



BSI Standards Publication

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

Part 4: Worksite topographical data

National foreword

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Technical Specification

ISO/TS 15143-4

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

Part 4: Worksite topographical data

*Engins de terrassement et machines mobiles de construction de
routes — Échange de données sur le chantier —*

Partie 4: Données topographiques sur le chantier

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at www.iso.org/patents. ISO shall not be held responsible for identifying any or all such patent rights.

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

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.

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

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

ISO/TS 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/TS 15143-3 focuses on data for management of a fleet of machines, independent of worksite, while this document 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 earth moving 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 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 earth-moving phase of a construction worksite. Earth-moving 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.

Certain nouns in this document are programmatic and key elements of implementation, such as types, enumerations, and URL elements. For clarity, these programmatic nouns are italicized and use a different font from the rest of the document.

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 earth-moving 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 <https://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 (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 surveying

Note 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 to 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 can 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 VISs and SMS, and their relationship within the scope of this document.

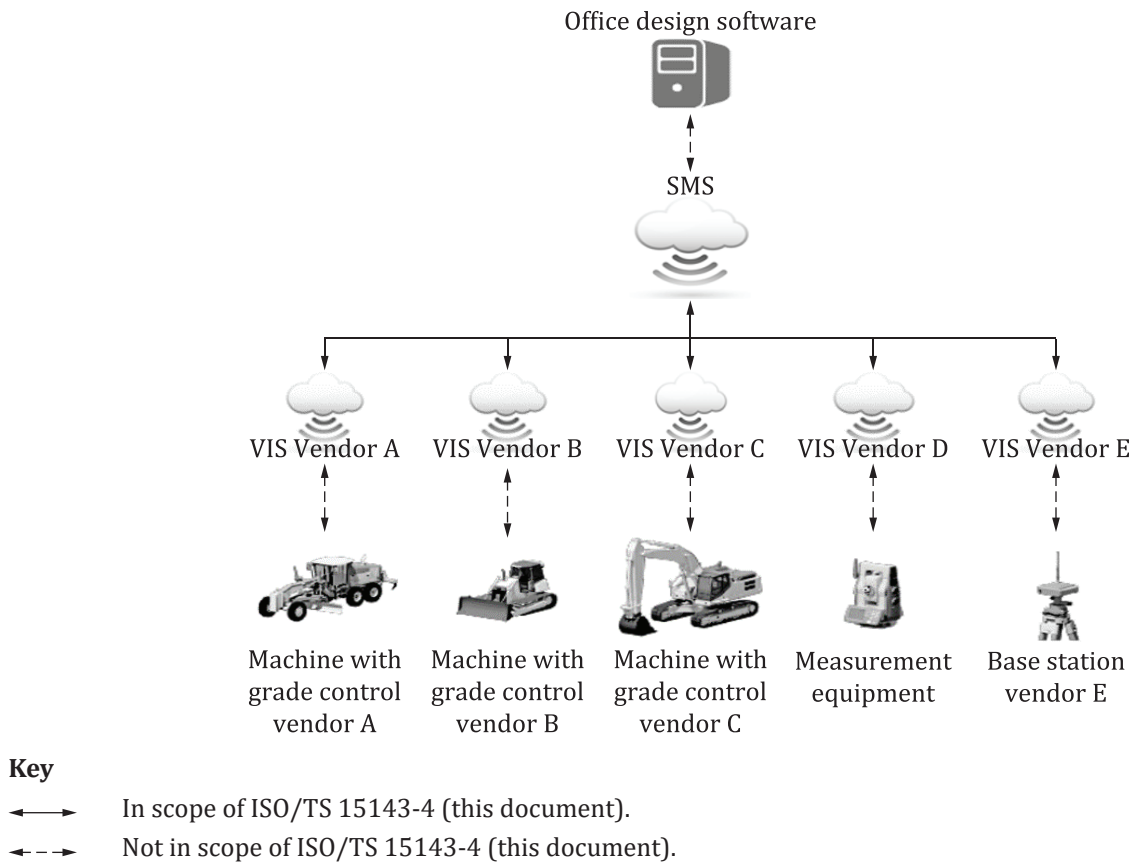


Figure 4.1 — Relationships between VIS and SMS

Due to the wide variety of VIS solutions and capabilities, not all requirements in this document are universally applicable to all VIS solutions. VIS solutions vary depending on scope of their product. Examples include:

- Not all VIS offer solutions that generate the breadth of data outlined in this document. For example, some VIS do not offer surveying or compacting solutions.
- There can be some VIS that do not offer solutions that leverage all included data (e.g., codelists).

On the other hand, an SMS will interact with multiple VIS's and in multiple use cases.

The following apply:

- a) The requirements in the document apply equally to VIS and SMS, unless specifically noted in the relevant clause.
- b) For solutions offered by the VIS or SMS, all relevant clauses in this document apply.
- c) All requirements in this document are universally applicable to all SMS solutions.

4.2 Project data

Project data is the data passed from the office to the field required to describe a construction project happening at a worksite. It consists of metadata such as materials, planning data such as work orders, and references to design files. This document defines a set of data types for exchanging project data between an SMS on one end and either a VIS or an SRS on the other end.

4.3 Design model exchange format

Worksite design information exists in various different formats and levels of detail. This information is harmonized and exported to a file in ISO LandXML format, as defined in [Annex L](#). The ISO LandXML includes objects relevant to field equipment, including (but not limited to) triangle mesh surfaces, lines, alignments, and pipe networks.

The SMS, VIS and field equipment may use proprietary design model exchange formats internally. However, for data exchange between SMS and VIS from different vendors, they shall convert such proprietary formats to the design model exchange formats defined in this document.

4.4 Common localization

The SMS supplies information to a VIS which is necessary to enable its field equipment to have a consistent transformation of GNSS positions to the local northing, easting and elevation coordinates (NEE).

Field equipment that uses RTK GNSS field for positioning require the use of a base station, either local or remote. This document defines the methods of interoperability for field equipment and the base station operating on a worksite.

4.5 Units and formatting

All measurements in this document are in SI units in accordance with ISO 80000-1. Units are assumed to be base units except for cases where non-base units are explicitly stated with the measurement.

ISO LandXML design data shall conform to ISO 80000-1 and is expected to convey values in base SI units.

Certain nouns in this document are programmatic and key elements of implementation, such as types, enumerations, and URL elements. For clarity, these programmatic nouns are italicized and use a different font from the rest of the document.

4.6 As-built and production data exchange

As-built and production data includes survey data, machine implement positions and sensor measurements, and machine local triangulated surfaces. This document defines a set of data types for exchanging as-built and production data between an SMS on one end and a VIS or an SRS on the other end.

4.7 Concept diagram

See [Figure 4.2](#) for an illustration of the high level scheme.

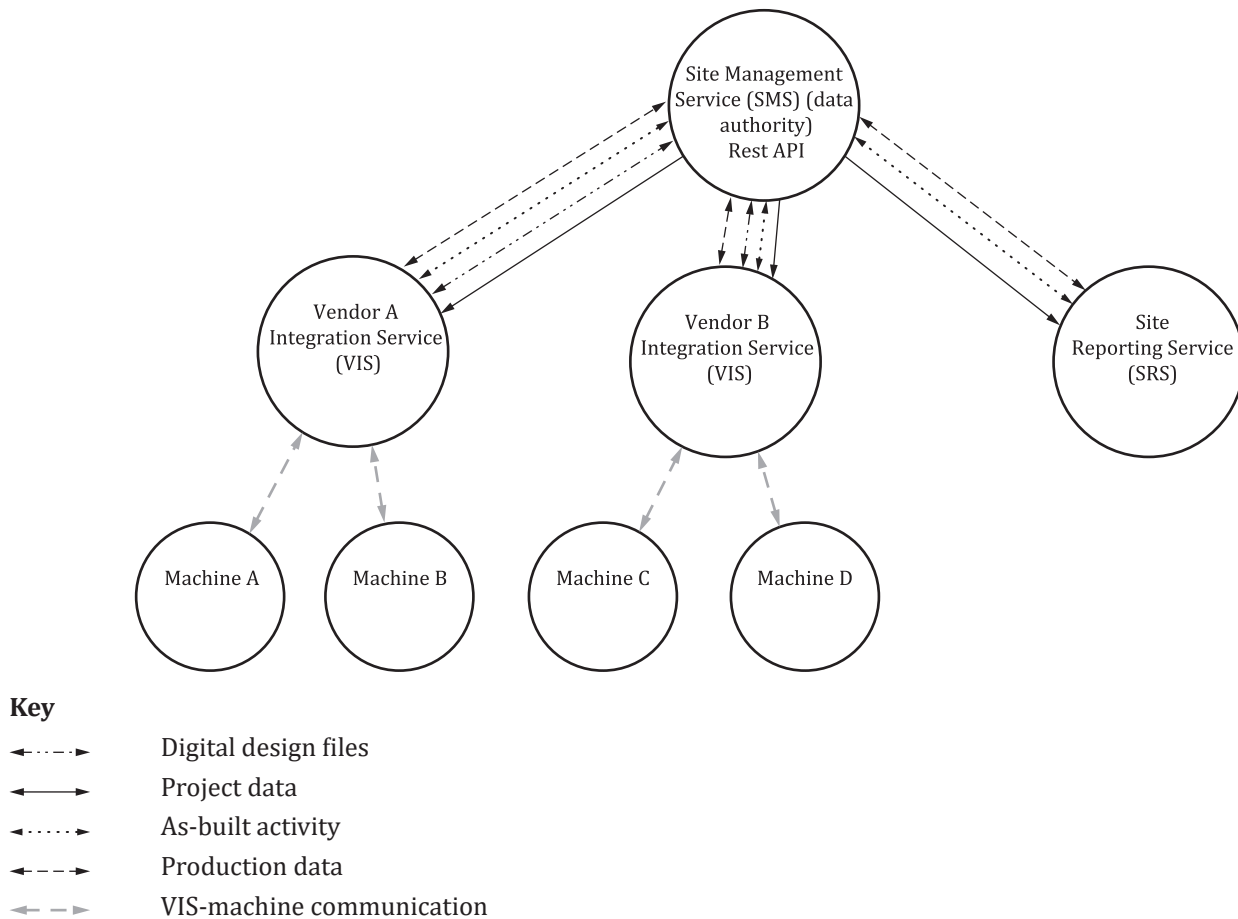


Figure 4.2 — Data flow

As shown in [Figure 4.2](#), project managers administer the worksite from the SMS.

The SMS is the source-of-truth for the aggregated Project data and provides access to it via a REST API. The VIS collects vendor machine worksite data and pushes it to the SMS. The VIS pulls worksite data from the SMS and distributes it to vendor machines.

5 Method of data exchange between servers

5.1 General

The SMS shall implement REST and WebSocket APIs for all data exchange as described in [Annex B](#), [Annex E](#), [Annex I](#) and [Annex J](#).

The SMS REST APIs should support HTTP2.0 in conformance with IETF RFC 7540 (or later). The SMS REST APIs shall support HTTP1.1 in conformance with IETF RFC 7231, secured with TLS. HTTP1.1 without TLS shall not be supported. A VIS should preference establishing HTTP2.0 (or later) client connections to an SMS, falling back to HTTP1.1 and TLS where HTTP2.0 (or later) is not available. For all SMS HTTP endpoints, the following requirements apply:

- The SMS shall support the HTTP header “Accept-Encoding” with value “gzip” and respond with “Content-Encoding” value “gzip”.
- For POST and PUT, the SMS shall support the HTTP header “Content-Encoding” with value “gzip”.
- A VIS shall POST and PUT with appropriate “Content-Type” headers, such as “application/json” for JSON bodies.

- The SMS shall respond with appropriate “Content-Type” headers, such as “application/json” for JSON bodies.
- A VIS and an SRS shall follow SMS redirects.

5.2 API URL

A VIS or SRS shall obtain an `apiURL` for each SMS it connects to. The `apiURL` shall be used by VIS and SRS to form REST API routes as specified in [Annex B](#). The method of how a VIS obtains the `apiURL` must be agreed upon between the VIS and SMS.

5.3 Discovering worksites

To facilitate the discovery of available SMS worksite resources, the SMS shall implement a worksite directory REST API as specified in [Annex B](#). This API shall list worksites shared to a VIS or SRS end-user for data exchange. For each worksite listed, the SMS shall provide a `worksiteBaseURL`. The `worksiteBaseURL` shall be used by VIS and SRS to form REST API routes specific to the worksite, as detailed in the document.

5.4 Reporting unexpected errors

The SMS shall implement an error reporting REST API as specified in [Annex B](#). VISs and SRSs should report unexpected errors (such as unexpected HTTP response codes and data which do not conform to schema) to the SMS using this API, allowing support staff at the SMS the opportunity to resolve issues in a timely manner.

5.5 Authorizing worksite data exchange

Data exchange, as discussed in this document, is between a VIS (or SRS) worksite resource and an SMS worksite resource. To facilitate data exchange, authorization relationships shall be established between the VIS (or SRS) and SMS worksites. While it is end-users who establish these relationships, once established the data exchange shall operate regardless of those end-users being logged into their respective system.

The SMS, VIS (or SRS) shall implement the mechanism needed for establishing these authorization relationships as specified in [Annex A](#).

5.6 Versioning

In order to allow for publication of different versions of this document, and of the schemata used by this document, the following definitions apply:

- the major version shall be of the value 2024. Future versions of this document are expected to change this value to a numerically greater one;
- where files are published in accordance with [Annex N](#), each published JSON Schema file shall have a minor version of the form YYYYMMDD, the date of publication of the schema file;
- the semantic version of a published JSON schema file shall be formed as `{major version}.{minor version}`.

Changes to types are managed by the maintenance agency as discussed in [Annex N](#).

6 Method of project data exchange

6.1 General

An SMS shall be responsible for maintaining worksite project data. Project data shall be communicated as JSON objects as described in [Annex E](#). An SMS shall make project data available by providing the endpoints specified in [Annex F](#) and in [Clause 6](#).

6.2 Obtaining project data

An SMS shall provide two separate APIs for obtaining data.

- a) A long-poll event API to provide a synchronization mechanism for a VIS described in [Clause F.3](#).
- b) A REST API to provide current project data elements to an SRS.

A VIS shall use the synchronization mechanism to both initialize the VIS project data and maintain synchronization with the SMS project data. A VIS shall pass applicable project data to worksite equipment.

A SRS may obtain a snapshot of current project data by sending GET requests to the relevant endpoint for each data type, as specified in [Clause F.4](#).

An SRS shall not contribute any project data or upload files.

6.3 Contributing project data

The SMS is responsible for maintaining project data and may use its own methods to create it.

A VIS may contribute project data that it owns by sending a POST request to the appropriate endpoint as per [Clause F.12](#). For the purpose of this document, the VIS is considered to only own data concerning the types *asset* and *operator*.

On receipt of such data, where correctly authorized by policy, the SMS shall:

- a) add the required metadata as described in [Clause E.2](#);
- b) not semantically modify the data in any other way;
- c) return this composite object to the VIS as the response body of the request;
- d) publish this object to any VISs currently subscribing to changes as per the above [Clause 6.2](#).

A VIS may contribute an update to project data that it created by sending a PUT request to the appropriate endpoint as per [Clause F.12](#).

A VIS may delete project data that it created by sending a DELETE request to the appropriate endpoint as per [Clause F.12](#). The VIS should delete the *asset* and *operator* objects when they permanently leave the site. When a VIS deletes an *asset* object, the VIS should notify the physical asset that their association with the worksite has terminated and it should delete the worksite's data from its local storage.

A VIS may upload files (such as from a survey) to an SMS by following the workflow described in [Clause F.7](#).

7 Method of as-built and production data exchange

7.1 General

As-built and production data originate from a variety of measuring equipment and positioning sensors in all phases of the construction process. Data collected by measuring equipment and positioning sensors is communicated from machine to VIS.

A VIS provides this data to the SMS using types defined in [Annex G](#) and [Annex H](#). The SMS aggregates the data and makes the aggregated data available to connected VISs or SRSs using the same types. Further aggregation of the data, such as to provide reports, is not in the scope of this document.

The SMS shall implement REST and WebSocket APIs as defined in [Annex I](#) and [Annex J](#) to enable this worksite data exchange.

There are two separate use-cases for as-built and production data.

- The need for an authoritative record of machine activity on the worksite. This use case is supported by the system-of-record data stream.
- The need for a low-latency data stream to support the here-and-now aspects of machine state, location, and posture. This use case is supported by the real-time data stream.

These two use cases trade off timeliness and reliability, with the system-of-record stream favouring reliability and the real-time stream favouring timeliness.

While the data representation in the two streams differ, the position and state described by them should match.

7.2 System-of-record data stream

The SMS shall implement a HTTP REST API for the system-of-record data stream as described in [Annex I](#). This stream contains as-built and production information in self-contained blocks designed to be an authoritative data record.

The system-of-record data types are defined in [Annex G](#). A VIS shall collect data objects of these types from worksite equipment and push them to the SMS. On receipt of these objects, the SMS shall append them to the system-of-record and make them available to polling VISs and SRSs. The SMS shall not modify the objects before making them available. If worksite equipment needs this data, the VIS shall poll the SMS API and pass the received objects to the equipment.

On the SMS, the system-of-record data stream is conceptualized as a sliding window of data aggregated across machines. The sliding window shall keep messages for a duration of at least 1 week from receipt. This allows for the SMS to persist aggregated data only for the duration of the window and for a VIS to resume pulling data from within the window in the event of system failure and subsequent recovery. The system-of-record shall present messages in the order they were received (transaction order), which is not necessarily the order in which events occurred in the field (temporal order).

7.3 Real-time data stream

The SMS shall implement a WebSocket API for the real-time data stream as described in [Annex J](#). This is a low-latency stream providing a best-effort communication about the position and pose of machine assets on worksite. This document makes no hard real-time or reliability constraints on the transmission of data. Accordingly, the data shall not be used for safety related purposes.

The real-time data types are defined in [Annex H](#). A VIS should publish data objects of these types to the SMS. On receipt of these objects, the SMS shall publish them to subscribed VISs. The SMS shall not modify the objects before publishing them. A VIS may subscribe to this API to communicate the locations of other vendors' assets to its own connected assets.

On the SMS, the real-time data stream is conceptualized as a message broker. A VIS may publish and subscribe to the real-time data stream for a worksite.

A SRS shall not publish or subscribe to the real-time data stream.

8 Method of design model data exchange

8.1 Design file format

Source design models shall be presented in the design file format defined in [Annex L](#), as it is communicated between the SMS and VIS. The VIS may convert the design file to a proprietary format prior to sending it to machine or field equipment. Conformance to this standard does not require grade control systems to directly use this design file format.

The design files communicated between an SMS on one end and a VIS or an SMS on the other shall validate against the ISO LandXML schema defined in [Annex L](#).

Content of the provided ISO LandXML schema focuses on elements needed to execute the tasks completed by typical grade control systems on a worksite.

8.2 Background drawings

A worksite's project data may reference background drawings. A background drawing is used for aiding in visualization of the design, but shall not be used for any field measurements or the grade control system for automatic control of the working tool.

Background drawings shall use DXF file format, and shall:

- use meters as distance unit, indicated by setting the `$INSUNIT` header variable to value 6;
- follow the specification of the DXF file of AC1012(R13) or later;
- set the `$ACADVER` header variable to the version in use.

8.3 Codelist

Codelist is a common concept in the surveying industry. In this document, codelist is applied for design, as-built and survey data objects.

Codelist may be used in combination with design files at VIS file import phase to enrich the contents of the design model file. The design model format defined in [Annex L](#) natively does not offer such functionality. See [Annex M](#) for more details.

9 Method of local position correction and localization

9.1 General

When field equipment using GNSS positioning comes onto a worksite, it should use the worksite's base stations together with the localization that is defined and communicated through project data.

9.2 RTK GNSS position correction

[Clause 9](#) shall apply only to those worksites that support RTK GNSS.

The base station shall make the base station observables available in accordance with RTCM 10403.3 (V3.3 or higher). Multi system message (MSM) shall be used.

This document does not require use of a narrow band UHF radio on the worksite. However, if a narrow band UHF radio is used then an RTCM 13500.1 (V1.0 or above), compatible radio shall be used. MSM3 or MSM4 should be used with UHF delivery.

When remote base stations with IP (internet) based delivery are utilized for a worksite, RTCM 10410.1 (NTRIP V2.0 or above) shall be used to provide the connection.

9.3 Localization

Within this document, all coordinates are reported in a local datum rectangular system consisting of NEE coordinates. It can be used in reverse to transform site coordinates into WGS-84.

The SMS should provide the localization to the VIS as defined in [Annex K](#), and the VIS should provide this information to field equipment in order to allow for a consistent transformation of GNSS positions to the local NEE coordinates. However, it is not required for VIS-connected field equipment to use the localization provided. Whenever the localization provided by the SMS is not used, users should ensure that the NEE values are consistent with the worksite coordinates.

The localization system defined in [Annex K](#) does not attempt to implement every possible coordinate transformation. Rather, [Annex K](#) provides a solution for the most common transformations. When a worksite coordinate system is not able to use the defined localization system, each VIS and its connected field equipment shall use its own method for a consistent transformation to the worksite coordinates.

This document focuses on the transformation of coordinates generated using RTK methods. Therefore, time dependent transformations are not supported. If a VIS and its connected field equipment do not use the same base station observables source as defined by the SMS for the worksite, then the VIS should ensure that the position of its source of observables is consistent with the site base station in order to be able to use the localization provided by the SMS and VIS.

Annex A (normative)

Authorization mechanisms for worksite data exchange

A.1 Authorization relationships between SMS and VIS worksite

Both SMS and VIS model a physical worksite with one or more virtual worksites. This annex concerns virtual worksites, which will subsequently be referred to as "worksites" without further qualification. SMS and VIS are typically multi-tenant systems. Accordingly, a worksite resource is owned by tenants at the VIS and SMS.

Data-exchange between VIS and SMS worksites shall be limited to a star topology. Each topology may have only one SMS worksite. This single-master limitation may be relaxed to support multi-master in future revisions of this document.

For a VIS, a star topology means that each (VIS, worksite) pair shall relate to at most one (SMS, worksite) pair. Accordingly, a VIS shall prevent end-users from establishing data-exchange to multiple SMS worksites for the one VIS worksite. For each VIS worksite, a set of VIS agents should operate to both push and pull worksite data (such as project data, as-built and production data system-of-record, as-built and production data real-time) to and from the SMS worksite. These agents shall transport data (using HTTP long-polling or WebSockets) for assets connected to the VIS worksite. Accordingly, these agents shall continue to run independently of the end-user (who initiated the data-exchange) being logged in.

A VIS shall maintain the following for each (VIS, worksite) to (SMS, worksite) relationship:

- the (SMS, worksite) `worksiteBaseURL` obtained from the worksite directory as specified in [Annex B](#);
- authorization parameters and scopes (also obtained from the worksite directory) required for the authorization and token requests;
- security token and refresh token for each agent;
- granted OAuth2.0 scopes;
- any other access policy information, such as permissions specifying which assets on the VIS worksite may exchange data with the SMS worksite.

For an SMS, each (SMS, worksite) pair may relate to zero or more (VIS, worksite) pairs.

The SMS (or its delegated OAuth2.0 authorization server) shall maintain the following for each (SMS, worksite) to (VIS, worksite) relationship:

- issued refresh tokens;
- granted OAuth2.0 scopes;
- any other access policy information, such as permissions specifying which assets on the SMS worksite may exchange data with the VIS worksite.

To avoid multi-master topologies, for a system which implements both SMS and VIS roles, on any worksite where the system operates as an SMS, it shall not also operate as a VIS, connecting to an upstream SMS. This does not preclude an SMS from having vendor-specific machines connecting directly to it.

[Figure A.1](#) illustrates the high-level concept, showing the intended relationships needed for data-exchange between SMS and VIS worksites. Each worksite in the diagram represents the same physical worksite.

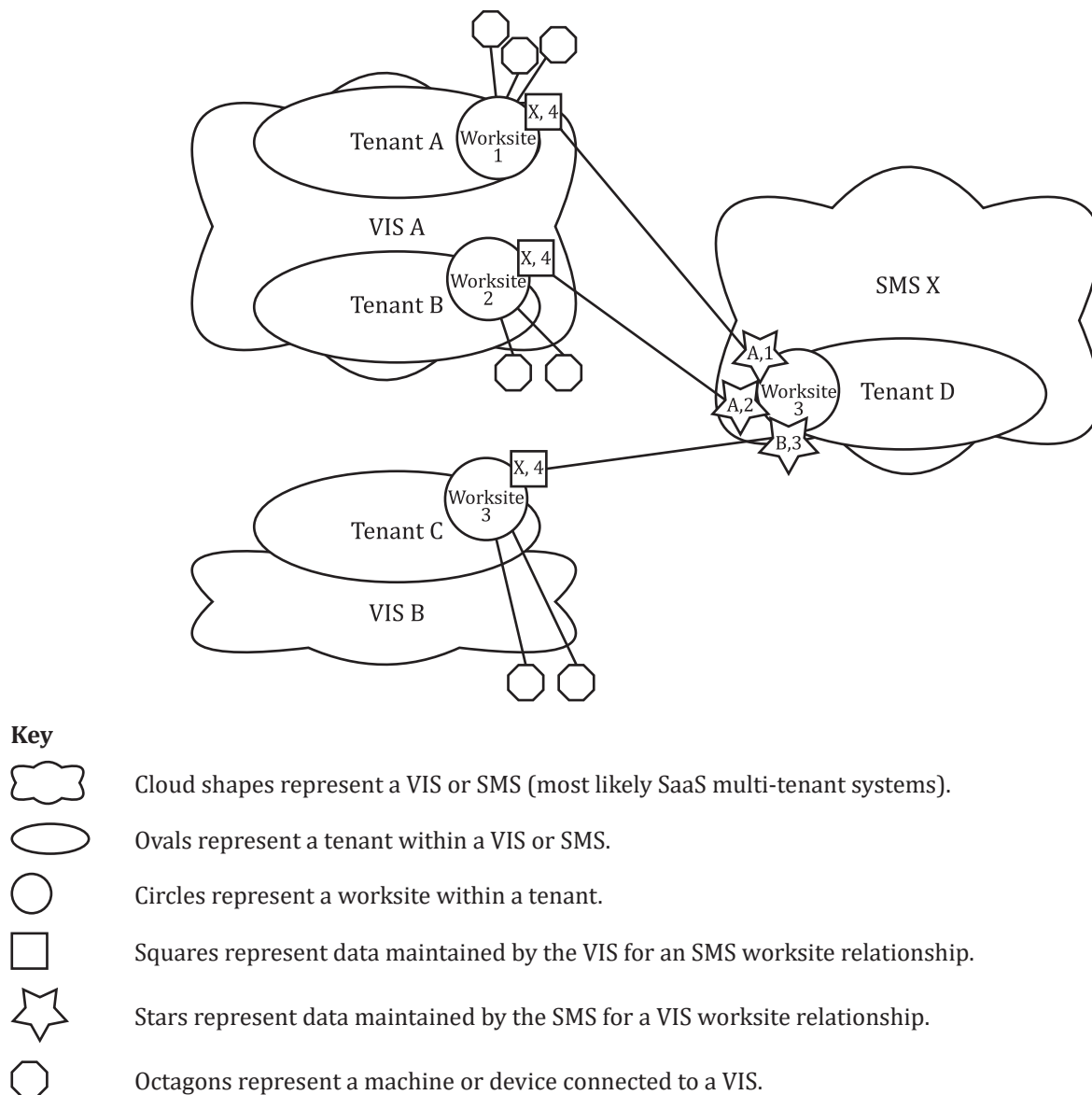


Figure A.1 — Authorization relationship overview

A.2 OAuth2.0

A.2.1 General

Authorization between VIS and SMS is broken into layers.

- a) The client credentials layer provides credentials for further layers.
- b) The worksite directory access layer authorizes a VIS user to discover worksites available for data exchange at an SMS.
- c) The worksite resource access layer authorizes a VIS to access SMS worksite-specific APIs, such as project data or system-of-record.
- d) The access policy layer allows SMS and VISs to control fine-grained access, such as which assets participate in the data exchange.

These layers are described in [Subclauses A.2.2](#) to [A.2.4](#).

Refer to [Annex C](#) for relevant example end-user stories.

A.2.2 Client credential layer

Each VIS shall acquire OAuth2.0 client credentials (in conformance with IETF RFC 6749:2012, Subclause 1.3.4) that are required for the authorization code grant (in conformance with IETF RFC 6749:2012, Subclause 4.1) for each SMS it accesses. VIS client registration with an SMS (in conformance with IETF RFC 6749:2012, Clause 2) is outside the scope of this document.

A.2.3 Worksite directory access layer

The SMS shall implement a worksite directory API as described in [Annex B](#). The worksite directory lists SMS worksite resources available to an authenticated identity at the SMS.

The SMS OAuth2.0 authorization server (AS) shall support Authorization Code Grant (in conformance with IETF RFC 6749:2012, Subclause 4.1) requests scoped with `iso15143-4.worksite_directory`. The SMS OAuth2.0 AS should issue a refresh token (in conformance with IETF RFC 6749:2012, Subclause 1.5) if an `offline_access` scope is requested.

A VIS shall obtain an OAuth2.0 access token using Authorization Code Grant (in conformance with IETF RFC 6749:2012, Subclause 4.1) with a scope of `iso15143-4.worksite_directory` for use with the SMS worksite directory. A VIS may long-poll the worksite directory for the purpose of discovering those worksites that it can establish data-exchange with, regardless of a VIS end-user being online. In this case, a VIS shall include an `offline_access` scope.

To establish data-exchange with a worksite listed in the worksite directory, a VIS shall use the worksite resource access layer described in [A.2.4](#).

A.2.4 Worksite resource access layer

A.2.4.1 General

The basic conditions for authorizing worksite data-exchange are:

- a VIS end-user is not required to be the owner of the SMS worksite resource;
- a VIS end-user requests access on behalf of the VIS agents which perform worksite data exchange;
- granted access remains in effect independently of the VIS end-user;
- fine-grained consent must be obtained for VIS access to an SMS worksite.

These conditions are not supported by common OAuth2.0 usage. The basic OAuth2.0 mechanism is sufficient to implement coarse-grained authorization requests based on an owner's profile. For authorizing worksite data exchange, however, there are three problems which basic OAuth2.0 does not readily address. These problems and their solutions are:

- a) The VIS end-user is possibly not the resource owner at the SMS. Accordingly, the SMS should provide a way to share worksite resources with external users.
- b) Requests to specific SMS worksites require fine-grained authorization, such that a competitor VIS client can never access worksite data not intended by the SMS end-user. To overcome the lack of readily available OAuth2.0 fine-grained support, the worksite directory states optional authorization parameters and authorization scopes required for gaining access to each worksite. This requirement is detailed in [Subclause A.2.4.2](#).
- c) A VIS shall have access tokens for its long-running agents which continue to exchange worksite data independently of the VIS end-user who established the data exchange. Accordingly, OAuth2.0 Client Credentials Grant (in conformance with IETF RFC 6749:2012, Subclause 4.4) shall be used to gain access tokens for long-running VIS agents. This requirement is detailed in [Subclause A.2.4.3](#).

A summary of the flow to establish worksite data exchange between VIS and SMS is as follows: a VIS end-user authenticates at the SMS authorization server using OAuth2.0 Authorization Code Grant (in conformance with IETF RFC 6749:2012, Subclause 4.1). For the OAuth2.0 authorization and token requests, the VIS shall build the authorization endpoint URL (in conformance with IETF RFC 6749:2012, Subclause 3.1) and token endpoint URL (in conformance with IETF RFC 6749:2012, Subclause 3.2) using authorization parameters and scopes stated for the specific worksite in the worksite directory as described in [Clause B.1](#). This access token is used to create a policy at the SMS as described in [Clause B.2](#). With a policy now in place, OAuth2.0 Client Credentials Grant (in conformance with IETF RFC 6749:2012, Subclause 4.4) is used to obtain access tokens used by the VIS agents to access the SMS REST endpoints as detailed in [Annex F](#), [Annex I](#) and [Annex J](#). This flow is detailed in [A.2.4.2](#) to [A.2.4.4](#).

A.2.4.2 Access tokens for policy creation

Each worksite listed by the worksite directory includes the following fine-grained authorization information needed by a VIS to request access tokens for policy creation:

- a) Authorization parameters: A VIS shall add worksite-specific URL parameters to the SMS authorization endpoint (in conformance with IETF RFC:2012 6749, [Subclause 3.1](#)) and token endpoint (in conformance with IETF RFC 6749:2012, Subclause 3.2) when authorizing for policy creation. This allows the SMS OAuth2.0 AS to use standards such as resource indicators (in conformance with IETF RFC 8707), or custom parameters (for JWT claims) for implementing fine-grained authorization.
- b) Authorization scopes: a VIS shall include worksite-specific scopes (in conformance with IETF RFC 6749:2012, Subclause 3.3) along with the `iso15143-4.worksite_directory` scope when authorizing for policy creation. This allows SMS OAuth2.0 AS to alternatively use dynamic scopes for implementing fine-grained authorization.
- c) A worksite URL: a VIS shall use the worksite URL as a root to form REST route URLs detailed in [Clause B.2](#).
- d) An `auto_create` flag: when this flag is true, authorization parameters and scopes shall not be provided.

An SMS should use standards such as resource indicators (in conformance with IETF RFC 8707), custom parameters for JWT claims, or dynamic scopes to implement fine-grained resource access. This means a VIS can only create a policy for a worksite when the VIS user performs a browser-agent authorization code flow specific to the worksite. Consequently, a VIS client can only access worksites which its end-users have previously explicitly authorized using a fine-grained authorization code flow. This is highly desirable when the SMS and VIS are competitors in the marketplace.

When the `auto_create` flag is true for a worksite, a VIS can create a policy for the worksite using the same access tokens as used for the worksite directory.

A.2.4.3 Access tokens for worksite data exchange

The SMS shall use OAuth2.0 Client Credential Grant (in conformance with IETF RFC 6749:2012, 4.4) to secure the SMS REST endpoints detailed in [Annex F](#), [Annex I](#) and [Annex J](#). The SMS shall permit access to worksites only where policies have been created for them by a VIS, as detailed in [Clause B.2](#).

A VIS shall use the client credentials specified [Subclause A.2.2](#) to request an access token, using OAuth2.0 Client Credentials Grant (in conformance with IETF RFC 6749:2012, Subclause 4.4.2), with scopes described in [Subclause A.2.4.4](#). A VIS shall include the parameters and scopes stated in the policy when requesting tokens for the worksite as detailed in [Clause B.2](#). A VIS shall use such access tokens for the SMS REST endpoints detailed in [Annex F](#), [Annex I](#) and [Annex J](#).

A.2.4.4 Authorization scopes

The following scopes apply when requesting access tokens for worksite resource access:

- `iso15143-4.project_data.read` grants project data read;
- `iso15143-4.project_data.write` grants project data write;

- `iso15143-4.production_data.sor.read` grants as-built and production data system-of-record read;
- `iso15143-4.production_data.sor.write` grants as-built and production data system-of-record write;
- `iso15143-4.production_data.rt.read` grants as-built and production data real-time read;
- `iso15143-4.production_data.rt.write` grants as-built and production data real-time write.

A.2.5 Access policy layer

When implementing policies, an SMS should provide a mechanism for fine-grained control of the data made available to any VIS tenancy. Examples of such fine-grained control can include:

- In the worksite directory, only share worksites that the resource owner has explicitly marked to be shared with a particular VIS.
- In the project data API, only share *file_entrys* and *file_packages* to a VIS when there is a related *assignment* for an asset or operator on that VIS.
- Do not share anything through the system-of-record API to a particular VIS.

Likewise, a VIS should implement a mechanism to provide fine-grained control of the data pushed to an SMS for a worksite. Examples of such fine-grained control can include:

- For system-of-record, only publish data related to particular assets or asset types on the VIS worksite.

A.3 Authorization relationships between SMS and SRS worksite

An SRS shall authenticate with an SMS in the same way as described for a VIS. The following scopes shall not apply for an SRS-only client:

- `iso15143-4.project_data.write`
- `iso15143-4.production_data.sor.write`
- `iso15143-4.production_data.rt.write`

Annex B (normative)

Worksite directory SMS API

B.1 Worksite directory API

B.1.1 General

The SMS shall implement a REST API to get a directory of worksites which can be accessed by an authenticated end-user. Routes in this REST API are detailed within [Clause B.3](#). Each route is relative to the `apiURL` as discussed in [Clause 5.2](#).

A VIS may use this API to discover worksites when required by an end-user. In addition, a VIS may poll the worksite directory to obtain worksites which can be automatically created at the VIS. A VIS shall not poll the SMS worksite directory more often than every 30 seconds.

Since the worksite directory contents are expected to change relatively rarely, and a VIS can frequently poll the API to quickly find any new worksites it can auto-create, this API uses conditional requests (in conformance with IETF RFC 7232). An SMS shall include the last-modified header in its responses, containing the last modification timestamp for the representation of the full list of worksites it returns. A VIS should include this timestamp in the If-Modified-Since header of further requests, so that the SMS can respond with 304 Not Modified as applicable.

The API accepts a `limit` parameter that defines the number of objects returned per page. Each call returns the following:

- a page of objects;
- a `next` link to obtain the next page of objects, if there is one.

The exact detail of the next link is the responsibility of the SMS and the VIS shall treat it as opaque. That is, it shall not rely on it being structured in any particular way. The VIS shall page through all available objects in one session and not retain `next` links once used. The SMS shall make every effort to return all objects current at the time of call.

An SRS may use this API in the same way as a VIS does.

B.1.2 Authorizing

These endpoints shall be accessed with an access token obtained using OAuth2.0 Authorization Code Flow, as detailed in [Subclause A.2.3](#). The SMS shall require the scope `iso15143-4.worksite_directory`.

Accordingly, worksite access tokens (as per [Subclause A.2.4.2](#)), and security tokens (as per [Subclause A.2.4.3](#)) shall not be used for worksite directory access.

B.1.3 Worksite directory routes

B.1.3.1 `worksite_directory` routes

B.1.3.1.1 GET {`apiURL`}/2024/`worksite_directory`

Description

Get a list of worksites accessible to the authenticated user of the SMS.

Parameters

This route shall support the parameters described in [Table B.1](#).

Table B.1 — GET *worksite_directory* parameters

Name	Source	Type	Use	Description
limit	query	<i>integer</i> between 1 and 100	Optional	Maximum number of values to return (default: 100).
If-Modified-Since	header	<i>string</i>	Optional	If-Modified-Since header (in conformance with IETF RFC 7232:2014, Subclause 3.3).

Responses

This route shall provide responses as described in [Table B.2](#).

Table B.2 — GET *worksite_directory* responses

Code	Schema	Description	Headers
200	<i>list_of_worksite</i>	Successful operation	Last-Modified
304	N/A	Not Modified	
401	N/A	Unauthorized	

Response headers

Responses from this route shall provide response headers as described in [Table B.3](#).

Table B.3 — GET *worksite_directory* response headers

Header	Type	Description
Last-Modified	<i>string</i>	Last-Modified header (in conformance with IETF RFC 7232:2014, Subclause 2.2).

B.1.4 Worksite directory definitions

B.1.4.1 *list_of_worksite*

Description

A list of worksites, together with links for REST navigation.

Properties

A *list_of_worksite* shall have the properties defined in [Table B.4](#).

Table B.4 — *list_of_worksite* properties

Name	Type	Use	Description
_links	<i>server_list_links</i>	Required	Links for REST navigation.
data	array of <i>worksites</i>	Required	An array of worksite.
limit	<i>integer</i>	Required	Number of entries per page of data, other than the last.

B.1.4.2 *server_list_links*

Description

A set of links supplied to enable pagination through a list of results.

Properties:

A *server_list_links* shall have the properties defined in [Table B.5](#).

Table B.5 — server_list_links properties

Name	Type	Use	Description
next	<i>character_string_url</i>	Optional	Link to the next page of results.

B.1.4.3 worksite

A worksite entry with basic project and connection information.

Properties:

A *worksite* shall have the properties defined in [Table B.6](#).

Table B.6 — worksite properties

Name	Type	Use	Description
authorization_parameters	<i>character_string_1000</i>	Optional	URI-encoded parameters particular to this worksite to be added to the SMS authorization and token endpoints to authorize for this worksite.
auto_create	<i>boolean</i>	Required	A flag indicating if the VIS can create this worksite regardless of a user being logged in at the VIS. An SMS shall not set this to true unless the VIS end-user is also the resource owner at the SMS, and has consented (at the SMS) to this worksite being auto-created for the requesting VIS. This consent is required in order to prevent unexpected costs at the VIS due to the auto-create feature. The <i>authorization_parameters</i> and <i>scopes</i> fields shall not be supplied when <i>auto_create</i> is true.
message	<i>character_string_1000</i>	Optional	An optional message, useful for the case where the requesting user is not the resource owner of this worksite.
owner	<i>character_string_255</i>	Optional	An optional name of the owning company or user, useful for the case where the requesting user is not the resource owner of this worksite.
scopes	array of at most 4 <i>character_string_255s</i>	Optional	Scopes particular to this worksite to be used with authorize and token requests to authorize for this worksite.
worksite_base_url	<i>character_string_url</i>	Required	The <i>worksiteBaseURL</i> used by VIS and SRS to form routes specific to this worksite, as described in Subclause 5.3 .
worksite_project_data	<i>worksite_project_data</i>	Required	Basic project details from project data.

B.1.4.4 worksite_project_data**Description**

Information provided by an SMS to enable an end-user to select a worksite. This data shall agree with the data provided by the SMS in the *basic_project_data* object of the relevant worksite.

Properties

A *worksite_project_data* shall have the properties defined in [Table B.7](#).

Table B.7 — worksite properties

Name	Type	Use	Description
beginning_date	<i>datetime_3339</i>	Optional	Anticipated or actual date construction began.
boundary	<i>points_wgs84</i>	Optional	Polygon enclosing a site. In the cases where systems treat this as 2D, then altitude (“alt”) should have the value of zero.
completion_date	<i>datetime_3339</i>	Optional	Anticipated or actual date construction completed.
job_code	<i>character_string_4</i>	Optional	Job code for the project.
name	<i>character_string_1</i>	Required	Name for the project.
timezone	<i>character_string_1</i>	Optional	An IANA timezone string identifying the timezone nominally associated to the project.

B.2 Worksite policy API

B.2.1 General

Each route in each API is relative to the `worksiteBaseUrl` as discussed in [Subclause 5.3](#).

B.2.2 Authorizing

These endpoints shall be accessed with an access token obtained using OAuth2.0 Authorization Code Flow, as detailed in [Subclause A.2.4.2](#). The SMS shall require the scope `iso151434.worksite_directory`.

B.2.3 Worksite policy routes

B.2.3.1 *policy routes*

B.2.3.1.1 POST {worksiteBaseUrl}/2024/policy

Description

Create a policy for the worksite. The SMS shall implement this as an idempotent operation.

Parameters

This route shall support the parameters described in [Table B.8](#).

Table B.8 — POST policy parameters

Name	Source	Type	Use	Description
body	body	<i>policy_request</i>	Required	Policy request.

Responses

This route shall provide responses as described in [Table B.9](#).

Table B.9 — POST policy responses

Code	Schema	Description
200	<i>policy</i>	Successful operation.
201	<i>policy</i>	Successful operation.
400	N/A	No VIS policy_key provided.
401	N/A	Unauthorized.

B.2.4 Worksite policy definitions

B.2.4.1 *policy*

Description

The object returned from successful policy creation.

Properties

A *policy* shall have the properties defined in [Table B.10](#).

Table B.10 — Policy properties

Name	Type	Use	Description
scopes	array of at most 4 <i>character_string_255s</i>	Optional	Scopes particular to this worksite to be added to the SMS token requests as specified in Subclause A.2.4.3 .
token_parameters	<i>character_string_1000</i>	Optional	URI-encoded parameters particular to the worksite to be added to the SMS token endpoints as specified in Subclause A.2.4.3 .

B.2.4.2 *policy_request*

The policy request object shall have the properties defined in [Table B.11](#).

Table B.11 — *policy_request* properties

Name	Type	Use	Description
policy_key	<i>character_string_1</i>	Required	An opaque and unique descriptor for the worksite in the VIS making the request. This is treated as an idempotency key by the SMS to differentiate VIS worksites being associated with the SMS worksite for the purposes of policy construction.
description	<i>character_string_255</i>	Optional	A human readable hint to aid SMS users in identifying the particular VIS worksite at the SMS.

B.3 Error notification API

B.3.1 General

The SMS shall implement a REST API to provide error notifications to the SMS. Routes in this REST API are detailed in [Subclauses B.3.2](#) through to [B.3.4](#). Each route is relative to the apiURL as discussed in [Subclause 5.2](#).

B.3.2 Authorizing

These endpoints shall be accessed with an access token obtained using OAuth2.0 client credentials, as specified in [Subclause A.2.2](#).

B.3.3 Error notification routes

B.3.3.1 *error_notification routes*

B.3.3.1.1 POST {apiURL}/2024/error_notification

Description

Allows a VIS or an SRS to provide details of an unexpected error (such as unexpected response code, schema violation) to the SMS.

Parameters

This route shall support the parameters described in [Table B.12](#).

Table B.12 — POST error_notification parameters

Name	Source	Type	Use	Description
body	body	<i>error_notification_post_body</i>	Required	An object describing an unexpected error.

Responses

This route shall provide responses as described in [Table B.13](#).

Table B.13 — POST error_notification responses

Code	Schema	Description
200	<i>error_notification_response_body</i>	Successful operation.
401	N/A	Unauthorized.

B.3.4 Error notification definitions

B.3.4.1 *error_notification_post_body*

Properties

A *error_notification_post_body* shall have the properties defined in [Table B.14](#).

Table B.14 — error_notification_post_body properties

Name	Type	Use	Description
description	<i>character_string_1000</i>	Required	An English description of the error, helpful to SMS support engineers.
id	<i>character_string_id</i>	Optional	The id of the entity relating to the error, where relevant.
time	<i>datetime_3339</i>	Required	The time at which the error occurred, which can differ to the time the error is reported.
url	<i>character_string_url</i>	Required	The URL being accessed which resulted in the error.
worksite_base_url	<i>character_string_url</i>	Optional	The <code>worksiteBaseUrl</code> relating to the error, where relevant.

B.3.4.2 *error_notification_response_body*

The response object currently has no fields.

Annex C (informative)

Server to server use cases

C.1 General

Each of these user-stories details how the SMS worksite directory can be used to achieve the security required by worksite data exchange in a competitive marketplace.

C.2 John

C.2.1 User story

The “John” end-user story relates to the case where an owner (“John”) wants to operate his mixed-fleet by using only his SMS.

John chooses an SMS and creates accounts there. John has a mixed-fleet and requires a few VISs to have his machines connect to his SMS. John must create an account at each VIS. John logs into each VIS and connects to his SMS, giving consent for the VIS to access the worksite directory of the SMS. This is done once for many worksites. Over time, John can log into his SMS and create a worksite, and inform the SMS which VISs can access the new SMS worksite. John can also inform the SMS which VISs can auto-create the worksite. This prevents John from having to log into each VIS, yet allows John to use machines connected to that VIS on his SMS worksite.

C.2.2 Worksite directory usage

The key part of this user story is that John gives consent for a VIS to access a worksite at the SMS. Therefore, when the SMS produces a directory listing for John’s identity at that VIS, it produces the worksite entry:

- without fine-grained `authorization_parameters` and `scopes` fields,
which means the VIS can use existing access tokens to access the new worksite resource, without John having to perform an Authorization Code Flow particular to the worksite at the VIS;
- with the `auto_create` field as true (if John indicated the VIS can auto-create the site).

C.3 Bill

C.3.1 User story

The “Bill” end-user story relates to the case where an owner (“Bill”) wants to operate his mixed-fleet using both SMS and VIS.

Bill chooses an SMS and creates accounts there. Bill has a mixed-fleet and requires a few VISs to have his machines connect to his SMS. Bill must create an account at each VIS. Bill logs into each VIS and connects to his SMS giving consent for the VIS to access the worksite directory of the SMS. This is done once for many worksites. Over time, Bill can log into his SMS and create a worksite. Bill can also log into his VISs and create worksites, using features particular to that VIS. Bill logs into a VIS and browses the worksite directory of his SMS. Bill can connect a worksite of the VIS to a worksite listed in the SMS worksite directory, establishing worksite data-exchange. This connection must be performed from a browser agent.

C.3.2 Worksite directory usage

The key part of this user story is that Bill gives consent for a VIS to access an SMS worksite from the VIS in a browser agent. When the SMS produces a directory listing for Bill's identity at that VIS, it produces the worksite entry:

- with fine-grained `authorization_parameters` and `scopes` fields particular to the worksite, this means the VIS must have Bill perform an Authorization Code Flow in a browser agent to mint an access token particular to the worksite;
- without the `auto_create` field.

C.4 Sally and Bob

C.4.1 User story

The “Sally and Bob” end-user story is relevant to larger projects, where there are many sub-contractors operating on a large mixed-fleet earth-works project.

Sally is a general contractor using an SMS to manage a worksite. Sally desires a sub-contractor, Bob, to also operate at the worksite. Bob uses one or more VISs to manage his mixed-fleet. Using her SMS, Sally shares her worksite with Bob providing Bob's email address to the SMS. Bob logs into one of his VISs, and then connects to the worksite directory of Sally's SMS. Bob must register a user with Sally's SMS if he does not already have credentials for that SMS. Bob selects the worksite which Sally shared with him and connects it to one of his VIS worksites.

C.4.2 Worksite directory usage

The key part of this user story is that Bob does not own the worksite resource at the SMS. Sally uses the SMS to share (or invite) Bob to the worksite by stating Bob's identity. When the SMS produces a directory listing for Bob's identity at the VIS, it produces worksite entries:

- which are available to Bob because of shares with his verified email address;
- with fine-grained `authorization_parameters` and `scopes` fields particular to the worksite;
- where the `auto_create` field should not be true, as Bob should opt-in to the worksite as it can cost him;
 - wherein Sally cannot consent to a site being created for Bob.

Annex D (normative)

Shared data types

D.1 General

This annex defines a set of types that are shared across the different schemata specified by this document.

D.2 JSON schema types

Types shall be defined as JSON schemata in accordance with <https://datatracker.ietf.org/doc/html/draft-bhutton-json-schema-01>, and make use of the following standard JSON schema names for JSON data types in conformance with IETF RFC 8259:

- *null*
- *boolean*
- *object*
- *array*
- *number*
- *string*
- *integer*

D.3 Simple types

D.3.1 General

The simple type descriptions in [Clause D.3](#) follow and expand on types introduced in ISO 15143-2:2010 Table A.2.

D.3.2 Type “*asset_type*”

A machine type, such as those defined in ISO 6165, ISO 22242, and ISO 9849.

asset_type is of the enumeration:

- *backhoe_loader*
- *compact_tool_carrier*
- *dozer*
- *driller*
- *dumper*
- *excavator*
- *grader*

- horizontal_directional_drill
- landfill_compactor
- loader
- milling_machine
- paver
- piler
- pipe_layer
- roller
- scraper
- survey_equipment
- trencher
- other

D.3.3 Type “*character_string_1*”

A string of at most 100 characters.

D.3.4 Type “*character_string_1000*”

A string of at most 1000 characters.

D.3.5 Type “*character_string_2*”

A string of at most 5 characters.

D.3.6 Type “*character_string_255*”

A string of at most 255 characters.

D.3.7 Type “*character_string_3*”

A string of at most 10 characters.

D.3.8 Type “*character_string_4*”

A string of at most 20 characters.

D.3.9 Type “*character_string_5*”

A string of at most 40 characters.

D.3.10 Type “*character_string_6*”

A string of at most 60 characters.

D.3.11 Type “*character_string_b64*”

A base-64 encoded string (encoded using the url and filename safe alphabet in conformance with IETF RFC 4648, not padded), matching the pattern:

$^{\wedge}[A-Za-z0-9_ -]+\$$

D.3.12 Type “character_string_id”

The type that project data IDs belong to, 255 characters at most, matching the pattern:

```
^[0-9A-Za-z][0-9A-Za-z._~-]*$
```

D.3.13 Type “character_string_url”

A URL shall conform to IETF RFC 1738. A VIS shall support HTTP redirects when GETting a URL. A VIS shall provide security tokens when GETting a URL.

D.3.14 Type “character_string_uuid”

A universally unique identifier in conformance with IETF RFC 4122, 36 characters at most, matching the pattern:

```
^[0-9A-Fa-f]{8}-[0-9A-Fa-f]{4}-[0-9A-Fa-f]{4}-[0-9A-Fa-f]{4}-[0-9A-Fa-f]{12}$
```

D.3.15 Type “datetime_3339”

Date and time in UTC, formatted in conformance with IETF RFC 3339 as outlined at <https://tools.ietf.org/html/rfc3339#section-5.6> with millisecond accuracy.

D.3.16 Type “direction_decimal”

A clockwise direction angle, in degrees between 0 and 360.

D.3.17 Type “file_entry_mime_type_enum”

A permissible media type for a project data *file_entry*.

file_entry_mime_type_enum is one of the enumerations:

- image/vnd.dxf:DXF Background Drawing
- application/xml:ISO LandXML
- application/pdf:PDF

D.3.18 Type “hexargbcolor”

The color entity indicates the color of an element. Color may be represented as hexadecimal RGB triples, as in HTML, or as hexadecimal ARGB tuples, with the A indicating alpha of transparency. An alpha value of 00 is totally transparent and FF is totally opaque. If RGB is used, the A value is assumed to be FF. For instance, the RGB value “#800080” represents purple. An ARGB value of “#40800080” would be a transparent purple. Colors are defined in terms of the sRGB color space (refer to IEC 61966), matching the pattern:

```
^(#[\dA-F]{6,6}([\dA-F][\dA-F])?)$
```

D.3.19 Type “interval_decimal”

An angular spacing, in degrees between 0 and 180.

D.3.20 Type “latitude_decimal”

A latitude measured in degrees between -90 (South Pole) and 90 (North Pole).

D.3.21 Type “longitude_decimal”

A longitude measured in degrees between -180 (180 degrees West of Greenwich Meridian) and 180 (180 degrees East of Greenwich Meridian).

D.3.22 Type “points_local”

An array of at most 100 points in local format. Each array element shall be as defined in [Table D.1](#).

Table D.1 — points_local fields

Field	Type	Use	Description
easting	<i>number</i>	Required	In meters.
elevation	<i>number</i>	Required	In meters.
northing	<i>number</i>	Required	In meters

D.3.23 Type “points_wgs84”

An array of at most 100 points in WGS-84 format. Each array element shall be as defined in [Table D.2](#).

Table D.2 — points_wgs84 fields

Field	Type	Use	Description
alt	<i>number</i>	Required	Ellipsoid height in meters.
lat	<i>latitude_decimal</i>	Required	Latitude measured in degrees between -90 (South Pole) and 90 (North Pole).
lon	<i>longitude_decimal</i>	Required	Longitude measured in degrees between -180 (180 degrees West of Greenwich Meridian) and 180 (180 degrees East of Greenwich Meridian).

D.3.24 Type “rotation_decimal”

A clockwise rotation angle, in degrees between -180 and 180.

Annex E (normative)

Project data types

E.1 Object definitions

This annex defines the data types for project data which are communicated between an SMS on one end and a VIS or an SRS on the other, using the API defined in [Annex F](#).

Project data shall be provided as a set of JSON objects. Each such object shall conform to a JSON schema as specified in [Annex N](#). JSON Objects shall be communicated using the UTF-8 encoding in conformance with IETF RFC 3629.

Objects are the smallest unit of project data that can be transferred. Accordingly, they are versioned and considered to be immutable. Any change to the value of an object is affected by issuing a new revision of the object.

Each project data object has attributes that are typed with a simple type or a subtype. Where the values for these attributes require units, those units shall be SI units unless otherwise explicitly stated in this document.

E.2 Definition “*project_metadata*”

Each object shall have a *project_metadata* entry as per [Table E.1](#), which identifies the following required information:

Table E.1 — *project_metadata* fields

Field	Type	Use	Description
at	<i>datetime_3339</i>	Required	Datetime that this object was last edited. Newer revisions of an object should have later at values.
id	<i>character_string_id</i>	Required	Unique identifier of the object in this collection of project data. Required to be unique for the project data for a given worksite.
type	<i>character_string_1</i>	Required	One of the types from the schema.json file.
v	<i>character_string_255</i>	Required	Semantic version of the schema set.

E.3 Type definitions

E.3.1 General

The project data types defined in JSONSchema files available as discussed in [Annex N](#) have intended uses detailed in [Clause E.3](#).

Changes to types are managed by the maintenance agency as specified in [Annex N](#). Changes are likely to be infrequent and should follow a ratification process similar to that discussed in ISO 15143-1, amended as necessary. The schemata files contain a “v” property that shall be amended to reflect the semantic version so that implementors can maintain correctness.

E.3.2 Type “*basic_project_data*”

Each worksite has one-and-only-one object of this type, which contains fields for the data that relate to the project as a whole.

On receiving a *basic_project_data* object, a VIS should pass the object’s file package and the files they contain to all assets.

A *basic_project_data* shall be as defined in [Table E.2](#).

Table E.2 — *basic_project_data* fields

Field	Type	Use	Description
background_image	<i>character_string_url</i>	Optional	URL for an image file for the site.
beginning_date	<i>datetime_3339</i>	Optional	Anticipated or actual date construction began.
boundary	<i>points_wgs84</i>	Optional	Polygon enclosing a site.
completion_date	<i>datetime_3339</i>	Optional	Anticipated or actual construction completed.
control_points	<i>character_string_id</i>	Optional	Reference to a <i>file_package</i> containing the control points for the project.
default_rtk	<i>character_string_id</i>	Optional	Default RTK settings.
geo_features	<i>character_string_id</i>	Optional	Reference to a <i>file_package</i> containing the avoidance zones for the project.
job_code	<i>character_string_1</i>	Optional	Job code for the project.
meta	<i>project_metadata</i> with id=basic_project_data and type=basic_project_data	Required	Metadata for this <i>basic_project_data</i> .
name	<i>character_string_1</i>	Required	Human oriented name for <i>basic_project_data</i> .
timezone	<i>character_string_1</i>	Optional	An IANA timezone string identifying the timezone nominally associated to the project.

E.3.3 Type “*localization*”

E.3.3.1 General

Each worksite has zero-or-one object of this type, which contains fields for the data that relate to the localization for the project as a whole.

A *localization* shall be as defined in [Table E.3](#).

Table E.3 — Localization fields

Field	Type	Use	Description
azimuth	<i>string</i> , one of(<i>north_az</i> , <i>south_az</i>)	Required	The direction of the 0 Azimuth on the worksite.
datum_transformation	<i>datum_transformation</i>	Optional	The datum transformation is a parametric datum that converts from WGS-84 positions into the local datum.
grid_orientation	<i>string</i> , one of(<i>NE</i> , <i>NW</i> , <i>SE</i> , <i>SW</i>)	Required	The direction of the positive coordinate on the worksite.
horizontal_adjustment	<i>horizontal_adjustment</i>	Optional	The horizontal adjustment is used to adjust the NEE coordinates that have been produced by the datum or projection. This also allows for local coordinate adjustment on published coordinates system coordinates.
meta	<i>project_metadata</i> with <i>id</i> =localization and <i>type</i> =localization	Required	Metadata for this localization.
projection	<i>projection</i>	Required	The projection will have one object based on the type of the projection. Field implementations are required to support the most common projections.
vertical_adjustment	<i>vertical_adjustment</i>	Optional	The vertical adjustment is used to provide a local height system. The object may contain zero, one or both of " <i>inclined_plane</i> " or " <i>geoid_model</i> ".

E.3.3.2 Definition “*datum_transformation*”

The datum transformation is a parametric datum that converts from WGS-84 positions into the local datum. A *datum_transformation* shall be as defined in [Table E.4](#).

Table E.4 — datum_transformation fields

Field	Type	Use	Description
ellipsoid	<i>ellipsoid</i>	Required	Local ellipsoid.
transformation	<i>datum_3p</i> , <i>datum_7p</i> or <i>datum_grid_ref</i>	Required	Datum transformation method.

E.3.3.3 Definition “*datum_3p*”

3-parameter datum translation.

A *datum_3p* shall be as defined in [Table E.5](#).

Table E.5 — datum_3p fields

Field	Type	Use	Description
dx	<i>number</i>	Required	Translation X.
dy	<i>number</i>	Required	Translation Y.
dz	<i>number</i>	Required	Translation Z.
type	the value “ <i>datum_3p</i> ”	Required	

E.3.3.4 Definition “datum_7p”

7-parameter datum transformation (translation+rotation+scale).

A *datum_7p* shall be as defined in [Table E.6](#).

Table E.6 — datum_7p fields

Field	Type	Use	Description
dS	<i>number</i>	Required	Scale factor (unitless).
dX	<i>number</i>	Required	Translation X.
dY	<i>number</i>	Required	Translation Y.
dZ	<i>number</i>	Required	Translation Z.
rX	<i>rotation_decimal</i>	Required	Rotation X.
rY	<i>rotation_decimal</i>	Required	Rotation Y.
rZ	<i>rotation_decimal</i>	Required	Rotation Z.
type	The value “ <i>datum_7p</i> ”	Required	

E.3.3.5 Definition “datum_grid_ref”

Datum grid transformation.

A *datum_grid_ref* shall be as defined in [Table E.7](#).

Table E.7 — datum_grid_ref fields

Field	Type	Use	Description
type	The value “ <i>datum_grid_ref</i> ”	Required	
url	<i>character_string_url</i>	Required	URL of a JSON file which contains a <i>datum_grid</i> object. The SMS shall ensure that the content of this URL remains unchanged over time.

E.3.3.6 Definition “ellipsoid”

An *ellipsoid* shall be as defined in [Table E.8](#).

Table E.8 — ellipsoid fields

Field	Type	Use	Description
inverse_flattening	<i>number</i>	Required	Local ellipsoid flattening (inverse).
semi_major_axis	<i>number</i>	Required	Local ellipsoid earth radius.

E.3.3.7 Definition “horizontal_adjustment”

A *horizontal_adjustment* shall be as defined in [Table E.9](#).

Table E.9 — horizontal_adjustment fields

Field	Type	Use	Description
origin_east	<i>number</i>	Required	East origin.
origin_north	<i>number</i>	Required	North origin.
rotation_angle	<i>rotation_decimal</i>	Required	Rotation about origin.
scale	<i>number</i>	Required	Scale factor.
translation_east	<i>number</i>	Required	Translation east.
translation_north	<i>number</i>	Required	Translation north.

E.3.3.8 Definition “*projection*”

A *projection* shall be as defined in [Table E.10](#).

Table E.10 — projection fields

Field	Type	Use	Description
parameters	<i>projection_parameters</i>	Required	Projection parameters. Used parameters vary by projection type.
projection_type	<i>string, one of (transverse_mercator, mercator, lambert_1, lambert_2, oblique_mercator, oblique_stereographic, albers)</i>	Required	Projection type.

E.3.3.9 Definition “*projection_parameters*”

Parameters for projection objects.

A *projection_parameters* shall be as defined in [Table E.11](#).

Table E.11 — projection_parameters fields

Field	Type	Use	Description
central_latitude	<i>latitude_decimal</i>	Optional	Geodetic latitude of the point from which the values of both the geographical coordinates on the ellipsoid and the grid coordinates on the projection are deemed to increment or decrement for computational purposes.
central_longitude	<i>longitude_decimal</i>	Optional	Geodetic longitude of the point from which the values of both the geographical coordinates on the ellipsoid and the grid coordinates on the projection are deemed to increment or decrement for computational purposes.
false_easting	<i>number</i>	Optional	Value assigned to the ordinate (north or south) axis of the projection grid at the natural origin.
false_northing	<i>number</i>	Optional	Value assigned to the abscissa (east or west) axis of the projection grid at the natural origin.
latitude_no	<i>latitude_decimal</i>	Optional	Latitude of the point at which the azimuth of the central line for an oblique projection is defined.
line_azimuth	<i>direction_decimal</i>	Optional	Direction (north zero) of the great circle which is the centre line of an oblique projection. The azimuth is given at the projection centre.
line_scale	<i>number</i>	Optional	Factor by which the map grid is reduced or enlarged during the projection process, defined by its value at the projection centre.
longitude_no	<i>longitude_decimal</i>	Optional	Longitude of the point at which the azimuth of the central line for an oblique projection is defined.

Table E.11 (continued)

Field	Type	Use	Description
parallel_1	<i>latitude_decimal</i>	Optional	Geodetic latitude of one of the parallels of intersection of the cone with the ellipsoid. Scale is true along this parallel.
parallel_2	<i>latitude_decimal</i>	Optional	Geodetic latitude of one of the parallels at which the cone intersects with the ellipsoid. Scale is true along this parallel.
rectified_angle	<i>rotation_decimal</i>	Optional	Angle at the natural origin of an oblique projection through which the natural coordinate reference system is rotated to make the projection north axis parallel with true north.
scale	<i>number</i>	Optional	Factor by which the map grid is reduced or enlarged during the projection process, defined by its value at the natural origin.

E.3.3.10 Definition “vertical_adjustment”

Vertical adjustment defined as an inclined plane and/or geoid,

A *vertical_adjustment* shall be as defined in [Table E.12](#).

Table E.12 — vertical_adjustment fields

Field	Type	Use	Description
geoid_model	<i>geoid_model</i>	Optional	Description of the geoid, either in this object data stream or in an external file.
inclined_plane	<i>inclined_plane</i>	Optional	Inclined plane.

E.3.3.11 Definition “geoid_model”

A *geoid_model* shall be as defined in [Table E.13](#).

Table E.13 — geoid_model fields

Field	Type	Use	Description
type	<i>string</i> , one of (<i>geoid_ref</i> , <i>geoid_model_ref</i>)	Optional	

A *geoid_model* shall also contain attributes as defined in exactly one of the following subschemata:

- a) *geoid_model_ref*;
- b) *geoid_ref*.

Subschema geoid_model_ref

A *geoid_model_ref* shall be as defined in [Table E.14](#).

Table E.14 — geoid_model_ref fields

Field	Type	Use	Description
type	the value “ <i>geoid_model_ref</i> ”	Required	
url	<i>character_string_url</i>	Required	URL of a JSON file which contains a <i>geoid</i> object. The SMS shall ensure that the content of this URL remains unchanged over time.

Subschema geoid_ref

A *geoid_ref* shall be as defined in [Table E.15](#).

Table E.15 — geoid_ref fields

Field	Type	Use	Description
ref	<i>character_string_id</i>	Required	Reference to a <i>geoid</i> .
type	the value “ <i>geoid_ref</i> ”	Required	

E.3.3.12 Definition “*inclined_plane*”

An *inclined_plane* shall be as defined in [Table E.16](#).

Table E.16 — inclined_plane fields

Field	Type	Use	Description
constant_adjustment	<i>number</i>	Required	Constant adjustment.
origin_east	<i>number</i>	Required	East origin.
origin_north	<i>number</i>	Required	North origin.
slope_east	<i>number</i>	Required	Scale factor for east slope, unitless.
slope_north	<i>number</i>	Required	Scale factor north slope, unitless.

E.3.3.13 Definition “*datum_grid*”

A *datum_grid* shall be as defined in [Table E.17](#).

Table E.17 — datum_grid fields

Field	Type	Use	Description
column_count	<i>integer</i>	Required	Number of columns in “separations” matrix.
interpolation_method	<i>string</i> , one of (<i>bilinear</i> , <i>biquadratic</i> , <i>spline</i>)	Required	Interpolation method. One of “bilinear”, “bi-quadratic”, or “spline”.
interpolation_window	<i>number</i>	Required	Interpolation window length.
latitude_interval	<i>interval_decimal</i>	Required	Angular spacing between “separations” matrix rows.
longitude_interval	<i>interval_decimal</i>	Required	Angular spacing between “separations” matrix cols.
name	<i>character_string_255</i>	Required	Name of datum grid.
origin_latitude	<i>latitude_decimal</i>	Required	Latitude origin (first “row” of “separations”). Latitude value of NW (top left).
origin_longitude	<i>longitude_decimal</i>	Required	Longitude origin (first “column” of “separations”). Longitude value of NW (top left).
row_count	<i>integer</i>	Required	Number of rows in “separations” matrix.
separations_height	array of <i>numbers</i>	Optional	Height separation data matrix in row major order.
separations_latitude	array of <i>numbers</i>	Required	Latitude separation data matrix in row major order.
separations_longitude	array of <i>numbers</i>	Required	Longitude separation data matrix in row major order.

E.3.4 Type “*geoid*”

A *geoid* shall be as defined in [Table E.18](#).

Table E.18 — geoid fields

Field	Type	Use	Description
column_count	<i>integer</i>	Required	Number of columns in “separations” matrix.
interpolation_method	<i>string</i> , one of (<i>bilinear</i> , <i>spline</i>)	Required	Interpolation method. One of either “bilinear” or “spline”.
interpolation_window	<i>number</i>	Required	Interpolation window length.
latitude_interval	<i>interval_decimal</i>	Required	Angular spacing between “separations” matrix rows.
longitude_interval	<i>interval_decimal</i>	Required	Angular spacing between “separations” matrix cols.
meta	<i>project_metadata</i> with <i>type=geoid</i>	Required	Metadata for this geoid.
name	<i>character_string_255</i>	Required	Name of geoid model.
origin_latitude	<i>latitude_decimal</i>	Required	Latitude origin (first “row” of “separations”). Latitude value of NW (top left).
origin_longitude	<i>longitude_decimal</i>	Required	Longitude origin (first “column” of “separations”). Longitude value of NW (top left).
row_count	<i>integer</i>	Required	Number of rows in “separations” matrix.
separations	<i>array of numbers</i>	Required	Geoid separation data matrix in row major order.

E.3.5 Type “*rtk*”

E.3.5.1 General

Settings required to obtain correction data for localizations.

Each project may provide a default object of this type, which contains fields for the data that relate to the RTK and correction settings for the project as a whole. This default object is provided in the *basic_project_data* object.

Each project may provide additional RTK objects in the case of multiple base stations; in this case, each *work_order* may specify the particular settings to use.

A *rtk* shall be as defined in [Table E.19](#).

Table E.19 — *rtk* fields

Field	Type	Use	Description
latitude	<i>latitude_decimal</i>	Optional	Geodetic latitude of the RTK.
longitude	<i>longitude_decimal</i>	Optional	Geodetic longitude of the RTK.
meta	<i>project_metadata</i> with <i>type=rtk</i>	Required	Metadata for this <i>rtk</i> .
name	<i>character_string_1000</i>	Optional	A name used to refer to the RTK.
ntrip	<i>ntrip_settings</i>	Optional	The settings for RTK where provided by an NTRIP base server.
uhf	<i>uhf_settings</i>	Optional	The settings for RTK where provided by a narrow band UHF radio.

E.3.5.2 Definition “*ntrip_settings*”

The settings for RTK where provided by an NTRIP base server A *ntrip_settings* shall be as defined in [Table E.20](#).

Table E.20 — ntrip_settings fields

Field	Type	Use	Description
mount_point	<i>character_string_1</i>	Required	Base station and mount point name.
password	<i>character_string_1</i>	Optional	
server_host	<i>character_string_1</i>	Required	IP address or DNS name of the server.
server_port	<i>integer</i>	Optional	Port number of the server for non-TLS connections.
tls_port	<i>integer</i>	Optional	port number of the server for TLS connections.
username	<i>character_string_1</i>	Optional	

If an SMS provides *ntrip_settings*, it shall provide at least one of *server_port* and *tls_port*. It should also provide a *tls_port*.

E.3.5.3 Definition “uhf_settings”

This object provides the settings required to access a narrow band UHF radio. Messages shall be sent using the protocol in conformance with RTCM 13500.1.

An *uhf_settings* shall be as defined in [Table E.21](#).

Table E.21 — uhf_settings fields

Field	Type	Use	Description
center_frequency	<i>integer</i>	Required	The center frequency for the base station transmission, in Hz.

E.3.6 Type “asset”

A piece of equipment used on a worksite.

For assets capable of performing multiple types of work, such as a machine equipped with both a drill and an excavator bucket, a separate *asset* object shall be created for each type.

An *asset* shall be as defined in [Table E.22](#).

Table E.22 — asset fields

Field	Type	Use	Description
asset_class	<i>asset_type</i>	Required	The type of the asset.
equipment_id	<i>character_string_255</i>	Optional	A user-friendly string identifying an asset such as a machine.
id	<i>character_string_uuid</i>	Required	The VIS asset ID, an identifier determined by the VIS for this asset, generated in conformance with IETF RFC 4122. On any worksite, no two assets shall have the same VIS asset id. A VIS should make this unique per asset per worksite.
meta	<i>project_metadata</i> with type=asset	Required	Metadata for this asset.
oem_iso_id	<i>character_string_255</i>	Optional	This is either a PIN or VIN. The pin shall be as defined by ISO 10261. The VIN shall be as defined by ISO 3779.
serial_number	<i>character_string_255</i>	Optional	This identifies the specific instance of the asset for those assets that are not identified by a PIN or a VIN.