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Industrial automation systems and integration — Industrial manufacturing management data: Resources usage management —

Part 32: Conceptual model for resources usage management data

Systèmes d'automatisation industrielle et intégration — Données de gestion de fabrication: Gestion d'emploi des ressources —

Partie 32: Modèle conceptuel pour les données de gestion d'emploi des ressources

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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/ IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 15531-32 was prepared by Technical Committee ISO TC184/SC4, *Industrial automation systems and integration*, Subcommittee SC4 *Industrial data*.

A complete list of parts of ISO 15531 is available from the Internet.

http://www.tc184-sc4.org/titles/

Introduction

Manufacturing resources form the basis and long-term potential of any company. The efficient use of these resources is one of the main goals in industrial management. Comprehensive information about available manufacturing resources is required in order to take the necessary decisions for efficient resource usage. Since many different enterprise functions and therefore also different IT-systems are dealing with manufacturing resources. A common, standardized model for resource description is necessary. That standardised model should enable a company to communicate internally and externally about manufacturing resources and furthermore enable to build up an industrial company's resource database. Its basis will be the definition of an information model for the description of manufacturing resources.

A complete description of manufacturing resources is out of scope of this information model. Only data relevant for decisions concerning the usage of manufacturing resources (e.g. within process planning or job scheduling) will be considered. Therefore only data describing manufacturing resources in terms of their static and dynamic capabilities and capacities to perform manufacturing tasks are within the scope of this information model for resource usage management. There mainly exist two different types of capabilities. On the one hand, there exist capabilities describing a manufacturing resource which are dedicated and unique characteristics in the context of resource management. On the other hand, there exist capabilities which are used within resource management but represent a specific view on characteristics belonging originally to the product description of a manufacturing resource.

EXAMPLE some geometrical or shape properties may belong to the product description and may be needed for the management of concerned resource.

Therefore there is a strong link to the product defining data of manufacturing resources, e.g. described by using the ISO 10303 standard.

On the other hand, the data residing in this information model for manufacturing resource management will mainly be used within process planning. This planning will result in the assignment of manufacturing resources and the required technological parameters for resource utilisation and these results will be documented by means of ISO 10303-240 On the other hand the data describing capability and capacity of manufacturing resources will be used together with process plans as input for scheduling tasks which will be conceptually defined in ISO 15531-4x series.

This part of ISO 15531 specifies a model of manufacturing resources that is written in EXPRESS and makes the fullest possible use of the "Integrated Resources" in ISO 10303. The model may therefore be used by other SC4 standards.

Industrial automation systems and integration – Industrial manufacturing management data: Resources usage management – Part 32: Conceptual model for resources usage management data

1 Scope

This part of ISO 15531 specifies the full description of the conceptual model for resources usage management data, based on the resource information model and basic principles described in ISO 15531-31.

The following are within the scope of this part 32 of ISO 15531:

— The description of the conceptual resource information model and related definitions for resource usage management data;

— The EXPRESS description of the model and related entities;

— The EXPRESS-G diagram of the model.

2 Normative references

The following referenced documents are indispensable for the application 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/IEC 8824-1, *Information Technology - Abstract Syntax Notation One (ASN.1): Specification of Basic Notation.*

ISO 10303-1, *Industrial automation systems and integration - Product data representation and exchange - Part 1: Overview and Fundamental Principles.*

ISO 10303-11:1994, *Industrial automation systems and integration - Product data representation and exchange - Part 11: Description methods: The EXPRESS language reference manual.*

ISO 10303-41, *Industrial automation systems and integration - Product data representation and exchange - Part 41: Integrated generic resources: Fundamentals of product description and support.*

ISO 10303-49, *Industrial automation systems and integration - Product data representation and exchange - Part 49: Integrated generic resources: Process structure and properties.*

ISO 10303-214, *Industrial automation systems and integration - Product data representation and exchange - Part 214: Application Protocol: Core data for automotive mechanical design processes.*

ISO 10303-224, *Industrial automation systems and integration - Product data representation and exchange - Part 224: Application Protocol: Mechanical product definition for process planning using machining features.*

ISO 13584-1, *Industrial automation systems and integration – Parts library – Part 1: Overview and fundamental principles.*

ISO 13584-42, *Industrial automation systems and integration – Parts library – Part 42: Description methodology: Methodology for structuring parts families.*

ISO 15531-1, *Industrial automation systems and integration - Industrial manufacturing management data - Part 1: General overview.*

ISO 15531-31, *Industrial automation systems and integration - Industrial manufacturing management data - Part 31: Resource information model.*

ISO 15531-42, *Industrial automation systems and integration - Industrial manufacturing management data - Part 42: time model*

3 Terms, definitions and abbreviations

3.1 Terms and definitions

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

3.1.1
attribute
a piece of information stating a property of an enterprise entity

NOTE – The concept provided here relates to the broad concept of entity as defined in European standard ENV 12204? The term entity used in the definition provided by the ENV 12204 has been replaced here by enterprise entity as in ISO 15531-1 to avoid any confusion and inconsistency with the reserved term “entity” defined in ISO 10303-11. The usage of this concept has been limited to the area of concern of ISO 15531 in order to enable the use of the term “enterprise entity” instead of “entity and the field of application of the term attribute is restricted to enterprise entities.

[ISO 15531-31]

3.1.2
capability
quality of being able to perform a given activity

NOTE The capability is defined by a group of characteristics that describes functional aspects of manufacturing resources or system.

[ISO 15531-1]

3.1.3
capacity
capability of a system, sub-system or resource to perform its expected function from a quantitative point of view

EXAMPLE The capacity of a system or a resource to produce a given quantity of output in a particular time period.

NOTE For a given system or resource the distinction between capacity available and capacity requested may be useful.

[ISO 15531-1]

3.1.4
classification
the process of arranging abstractions into a structure organised according to their distinguishing properties

[ISO 15531-31]

3.1.5
component
a product that is not subject to decomposition from the perspective of a specific application

[ISO 10303-1]

3.1.6
data
a representation of information in a formal manner suitable for communication, interpretation, or processing by human beings or computers

[ISO 10303-1]

3.1.7
definition of resource characteristics
set of resources properties that are characterised by physical values

NOTE - Those physical values may be qualitative or quantitative.

[ISO 15531-31]

3.1.8
definition of resource views
classified set of resource views

NOTE - Those resource view may be defined either by the user or catalogues.

[ISO 15531-31]

3.1.9
generic resource
structure belonging to resource hierarchy and encompassing the common properties of several resources

NOTE - The corresponding entity `generic_resource` includes a complete definition of the related attribute without link to actual value.

[ISO 15531-31]

3.1.10
information
facts, concepts, or instructions

[ISO 10303-1]

3.1.11
interpretation
the process of adapting a resource construct from the integrated resources to satisfy a requirement of an application protocol. This may involve the addition of restrictions on attributes, the addition of constraints, the addition of relationships among resource constructs and application constructs, or all of the above

[ISO 10303-1]

3.1.12
information model
a formal model of a bounded set of facts, concepts or instructions to meet a specified requirement

[ISO 10303-1]

3.1.13
integrated resource
a part of this International Standard that defines a group of resource constructs used as the basis for product data

[ISO 10303-1]

3.1.14
model
representation or description of an entity or a system, describing only the aspects considered to be relevant for its purpose

NOTE Entity is not used here with the meaning provided by ISO 10303-11 but with the sense usually given in ENV 12204

[ISO 15531-1]

3.1.15
object
concept or a physical thing which may exist in the real world

[IS015531-31]

3.1.16
process
structured set of activities involving various enterprise entities, that is designed and organised for a given purpose

NOTE The definition provided here is very close to that given in ISO 10303-49. Nevertheless ISO 15531 needs the notion of structured set of activities, without any predefined reference to the time or steps. In addition, from the point of view of flow management, some empty processes may be needed for a synchronisation purpose although they are not actually doing anything (ghost task).

[ISO 15531-1]

3.1.17
product
a thing or substance produced by a natural or artificial process

[ISO 10303-1]

3.1.18
product data
a representation of information about a product in a formal manner suitable for communication, interpretation, or processing by human beings or by computers

[ISO 10303-1]

3.1.19
property
a real world characteristic which is represented by either attributes or constraints

[ISO 15531-31]

3.1.20
resource
any device, tool and means, excepted raw material and final product components, at the disposal of the enterprise to produce goods or services

NOTE 1 Resources as they are defined here include human resources considered as specific means with a given capability and a given capacity. Those means are considered as being able to be involved in the manufacturing process through assigned tasks. That does not include any modelling of an individual or common behaviour of human resource excepted in their capability to perform a given task in the manufacturing process (e.g.: transformation of raw material or component, provision of logistic services). That means that human resources are only considered, as the other, from the point of view of their functions, their capabilities and their status (e.g.: idle, busy). That excludes any modelling or representation of any aspect of individual or common «social» behaviour.

NOTE 2 This definition includes ISO 10303-49 definition.

[ISO 15531-1]

3.1.21
resource characteristic
main property of a resource according to a given purpose

NOTE In ISO 15531 resource characteristics are mainly related to the management of the manufacturing resources.

[ISO 15531-31]

3.1.22
resource configuration
set of properties of resource configured for a specific manufacturing task

[ISO 15531-31]

3.1.23
resource hierarchy
structure designed to enable a classification of resources

[ISO 15531-31]

3.1.24
resources information model (RIM)
model of information addressing management of resources usage

[ISO 15531-31]

3.1.25
resource status
property which identifies an individual resource availability at some point in time

[ISO 15531-31]

3.1.26
resource view
specific set of resource characteristic associated to a given purpose

[ISO 15531-31]

3.1.27
structure
a set of interrelated parts of any complex thing, and the relationships between them

[ISO 10303-1]

3.1.28
structure of resource characteristics
set of classified resource characteristics

[ISO 15531-31]

3.2 Abbreviations

For the purpose of this part of ISO 15531, the following abbreviation applies:

ERP enterprise resources planning

RIM resources information model

SDAI standard data access interface

4 ISO 15531 general

ISO 15531 specifies the characteristics for a representation of manufacturing management information over the entire industrial process with the necessary mechanisms and definitions to enable manufacturing management data to be shared and exchanged within the factory, with other plants or with companies.

Exchanges are made through different computer systems and environments associated with the complete industrial process. The standard is focused on discrete manufacturing but not limited to it. Nevertheless any extension to industrial processes which does not belong to discrete manufacturing is always under consideration when it does not imply any contradiction or inconsistency with the initial objective of the standard.

The following are within the scope of ISO 15531:

— the representation of production and resources information including capacity, monitoring, maintenance constraints and control;

NOTE - Maintenance constraints and relevant maintenance management data are taken into account from the point of view of their impact on the flow control.

— the exchange and sharing of production information and resources information including storing, transferring, accessing and archiving.

The following are outside the scope of ISO 15531:

— enterprise modelling;

NOTE - That means that tools, architecture and methodologies for the modelling of an enterprise in its whole are not in the scope of ISO 15531.

— product data (representation and exchange of product information);

— component data (parts library: representation and exchange of computer-interpretable parts library information);

— cutting tools (electronic representation for exchange of cutting tool data);

— technical maintenance information (technical information such as those included in devices repair, operation and maintenance manuals).

5 Conceptual information model for resources usage management data

5.1 Structure of the schema

According to ISO 15531-31 the conceptual information model for resources usage management data is structured into six logical modules (see figure 1). The entity *resource* forms the central element within the schema. Each further description classifying or detailing a resource's characteristics is related to this resource. The enumeration of these six modules follows a logical order. The ascending order corresponds to the sequences for developing an information model.

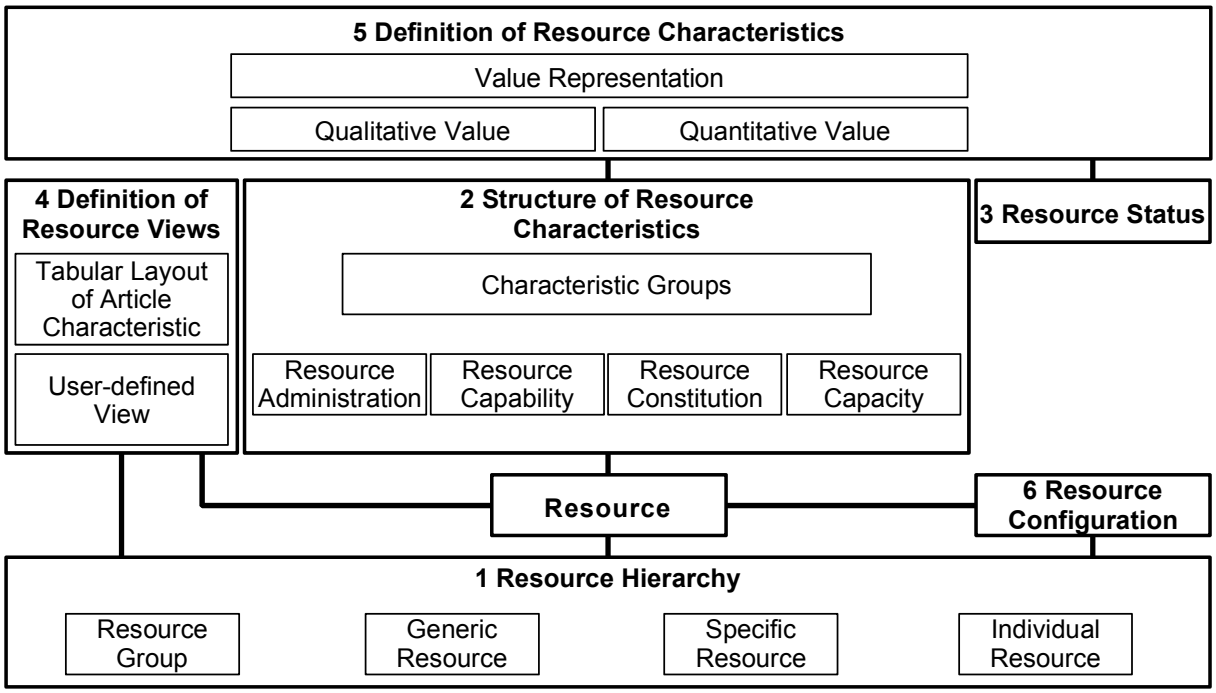

Figure 1: Overview of resource information model

NOTE Examples for the instantiation of the conceptual information model for resources usage management are described in annex B.

5.1.1 Resource hierarchy

A resource hierarchy can be represented by instantiating a resource group. A generic resource captures generic characteristics of a resource type. A specific resource is the specialisation of a generic resource and captures a set of characteristics which represent a resource which can or does exist. The individual resource represents the occurrences of manufacturing resources within the business.

NOTE See box number 1 in figure 1.

5.1.2 Structure of resource characteristic

For the purposes of resource usage management, a resource characteristic comprises information about a resource. The attribute classification enables the assignment of a resource characteristic classification to a resource characteristic.

A resource administration represents a characteristic describing administrative information. A resource capability identifies a characteristic specifying a functional aspect of a manufacturing resource. A resource constitution represents a characteristic describing the constitution of a manufacturing resources. A resource capacity identifies a characteristic dealing with job related data.

NOTE See box number 2 in figure 1.

5.1.3 Resource status

A resource status is assigned to each individual resource. The resource status indicates the availability or otherwise of the resource.

NOTE See box number 3 in figure 1.

5.1.4 Definition of resource views

A resource view is derived from a specific aggregation of resources. A resource view is assigned to a resource and can either be represented by a resource tabular layout of article characteristics or by a resource user defined view.

NOTE See box number 4 in figure 1.

5.1.5 Definition of resource characteristics

A resource representation is assigned to a resource qualitative or a resource quantitative to represent physical values of the characteristic of a manufacturing resource.

NOTE See box number 5 in figure 1.

5.1.6 Resource configuration

A resource configuration describes the configuration of a specific manufacturing resource.

NOTE See box number 6 in figure 1.

5.2 Schema definition

The following EXPRESS declaration begins the **resources_usage_management_schema** and identifies the necessary external references.

EXPRESS specification:

```
*)
SCHEMA resources_usage_management_schema;
REFERENCE FROM management_resources_schema
   (person_and_organization);
REFERENCE FROM measure_schema
   (measure_with_unit);
REFERENCE FROM support_resource_schema
   (identifier,
    label,
    text);
REFERENCE FROM action_schema
     (action_resource);
(*
```

NOTE 1 The schemas referred to above can be found in the following parts of ISO 10303-41:
date_time_schema: clause 16;
management_resources_schema: clause 8;
measure_schema: clause 21;
support_resource_schema: clause 20;
action_schema: clause 10.

```
*)
REFERENCE FROM process_property_schema
     (resource_property);
(*
```

NOTE 2 The schemas referenced above can be found in the following part of ISO 10303-49:
process_property_schema: clause 5.

```
*)
REFERENCE FROM time_schema
    (point_in_time);
(*
```

NOTE 3 The schema referred to above can be found in ISO 15531-42: clause 4.

```
*)
REFERENCE FROM ISO13584_IEC61360_dictionary_schema
   (property_bsu, class_bsu);
(*

NOTE 4  The schema referred to above can be found in ISO 13584_IEC61360.
```


5.3 Resources usage management type definitions

5.3.1 Resource classification type

The **resource_classification_type** type is one means by which the value of manufacturing resource characteristics can be classified. It enables values to be represented which relate to what a resource has been proposed to achieve, what a resource is required to achieve and what a resource has actually achieved.

EXPRESS specification:

```
*)
TYPE resource_classification_type = ENUMERATION OF
   (proposed,
   required,
   realised);
END_TYPE;
(*
```

5.4 Resources usage management entity definitions

5.4.1 resource, library_resource_assignment and library_property_assignment

5.4.1.1 resource

The **resource** is the basic element for resource management. Each further detailed description, classification or configuration of resources relates to **resource**. A resource can be generic, specific or individual and may in turn comprise of a number of other resources. Each resource has characteristics and can also be considered from different viewpoints.

NOTE : A resource is not related a priori to a given activity. It exist and may be managed before any appointment to any activity (See ISO 15531-1, ISO 15531-31). That is typically the case for Human resources.

EXAMPLE 1: A Factory can be considered as a resource, which contains other resources such as milling machines and machine operators.

EXAMPLE 2: A 5 axis machining centre can be considered to have a generic set of characteristics. Alternatively a particular manufacturers 5 axis machining centre will have a specific set of characteristics. An actual occurrence of a resource used within the enterprise is an individual resource

EXPRESS specification:

```
*)
ENTITY resource
    SUPERTYPE OF (ONEOF(generic_resource, specific_resource,
individual_resource));
      holds_view   : SET OF resource_view;
      described_by : SET [1:?] OF resource_characteristic;
      id           : identifier;
      name         : label;
```

```
      contains     : OPTIONAL resource_group;
      used_in      : action_resource;
  END_ENTITY;
(*
```

Attribute definitions:

described_by: the set of **resource characteristics** entities that describes a manufacturing resource.

holds_view: the set of **resource view**s that are defined for the **resource**.

id: the **identifier** by which the **resource** is identified

name: the **label** by which the **resource** is known.

contains: the resource group which defines the set of manufacturing resources within this manufacturing resource

used_in: the action resource utilising the **resource**.

5.4.1.2 library_resource_assignment

A **library_property_assignment** is the association of the identification of a property, defined in an ISO 13584-42 compliant library, with specializations of **resource_characteristic_group**.

EXPRESS specification:

```
*)
ENTITY library_resource_assignment;
   library_id: class_bsu;
   resource_link:label;
END_ENTITY;
(*
```

Attribute definitions:

library_id: identifier for the external dictionary.

resource_link: the label for the **resource**.

5.4.1.3 library_property_assignment

A **library_property_assignment** enables the characterisation of entities and types by a dictionary in compliance with ISO 13584-42.

EXPRESS specification:

```
*)
ENTITY library_property_assignment;
   property: property_bsu;
```



```
   resource_capability_characterized: resource_capability;
   resource_capacity_characterized: resource_capacity;
   resource_classification_type_characterized:
   resource_classification_type;
END_ENTITY;
(*
```

Attribute definitions:

property: the **property** of the object directly or indirectly including the information about the **property_bsu**.
resource_capability_characterized: characterization of **resource_capability** by an ISO 13584-42 compliant dictionary.

resource_capacity_characterized: characterization of **resource_capacity** by an ISO 13584-42 compliant dictionary.

resource_classification_type_characterized: characterization of **resource_classification_type** by an ISO 13584-42 compliant dictionary.

5.4.2 Resource hierarchy

5.4.2.1 resource_group

a resource group describes a set of manufacturing resources

EXPRESS specification:

```
*)
ENTITY resource_group;
      described_by : SET [1:?] OF resource;
  END_ENTITY;
(*
```

Attribute definitions:

Described_by: the set of **resource** which describes the **resource_group.**

5.4.2.2 generic_resource

A **generic_resource** is a type of **resource** that is characterized by a complete definition of all related attributes without the mandatory link to actual company specific values.

EXPRESS specification:

```
*)
ENTITY generic_resource
   SUBTYPE OF (resource);
END_ENTITY;
(*
```

5.4.2.3 specific_resource

The **specific_resource** is a type of **resource** which is not abstract. It is a type of **resource** for which occurances of the resource are likely to exist within the business.

Example: a company can be aware of the capabilities of a particular type of resource without having that resource available for use within its manufacturing environment.

EXPRESS specification:

```
*)
ENTITY specific_resource
   SUBTYPE OF (resource);
      belongs_to : generic_resource;
END_ENTITY;
(*
```

Attribute definitions:

belongs_to: the **generic_resource** the **specific_resource** is derived from.

5.4.2.4 individual_resource

An **individual_resource** entity represents an actual occurrence of a **resource** utilised within the enterprise.

EXAMPLE - There may be a specific machine tool of which the factory owns 3 identical machines. One machine may be in setup, one may be under maintenance and the other in operation. Each machine is an individual_resource.

EXPRESS specification:

```
*)
ENTITY individual_resource
   SUBTYPE OF (resource);
      occurrence_status: resource_status;
      belongs_to       : specific_resource;
END_ENTITY;
(*
```

Attribute definitions:

occurrence_status: the status of the particular occurrence of this individual resource.

belongs_to: the **specific_resource** the **individual_resource** is derived from.

5.4.3 Structure of resource characteristics

5.4.3.1 Resource characteristic

A **resource_characteristic** definition provides one piece of information needed and defined for resource management purposes. The set of **resource_characteristics** describes the set of information needed.

EXPRESS specification:

```
*)
  ENTITY resource_characteristic;
      Classification : resource_characteristic_classification;
      value_of       : resource_representation;
      name           : label;
      id             : identifier;
      relates_to : resource_property;
  END_ENTITY;
(*
```

Attribute definitions:

classification: the **resource_characteristic_classification** to which the **resource_characteristic** belongs.

value_of: the **resource_representation** for this **resource_characteristic**.

id: the **identifier** by which the **resource_characteristic** is identified

name: the **label** by which the **resource_characteristic** is known.

relates_to : the resource property to which the **resource_characteristic** relates.

5.4.3.2 resource_characteristic_classification

The **resource_characteristic_classification** allows the classification of the resource characteristic as one of administration, capability, constitution or capacity.

EXPRESS specification:

```
*)
  ENTITY resource_characteristic_classification
    SUPERTYPE OF (ONEOF(resource_capability, resource_constitution,
resource_capacity, resource_administration));
  END_ENTITY;
(*
```


5.4.3.3 resource administration

A **resource_administration** is a type of **resource_characteristic_classification** that describes administrative information of a manufacturing resource.

EXAMPLE Administrative information that are used for the management of resources on an enterprise level are disposition characteristics, actual workload, economic characteristics and production cost. The approval of a resource, especially for human resources is an example for disposition characteristics. A complex machine needs the approval of a permitted person or organization to be used in general.

EXPRESS specification:

```
*)
ENTITY resource_administration
    SUBTYPE OF(resource_characteristic_classification);
  END_ENTITY;
(*
```

5.4.3.4 resource_capability

A **resource_capability** is a type of **resource_characteristic_classification** that describes the functional aspects of manufacturing resources. In particular this comprises the specification of tasks of the activity which a manufacturing resource can execute.

NOTE1 A **resource_capability** can be described by its functions, connections, technical characteristics.

EXPRESS specification:

```
*)
  ENTITY resource_capability
    SUBTYPE OF(resource_characteristic_classification);
  END_ENTITY;
(*
```

NOTE 2 Capabilities of a resource that are necessary for the use of the RIM can be represented by reference to the PLib dictionary defined in ISO 13584-1.

NOTE 3 refer to annex D of ISO 15531 part 31 for further explanation of capability and capacity.

5.4.3.5 Resource constitution

A **resource_constitution** is a type of **resource_characteristic_classification** that describes the constitution of manufacturing resources. The description of the constitution comprises information about the actual status of manufacturing resources.

EXAMPLE A **resource_constitution** consists of geometrical, tolerance, material and surface oriented characteristics of resources.

EXPRESS specification:

```
*)
  ENTITY resource_constitution
    SUBTYPE OF(resource_characteristic_classification);
  END_ENTITY;
(*
```

5.4.3.6 resource_capacity

A **resource_capacity** is a type of **resource_characteristic_classification** that describes the capacity of manufacturing resources. The description of the capacity comprises information about the potential workload of manufacturing resources.

EXAMPLE The maximum completion time or power available for a given milling machine is its capacity. This maximum completion time, for example, may be limited technically by maintenance, humanly or by law.

EXPRESS specification:

```
*)
  ENTITY resource_capacity
    SUBTYPE OF(resource_characteristic_classification);
  END_ENTITY;
(*
```

5.4.4 Resource status

A **resource_status** provides information associated with an **individual_resource** as an element for the description of the availability of the manufacturing resource.

EXPRESS specification:

```
*)

  ENTITY resource_status;
      time_reference : point_in_time;
      availability   : BOOLEAN;
  END_ENTITY;

(*
```

Attribute definitions:

time_reference: the **point_in_time** to which the **resource_status** refers.

availability: the **boolean** value depicting the availability of the **resource**.

5.4.5 Definition of resource views

5.4.5.1 resource_view

A **resource_view** is a specific view of **resource**. A **resource_view** is described by a **resource** which will typically be represented in turn by a **resource_group**

EXPRESS specification:

```
*)
ENTITY resource_view
    SUPERTYPE OF (ONEOF(user_defined_resource_view,
resource_tabular_layout_of_article_characteristic));
      described_by : resource;
      id           : identifier;
      name         : label;
  END_ENTITY;
(*
```

Attribute definitions:

described_by: the **resource** that is defined as relevant for this **resource_view**.

id: the **identifier** by which the **resource_view** is identified

name: the **label** by which the **resource_view** is known.

5.4.5.2 User_defined_resource_view

A **user_defined_resource_ view** is a resource_view that is a combination of **resource_ characteristic**s suited to a given application.

NOTE : This entity enable the user to select specific characteristic in its application, it may be defined according to a table of manufacturing properties (with a fixed set of values).

EXAMPLE The selection of manufacturing resources for a special shop floor area could be an **user_defined_resource_ view**. Manufacturing resources could be grouped by their location, products they manufacture and so on.

EXPRESS specification:

```
*)
  ENTITY user_defined_resource_view
    SUBTYPE OF(resource_view);
  END_ENTITY;
(*
```

5.4.5.3 resource_tabular_layout_of_article_characteristic

A **resource_tabular_layout_of_article_characteristic** is a **resource_view** that is used to combine and select physical and abstract objects with similar characteristics.

NOTE This resource_view enable the definition of properties by the supplier of the resource, on request, on demand from the resource client (e.g. : very particular properties that needs a hand-making of a tool).

EXAMPLE The German standard DIN 4000 is an example for the usefulness of this combination to ease the use of article characteristics [8].

EXPRESS specification:

```
*)
ENTITY resource_tabular_layout_of_article_characteristic
   SUBTYPE OF (resource_view);
   time_reference   : OPTIONAL point_in_time;
   author: person_and_organization;
   identifying_code: STRING;
   graphics: STRING;
END_ENTITY;
(*
```

Attribute definitions:

time_reference: the **point_in_time** by which the **resource_tabular_layout_of_article_characteristic** refers.

author: identifies the author of the **resource_tabular_layout_of_article_characteristic**.

identifying_code: identifier.

graphics: relates to a possible graphical representation.

NOTE The attribute **graphics** represents the name or file name of a graphical representation such as a drawing.

5.4.6 Definition of resource characteristics

5.4.6.1 resource_representation

A resource_representation defines manufacturing resource characteristics and supports the distinction between qualitative and quantitative values.

EXAMPLE A **resource_characteristic** can be quantitative such as the capacity in hours of production time for a milling machine. A qualitative value of a resource could be its ability to be integrated in a production cell including automation.

EXPRESS specification:

```
*)
  ENTITY resource_representation
    SUPERTYPE OF (ONEOF(resource_qualitative, resource_quantitative));
      classification : resource_classification_type;
       END_ENTITY;

(*
```

Attribute definitions:

classification: the **resource_classification_type** enumeration provides a classification of the value of a manufacturing **resource_characteristic**.

5.4.6.2 resource_qualitative

A **resource_qualitative** is a **resource_representation** that describes qualitative values of a **resource_characteristic**.

EXAMPLE A **resource_characteristic** of a manufacturing resource can have qualitative values such as its automation, used palette system or palette identification.

EXPRESS specification:

```
*)
ENTITY resource_qualitative
   SUBTYPE OF (resource_representation);
   optional_descriptions: OPTIONAL text;
   description: text;
END_ENTITY;
(*
```

Attribute definitions:

optional_descriptions: defines a optional qualitative values providing additional qualitative information about the resource.

description: text that relates to the nature of a qualitative representation.

NOTE The attribute **optional_descriptions** allows the definition of a set of optional qualitative values to make the qualitative description more concrete. In this context "qualitative" means: not exactly describable or described in quantitative terms.

5.4.6.3 resource_quantitative

A **resource_quantitative** is a **resource_representation** that describes quantitative values of a **resource_characteristic**.

EXAMPLE 1 A **resource_characteristic** of a manufacturing resource can have quantitative values such as the dimensions of the workpieces a resource can manufacture.

EXPRESS specification:

```
*)
ENTITY resource_quantitative
   SUBTYPE OF (resource_representation);
   optional_descriptions: OPTIONAL SET OF measure_with_unit;
   description: measure_with_unit;
END_ENTITY;
(*
```


Attribute definitions:

optional_descriptions: the set of **measure_with_unit** that give optional quantitative values to the **resource_characteristic**.

description: the measure_with_unit that express the physical quantity of a **resource_characteristic**.

NOTE The attribute **optional_descriptions** allows optional descriptions that could be used to represent different measures with unit to ease the models use.

EXAMPLE 2 The maximum temperature for a fluid could be fixed in degree Celsius or in degree Kelvin.

EXAMPLE 3 The weight of a machine can be fixed in metric kilograms or in British pounds.

5.4.7 resource_configuration

The **resource_configuration** describes the configuration of resources for a specific manufacturing task. The use of a **resource** by another one can be represented by **resource_configuration** and by the current resource status.

EXAMPLE The resource milling machine includes the combination of several cutting tools as a resource. These cutting tools could be specific for the machine type and limit their use. On the one hand the milling machine is limited by tools that can be used (size, material). On the other hand the tools as a resource can only be used by a specific machine and were limited in their use.

EXPRESS specification:

```
*)
ENTITY resource_configuration;
   relating_resource: resource;
   related_resource: resource;
END_ENTITY;

END_SCHEMA; -- resources_usage_management_schema;
(*
```

Attribute definitions:

relating_resource: one of the **resources** which is a part of a given **configuration**.

related_resource: resource which is a part of the **configuration.** If one element of the relationship is dependent upon the other, then this attribute shall be the dependent one.

NOTE : In the example of the milling machine and cutting tools, the milling machine is the relating resource and the cutting tools are the related resources. A configuration may be made of several relating resources, some of them may use related resources or not.

Annex A
(Normative)
Use of ASN.1 Identifiers in SC4 standards

To provide for unambiguous identification of an information object in an open system, the object identifier

```
iso standard 15531 part 32 version 1
```

is assigned to this part of ISO 15531. The meaning of this value is defined in ISO/IEC 8824-1 and is described in ISO 15531-1.

Annex B
(Informative)
RIM usage cases

B.1 General usage

B.1.1 Resource Information Models

Manufacturing resource information is fundamental to any decision making process which is concerned with the use of manufacturing resources. Examples of decision making processes which require manufacturing resource information include enterprise resource planning, process planning and production scheduling. The effective provision of resource information required for resource usage management requires a clear model of that information. The model provided here offers a structure of information based on a flexible resource hierarchy, resource characteristics, resource views and resource status. The data values can be linked to existing parts library information. This annex provides examples to describe the key elements of the resource information model.

B.1.2 Manufacturing Resources and Resource Hierarchies

Machine tools, fixtures, cutting tools, manufacturing personnel, pallets, transfer devices, coolant etc can all be considered as being manufacturing resources. The combination of a range of such resources provides a manufacturing capability which can be assessed in terms of its usage. Resource information can be combined in many different ways dependent on the purpose for which it is needed. Figure B1 illustrates the combination of a machine operator, a machine tool and a pallet changer. In combination with cutting tools and fixtures this becomes a useful machining cell.

Figure B.1 A combination of resources to provide a useful resource

We can consider many combinations of resource. Figure B2 illustrates another example. Here an assembly shop is illustrated which has a range of assembly machines each of which can perform different assembly operations. The combination of these machines and the characteristics of each influences the overall potential usage of the shop. The shop itself can be considered to be a resource

with a set of characteristics as can each of the cells within the shop and each of the machine stations within each cell.

The machine in Figure B1 is an example of a specific resource. It has a set of characteristics such as capacity and capability. However if we consider it to be a machine supplier's machine it is therefore not an actual resource which exists within the business. This illustrates the difference between a specific resource and an individual resource. An individual resource can be considered as a resource occurrence which will have some status a some point in time. The machines illustrated in figure B2 are examples of individual resources.

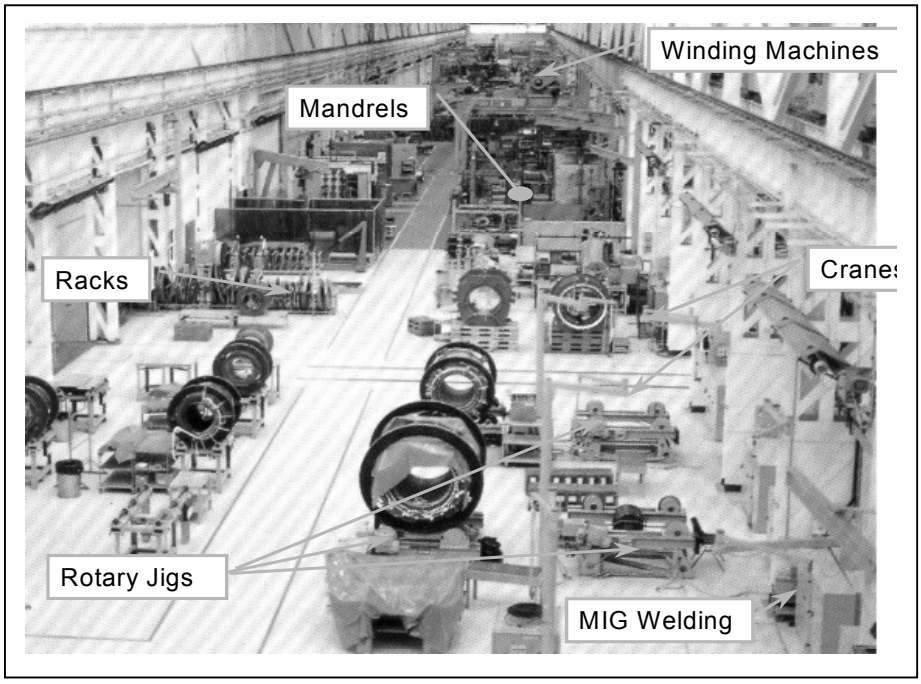

Figure B.2: An assembly shop example

Figure B2 can be used to offer a further example of the difference between specific and individual resources. The figure shows 2 rotary jigs. Each one is an individual resource. However, they have identical specifications and a specific resource can be defined which captures their capability and capacity.

The third sub-type of resource is the generic resource. This is used to capture generic characteristics of a resource type. For example all turning centres have some generic capability; all 3-axis vertical machining centres have a generic capability.

The resource_group entity enables groups of resources and resource hierarchies to be developed to suit the needs of the resource usage.

B.1.3 Resource Characteristics

The resource characteristic is the means by which sets of values are assigned to resources. Each resource is defined by a set of characteristics and each characteristic has a representation and a

grouping. The representation of the characteristic simply relates to quantitative or qualitative values. However the representation is also classified in terms of whether the value is a proposed value, a required value or a value which has been realised. It is recognised that additional classifications may be required and this can be achieved through the link from library properties.

The grouping of the resource characteristic is effectively another classification of the characteristic in terms of whether it is concerned with the administration of the resource, the capacity or capability of the resource or the constitution of the resource.

B.1.4 Resource Views

While the recursive resource definition enables flexible resource groups to be defined a resource may be viewed from a number of different perspectives. For example a factory may be considered to be a resource which can be broken down into shops, cells and stations. However, views of the personnel within the factory could be defined; views of a particular set of machine types could be defined; views of the tooling for tool management purposes could be defined.

The resource view allows views of resources to be defined either as a user defined view or following the DIN 4000-1 approach of specifying resources by a tabular layout of article characteristics.

B.2 Autonomous production cell

By common understanding autonomous production cells stand for self-reliant production units, which allow long lasting production cycles without any external intervention. These objectives require the capability to react independently to disturbances and modifications during the production process. New ways to allocate planning and control functions are developed within this context. Functions of the autonomous production cell reach from CAD-data-input to delivery of the finished part. Therefore the decentralised cell has to contain a number of specific characteristics, by far exceeding e. g. conventional flexible manufacturing cells [2].

Manufacturing processes are operated in conformance to a parallel run of the corresponding process model that predicts the planned performance. Any difference detected by sensors results in messages to the operator, who is able to introduce the reaction. A disturbance management module proposes measures and evaluates process situations in order to adapt planning bases later. A new user interface is developed, integrating alternative techniques for visualisation. Head-mounted displays with structured representation of necessary information support machine operators receiving and processing data within the shop floor situation. The kernel of an autonomous production cell is formed by a sophisticated machine tool. It is completed by additional machines, that the cell to manufacture working pieces of a nearly complete part family. Hence autonomous production cells represent a bottom-up approach with a company-internal focus.

As described above in autonomous production cells a lot of information has to be transferred among the integrated functions of the unit. Intermediate results of planning have to be stored in order to provide necessary information for each step of order processing. For order specific information management a feature-based product data model was developed and invented [3]. Resource information, which is order-neutral, is the other decisive part of data management in autonomous production cells. For each planning step a suitable set of information is required. Size and kind of cutting edges are e. g. important data for NC-planning. A machine tool list with information about the capabilities of the machine (processes, size, power, feed-rates etc.) is required to choose the

manufacturing equipment during the planning process. The availability of current data about machine tool condition, e. g. present tool magazine load, is crucial. Although all of these objects (cutting edge, tool, machine tool) are resources, their totality contains more information than the single resource. The cutting edge belongs to certain tools, which can only be used in certain machine tools. This hierarchic structure has to be represented in a resource information model. Obviously a number of resource classes can be defined. Each one is described by a certain set of parameters, which is also valid for lower classes of the resource hierarchy. All machines have an inventory ID, an hourly rate or an axes specification. Each milling machine is described by additional parameters like tool cone size or zero offset. A resource information model should be able to maintain different resource types and sub-types together with its sets and sub-sets of parameters.

All requirements mentioned so far must result in a resource information model.

The main requirements concerning the resource information model are the representation of a resource hierarchy and the representation of links between resources. Furthermore inconsistencies and redundancy must be avoided. In addition, in order to reflect the mentioned criteria of platform neutral location, independent multiple data access has to be ensured. Therefore a standard modelling method resulting in a standardised model is necessary. Using the standard model for representing resource information is an elementary condition for the exchange of this data between different users.

B.3 Human resources

Despite increasing mechanisation of work in industry and business [6], people are still associated with, and are essential to most operating systems. Certainly the worker's role is changing, the worker being relieved of many routine and/or hazardous tasks. This trend will continue, but there will always be a need for people, and the emphasis will therefore move to the design and management of worker-machine systems.

Let us consider the situation in which worker and machine are interdependent, in which neither can work effectively or continually without the other. When a worker uses a machine, a loop or closed system results. The worker will receive certain information from the machine, either from dials, displays, etc., designed for that purpose, or by observations of the machine itself. He or she will process this information and make decisions on what action, if any, to take and may then manipulate controls or attend to the machine in some other way so as to affect its behaviour in the desired manner.

A work system, whether manual, automated or a combination of both, is established to fulfil certain job requirements. Certain tasks or activities must be performed. One requirement in the design of the system, therefore, is the allocation of these tasks to the active parts of the system, i.e. their division between man and machine. This allocation of functions must reflect the abilities of man and machine, that is their skills, capabilities and limitations.

In the context of manufacturing management systems, since both of them, men and machines, are essential for the manufacturing process of a product, their function, or their role, has to be considered, therefore depicted by the term of "resources". As such, the functions assumed by either man, or machine, will have to be considered and allocated through a three steps analysis:

— step 1: job or task analysis: to determine jobs/tasks which must be undertaken by the work system;

— step 2: skill analysis: to identify the skills/abilities of the component parts of the work system, i.e. the worker(s) and the machines;

— step 3: allocation of tasks: to allocate tasks from step 1 to the component parts of the system as far as possible to match step 2.

All these functions can be found in the current Resource Information Model.

The applicability of the Resource Information Model to human resources will be shown here on the test case of a manufacturing company whose production is organised in three product lines (three types of screws), or “Channels”, called Scr1-C, Scr2-C and Scr3-C.

Each channel is responsible for its own production, from raw materials to despatch.

The number of people involved in the three production lines are:

—channel 1: 20 (support) + 80 (production);

— channel 2: 10 (support) + 30 (production);

— channel 3: 6 (support) + 20 (production).

Each channel is in turn subdivided into several sub-channels, corresponding to:

— administration of the production line;

— standard products (screws and nuts, stock);

— customer order products (small or big quantities, quick production).

Each sub-channel can be described according to the same organisational structure, in two axes (machine tools and tooling, personnel) [see figure B3].

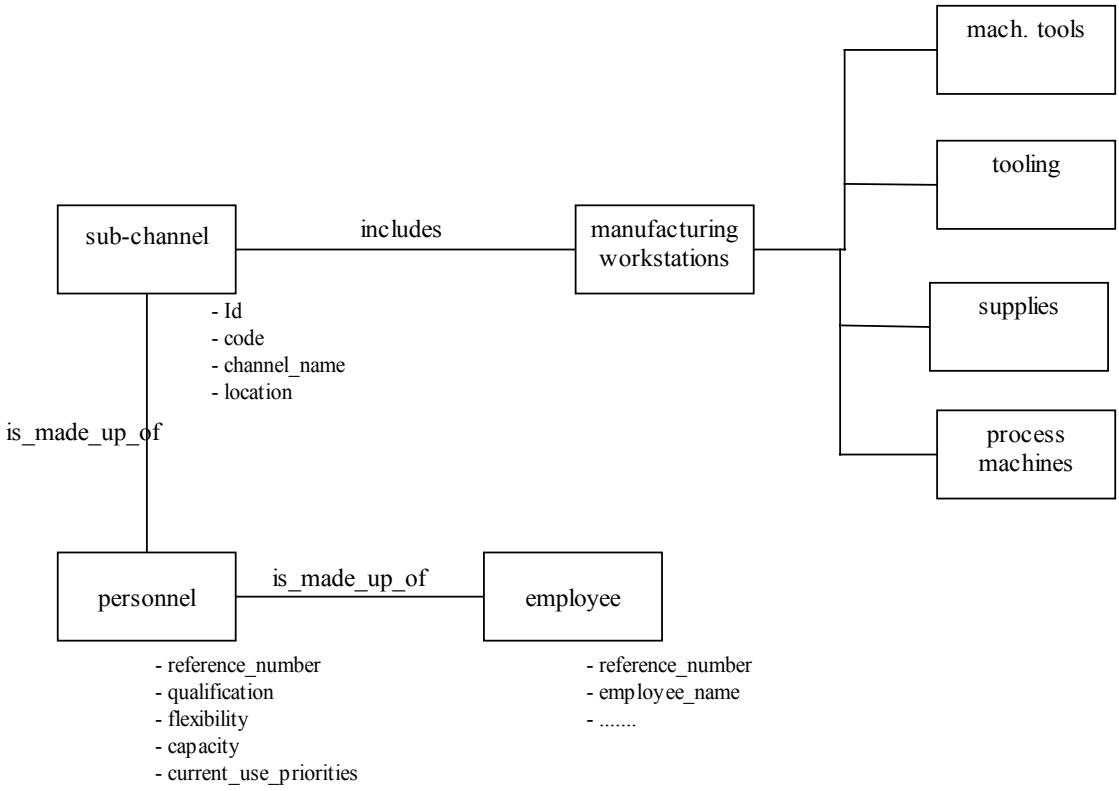

Figure B.3: A resource example which combines people and equipment

Figure element	Definition
ID	reference of the channel
Code	code of the channel
Chanel_name	name of the channel
Location	physical location of the channel in the workshop (layout)
Reference number	personal id of the employee
Qualification	recognized skills of the person
Flexibility	possibility to vary the time schedule (work in shifts), possibility of over time etc
Capacity	normal working schedule: full time, half time, holidays, illness, etc
Current_use_priorities	personal id of the employee
Employee_name	name of the employee

Table B.1: Legend for figure B.3

People traditionally belong to a channel, however, when necessary and according to their skill (represented by the entity **resource_qualitative**), workers can be allocated to another production line. People working for the same channel belong to a **resource_group**.

The name of the worker is defined by a **name**. **Individual_resource** will be used to describe the worker by the role, the function he assumes within the channel.

Resource_status describes his current availability in the production system.

Features of the personnel of the channel are defined through **resource_characteristic**, then classified into **resource_characteristic_classification**, super-type of the following entities:

— **resource_administration**: for the general administration of company's people, through the channel they work for;

— **resource_capability**: for human beings, this primarily concerns skills and competencies possessed, responsibilities which can be assumed and authorities which can be exercised by them;

— **resource_capacity**: providing the normal working schedule (full time, half time, holidays, illness, etc.).

Generally speaking, a **resource_characteristic** set provides information related to the people involved in the work system, describing their qualification, flexibility, capacity and current use priority. A powerful use of this entity, when applied to workers, offers the possibility to deal with the concept of "resource potential": within a production system, it is important to be able to know if there is a possibility of additional capacity for a resource, for example the extraordinary use of a person for an extraordinary task. This potential is expressed in terms of resources, and defines a reserved capacity that can be allocated on demand. Of course, this human resource potential relies on the skill of the worker, his capacities and the *current use priorities* of the manufacturing company.
Once this potentiality identified for a resource, its effective translation into the work system can be made by the entity **resource_configuration**, describing the configuration of the resource for a specific manufacturing task.

This case study based on the description of the production line of a manufacturing company, from the point of view of the staff involved in the manufacturing process, provides a good example of the possibility of use of the Resources Information Model for representing human resources.

B.4 Software and Data set

The RIM is generic enough to be applied to any software or data set resources usage management data as well. Any needed specialisation may be obtained by reference to the ISO13584/IEC61360 dictionary schema included in the model.

First of all, a resource hierarchy can be defined using one or more **resource_groups** associated to one or more **generic_resources**. That shall include the definition of a **resource_view.** Then a **specific_resource** is a specialisation of a **generic_resource**, used to specify a given class of software or data set, while the **individual_resource** represents physically available software or data set.

The **resource_configuration** is used to characterise, from a the point of view of a software or for data set usage management, the configuration of the software or data set (the parameters needed for its management). Physical value of software or data set characteristic are represented by **resource_representation**.

The features of the software or the data set are defined through a set of **resource_characteristics** and classified by **resource_characteristic_claasification.**

A **resource_characteristic_classification** may be one of the following:

— **resource_administration:** for general administration purpose like usage rights, key validity etc.

— **resource_capability and resource_capacity:** by the reference to the ISO 13584 data dictionary schema, allows to describe any needed capability or capacity feature for the management of the software or data set during the manufacturing process**.**

— a **resource_constitution** may be used to represent information about the actual physical characteristics of software or data set such as their size or language etc.

Generally speaking, **resource_characteristic** collects all the information related to the software and data set involved in the manufacturing process and especially all the information needed to manage their usage: capability, capacity, administration characteristic, size, languages, associated software and data set, starting and ending conditions, etc.

This quick and rough implementation "guideline" or usage case of the RIM for software and data set shows its capabilities to manage the usage of this type of resources during the manufacturing process as well as the other resources described in the previous clauses of this annex.

Annex C
(informative)
EXPRESS listing

This annex provides a listing of the EXPRESS specified in this Part of ISO 15531. No text or annotation is included.

This annex is provided only in computer-interpretable form.

```
SCHEMA RESOURCE_USAGE_MANAGEMENT_SCHEMA;

  REFERENCE FROM TIME_SCHEMA
    (point_in_time);

  REFERENCE FROM SUPPORT_RESOURCE_SCHEMA
    (identifier,
     label,
     text);

  REFERENCE FROM MANAGEMENT_RESOURCES_SCHEMA
    (person_and_organisation);

  REFERENCE FROM MEASURE_SCHEMA
    (measure_with_unit);

  REFERENCE FROM ACTION_SCHEMA
     (action_resource);

  REFERENCE FROM PROCESS_PROPERTY_SCHEMA
     (resource_property);

  REFERENCE FROM ISO13584_IEC61360_DICTIONARY_SCHEMA
    (property_bsu,
     class_bsu);

  TYPE resource_classification_type = ENUMERATION OF
    (PROPOSED,
     REQUIRED,
     REALISED);
  END_TYPE;

  ENTITY resource
    SUPERTYPE OF (ONEOF(generic_resource, specific_resource,
individual_resource))
      holds_view   : SET OF resource_view;
      described_by : SET [1:?] OF resource_characteristic;
      contains     : OPTIONAL resource_group;
      id           : identifier;
      name         : label;
      used_in      : action_resource;
  END_ENTITY;

  ENTITY library_property_assignment;
      property                                  : property_bsu;
```

```
      resource_classification_type_characterised :
resource_classification_type;
      resource_capacity_characterised           : resource_capacity;
      resource_capability_characterised         : resource_capability;
  END_ENTITY;

  ENTITY library_resource_assignment;
      library_id    : class_bsu;
      resource_link : label;
  END_ENTITY;

  ENTITY generic_resource
    SUBTYPE OF(resource);
  END_ENTITY;

  ENTITY specific_resource
    SUBTYPE OF(resource);
      belongs_to : generic_resource;
  END_ENTITY;

  ENTITY individual_resource
    SUBTYPE OF(resource);
      occurrence_status : resource_status;
      belongs_to        : specific_resource;
  END_ENTITY;

  ENTITY resource_characteristic;
      classification : resource_characteristic_classification;
      value_of       : resource_representation;
      name           : label;
      id             : identifier;
     relates_to     : resource_property;
  END_ENTITY;

  ENTITY resource_characteristic_classification
    SUPERTYPE OF (ONEOF(resource_capability, resource_constitution,
resource_capacity, resource_administration));
  END_ENTITY;

  ENTITY resource_administration
    SUBTYPE OF(resource_characteristic_classification);
  END_ENTITY;

  ENTITY resource_capability
    SUBTYPE OF(resource_characteristic_classification);
  END_ENTITY;

  ENTITY resource_constitution
    SUBTYPE OF(resource_characteristic_classification);
  END_ENTITY;

  ENTITY resource_capacity
    SUBTYPE OF(resource_characteristic_classification);
  END_ENTITY;

  ENTITY resource_status;
      time_reference : point_in_time;
      availability   : BOOLEAN;
  END_ENTITY;
```



```
  ENTITY resource_view
    SUPERTYPE OF (ONEOF(user_defined_resource_view,
resource_tabular_layout_of_article_characteristic))
      described_by : resource;
      id           : identifier;
      name         : label;
  END_ENTITY;

  ENTITY user_defined_resource_view
    SUBTYPE OF(resource_view);
  END_ENTITY;

  ENTITY resource_tabular_layout_of_article_characteristic
    SUBTYPE OF(resource_view)
      author           : person_and_organisation;
      identifying_code : STRING;
      time_reference   : OPTIONAL point_in_time;
      graphics         : STRING;
  END_ENTITY;

  ENTITY resource_representation
    SUPERTYPE OF (ONEOF(resource_qualitative, resource_quantitative));
      classification : resource_classification_type;
  END_ENTITY;

  ENTITY resource_qualitative
    SUBTYPE OF(resource_representation);
      description           : text;
      optional_descriptions : OPTIONAL SET OF text;
  END_ENTITY;

  ENTITY resource_quantitative
    SUBTYPE OF(resource_representation);
      optional_descriptions : OPTIONAL SET OF measure_with_unit;
      description           : measure_with_unit;
  END_ENTITY;

  ENTITY Resource_group;
      described_by : SET [1:?] OF resource;
  END_ENTITY;

  ENTITY resource_configuration;
      related_resource  : resource;
      relating_resource : resource;
  END_ENTITY;

END_SCHEMA;
```


Annex D
(informative)
EXPRESS-G diagram

Figure D.1 corresponds to the EXPRESS listing given in annex C. The figure uses the EXPRESS-G graphical notation for the EXPRESS language. EXPRESS-G is defined in annex A of ISO 10303-11

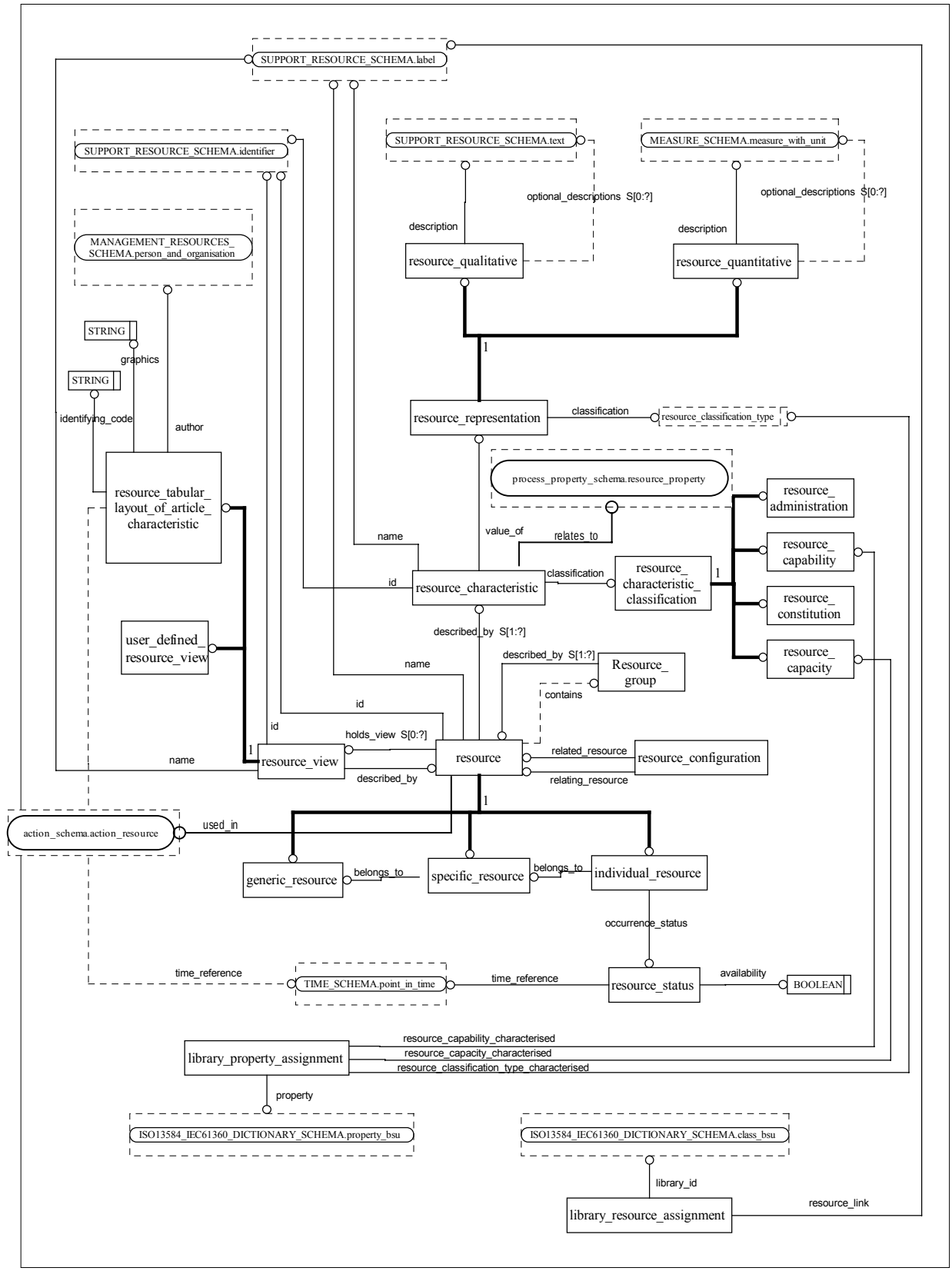

Figure D.1: Resources_usage_management schema – EXPRESS-G diagram

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