



International Rock Excavation Data Exchange Standard

IREDES

Standard documentation

Part 0

General Definitions and Standard Architecture

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1 Document Information

1.1 Change history:

<i>Date</i>	<i>Initials</i>	<i>Vers</i>	<i>Major Changes made</i>
2016-10-23	CM		Initial release to IREDES community
2017-01-15	CM		Extensions and corrections
2020-02-16	CM	41	Corrections and IREDES V2.0 extensions

1.2 Document Draft Information

Sections in which the document is regarded incomplete or where specific topics are not complete or missing, related text or resulting questions are written in bold italics embraced by []:

[This topic has to be added...]

1.3 Disclaimer

This is an uncorrected, not reviewed and not formally released draft of a development document still in the progress of being set up.

This document therefore is not a formally binding standard specification nor of any contractual relevance. Until officially released, it may not be used for development of equipment or software claiming IREDES standard compliance.

The document is used to reflect the ongoing status of standard development. Copyright and all rights reserved by the IREDES initiative.

Comments and corrections please send to:

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2 Introduction

IREDES is a flexible standard architecture for convenient worksite information exchange in the mining industry. It is used for information exchange between mainly mobile equipment and devices on one side and central computer systems on the other side. Also Machine-to-Machine (“M2M”) communication is covered to a certain extend. Excluded from the standard is any direct communication related to machine remote control as this is inside the product responsibility of the respective suppliers.

The standard covers definitions of how to exchange information and what kind of content is exchanged.

The standard consists of different parts:

IREDES Part 0: General definitions and standard architecture (This document)

IREDES Part 1: Generic and equipment type independent parts used in common in all specific parts of the standard: Application Profiles, Commonly Used Objects

IREDES Part 2: Drill Rigs and Bolters

IREDES Part 3: Explosives Chargers

IREDES Part 4: LHD's, Trucks and rubber tire based transportation vehicles

IREDES Part 5: Tracking, Messaging and Work order handling

These standard parts are being extended basing on the demands of the IREDES members.

3 Scope of this document

This document describes the architecture of the information exchange following the IREDES standard. These definitions are applicable to all other parts of the standard in identical way. This document does not cover any equipment type specific definitions.

4 Normative References

Normative references are to be given in ISO standardized format:

ISO #####-#:20##, General title — Part #: Title of part

ISO 8859-1:1987,, Part 1: Latin Alphabet No 1

XML Schema Part 0: Primer: <http://www.w3.org/TR/xmlschema-0/>

XML Schema Part 1: Structures: <http://www.w3.org/TR/xmlschema-1/>

XML Schema Part 2: Datatypes: <http://www.w3.org/TR/xmlschema-2/>

XML Base: <http://www.w3.org/TR/xmlbase/>

Extensible Markup Language (XML) 1.0: <http://www.w3.org/TR/2000/REC-xml-20001006>

XML Namespaces: <http://www.w3.org/TR/REC-xml-names>

RFC1321: <http://www.faqs.org/rfcs/rfc1321.html>

5 Terms and definitions

5.1 Application Object

Data structure within a Data Set containing all information exchanged for a particular application level information for the purpose of the Data Set. This might e.g. be Planning data, Production Performance data etc. The "Application Object" may consist of multiple sub-objects containing detail information. In the Data set, all information sub-objects are located in a sequential order. The type of Application Object carried by a Data Set is defined in the Data Set's General Header.

5.2 Application Profile

Data Set containing definitions for a specific Data Set's purpose. This might be a Planning Data Set, a Production Performance log or a Production Quality log. This is the basic type of application level information in IREDES where every equipment type specific information is derived from if applicable for the relevant type of equipment. An Application profile consists of:

1. A Data Block and the corresponding parameter definitions for general information applicable to any equipment regardless of it's type when using the corresponding Application Profile
2. Equipment type specific information e.g. for Drill Rigs, LHD's etc, for the Application Profile's purpose as defined in the corresponding Equipment Profiles.

5.3 Commonly Used Objects (CuO)

In many cases, a set of belonging parameters is used multiple times in different profiles. To prevent from multiply defining nearly identical parameter sets, in repeating profiles, „*Commonly Used Objects*“ ("CuO") are used. A CuO can be used by any IREDES profile wherever applicable.

5.4 Data Set

Complete Information structure for one single purpose including all Header and Trailer Data Blocks. The purpose might e.g. be planning Data, Production Performance data or Production Quality data. The Data Set is created by an IREDES conformant application either on a machine or on a central computer system.

5.5 Equipment Profile

Standard Definition to cover all standardized application parameters applicable to

one individual type of equipment (e.g. Drill Rig, LHD,...) regardless of its manufacture. A complete Equipment Profile covers one specific set of equipment type individual parameter definitions for each Application Profile relevant for this particular type of equipment.

5.6 General Header

Header specifying general information on file generation, software and standard versions as well as on the type of Application Object transferred by this Data Set. The General Header is always located on the very top of the Data Set.

5.7 General Trailer

Administrative Data Block in each IREDES Data Set containing information required for consistency check of an exchanged Data Set.

5.8 IREDES

International Rock Excavation Data Exchange Standard.

5.9 Site Header

Optional Site Header specifying customer specific information not to be modified by the machine. For customer use only. The Site Header is mirrored back to the customer with each response telegram until the machine receives a new Site Header or a telegram without any Site Header. The content of the Site Header is not subject to standardization.

6 IREDES Standard Architecture

6.1 General Principle

The purpose of IREDES is to provide an universal and flexible way of electronic communication, open for extensions and enhancements without affecting existing parts of the standard.

This purpose of a flexible electronic information exchange and a standard easy to extend without touching existing parts is achieved by separation between the purpose of an information exchange (“Application Profile”) and the dedicated type of equipment using and extending the generic Application Profile information by specific entries for dedicated types of equipment (“Equipment Profile”).

This principle leads to a matrix structure of the information exchange interface:

- 1. Application purpose in the Application Profile (“vertical structure”)
- 2. Equipment specific purposes in the respective Equipment Profiles (“horizontal structure”)

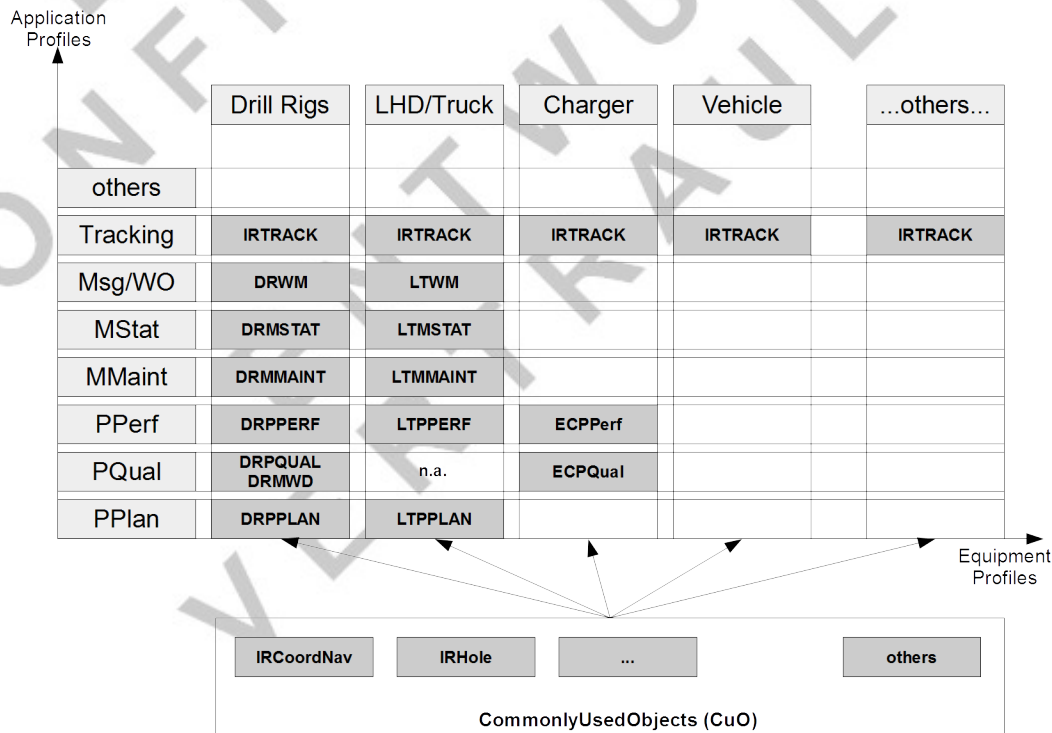


Figure 1: IREDES Profile Structure

An Equipment Type specific profile is created by adding equipment type specific information to the generic application level information defined in the Application Profile which the entry is derived from.

In cases, where an extension of the Application Profile within an Equipment Profile does not make sense (like e.g. in the case of Tracking information), the respective Application Profile is used in a plain form without being renamed and extended by the respective Equipment Profile.

To avoid redefinition of identical objects in different profiles (like e.g. a mine's coordinate system or the definitions for a drill hole), the structure of “*Commonly Used Objects*” (CoU) is available. All definitions made as CuO may be used in any object of the standard. The directory CuO also contains all IREDES standard generic definitions.

6.2 Architecture implementation basics

The technology used for implementing the IREDES standard is XML Schemas in accordance to the W3C standard XML Schemas.

IREDES V1.x bases on XML Schema version 1.0

IREDES V2.x bases on XML Schema version 1.1

In the XML schemas, each single Application Profile entry is defined as a separate Complex Type, derived from the generic IREDESType to assure an identical layout of all IREDES profiles (Figure 2).

The notation for such complex types is: IR*ppp*GenType with *ppp* representing the name of the particular Application Profile, while *ppp* not being limited to three characters.

An Equipment Profile is defined as derived 1-n entries, each of them derived by extension from one particular Application Profile entry.

Both Application Profiles and Equipment Profiles are allowed to make use of Commonly Used Objects (CuO). CoU's are also defined as XML Complex Types.

The entire architecture is implemented in different physical XML schema files which are hierarchically grouped. The hierarchy from bottom to top is as follows:

IRtypes.xsd Basic IREDES Data Types

IRappBaseClasses.xsd IREDES base classes and Application Profile Definitions

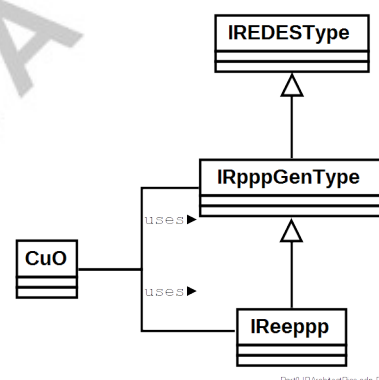


Figure 2: IREDES Architecture Dependencies

*EE*baseClasses.xsd Optional Schema file for Equipment Type specific base classes. *EE* = Equipment Type denominator

Equipment.xsd Equipment type specific schema definitions containing definitions for all data sets implemented by this particular type of equipment. In case a non equipment specific IREDES definition is created (e.g. for Tracking or messaging), this schema is set up purpose specific.

Separated from this (outside of the hierarchy), the CuO schema files are available as they may be used by any of the schemas. Alternatively, they may also be part of the generic IREDES schemas or integrated into a specific Equipment Profile schema file if their use is strictly limited to this particular type of equipment.

Any type of equipment may implement all Equipment Profiles which are applicable for the type of equipment. Consequently, it may be the case, that one machine implements two or more Equipment Profiles like a Drill Rig equipped with a Profiler implements the Drill Rigs profile and the Tunnel Profiler IREDES profile.

6.3 Versioning and Compatibility

The IREDES standard is used in large applications running fleets of heterogeneous machines of different manufacture and age.

Control systems on machines have to be regarded static at their time of delivery. This means that in worst case, the control system software on a machine never is updated from the delivery until end-of-life.

Furthermore, an update in most cases is impossible to be performed at the same point of time for all machines in the field.

The IREDES standard therefore takes care of these situations:

A machine equipped with the IREDES data exchange is regarded to run one static IREDES version which was applicable at the point of machine delivery. This means that the field-side of the information exchange may consist of completely different versions of the standard, even related to a single type of machines: Thereby different machines in a fleet of underground LHD's may run different IREDES versions.

Regarding the machine side static provides the advantage that no flexible XML processing is needed to be performed by the machine control systems, which often are implemented as resource limited embedded computers.

Consequently, the software preparing and interpreting the IREDES data sets may be conveniently hard-coded on the embedded systems even using off-the-shelf libraries.

On the other hand, the central IT systems used for the IREDES information exchange have to provide the highest possible amount of flexibility in accepting and processing different versions of the IREDES standard. This can be performed by standard XML schema processing routines, potentially with some IREDES specific extensions.

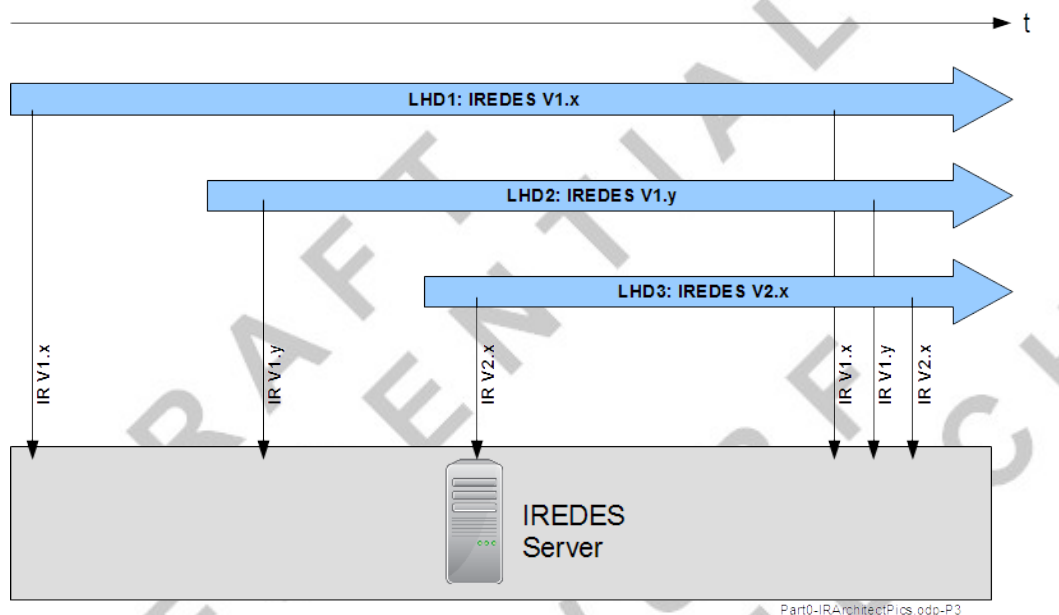


Figure 3: Flexible IREDES version processing on Server side only

Machines running Machine-to-Machine communication (M2M) however have to be equipped with identical versions.

The routines for version handling are explained in detail in chapter 8.

6.4 Naming Conventions

The following naming conventions apply to IREDES standardized XML objects and files:

Prefixes of data type and object definitions and file names for:

IR IREDES standard wide definitions as used for IREDES data types and for definitions in Commonly used Objects (as they also may be used standard wide). The prefix IR is also used for related schema file names which are used standard wide.

Prefixes of Equipment Profiles:

DR Exclusive use in the Drill Rigs Equipment Profile

1	LT	Exclusive use in the LHD / Trucks Equipment Profile
2	EC	Exclusive use in the Explosives Chargers Equipment
3		Profile
4	PF	Exclusive use in the Tunnel Profiler Equipment Profile
5	TR	Exclusive use in the Tracking Equipment Profile
6	MW	Exclusive use in the Messaging / Work Order Profile
7	Prefixes of the Application Profiles, to be stated in the name after the Prefix of the	
8	Equipment Profile implementing the respective Application Profile:	
9	PPERF	Production Performance Reporting (Direction from
10		Machine to
11	PQUAL	Production Quality Reporting
12	PPLAN	Production Plan
13	the list may be extended when the standard extends.	

7 Data Set Composition

7.1 Technology used

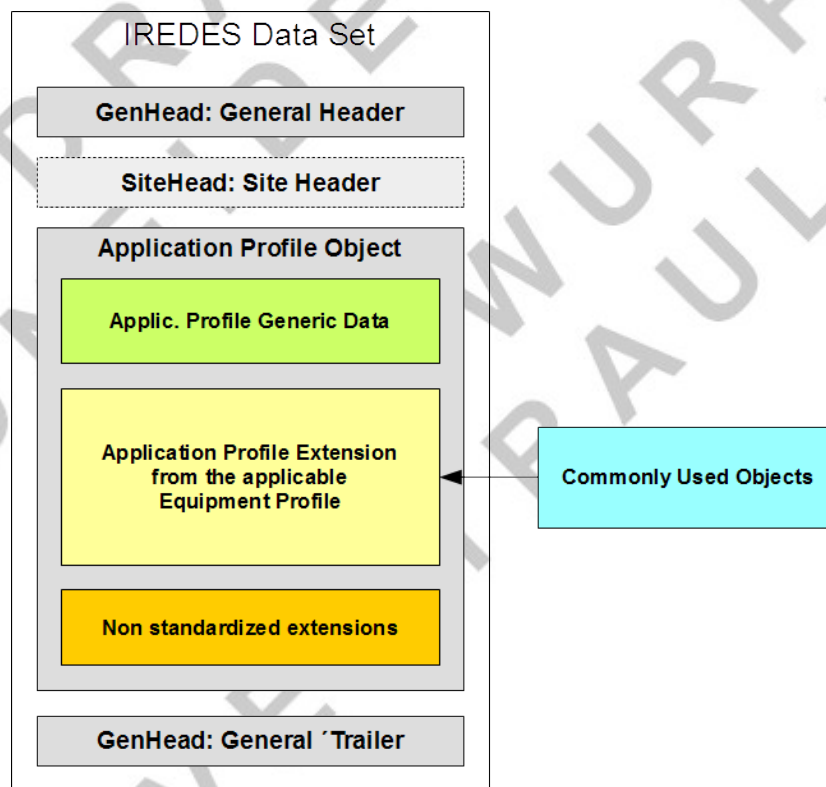
All IREDES data sets are basing on the XML Schema technology.

The IREDES 1.x standard bases on the XML Schema 1.0 version

The IREDES 2.x standard bases on the XML Schema 1.1 version.

7.2 Components of an IREDES data Set

Every IREDES data set consists of the following components as illustrated in figure 4:



Part0-IRArchitectPics.odp-P2

Figure 4: Components of an IREDES data set

These components are explained in detail in the following chapters:

7.2.1 General Header

The General Header (“GenHead”) contains all information needed for interpretation of the information contained in the following sections:

- date and time of data set generation
- Version of the IREDES standard used for data set generation
- Backwards compatibility information stating the first IREDES standard version this data set can be interpreted by in case an interpretation routine for the version stated above is missing

For details of the parameters and their interpretation conventions please refer to the IREDES Part 1 document.

7.2.2 Optional Site Header

The optional Site Header may be used by the user of the standard, e.g. a mining company in order to define the current work place of the machine, the internal machine ID number and other site or user specific information.

If not used, the Site Header may be left out as this is an optional entry.

7.2.3 Application Profile Body

The body of the Application Profile contains all information which is typical for this type of application but independent from the particular machine type it is used for.

So, all entries defined in this part are identical for all types of machines it is used for like Drill Rigs, LHD's, Trucks etc.

Typical Application Profiles are:

PPLAN	Production Plan to be provided to a machine from a central computer system
-------	--

PPERF	Production Performance Report, generated by the machine for use with central computer systems. This profile typically reports on the quantity of work carried out. This report is typically generated in fixed time intervals (e.g. shift or day).
-------	--

PQUAL	Production Quality profile which reports on the quality of work carried out. This data may be generated on the basis of a previously provided PPLAN profile. It tells about how the work has been carried out. For a Drill rig this is by example the position and orientation of the holes drilled, problems during drilling, or Measurement While Drilling data. A data set in accordance to this profile typically is
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generated when a job (like a drilling round) has been finished.

These Application Profiles are created in order to match the requirements of the different operational requirements: The Production Performance information is typically used and reported on a daily / shift (time based) basis, while the Production Quality information is typically generated once a work order has been completed. For details on the dependencies and see chapter 9.1.

7.2.4 Equipment Profile Body extension

For each Application Profile, 1-n Equipment Profile extensions may exist. In IT terminology, the Equipment Profile Body is derived by extension from the Application Profile Data Type.

For each type of equipment, the applicable Application Profiles are extended by one Equipment Profile.

The Equipment Profile contains all machine specific information e.g. the drilling specific data for a Drill Rig or the loader specific information for an LHD.

As the machine type is the leading denomination for a machine profile, the related profiles are named with the machine denomination as a prefix (see 5.5). In this way, a profile can be uniquely identified by using the Equipment Type prefix together with the Application Profile denominator as in the following examples:

DRPPLAN	Drill Rig Production Plan
DRPQUAL	Drill Rig Production Quality Report
LTPPERF	LHD/Trucks Production Performance Report

7.2.5 Optional extensions

An optional extension may not affect the standard's general usability. Data Sets containing non standardized, optional information has to be compatible for use with any standard compliant equipment or computer system, even if it is not able to make use of the additional non - IREDES information provided additionally.

Consequently, the following rules apply to the use of individual options and extensions:

1. The basic IREDES Schemas may not need to be altered for adding options
2. Adding optional information is only allowed at special points in the IREDES Data Sets. These entry points are clearly marked in the IREDES xml schemas.
3. Multiply defined structures should be avoided. The use of clearly defined

prefixes in the parameter names is highly recommended!

The IREDES standard allows the integration of any information not covered by schema definitions at certain points by using IROptionType elements. This feature is used in the IREDES standard to define „hookup points“ for individual, optional information.

ATTENTION: Individual information may only be used in addition to the standard to enhance accuracy or operational comfort. IT MAY NOT BE USED TO MAKE A MACHINE INCOMPATIBLE TO IREDES COMPLIANT OPERATION!

It is very recommended to create a separate XML schema for the extensions in the same way as the IREDES schemas are set up. In this case, IREDES and xml based procedures for information parsing and validation can be used without additional effort even for the optional elements.

A recommended handling is a multi pass procedure:

1. Validation and interpretation of the IREDES standardized elements, ignoring all extensions.
2. Separate validation and interpretation of any optional extension in the IREDES Data set: Loading the corresponding xml schema, validation against the schema and call to the interpretation routines.

In this procedure, just the interpretation routines remain individual. For schema validation, standard xml procedures are used.

7.2.6 General Trailer

The Trailer of each Data Set (“GenTrailer”) contains administrative information to assure consistency of the data set sent. This includes a checksum.

7.2.7 Data Compression

Compression of IREDES data sets is allowed by using the gzip algorithm [2].

7.2.8 Encryption

From IREDES Version 2.0 parts of an IREDES data sets may be encrypted in order to contain protected information. This may be required e.g. when dealing with explosives recipes and explosives tracking information.

IREDES uses the XML-Enc Routines which define how to encrypt the content of XML elements [3].

8 Versioning

IREDES provides a flexible version handling with the aim to prevent from regular updates of field equipment as such updates never can be carried out simultaneously for all equipment involved.

The version information allows to automatically process IREDES Data Sets in an environment of different IREDES versions used e.g. by equipment of different age.

If an IREDES Data Set has to be validated against a corresponding schema the interpreting computer is able to automatically assign the right schema version to be used according to the version tags.

Is the computer not able to find a suitable schema, it also may use available schemas down to the version stated in the tag „*DownwCompat*“. Thereby it can be checked, whether the Data Set can be interpreted by an alternative version which may be available. These attributes are used if new tags are added in a newer version and other changes have been made that did not affect the interpretability of the „older“ parameters.

Consequently, when the meaning and the definition of parameters is changed resulting in the loss of the compatibility, the *DownwCompat* attributes are set to a higher version. In the version with such changes, the *DownwCompat* attribute will be identical to the version attribute.

All version numbers have to follow the character sequence (patterns) as defined in the *IRVersion* data type.

Each top level („root“) element of any IREDES Data Set carries four version attributes to provide information about the IREDES standard version:

IRVersion: IREDES Base version needed to process this Equipment Profile schema

IRDownwCompat: Earliest version the IREDES Base system version stated in *IRVersion* is downward compatible to. Since this version, only extensions have been made but no changes affecting compatibility issues (data type changes etc).

ProfileVersion: Version number of this Equipment Profile

ProfileDownwCompat: Earliest version the Profile version stated in *ProfileVersion* is downward compatible to. Since this version, only extensions have been made but no changes affecting compatibility issues (data type changes etc).

The general attributes for the IREDES version information (*IRVersion* and

IRDownwCompat) are taken from the *IREDESType* datatype. They are indirectly inherited from the *IREDESType* data type via the Application Profile's base type. These are fixed values defined with the schema definition when the schema is created. They may not be changed by the applications creating IREDES Data Sets.

As additional information, the versioning information contains Downward Compatibility information:

The related procedure is shown in Figure 5. This procedure is performed on the top level using the information available in the General Header (*GenHead*) and again on Equipment Profile level using the Attributes *IRVersion* and *IRDownwCompat* (From Version 2.0: Attributes *ProfileVersion* and *ProfileDownwCompat*) in the *IREDESType* definitions.

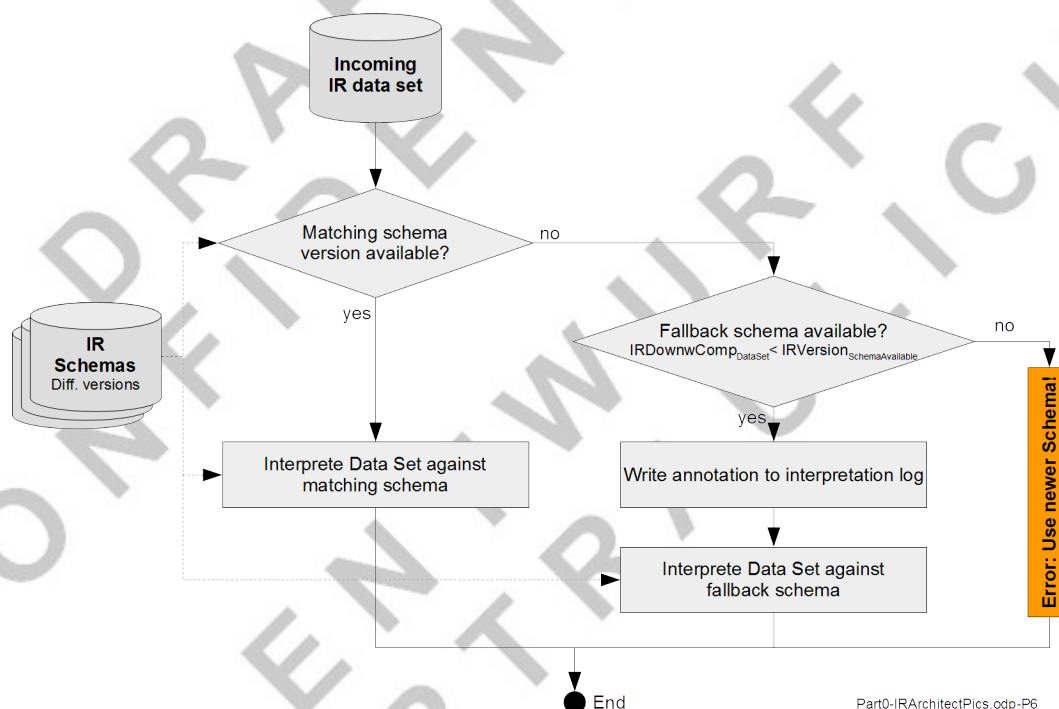


Figure 5: IREDES version handling sequence

Before entering into the IREDES schema interpretation the XML validator automatically checks for the respective XML schema versions. In case a mismatch is identified on this level, no IREDES schema processing can be performed – as IREDES bases on the W3C schema definitions.

9 Information exchange routines

9.1 Data Set Generation Sequences

IREDES distinguishes between Production Performance and Production Quality information as this follows different typical reporting periods: Reports on production performance are exchanged on a shift or day basis while production quality is relevant for reporting once a working sequence is finished.

Therefore, an individual application is allowed to decide in what intervals Production Performance reports will be generated. A Production Quality Report is always generated when a work sequence (e.g. one round on a drill rig) is finished.

Production Quality reports may be generated basing on Production Plans: If a machine got submitted a Production Plan, the result information on how the work was carried out is filled in by the machine during the ongoing work. Once the work sequence (e.g. Drill Rig: round) is finished, the Production Quality Report is closed and the IREDES data set is generated (fig. 5)

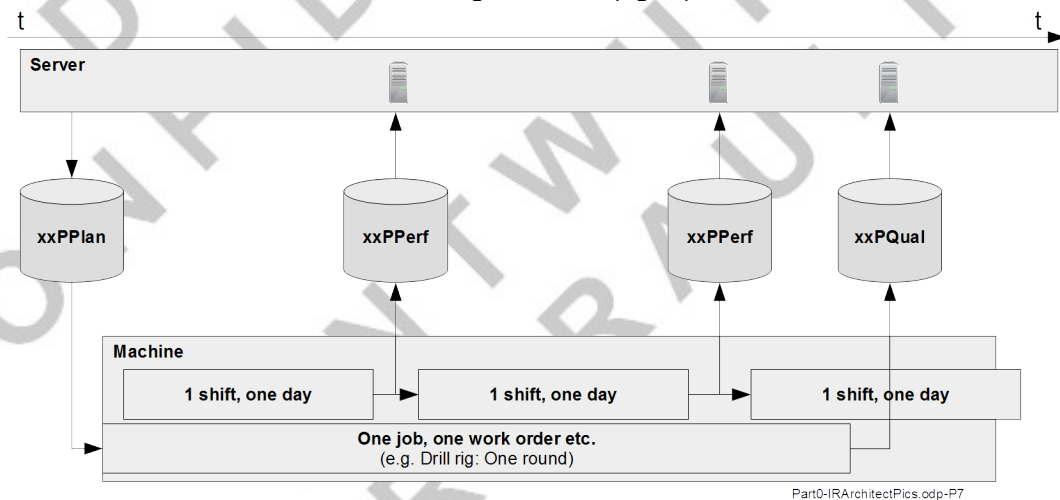


Figure 6: Data Set Exchange Sequence

9.2 Data Set Communication

IREDES Data Sets are to be communicated preferably via the following channels:

1. As files on physical memory media (USB-Stick, memory card, ...)
2. Using file transfer via TCP/IP in a network environment
3. Using Web Services

4. Using OPC-UA Web Services

In any case, the machine has to provide sufficient amount of non volatile memory in order to buffer a significant number of reporting files as in many cases mining machinery is used off-line. This intermediate storage shall be sufficient for at least 4 weeks reporting information.

9.2.1 Physical Memory Media

The IREDES Data Sets are stored as files on the machine or on a memory media attached to the machine. The media is physically transferred to the central computer systems where the IREDES data sets are uploaded.

The type and size of memory media to be used is not standardized.

9.2.2 File Transfer via Network

IREDES compliant machines which offer File Transfer via network capabilities shall be equipped with a standard network interface (wired or wireless) to be able to access the IREDES files via the network.

For this purpose, no proprietary hardware or software shall be required.

Ideally, the machine is accessible via the web browser port to select and access the files via a web browser on an external device.

The related network access shall provide a DHCP server so an external device is able to connect even when no network infrastructure is available. This can be configurable on the machine. A login to is recommended.

A sufficient permanent storage on the machine's computer system is recommended to allow a sufficient time of operation and logging without the machine being able to access a network.

9.2.3 Web Services

Web Services are the preferred way of information exchange into regular IT environments.

For all online exchange of IREDES Data Sets, a standard Web Service [6] shall be configurable on the machine's computer system. The information exchange is then performed via this channel as soon or whenever the machine has access to the network.

IREDES compatible equipment offering network access has to provide this form of information exchange.

9.2.4 OPC/UA

OPC/UA information exchange is preferably used for integration of the IREDES conformant equipment into Process Automation IT infrastructures. OPC/UA also bases on Web Services and alternatively on the binary OPC/UA structures. OPC/UA is a secondary, optional way of exchanging the XML Schema defined IREDES content.

OPC/UA is an optional addon.

9.3 Machine-to-Machine Communication

Machine-to-Machine (M2M) communication is used when working machines have to directly communicate with each other. This is the case, when e.g. an LHD dumps a scoop of load to a truck while at the same time the loaded mass is communicated from the LHD to the Truck. As this often happens in the field without access to any network infrastructure, a direct communication without involving central computers or servers is needed.

Using IREDES for Machine-to-Machine communication means that all embedded computers on two or more machines are exchanging information among each other. As no central computer system is involved, which could take care of different IREDES standard versions potentially running on the machines, all machines in such an application have to run compatible IREDES versions.

Therefore, it is highly recommended in any IREDES application to make use of checking the version tags of all incoming Data Sets.

M2M Communication is an optional addon.

10 Nomenclature

To make navigation in the IREDES standard easier, a nomenclature is used in the XML schemas. Using this nomenclature, the origin of all major objects can be easily identified by their name.

The first prefix (two capital letters) also determines the XML-namespace the corresponding object is residing in.

These prefixes are used as part of the name of the corresponding XML tag names. Thereby they safely prevent from unintended name collisions if different profiles are developed in different work groups.

The lists below are being extended when new profiles are defined. For a most complete list refer to the IREDES web page.

10.1 Object Prefixes

CH Objects specifically defined for the Chargers Equipment Profile.

DR Objects specifically defined for the Drill Rigs Equipment Profile.

GN Generic Equipment Profile used for all purposes where no specific Equipment Profile can be assigned, so e.g. for Tracking Information, Messaging etc. if no equipment specific entries are used.

IR IREDES general objects, IREDES standard wide data types and other tool objects available throughout the entire standard. Also applicable to IREDES wide available Commonly used Objects.

LT Objects specifically defined for the LHD/Trucks/Loaders Equipment Profile

10.2 Additional Application Profile Prefix

A second additional prefix (also two capital letters) is introduced for each Application Profile. This prefix follows the Equipment Profile prefix and is as follows:

MM Machine Maintenance Application Profile

MS Machine Status Application Profile

1	PL	Production Plan Application Profiles.
2	PP	Production Performance Application Profile
3	PQ	Production Quality reporting Application Profile
4	TR	Tracking information
5	WM	Work Orders and structured message exchange

10.3 Example

The following examples show the setup of XML name tags following this nomenclature:

DRPPerf	Uppermost object of the Production Performance object for Drill Rigs
LHPQual	Uppermost object of the Production Quality object for LHD's/Loaders/Trucks

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References

- [1] XML Tutorial: http://www.w3schools.com/Xml/schema_intro.asp
- [2] Gzip Algorithm www.gzip.org
- [3] W3C XML Encryption: <https://www.w3.org/TR/xmlenc-core/>
- [4] W3C XSD 1.1 Structures: <https://www.w3.org/TR/xmlschema11-1/>
- [5] W3C XSD 1.1 Datatypes: <https://www.w3.org/TR/xmlschema-2/>
- [6] W3C WSDL 2.0 Primer: <https://www.w3.org/TR/wsdl20-primer/>

1 Appendices

DRAFT
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