SLOVENSKI STANDARD
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Vesoljska tehnika - Ugotavljanje oddaljenosti in doplersko sledenje

Space engineering - Ranging and Doppler tracking

Raumfahrttechnik - Entfernungsbestimmung und Dopplerverfolgung

Ingénierie spatiale - Mesure de distance et suivi Doppler

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Space engineering - Ranging and Doppler tracking

Ingénierie spatiale - Mesure de distance et suivi Doppler

Raumfahrttechnik - Entfernungsbestimmung und Dopplerverfolgung

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Foreword

This document (EN 16603-50-02:2014) has been prepared by Technical Committee CEN/CLC/TC 5 “Space”, the secretariat of which is held by DIN.

This standard (EN 16603-50-02:2014) originates from ECSS-E-ST-50-02C.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by March 2015, and conflicting national standards shall be withdrawn at the latest by March 2015.

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This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association.

This document has been developed to cover specifically space systems and has therefore precedence over any EN covering the same scope but with a wider domain of applicability (e.g. aerospace).

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Introduction

The purpose of this Standard is to:

- Ensure compatibility between space agencies' spacecraft transponders and the ranging and Doppler tracking facilities of the Earth stations for the Space Operation, Space Research and Earth Exploration Satellite services.
- Ensure, as far as possible, compatibility between space agencies' spacecraft transponders and other networks from which they request support.
- Ensure an adequate level of ranging and Doppler tracking accuracy for missions conforming to this standard.

Facilitate the early design of flight hardware and ensure that the resulting interfaces and system performances are compatible with given ranging and Doppler tracking configurations and specifications.

1 Scope

This Standard is applicable to spacecraft that are supported for ranging or Doppler tracking by direct links to Earth stations and to all related Earth stations (therefore, this Standard is not applicable for spacecraft supported by data relay satellites) operating within the Space Operation, Space Research and Earth Exploration Satellite services (therefore, this Standard is not applicable to the Meteorological Satellite service) as defined in ECSS-E-ST-50-05 clause 1.

Other space telecommunication services are not covered in this issue.

This Standard applies to projects with unprocessed ranging accuracies of 2,5ns to 30 ns (for conventional projects with tracking accuracies less stringent than these, CCSDS 401.0-B recommendations may be sufficient) and Doppler tracking accuracies of 0,1 mm/s to 1 mm/s. The analysis of compatibility between systems compliant with this standard and with the CCSDS recommendations is given in Annexes A.2 and A.3.

This document:

- Defines the requirements concerning spacecraft transponder and Earth station equipment for the purposes of ranging and Doppler tracking.
- Provides criteria by which the extent to which the accuracy of the measurements is influenced by equipment effects can be determined. This accuracy is different to the accuracy of the overall orbit determination process, which is also influenced by effects outside the scope of the standards, i.e. modelling of gravitational and non-gravitational forces, modelling of propagation effects, pre-processing and screening of data.

This standard may be tailored for the specific characteristics and constraints of a space project in conformance with ECSS-S-ST-00.

2
Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this ECSS Standard. For dated references, subsequent amendments to, or revisions of any of these publications, do not apply. However, parties to agreements based on this ECSS Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references the latest edition of the publication referred to applies.

EN reference	Reference in text	Title
EN 16601-00-01	ECSS-S-ST-00-01	ECSS system – Glossary of terms
EN 16603-50	ECSS-E-ST-50	Space engineering – Communications
EN 16603-50-05	ECSS-E-ST-50-05	Space engineering – Radio frequency and modulation

3 Terms, definitions and abbreviated terms

3.1 Terms from other standards

For the purpose of this Standard, the terms and definitions from ECSS-S-ST-00-01 and ECSS-E-ST-50 apply.

3.2 Terms specific to the present standard

3.2.1 category A

category of those spacecraft having an altitude above the Earth's surface of less than 2×10^6 km

3.2.2 category B

category of those spacecraft having an altitude above the Earth's surface equal to, or greater than, 2×10^6 km

3.3 Abbreviated terms

For the purpose of this Standard, the abbreviated terms from ECSS-S-ST-00-01 apply:

Abbreviation	Meaning
AGC	automatic gain control
AU	astronomical unit
$2B_L$	double-sided phase locked loop noise bandwidth
BPSK	binary phase shift keying (see PSK)
CCSDS	Consultative Committee for Space Data Systems
CLCW	command link control word
C/N	carrier to noise ratio
dB	decibel
dBc	dB with respect to the unmodulated carrier
DRVID	differenced range versus integrated Doppler

IF	intermediate frequency
LO	local oscillator
NRZ	non-return to zero
NRZ-L	NRZ-level
PCM	pulse code modulation
PLL	phase-locked loop
PM	phase modulation
PSK	phase shift keying
Pp	peak to peak
RF	radio frequency
r.m.s.	root-mean-square
SNR	signal-to-noise ratio
SPE	static phase error
SP-L	split phase-level
TC	telecommand
TM	telemetry
TR	tracking
UTC	universal time (coordinated)

4 Requirements

4.1 Functional

4.1.1 Functional breakdown

The ranging and Doppler tracking system is a spacecraft tracking system capable of providing information on the range and range rate between a spacecraft and an Earth station. It uses an active transponder on-board the spacecraft for the retransmission to the ground of an Earth-to-Space link signal: ranging signal generation and measurement are performed in the Earth station. As a baseline, it is assumed that the spacecraft transponder is used not only for ranging purposes, but also for receiving telecommand signals from Earth and for transmitting telemetry signals to Earth modulated on the same RF carriers. When a transponder is used exclusively for ranging, the requirements in this standard concerning sharing with telecommand and telemetry have no relevance.

A functional breakdown of the ranging and Doppler tracking system is presented in Figure 4-1. It depicts the five major functions of the system, broken down into functional blocks, as follows:

- The Earth-to-Space link function, employing ground communication, process control, ranging signal generation and Earth-to-Space communication.

  NOTE Ground communication between the Earth station and the Control Centre is not part of the present Standard.

- The transponder function, either spacecraft transponder or ground-calibration transponder depending on the application.
- The Space-to-Earth link function, employing Space-to-Earth communication, Doppler measurement, ranging replica generation, ranging correlation, process control and ground communication.
- The link-control function, resident partly in the Space-to-Earth and Earth-to-Space communication and partly in the process control.
- The data-acquisition function, concerned with collection, measurement, processing and transfer of data to the control centre, employing the process-control and the ground communication functions.

The requirements relevant to these five major functions are listed in clauses 4.1.2 to 4.1.6.

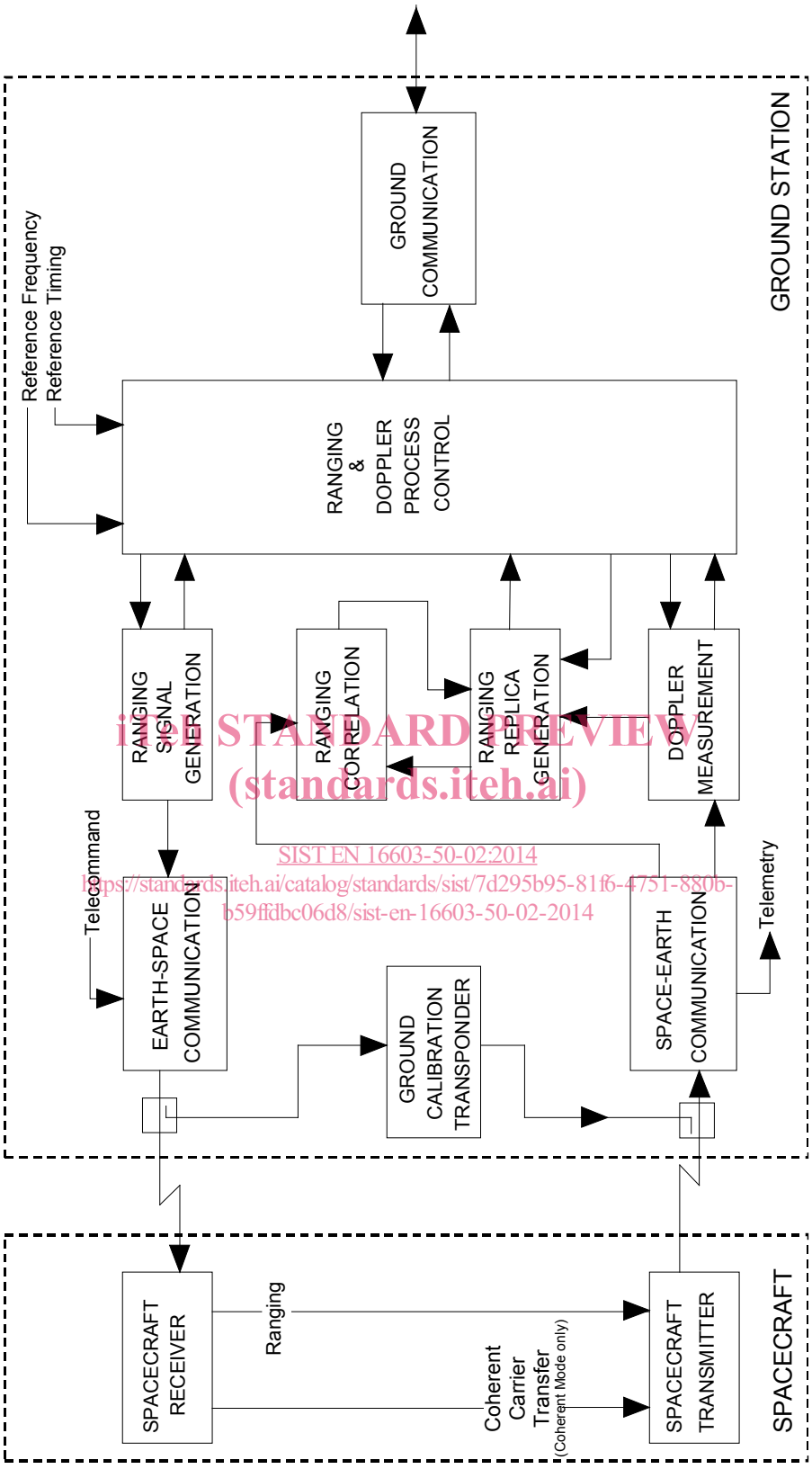

Figure 4-1: Ranging and Doppler tracking: functional block diagram