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ISO/DTS 15143-4

Earth-moving machinery and mobile road construction machinery — Worksite data exchange —

Part 4: Worksite topographical data

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Foreword

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This document was prepared by Technical Committee ISO/TC 127, *Earth-moving machinery,* Subcommittee SC 03, *Machine characteristics, electrical and electronic systems, operation and maintenance.*

A list of all parts in the ISO 15143 series can be found on the ISO website.

This document is intended to be used in conjunction with ISO 15143-1 and ISO 15143-2.

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 the fourth part in a series of documents covering data communication involving earth moving machinery, as defined in ISO 6165, on construction worksites.

ISO/DTS 15143-1 defines the architecture of a worksite information system used to transfer information from the earth moving machinery (EMM) to various users via the worksite information system.

ISO/DTS 15143-2 defines the individual data elements in a data dictionary.

ISO/DTS 15143-3 defines a set of data elements common to the status and health of EMM that is collected by multiple OEMs or third party telematics suppliers and distributed over the internet to application software used to manage machine operation.

ISO/DTS 15143-3 focuses on data for management of a fleet of machines, independent of worksite, while ISO/DTS 15143-4 focuses on data for management of a worksite and the assets specific to that worksite.

Construction worksites vary greatly in size, tasks, complexity, and scope of work. Some worksites have more design models, stakeholders, tasks and local regulations than others. In addition, most worksites have different construction contractor companies involved in various phases of the construction process. Each company can use different technologies for executing tasks. Grade control is a common technology used for earthmoving to enhance operator productivity by augmenting control of a machine's working tool using a 3D design model of the worksite. The main high level elements of a grade control solution are on-machine hardware, local job correction, field measurement equipment, design models, and offboard software tools. This document takes into account the current state of the art in machine guidance technology (grade control, compaction, etc.).

Stakeholders on the worksite must be able to interact effectively in order to complete a construction project as efficiently as possible. ISO/DTS 15143-1 defines protocols enabling different vendors of various grade control systems to efficiently interoperate on the same worksite. This document defines specifications relating to solutions both on and off the worksite.

This document focuses on the earthmoving phase of a construction worksite. Earthmoving activities are needed for many applications, such as water runoff management, stripping and reclamation, sanitary landfills, worksite development and roadbuilding.

Conformance to this document means that the relevant solutions have the specified capabilities. However, this document does not imply designing solutions that require the end-users to use these features. Since there are so many variations in job sites, tasks, and business relationships between stakeholders on a project, possibly not all of the capabilities provided on specific sites will be used. While it is possible that the end-user will not use all of the capabilities provided, conformance to this document means that the solutions include the required capabilities. Some examples include the following:

— The ability to provide information on RTK data sources to the vendor integration system (VIS) is a required capability of the site management system (SMS); however, the end-user of a particular SMS on a specific site can choose to not provide information on RTK data sources to the VIS on that site.

— A VIS can provide information about asset operators; however this document does not require the VIS end-user to enter this information

It is the responsibility of the user of this document to determine the applicability of legal and regulatory requirements prior to use.

Earth-moving machinery and mobile road construction machinery — Worksite data exchange —

Part 4: Worksite topographical data

1 Scope

This document specifies requirements for data exchange at the interface between earth-moving machinery, as defined in ISO 6165, mobile road construction machinery, as defined in ISO 22242, and the worksite information systems. It focuses on data for management of a worksite and the assets specific to that worksite.

This document includes:

a) methods of local position correction and localization, including standardization of RTK corrections;

b) method of implementation of a common design model;

c) types of data and methods of data exchange between servers. This includes application programming interfaces (APIs) to exchange data between servers regardless of vendor. These APIs focus on project data, as-built data, and production data. Field-equipment-to-server and machine-to-machine are not included.

This document covers both hardware mounted on earthmoving equipment and field measurement equipment.

This document does not define methods of on-machine data collection, on-machine communication protocol (e.g. CAN bus), wireless transmission of data to the vendor's server, or wireless transmission of data directly between machines onsite. This document also does not include design software requirements or other areas related to building information management (BIM). Data formats and transfer methods from design software to the SMS are not in scope.

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 3779, *Road vehicles — Vehicle identification number (VIN) — Content and structure*

ISO 8601 (all parts), *Data elements and interchange formats – Information interchange – Representation of dates and times*

ISO 10261, *Earth-moving machinery — Product identification numbering system*

ISO/IEC 12113, *Information technology — Runtime 3D asset delivery format — Khronos glTF™ 2.0*

ISO/IEC 10118-3:2018, *IT Security techniques — Hash-functions — Part 3: Dedicated hash-functions*

ISO 80000-1, *Quantities and units — Part 1: General*

IETF RFC 8259, *The JavaScript Object Notation (JSON) Data Interchange Format*

IETF RFC 7231, *Hypertext Transfer Protocol (HTTP/1.1): Semantics and Content*

IETF RFC 6455, *The WebSocket Protocol*

IETF RFC 7692:2015, *Compression Extensions for WebSocket*

IETF RFC 6749:2012, *The Oauth 2.0 Authorization Framework*

IETF RFC 4122, *A Universally Unique Identifier (UUID) URN Namespace*

IETF RFC 1738, *Uniform Resource Locators (URL)*

IETC RFC 3629:2003, *UTF-8, a transformation format of ISO 10646*

IETF RFC 3339, *Date and Time on the Internet: Timestamps*

IETC RFC 7232:2014, *Hypertext Transfer Protocol (HTTP/1.1): Conditional Requests*

RTCM 10403.3, *Differential GNSS (Global Navigation Satellite Systems) Services*

RTCM 10410.1, *Standard for Networked Transport of RTCM via Internet Protocol (Ntrip)*

RTCM 13500.1, *Radio Layer for Real-Time DGNSS Applications*

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 General terms relating to construction worksites and technology

3.1.1
as-built data
data which is used to document the shape and quality of work done on a worksite

Note 1 to entry: As-built data can be other than just topographic data.

3.1.2
contractor
person or organization that undertakes construction work in accordance with a contract

[SOURCE: ISO 15143-1:2010, 3.2.11]

3.1.3
design data
data prepared in the pre-construction phase presenting shape, structures and quality of the object of the construction concerned

[SOURCE: ISO 15143-1:2010, 3.4.7]

3.1.4
design file
file containing at least one design model

3.1.5
design model
virtual representation of design data comprised of design objects intended to represent an object on the construction worksite

3.1.6
design object
individual element in a design model (ie point, line, surface etc.)

3.1.7
field equipment
assets, such as grade control systems and rovers, that are connected with a VIS

3.1.8
grade control
system of 3D positioning devices (e.g. GNSS receivers), data radios, embedded computers and software to control the working tool on an earth moving machine with respect to a design file

3.1.9
localization
series of mathematical computations that transform WGS-84 coordinates into local Cartesian coordinates and vice versa

Note 1 to entry: The conversion of geodetic positions produced using GNSS (WGS-84) positioning into local worksite northing, easting and elevation (orthometric height) coordinates.

3.1.10
northing, easting, and elevation
NEE
Cartesian axes X (easting), Y (northing), and Z (elevation) in surveyingNote 1 to entry: Elevation is also known as orthometric height.

3.1.11
production data
data which is used to determine progress towards a target outcome

Note 1 to entry: The measurement of progress can vary based on site. For example, streaks and acres are two measurements of progress.

3.1.12
project data
basic data related to a construction project passed from the design phase to the field

Note 1 to entry: Project data includes data related to the project, tasks, as well as references to design files.

3.1.13
site management system
SMS
system which serves end-users in managing a construction worksite by managing design objects, maintaining an aggregation of as-built and production data, and managing project data

Note 1 to entry: The SMS supports end-users in managing a mixed-fleet of machines on a worksite, and holds the authoritative data for a worksite.

3.1.14
site reporting system
SRS
system which serves end-users in analysing the performance of a construction worksite by providing means to report on or otherwise post-process data

Note 1 to entry: The SRS does not provide data, it only retrieves it.

3.1.15
streak
journal of working tool positions and attributes

3.1.16
survey
process of making the measurements that are necessary to determine the relative position of points above, on, or beneath the surface of the Earth, or to establish such points

[SOURCE: ISO 22932-1:2020, 3.2.1.32, modified — "Science or art" replaced with "process".]

3.1.17
survey point
location collected on the worksite from survey equipment or grade control equipped machines

Note 1 to entry: Survey points have several use cases, such as mapping existing objects, as-built reporting, progress reporting, or quality control testing.

3.1.18
topographic data
data in three-dimensional form representing the surface of the ground or any layer of the finished surface and comprised of as-of-present (or as-built) and as-designed data

[SOURCE: ISO 15143-1:2010, 3.2.46, modified — “Road” replaced with “ground”, and “road” replaced with “finished surface”.]

3.1.19
vendor integration system
VIS
system, connected to on-machine grade control solutions, which makes vendor machine data available to the SMS for a worksite, and makes SMS worksite data available to machines

3.1.20
working tool
component on an earth moving machine that engages the dirt

Note 1 to entry: Examples of working tools are blades on a motor grader or the bucket on an excavator.

3.1.21
worksite
physical location or virtual representation of the operation of a fleet of mobile equipment generally identified as construction machines or measurement equipment where the machines are used to perform work

3.2 Terms specific to field positioning

3.2.1
base station
non-moving GNSS receiver that provides local worksite observables, often called corrections or signals

Note 1 to entry: These signals are used in RTK processing.

Note 2 to entry: See also *real-time kinematic* (3.2.14).

3.2.2
coordinate
one of a sequence of numbers designating the position of a point

[SOURCE: ISO 19111:2019, 3.1.5, modified — Note 1 to entry has been removed.]

3.2.3
coordinate reference system
coordinate system that is related to an object by a datum

[SOURCE: ISO 19111:2019, 3.1.9, modified — Notes to entry have been removed.]

3.2.4
datum
reference frame
parameter or set of parameters that realize the position of the origin, the scale, and the orientation of a coordinate system

[SOURCE: ISO 19111:2019, 3.1.15]

3.2.5
ellipsoid
reference ellipsoid
geometric reference surface embedded in 3D Euclidean space formed by an ellipse that is rotated about a main axis

[SOURCE: ISO 19111:2019, 3.1.22, modified — Domain and Note 1 to entry have been removed.]

3.2.6
flattening
ratio of the difference between the semi-major (a) and semi-minor axis (b) of an ellipsoid to the semi-major axis: $f = (a - b)/a$

[SOURCE: ISO 19111:2019, 3.1.28, modified — Symbol and Note 1 to entry have been removed.]

3.2.7
global navigation satellite system
GNSS
system consisting of several satellites in different orbital planes, which allow absolute navigation solutions as well as highly precise (e.g. differential) positioning and broadcasting of time due to the global coverage

[SOURCE: ISO 9849:2017, 3.1.5, modified — Note 1 to entry and all examples have been removed.]

3.2.8
GNSS receiver
electronic device that receives and processes the signals from GNSS satellites in order to provide position, velocity and time (of the receiver)

[SOURCE: ISO 9849:2017, 3.1.5.1]

3.2.9
measurement equipment
apparatus installed on a construction machine or placed on a worksite in order to acquire information on site conditions and situation

Note 1 to entry: Examples of measurement equipment include total stations, robotic total stations, theodolites, GNSS receivers, retroreflectors, 3D scanners, subsurface locators, drones etc.

[SOURCE: ISO 15143-1:2010, 3.2.25, modified — Note 1 to entry has been added.]

3.2.10
meridian
intersection of an ellipsoid by a plane containing the shortest axis of the ellipsoid

Note 1 to entry: This term is generally used the describe the pole-to-pole arc rather than the complete closed figure.

[SOURCE: ISO 19111:2019, 3.1.42]

3.2.11
positioning sensors
object or device used to measure points on a surface that are aggregated to create as-built topographic data

Note 1 to entry: Examples of positioning sensors include the tool-tip of the working tool on a machine, traditional field measurement equipment, unmanned aerial vehicles, LIDAR systems, stereo cameras, etc.

3.2.12
projection
projected coordinate reference system

Note 1 to entry: A map projection is a coordinate conversion from an ellipsoidal coordinate system to a plane.

3.2.13
Radio Technical Commission for Maritime Services
RTCM
standards organization focused on in-depth radio communication and radio navigation areas

Note 1 to entry: The RTCM features two Special Committees that produce standards applicable to construction worksites:

Note 2 to entry: — SC 104, Differential GNSS Service — see RTCM 10403.3 *Differential GNSS (Global Navigation Satellite Systems) Services*, Version 3.2 or higher;

Note 3 to entry: — SC 135, Radio Layer for Real-Time DGNSS Applications.

3.2.14
real-time kinematic
RTK
real-time processing algorithm technique of mobile GNSS receivers using the carrier phase of GNSS observations for a positioning of the mobile GNSS receiver within a reference network, or from a single base station, in a low cm-level resolution

Note 1 to entry: In real-time kinematic (RTK) application, measurements of the phase of the signal's carrier wave are used to provide real-time corrections. By a data link from the reference station to the rover station, the corrections are transmitted to enhance the precision of the position up to cm-level.

[SOURCE: ISO 9849:2017, 3.1.5.4, modified — "or from a single base station" and "resolution" added.]

3.2.15
WGS-84
reference system used in the satellite-based positioning system NAVSTAR Global Positioning System (GPS)

Note 1 to entry: The World Geodetic System (WGS) is a standard for use in cartography, geodesy, and navigation. The latest revision is WGS-84.

[SOURCE: ISO 13184-2:2016, 3.11, modified — "WGS-84 coordinate system" changed to "WGS-84".]

3.3 Terms specific to data exchange

3.3.1
application programming interface
API
invocation method or associated parameter used by one piece of software to request actions from another piece of software

[SOURCE: ISO/IEC 18012-1:2004, 3.1.1. modified — "Collection of" removed.]

3.3.2
background drawing
non-measurable drawing that is intended for view-only purposes in the field

3.3.3
coarse-grained
authorization statements which can be minted in the token, such as the OAuth scopes

Note 1 to entry: An example is that a VIS can read but not write.

3.3.4
endpoint
address for the provider's server for a specific API method

Note 1 to entry: Endpoints are typically accessed by a URL.

3.3.5
end-user
real person who has authentication and authorization access for a tenant within an SMS or VIS

3.3.6
equipment _ID
user-friendly name provided by an end-user and used to identify equipment

Note 1 to entry: The end-user provides this information to the VIS provider during registration.

Note 2 to entry: This concept is also identified in ISO/TS 15143-3.

3.3.7
fine-grained
detailed statements which are made in a policy, to which the token refers

Note 1 to entry: An example is that a VIS can read machine as-built for graders and bulldozers, but can only write data for bulldozers.

3.3.8
media type
description of the content type of a message in conformance with IETF RFC 2045

3.3.9
policy
authorization information stored in the SMS and VIS which grants access to worksite resources

3.3.10
system-of-record
information system considered to be the authoritative source for a specific piece of information

3.3.11
tenant
organization or customer being represented within an SMS or VIS

3.3.12
timestamp
date and time at which a data point is created

3.3.13
token
sequence of characters representing either a verified identity or access, or both

[SOURCE: ISO 20078-1:2021,3.2.8, modified — Notes to entry have been removed.]

3.3.14
VIS asset ID
identifier created in conformance with IETF RFC 4122 by a VIS for an asset such as an earth moving machine

3.4 Terms specific to codelist

3.4.1
codelist
dictionary and visualization scheme for worksite design model, as-built and survey data objects

3.4.2
category code
substitutes CAD layer concept providing human readable names and visualization for a group of design model, as-built and survey data objects through codelist concept

3.4.3
feature code
type and codelist attributes for design, as-built and survey objects

3.4.4
codelist attribute
individual triple (name, type, unit) within a feature code or category code

3.4.5
code group
virtual group holding a number of category and feature codes

4 System overview

4.1 Service roles

To help manage their worksites, construction contractors choose a software system which serves as the site management system (SMS) role for their operation. This software:

— stores all design files and project data;

— collects and stores as-built and production data for the worksite;

—provides a way to manage and report on the worksite.

A worksite frequently utilizes grade control solutions from different vendors. These vendors provide systems which implement the vendor integration system (VIS) role. Server-to-server data communication happens between an SMS and one or more VIS. A VIS pulls worksite design files and project data from the SMS, and pushes as-built and production data from the worksite to the SMS. The VIS also pulls as-built and production data from the SMS, as needed.

Each VIS exchanges data with the connected grade control machines and other field equipment that it manages.

The data available from a worksite will possibly need to be made available to other systems for the purpose of reporting or other post-processing. A vendor can provide a system for this purpose, referred to as a site reporting system (SRS). When acting as an SRS, the system shall not provide data, only retrieve it.

One software system can implement any combination of SMS, VIS and SRS roles.

Figure 4.1 illustrates the connection between a VIS'es and SMS, and their relationship within the scope of this document.