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Space systems — Space-based services for a high accuracy positioning system with safety requirements

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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

This document is a technical specification of space-based services. Space systems provide a huge merit for the society and economy in each country today; and space-based services contribute to people's quality of life across the world. Space systems should be utilized furthermore in the industry worldwide in the future.

Space systems are utilized in the application of other areas. Therefore, this document has harmonized the content in the GNSS (global navigation satellite system) relevant area as shown in Figure 1.

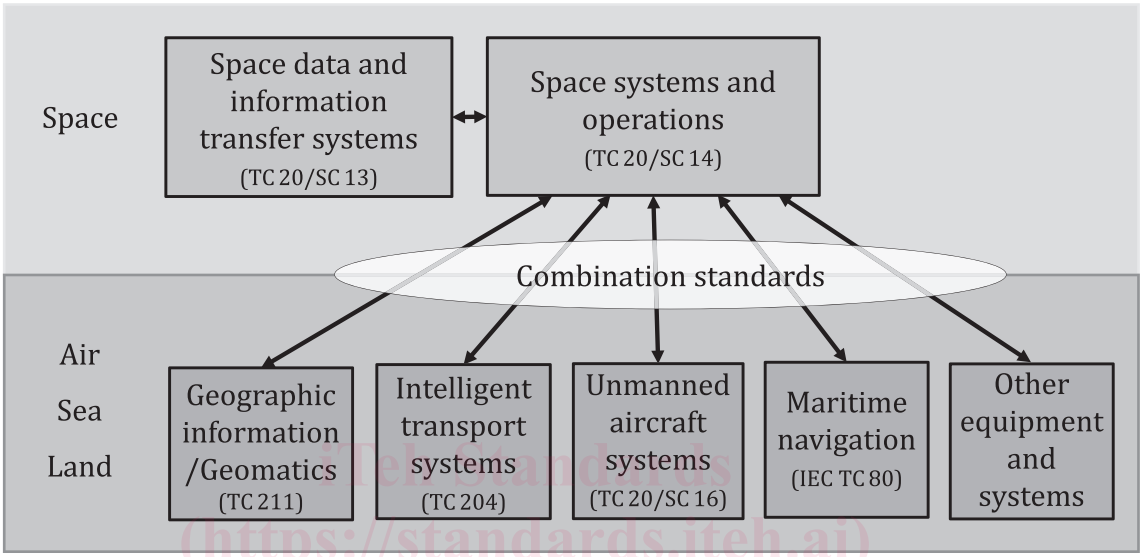

Figure 1 — Standardization of space-based services: GNSS relevant area

Space systems often become the last hope for people in harsh weather conditions to ensure the safety of life. This document is intended to ensure the safety with the power of space systems.

The operation of moving machines under such harsh conditions is difficult and unsafe for machine operators. For example, snow removal work with a snowplough is very difficult and unsafe for non-skilled workers. It is necessary to have experience and skills to operate the vehicle near the edges and features of a course. Because it takes a long period of training time to learn the operation skills for manoeuvring a work vehicle, it is becoming a serious problem in areas with heavy snow to secure the highly skilled workers who operate these vehicles and to maintain a continuous plan for subsequent replacement due to the retirement of skilled workers.

The purpose of this document is to mainly determine the safety requirements for a space-based high accuracy positioning system by which vehicles can be operated safely even in low visibility conditions with less experienced operators having minimum experience and skills.

This document refers to some general systems such as agricultural machines, road cleaning machines or construction machines which require positioning accuracy. It applies to general works such as staying the course, docking, and unloading works.

In general, it is difficult and dangerous to operate machines in low visibility due to harsh optical conditions. In such situations, the machine's positioning system requires a high degree of accuracy. This document considers the following two distinctive features commonly observed in the high accuracy positioning applications requiring safety.

— Generally speaking, a rover needs to be operated in situations where image sensors (cameras or LiDARs or both) cannot be used and the risk of accidents becomes higher.

— In addition, a machine needs to be operated in close proximity to various kinds of obstacles such as signals, signs and guide-rails on boundary lines because of its purpose. This is the main reason for the necessity of having skilled operators.

Ultimately, this document aims to help system design by which a rover can be operated safely even in low visibility situations with less experienced operators to contribute to improving the quality of life through the space-based service.

Space systems — Space-based services for a high accuracy positioning system with safety requirements

1 Scope

This document provides requirements and recommendation for space-based systems that, using satellite radionavigation services, provide high accuracy positioning of rovers. It is particularly intended for rovers whose operation requires meeting specific safety requirements, including in situations of low visibility. This document also provides methods to verify the system requirements, as well as complementary information on particular applications (Annex A), mobile mapping systems (Annex B) and augmented positioning (Annexes C and D).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 18197:2015, *Space systems — Space based services requirements for centimetre class positioning*

3 Terms and definitions

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

ISO and IEC maintain terminological 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
satellite radionavigation
satellite radiodetermination (3.2) used for *radionavigation* (3.3)

[SOURCE: IEC 60050-725:1994, 725-12-51]

3.2
satellite radiodetermination
radiodetermination (3.4) which makes use of a satellite system

[SOURCE: IEC 60050-725:1994, 725-12-49]

3.3
radionavigation
radiodetermination (3.4) used for the purpose of navigation, including obstruction warning

[SOURCE: IEC 60050-725:1994, 725-12-50]

3.4
radiodetermination
determination of the position, velocity and/or other characteristics of an object, or the obtaining of information relating to these characteristics, by means of radio waves

[SOURCE: IEC 60050-725:1994, 725-12-48]

3.5
safety
state where an acceptable level of *risk* (3.6) is not exceeded

Note 1 to entry: Risk relates to:

— fatality,

— injury or occupational illness,

— damage to hardware or facilities,

— damage to an element of an interfacing manned system,

— the main functions of a system itself,

— pollution of the environment, atmosphere or outer space, and

— damage to public or private property.

[SOURCE: ISO 10795:2019, 3.210, modified — Note 1 to entry has been generalized for activities on planets or moons.]

3.6
risk
undesirable situation or circumstance that has both a likelihood of occurring and a potentially negative consequence on a project

Note 1 to entry: Risks arise from uncertainty due to a lack of predictability or control of events. Risks are inherent to any project and can arise at any time during the project life cycle; reducing these uncertainties reduces the risk.

[SOURCE: ISO 17666:2016, 3.1.12]

3.7
accuracy
closeness of agreement between a test result or measurement result and the true value

Note 1 to entry: In practice, the accepted reference value is substituted for the true value.

Note 2 to entry: The term "accuracy", when applied to a set of test or measurement results, involves a combination of random components and a common systematic error or bias component.

Note 3 to entry: Accuracy refers to a combination of bias and precision.

[SOURCE: ISO 3534-2:2006, 3.3.1, modified — In note 3 to entry, "trueness" has been changed to "bias".]

3.8
integrity
measure of the trust that can be placed in the correctness of the information supplied by a navigation system and that includes the ability of the system to provide timely warnings to users when the system should not be used for navigation

[SOURCE: 2019 Federal Radionavigation Plan, DOT-VNTSC-OST-R-15-01, A.1.10]

3.9
dead reckoning
method to obtain a vehicle position by using a compass or inertial measurement or both, and which can be connected with vehicle sensors which record a forward distance and steering direction

3.10
integrated positioning
positioning incorporating two or more positioning technologies

[SOURCE: ISO 19116:2019, 3.14, modified — "system" has been removed from the term and the definition; note 1 to entry has been removed.]

3.11
mountainous district
district where necessary satellites are not visible for positioning regularly due to being blocked by mountains

4 Abbreviated terms

DGNSS	differential GNSS
GNSS	global navigation satellite system
HDOP	horizontal dilution of precision
IMU	inertial measurement unit
LiDAR	light detection and ranging
MMS	mobile mapping system
RFID	radio frequency identification
RMS	root mean square

5 Service system and risks

5.1 Service system

The high accuracy positioning system for rovers is intended to serve general works such as staying the course, docking, and unloading, as illustrated in Figure 2.

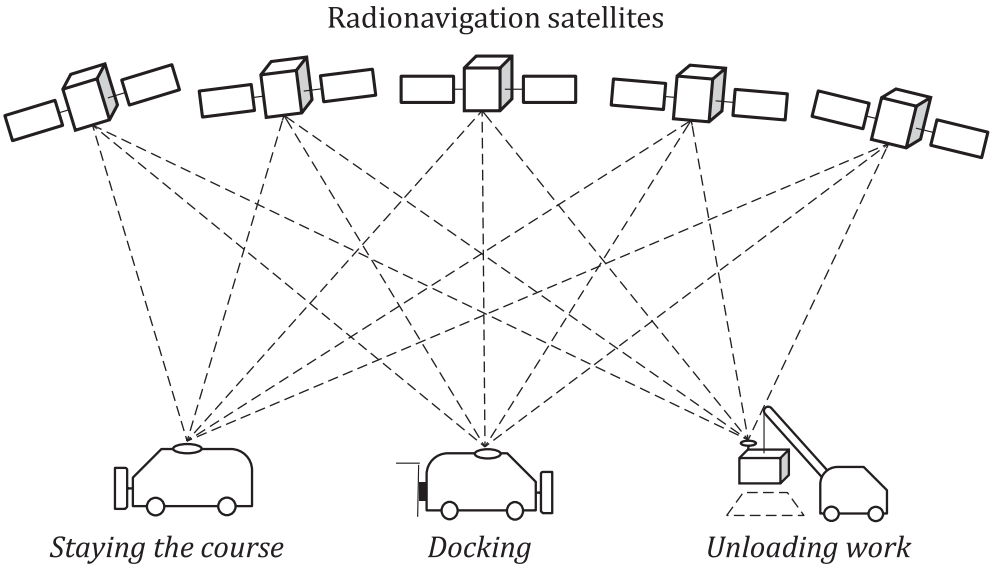

Figure 2 — System overview: work examples

To establish this service system, it is necessary to clarify the target of the rover works. In this document, the works have been classified into 4 categories by target works and object sizes as shown in Table 1. The service system varies depending on the category of the target work. The object size is the size that should be recognized by a precise positioning rover to execute the target work.

Table 1 — Categorization and target work

Work category	Example of target work	Guide of object size in RMS
1	— Keep course edge or side line clear from dirt or snow — Keep docking position between the vehicle and the supply station such as power, fuel	0,1 m to 0,25 m
2	— Keep side strip or side path clear	0,25 m to 0,5 m
3	— Keep course width or flatness roughly — Spread usable area of intersection	0,5 m to 1 m
4	— Stay along the wide course — Keep landing area	Over 1 m

ISO 18197 applies to the work category 1. ISO 18197:2015, 5.4.1 also specifies metre class positioning, which applies to the work categories 2 to 4.

5.2 Risks

The following risks are inherent to a rover making use of the high-accuracy positioning system:

a) collision to obstacles;

b) dropping from course edge;

c) damage through the works;

d) collision to other vehicles.

In order to manage these risks, Clause 6 specifies safety requirements.

6 Rover safety requirements

6.1 General

In order to establish general principles for a high accuracy positioning of rovers, it is important to clarify the related rover safety requirements and recommendations. Seven rover safety provisions are identified in 6.2 to 6.8. Depending on which safety provisions need be met, the positioning system can vary. The specific system specifications and their verification are covered in the subsequent subclauses as specified in Table 2.

6.2 Usage of accurate map data (safety provision 1)

The high accuracy positioning rover shall use the accurate map data.

6.3 Indication of positioning quality (safety provision 2)

The high accuracy positioning rover shall check the positioning quality and shall be operated depending on the quality indication.