out to evaluate whether the collocation strategies meet the demanded requirements of all parties.

e) If the selected initial collocation strategy can't meet the specified requirements, the collocation strategies are reviewed in order to identify what can be improved. If improvements are identified, the collocation strategies are revised and the simulation evaluation step d) is carried out again. Else, the initial design of collocation strategy step c) is carried out again.

f) If the chosen strategy meets all the specified requirements then the strategy can be confirmed as the decided solution.

g) Once the optimal strategy is selected then the collocation agreement formalized and signed in accordance with Clause 5.

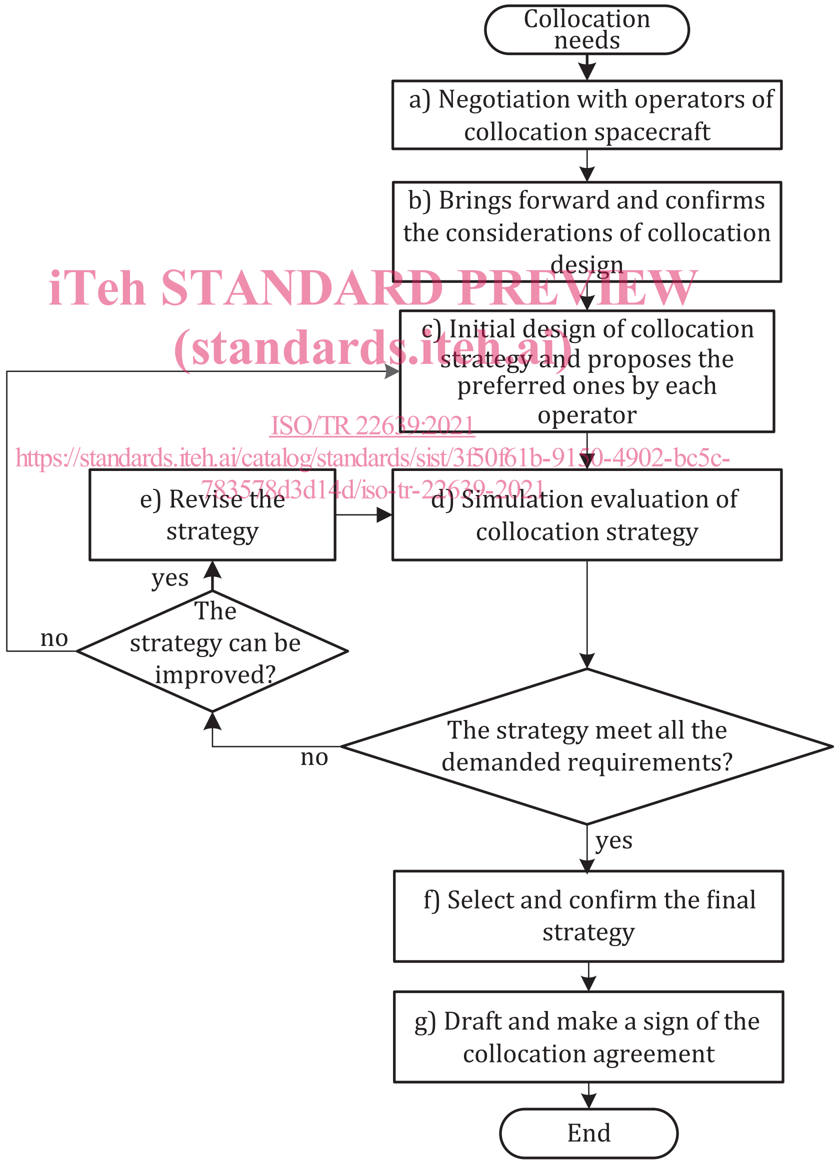


Figure 5 — Collocation working flow