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**PRODUCT DATA REPRESENTATION AND EXCHANGE**

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**Purpose of this document as it relates to target document is:**

- Primary Content**
- Issue Discussion**
- Alternate Proposal**
- Partial Content**

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**ABSTRACT:** This document defines the concept and components of STEP application protocols and explains the process of developing, qualifying, and approving STEP application protocols. This document also provides the forms for proposing STEP application protocol planning projects and STEP application protocol projects to ISO TC184/SC4.

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**Comments to Reader:**

This version of the *Guidelines for STEP APs* has not been approved by SC4. The concept of the Quality Committee has been added to this version. This version is circulated for review and comment by members of SC4 and PPC and participants in SC4 projects. The changes to this document since PMAG N103 are marked with **redline text** for additions and ~~strike-out-text~~ for deletions. Comments on the document should be sent to the document editor.



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## 1 Introduction

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Industry and government require comprehensive and reliable information exchange mechanisms to effectively integrate computer-aided (CAx) systems and evolving information technologies. Sub-committee 4 (Industrial data and global manufacturing programming languages) of ISO Technical Committee 184 (Industrial automation systems and integration) is developing a standard, commonly known as STEP (Standard for the Exchange of Product Model Data), to meet this requirement. The title of this standard is ISO 10303, *Industrial automation systems and integration - Product data representation and exchange*.

ISO 10303 ~~will provide~~ **provides** a neutral mechanism for describing product data throughout the life cycle of a product, independent of any particular CAx system. ISO 10303 is suitable for file exchange and for implementing, sharing, and archiving product databases. The development of ISO 10303 is based upon the use of information models, a framework for product data modelling, formal data specification languages, and an architecture that separates information requirements from implementation methods.

A fundamental concept of STEP is the definition of application protocols (APs) as the mechanism for specifying information requirements and for ensuring reliable communication. An **application protocol** is a Part of ISO 10303 that defines the context, scope, and information requirements for designated application(s) and specifies the **STEP** resource constructs used to satisfy these requirements. The scope of an AP is defined by the type of product, the supported stages in the life cycle of the product, the required types of product data, the uses of the product data, and the disciplines that use the product data. Additionally, an AP enumerates the conformance requirements for conformance testing of implementations of the AP.

This technical report defines the components of an ISO 10303 AP and provides the guidelines for developing and approving ISO 10303 APs.<sup>1)</sup> Clause 1 provides a general introduction to the STEP project and the fundamental principles of APs. Clause 2 defines the terms relevant to the development of APs. Clause 3 describes the contents of an AP. Clause 4 provides a detailed description of the process and responsible agents for developing and reviewing an AP. Clause 5 explains the process for approving an AP within ISO TC184/SC4.

### 1.1 Background

ISO 10303 has been designed to support an extensive domain of product data communication requirements, i.e., all product data necessary to completely define any product for all applications over the product's entire life cycle. With the broad scope and complexity of ISO 10303, the implementation of the entire International Standard by any one organization is unlikely. At the June 1989 meeting, ISO TC184/SC4 established the following working policy for developing application protocols:

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<sup>1)</sup> The AP development process is subject to refinement. These guidelines will be updated as these refinements are approved by the SC4 Working Groups, **SC4 Policy and Planning Committee** and SC4.

"The practical implementation of the STEP standard to support data exchange for a particular application shall not require the use of every STEP entity. In addition, STEP entities may be constrained within the context of a particular application context, in terms of use or understanding."

An additional objective of ISO 10303 is to support conformance testing of implementations. A mechanism was needed for specifying: 1) the resource constructs required for information exchange within a defined application and 2) the requirements for conformance testing of implementations of these constructs. Based on the Open Systems Interconnection (OSI) concept of protocols and the information communication methods developed for the Initial Graphics Exchange Specification (IGES), the application protocol methodology was developed.

For the use of STEP within a particular application context, an application protocol shall provide the information required for practical implementation. This shall include:

- the definition of the application context, scope, and functional requirements;
- the definition of the application information requirements;
- the required use of the STEP integrated resource constructs to support the application information requirements;
- the specification of conformance requirements for evaluating implementations of the AP.

## **1.2 The STEP integration framework and the role of application protocols**

The STEP integration framework [1] establishes an explicit architecture for the conceptual models that are part of ISO 10303. This architecture provides the structure for the integrated resources and application protocols. The integrated resources provide constructs that are independent of a specific product data application context. These constructs are used for developing the application interpreted models of application protocols [2] [3].

### **1.2.1 Application protocol models**

Application protocols employ three types of models: an application activity model, an application reference model, and an application interpreted model. The models are application context-dependent.

- Application activity model (AAM)

A model that describes the activities and processes that use and produce product data in a specific application context. The AAM shall be defined in IDEF0, a formal process modelling language [4].

- Application reference model (ARM)

A model that specifies conceptual structures and constraints used to describe the information requirements of an application. The ARM shall be documented in a

formalized modelling language such as EXPRESS [5], IDEF1X [6], or NIAM [7]. Each information requirement has a normative definition.

– Application interpreted model (AIM)

A model of selected integrated resources which are constrained, specialized or completed to satisfy the information requirements of the ARM. The AIM shall be defined in EXPRESS and EXPRESS-G (a graphical subset of EXPRESS) [5].

### 1.3 Principles of application protocols

The following principles shall guide the AP development process.

1) ISO 10303 is defined in a collection of parts that include integrated resources, ~~and APs~~ application protocols, **application interpreted constructs, and abstract test suites**. The integrated resources shall only be available for conforming implementations through an AP. Integrated resource constructs are interpreted in an AIM by

- specifying global rules, for example, to modify optional attributes of entities to be non-existent or mandatory, or to constrain entity behavior and/or entity interactions;
- specifying subtypes of an entity to specialize the meaning of an attribute, localize a constraint on an entity within the reference path defined by an attribute or define a behavioral constraint on the subtyped entity<sup>2)</sup>.

2) The AIM specifies implementable constructs of a specific AP. The AAM and the ARM provide the ~~basis~~ **context and requirements** for the AIM. The AIM is a required normative clause of an AP. The AAM and the ARM are required informative annexes of an AP.<sup>3)</sup> This principle **of specifying the application semantics in the ARM and mapping the application semantics to the integrated resources** is ~~fully~~ explained in clause 4.

3) The definition of an AIM shall be consistent with the semantics of the integrated resources **and shall maintain the application semantics documented in clause 4 of the AP**.

4) APs specify the data content and conformance requirements for standardized implementations of ISO 10303. This is explained in 4.5.

5) There will inevitably be some overlap between APs. Whenever a resource construct(s) is used to represent the same information requirement in different APs, the same interpretation of the resource construct(s) shall be used.

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<sup>2)</sup> ~~Refer to issue #2 in annex D.~~

<sup>3)</sup> A normative element of an ISO standard defines provisions with which it is necessary to comply in order to be able to claim conformity with the standard. An informative annex is a supplementary element of an ISO standard that provides additional information intended to assist the understanding or use of the standard.

6) APs shall be developed and documented in accordance with ~~these guidelines~~ **this technical report** and the following documents:

- *ISO TC184/SC4 Organization Handbook* [8]
- *ISO Directives Part 1: Procedures for the technical work*
- *ISO Directives Part 3: Drafting and presentation of International Standards*
- *Supplementary directives for the drafting and presentation of ISO 10303* [9]
- ISO 10303-1        *Industrial automation systems and integration - Product data representation and exchange - Part 1: Overview and fundamental principles*
- ISO 10303-11     *Industrial automation systems and integration - Product data representation and exchange - Part 11: Description methods: The EXPRESS language reference manual*
- ISO 10303-31     *Industrial automation systems and integration - Product data representation and exchange - Part 31: Conformance testing methodology and framework: General concepts*
- ISO 10303-33<sup>4)</sup>   *Industrial automation systems and integration - Product data representation and exchange - Part 33: Conformance testing methodology and framework: Structure and use of abstract test suites*
- ISO 10303-41     *Industrial automation systems and integration - Product data representation and exchange - Part 41: Integrated resources: Fundamentals of product description and support*

7) The following documents shall be used for guidance in developing APs:

- *STEP Part qualification procedures* [10]
- *STEP application protocol qualification manual* [11]
- *Guidelines for the development of mapping tables* [12]
- *Guidelines for AIM Development* [13]
- ~~*Guidelines for use of EXPRESS in ISO 10303*~~

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<sup>4)</sup> To be published.

8) The AP development process will deliver APs with the following characteristics:

- **Appropriate scope of the AP:** An AP shall have a scope that is well defined, self contained, and satisfies an **international** industrial need.
- **Consistent usage of the integrated resource constructs:** All APs shall use the integrated resource constructs consistently. If two APs have the same information requirement, these APs shall use the same resource constructs for the common requirements. Shared specifications shall be stored in a library of standardized application interpreted constructs (**AICs**).

The reuse of interpreted constructs provides the mechanism for ensuring that the relevant product data can be exchanged between APs and allows for interoperable APs. This library of shared application interpreted constructs (AICs) shall be used as an **additional** resource for defining the AIMS of APs. The WG4 AP Integration Project is responsible for maintaining this library.

- **Testability:** APs shall specify requirements for conformance testing of AP implementations. A standard abstract test suite for each AP shall be documented as a separate Part of ISO 10303. Requirements of an abstract test suite are specified in ISO 10303-33.

## 2 Definitions and abbreviations

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### 2.1 Definitions

The following definitions apply **for this technical report**.

**abstract test case:** one or more files, encapsulating a test purpose, <ideally> independent of both the implementation and the values, that provide the formal basis from which executable test cases are derived (ISO 10303-31).

**abstract test method:** a description of how a candidate product is to be tested, given at the appropriate level of abstraction to make the description independent of any particular implementation of testing tools or procedures, but with sufficient detail to enable these tests to be produced (ISO 10303-31).

**abstract test suite (ATS):** a part of ISO 10303 that contains the set of abstract test cases **necessary for conformance testing of an implementation of an application protocol (ISO 10303-1)**.

**application:** a group of one or more processes creating or using product data (ISO 10303-1).

**application activity model (AAM):** a model that describes an application in terms of its processes and information flows (ISO 10303-1).

**application interpreted construct (AIC):** a logical grouping of **integrated resource** constructs that is shared by two or more AIMS.

**application interpreted model (AIM):** an information model that uses the integrated resources necessary to satisfy the information requirements and constraints of an application reference model, within an application protocol (ISO 10303-1).

**application object:** an atomic element of an application reference model that defines a unique application concept and contains attributes specifying the data elements of the object (ISO 10303-1).

**application protocol (AP):** a part of ISO 10303 that specifies an application interpreted model satisfying the scope and information requirements and constraints of a specific application (ISO 10303-1).

**application reference model (ARM):** an information model **that describes the information requirements and constraints for a specific application (ISO 10303-1)**. The application reference model employs application-specific terminology and rules familiar to experts in the application.

**application protocol validation:** the process of evaluating a candidate AP and its components, **e.g., ARM and AIM**, to determine whether these satisfy **the specified scope and requirements for the AP**.

**conformance class:** **a subset of an application protocol for which conformance may be claimed (ISO 10303-1)**.

**conformance testing:** the testing of a candidate product for the existence of specific characteristics required by a standard in order to determine the extent to which that product is a conforming implementation (ISO 10303-31).

**construct:** a data modelling structure that represents the semantics ~~abstraction~~ of a concept.

**data:** a representation of information in a formal manner suitable for communication, interpretation, or processing by human beings or computers (ISO 10303-1).

**data exchange:** the storing, accessing, transferring, and archiving of data (ISO 10303-1).

**fitness testing:** the determination of whether or not a model, e.g., AAM, ARM, or AIM, is useful in a particular context.

**implementation method:** ~~a technique used by computer systems to exchange product data that is described using the EXPRESS data specification language~~ a part of ISO 10303 that specifies a technique used by computer systems to exchange product data that is described using the EXPRESS data specification language (ISO 10303-11).

**information:** facts, concepts, or instructions (ISO 10303-1).

**information model:** a formal model of a bounded set of facts, concepts, or instructions to meet a specified requirement (ISO 10303-1).

**integrated resource:** a part of ISO 10303 that defines a group of resource constructs used as a basis for product data (ISO 10303-1).

**integrity testing:** testing ~~which that~~ demonstrates ~~that when~~ a model, e.g., ARM or AIM, is syntactically correct and self-consistent.

**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).

**PICS proforma:** a standardized document in the form of a questionnaire, which, when completed for a particular implementation, becomes the protocol implementation conformance statement (PICS) (ISO 10303-1).

**product:** a thing or substance produced by a natural or artificial process (ISO 10303-1).

**product data:** a representation of ~~facts, concepts, or instructions~~ information about ~~one or more a~~ products in a formal manner suitable for communication, interpretation, or processing by human beings or by ~~automatic means~~ computers (ISO 10303-1).

**product information:** facts, concepts, or instructions about a product (ISO 10303-1).

**protocol implementation conformance statement (PICS):** a statement made by the client stating of which capabilities and options have been implemented in the **are supported within an implementation under test for** of a given standard. This statement is produced by completing a PICS proforma (ISO 10303-31).

**resource construct:** a collection of EXPRESS language entities, types, functions, rules and references that together define a valid description of an aspect of product data (ISO 10303).

**test group:** a named set of related test purposes.

**test group objective:** a description of the common objective which the test purposes within a specific test group are designed to achieve (ISO/IEC 9646-2).

**test model:** a specification of an example product model, e.g., design and surface finish specification for a gear, which is structured to support the incremental testing of the information models of an AP, e.g., ARM, AIM, and implementations of the AP. The test model shall include sufficient detail to populate the relevant objects, attributes, relationships and assertions of an information model.

**test purpose:** a description of an objective to be tested to assess if a specific requirement is met by an implementation (ISO 10303-1).

**unit of functionality (UoF):** a collection of application objects and ~~assertions~~ **their relationships** that defines one or more concepts within the **application** context of the ~~application reference model~~ such that the removal of any component would render the concepts incomplete or ambiguous (ISO 10303-1). **UoFs** are a mechanism for modularising the information requirements of the AP into primary concepts. The UoFs are also used as modules for defining conformance classes.

**usage scenario:** a specification of a sequence of industry events which create, access, modify, or exchange some portion of the product data considered for inclusion in the scope of an application protocol. The usage scenario includes the description of the types of information used in the events, the tasks and objectives of each event, and the roles executed by software tools and humans during or after the events.

**usage test:** a specification of the usage scenario, test model, test queries and verdict criteria for assessing an information model or an implementation of an AP.

**validation:** the process of evaluating a system or component to determine whether it satisfies specified requirements.

## 2.2 Abbreviations

**AAM:** application activity model

**ADP:** AIM Development Project (WG4/Project 3) [148]

**AIC:** application interpreted construct

**AIM:** application interpreted model

**AP:** application protocol

~~**APGP:** Application Protocol Guidelines and Framework Project (WG4/Project 5) [14]~~

**APIP:** Application Protocol Integration Project (WG4/Project 6) [148]

**ARM:** application reference model

**ATC:** abstract test case

**ATS:** abstract test suite

**CAX:** computer-aided systems, including computer-aided design (CAD), computer-aided engineering (CAE), computer-aided manufacturing (CAM), computer integrated construction (CIC), and computer integrated manufacturing (CIM)

**CD:** Committee Draft

**DIS:** Draft International Standard

**FDIS:** Final Draft International Standard

**ICAM:** integrated computer-aided manufacturing

**IDEF0:** ICAM definition language 0

**IDEF1X:** ICAM definition language 1 extended

**IS:** International Standard

**ISO:** International Organization for Standardization

**IUT:** implementation under test

**JWG9:** Joint Working Group 9, Electrical/Electronics Applications [148]

**NIAM:** Nijssen's information analysis method

**NP:** New Work Item Proposal

**OSI:** Open Systems Interconnection

**PICS:** protocol implementation conformance statement

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~~**PMAG:** Project Management Advisory Group (for ISO TC184/SC4) [12]~~

**PPC:** Policy and Planning Committee (for ISO TC184/SC4) [8]

**QC:** Quality Committee

~~**QVP:** STEP Part Qualification and Validation Project (WG4/Project 1) [14]~~

**SC:** ISO Sub-committee

**SC4:** Sub-committee 4 of ISO Technical Committee 184 [148]

**STEP:** Standard for the Exchange of Product Model Data (ISO 10303)

**TC:** ISO Technical Committee

**TC184:** ISO Technical Committee 184

**UoF:** unit of functionality

**WG:** working group

**WG2:** Working Group 2, Part Libraries [148]

**WG3:** Working Group 3, Product Modeling [148]

**WG4:** Working Group 4, Qualification and Integration [148]

**WG5:** Working Group 5, STEP Development Methods [148]

**WG6:** Working Group 6, Conformance Testing Procedures [148]

**WG7:** Working Group 7, Implementation Specifications [148]

**WG8:** Working Group 8, Industrial Manufacturing Management Data [148]

**WG10:** Working Group 10, Technical Architecture [8]

### 3 Contents of a STEP application protocol

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This clause provides an overview of the contents of an application protocol. The contents for a STEP AP are given in figure 3-1 and are explained in the subsequent subclauses. The four major components of an AP are: 1) the scope and functional requirements; 2) the application reference model as a representation of the **application domain** information requirements; 3) the application interpreted model that specifies the required use of the STEP integrated resource constructs, and 4) conformance requirements for implementations of the AP.

- Foreword
- Introduction
- 1** Scope
- 2** Normative references
- 3** Definitions and abbreviations
- 4** Information requirements
  - 4.1** Units of functionality
  - 4.2** Application objects
  - 4.3** Application assertions
- 5** Application interpreted model
  - 5.1** Mapping table
  - 5.2** AIM EXPRESS short listing
- 6** Conformance requirements
  
- Annexes**
- A** AIM EXPRESS ~~annotated~~**expanded** listing
- B** AIM short names
- C** Implementation method specific requirements
- D** Protocol Implementation Conformance Statement (PICS) proforma (~~normative~~)
- E** **Information object registration**
- F** Application activity model
  - F.1** Application activity model definitions and abbreviations
  - F.2** Application activity model diagrams
- G** Application reference model
- H** AIM EXPRESS-G
- J** AIM EXPRESS listing
- K** Application protocol **implementation and** usage guide
- L** Technical discussions
- M** Bibliography
- Index
- Figures**
- Tables**

**Figure 3-1: Contents of a STEP application protocol**

The AP development process starts with the definition of the application context, **the proposed scope of the AP**, and an application activity model. These elements of an AP are used for identifying the information requirements of the application **protocol** and documenting them in an application reference model. **The semantics of the application reference model are documented in clause 4 of the AP as definitions for application objects and application assertions.** The application reference model **and clause 4**—~~is~~ **are** then used to select constructs from the integrated resources and identify constraints or specializations of entities for describing the application information in an application interpreted model.

An AP issues log and an AP validation report shall be maintained by the AP project and are required for the successful qualification of the AP and the approval of the AP by SC4. The issues log summarizes the discussions and resolutions of technical issues raised during the development of the AP. The validation report documents how the components of the AP were successfully validated to ensure that the AP ~~delivers the functionality to meet~~ **fulfills** the documented requirements. The issues log and validation report are used in the AP review and ballot process, but they do not become part of the International Standard.

An abstract test suite (ATS) shall be available for each application protocol of ISO 10303.<sup>5)</sup> Each standard abstract test suite shall be a separate Part of 10303 and shall be referenced by the corresponding application protocol as a normative reference.<sup>6)</sup>

Detailed requirements for documenting AP Parts of ISO 10303, including any required text, are provided in the *Supplementary directives for the drafting and presentation of ISO 10303 (STEP)* [9]. Detailed assessment criteria for evaluating the quality of an AP are provided in the *STEP application protocol qualification manual* [11].

**The Introduction for the AP shall provide an overview of the technical content and explain how the AP can be used for industrial activities. The Introduction should include a planning model that provides a high level description of the information supported by the AP. For APs which are designed as part of a suite of harmonized APs, the Introduction shall explain the overlaps and interfaces between the APs, and the planning model should illustrate these overlaps and interfaces.**

### 3.1 Scope

Clause 1 of an AP shall define the domain of the AP and summarize the functionality ~~and~~, **fundamental concepts and assumptions about the scope, and the types of** product data that are accommodated by the AP. A description of the functionality and data that are specifically outside the scope of the application may also be defined to clarify the domain.

This clause shall define the following characteristics of the scope of the application:

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<sup>5)</sup> Refer to ISO 10303-33, *Industrial automation systems and integration - Product data representation and exchange - Part 33: Conformance testing methodology and framework: Structure and use of abstract test suites*.

<sup>6)</sup> For the committee draft (CD) ballot(s) of an AP, the ATS is not required. Except for the first APs, i.e., APs 201 - 205, a CD version of the ATS is required before the AP can be approved as a draft International Standard (DIS). ~~Parts of ISO 10303 containing the abstract test suites shall be numbered by adding 1000 to the number of the corresponding AP.~~

- type of product;
- types of product data;
- stages in the product life cycle supported;
- uses of the product data, e.g., functional processes, supported;
- discipline views of the product supported;
- exclusions from scope for the purpose of clarification.

The scope definition shall be supported by an application activity model (AAM), provided as annex EF. **and may reference a planning model, provided in the Introduction.** The scope description shall reference annex EF.

### 3.2 Normative references

All normative references shall be listed in clause 2 of an AP. The minimal required set of normative references are:

- ISO 10303-1 *Industrial automation systems and integration - Product data representation and exchange - Part 1: Overview and fundamental principles.*
- ISO 10303-11 *Industrial automation systems and integration - Product data representation and exchange - Part 11: Description methods: The EXPRESS language reference manual.*
- ISO 10303-31 *Industrial automation systems and integration - Product data representation and exchange - Part 31: Conformance testing methodology and framework: General concepts.*
- ISO 10303-41 *Industrial automation systems and integration - Product data representation and exchange - Part 41: Integrated resources: Fundamentals of product description and support.*

### 3.3 Definitions and abbreviations

Clause 3 of an AP shall include definitions of all concepts necessary to understand the Introduction, Scope, and Information requirements clauses. This clause may include concepts that are defined further in the Information requirements clause. The concept definitions provided in this clause shall be consistent with the complete definitions provided in the Information requirements clause.

This clause shall contain at least three subclauses: list of terms defined in ISO 10303-1 and used in the AP, terms defined in the AP, and abbreviations and symbols used in the AP. This clause shall not include the definitions of objects defined in the application interpreted model. This clause shall list the terms defined in other ISO standards that are necessary for understanding the AP.

### 3.4 Information requirements

Clause 4 of an AP shall describe the functionality and information requirements of the AP. The first paragraphs of this clause provide a high level description of the information requirements that are supported by the AP and a summary of the structure used to partition the information requirements. This clause may include a description of the types of products supported by the AP, any restrictions on product classes supported, and the supported uses of the defined information. These information requirements may be organized by the product types, life cycle phases, or application views supported by the AP. **This clause shall provide all additional information on the fundamental concepts and assumptions (initially introduced in clauses 1 and 3) which is necessary for complete understanding of the information requirements and the scope boundaries.**

This clause shall include a note that refers the reader to the application activity model (annex EF) and to the application reference model (annex FG) to explain the relevance and roles of the required information. **If a planning model is provided in the introduction, this clause shall reference the planning model.**

This clause shall include subclauses for units of functionality, application objects, and application assertions.

#### 3.4.1 Units of functionality

Clause 4.1 of an AP shall specify a list of the UoFs defined in the AP and the definition of each UoF. ~~A UoF is a concept that has significance from the perspective of the experts defining the AP~~ **a grouping of data constructs which is important in the application context. A UoF specifies the set of application objects that constitute one or more concepts of the application reference model. UoFs are a mechanism for modularising the information requirements of the AP into primary concepts. The UoFs are used to organize and summarize the functionality of the ARM. The UoFs are also used as modules for defining conformance classes.** Each UoF definition shall include the scope of the UoF, a description of the function(s) that the grouping of data is intended to support, and a list of the application objects **and assertions** that are included in each UoF.

#### 3.4.2 Application objects

Clause 4.2 of an AP shall include the definitions for all application objects and attributes supported by the AP. An application object is an atomic element of an application reference model that defines a unique application concept and contains attributes specifying the data elements of the object.

#### 3.4.3 Application assertions

Clause 4.3 of an AP shall specify all relationships among application objects, the cardinality of the relationships, and the rules required for the integrity and validity of the application objects and UoFs (see 4.3.).

### 3.5 Application interpreted model

Clause 5 of an AP shall specify the application interpreted model. The AIM shall be defined in the EXPRESS language and is constructed from the resource constructs using the EXPRESS interfacing mechanism (USE FROM) defined in ISO 10303-11. Needs for refinement of the resource constructs arises out of the information requirements supplied by the particular application.

### 3.5.1 Mapping table

Clause 5.1 of an AP shall specify the mapping table. The mapping table documents the correspondence between the information requirements and the constructs of the AIM. This mapping table shall specify a complete and unambiguous mapping between the application objects and assertions defined in the information requirements clause and the constructs of the AIM. The mapping shows how the integrated resource constructs are used to meet the information requirements of the application.

### 3.5.2 AIM EXPRESS short listing

Clause 5.2 of an AP shall specify the AIM EXPRESS short listing. The AIM EXPRESS short listing shall consist of USE FROM statements that select resource constructs and AICs, ~~and AP specific declarations,~~ and any appropriate modifications to textual material that applies to constructs imported into the AIM schema from the integrated resource parts of ISO 10303. These declarations include TYPE declarations, ENTITY declarations that create ~~additional~~ subtypes of resource entities, and any necessary RULES, FUNCTIONS, and PROCEDURES that are required to ~~fully represent~~ satisfy the information requirements. Any declarations of entities, rules, functions, and procedures specific to the AP are fully documented in the AIM EXPRESS short listing. **Textual modifications include:**

- clarification of application specific interpretation of the meaning of a generic entity definition;
- clarification of application specific interpretation of the meaning of one or more attributes;
- specification of application specific informal propositions;
- specification of all associated global rules defined in the AP;
- addition of application specific examples and notes;
- specification of text in the resource Part that is to be rendered inapplicable in the AIM.

### 3.6 Conformance requirements

Clause 6 of an AP shall specify the conformance requirements an implementation shall satisfy. Only those aspects that are stated as conformance requirements in this clause, or referenced through this clause, are requirements for conformance to this Part of ISO 10303.

A subclause describing conformance classes shall be included for APs that specify conformance classes. Conformance to a particular conformance class requires that all AIM entities, types, and associated constraints defined as part of that class shall be supported.

### 3.7 Annexes

#### A AIM EXPRESS ~~annotated~~expanded listing (normative)<sup>7)</sup>

This annex shall contain the AIM EXPRESS ~~annotated~~expanded listing. The AIM EXPRESS ~~annotated~~expanded listing is based on the AIM EXPRESS short listing (5.2) and contains the complete listing of the AIM EXPRESS. The ~~annotated~~expanded listing ~~replaces~~contains the results of the application of all USE FROM statements in the short listing with copies of the corresponding EXPRESS specifications, definitions, and propositions from the integrated resources and the AICs<sup>8)</sup>. ~~Each AIC used in the AIM shall be included in this annex as a separate schema.~~

~~NOTE — AP specific declarations are not repeated in annex A. Instead, the annotated listing includes references to the subclauses where the AP specific declarations occur.~~

#### B AIM short names (normative)

This annex shall contain a correspondence list between the entities used in the AIM and the short names. This list is derived from the short names specified in the integrated resources together with the short names for entities introduced in the AP.

#### C Implementation method specific requirements (normative)

This annex shall contain additional requirements for the specified implementation methods. For example, an AP to be used with Part 21, requires the schema name of the AP to be specified in the header section of a file. The required schema name for the header section would be specified in Annex C of the AP.

The implementation method specific requirements shall be in addition to those listed in the AP's conformance requirements clause. This annex may specify the meaning of values not given in the normative clauses. If no implementation specific requirements are specified, this fact shall be stated in this annex.

#### D Protocol Implementation Conformance Statement (PICS) proforma (normative)

This annex shall contain the PICS proforma that explicitly defines the implementation flexibility, if any, allowed by the application protocol specification. The PICS proforma is given in the form

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<sup>7)</sup> ~~WG4 and WG5 are reviewing the structure and content of this annex.~~

<sup>8)</sup> ~~Documentation and publication of AICs are still under review within WG4 and WG5.~~

of a questionnaire to be completed by the supplier or implementor of an implementation of the AP before it undergoes conformance testing. The PICS proforma shall cover all optional functions, preparation procedures for the conformance assessment process, parameters, and other capabilities identified in the AP. The completed questionnaire shall be used by conformance testing laboratories for abstract test case selection and parameterization.

#### E Information object registration (normative)

This annex shall specify the information object identifiers for the application protocol. This shall include identifiers for the AP document and for the AIM schema

#### EF Application activity model (informative)

This annex shall contain the application activity model (AAM) that provides a representation of the application context of the AP and of the activities which use product data in the application context. AAMs are mechanisms for scoping the information requirements for individual APs and for planning the development of nested APs. The AAM shall be represented in IDEF0 [4].

The AAM includes the definition of the inputs, controls, outputs, and some of the mechanisms of those activities. Only those mechanisms that are organization and enterprise independent shall be included.

The first paragraphs of this annex shall explain the context of the AAM and summarize the assertions on which the AAM is based. The definitions for all activities and information flows in the AAM shall be provided in annex EF.1, and the IDEF0 diagrams shall be provided in annex EF.2.

#### FG Application reference model (informative)

This annex shall contain the application reference model (ARM) that is a formal model of the information requirements and constraints of the application context as defined by the scope and the AAM. The ARM provides the basis for specifying the application objects and assertions in clause 4 of the AP.

The first paragraphs of this annex shall summarize the scope of the ARM. The ARM uses application-specific terminology and rules familiar to an expert from the application context. The ARM is independent of any physical implementation. The ARM shall be documented by use of a formal modelling language, i.e., EXPRESS [5], IDEF1X [6], or NIAM [7]. The ARM, together with the AAM and the scope statement, shall be sufficient for a person familiar with the application to understand the AP domain.

#### GH AIM EXPRESS-G (informative)

This annex shall contain the EXPRESS-G representation of all entities in the AIM. This representation shall be documented in accordance with annex D of ISO 10303-11 and the *Supplementary directives for the drafting and presentation of ISO 10303 (STEP)* [9].

**HJ** AIM EXPRESS listing (informative)

This annex shall contain a disk with the entire AIM EXPRESS listing without comments or embedded references. Tail comments identifying the source Parts of ISO 10303 shall be included.

**-K** Application protocol **implementation and** usage guide (optional and informative)

This annex, if provided, contains **informative guidance on implementing and using the AP**. ~~The usage guide~~ **This annex** provides guidance to the different users of the AP, e.g., implementor or end user of AP compliant implementations. The inclusion of an exchange structure with values which are representative of those for which the AP was specified is an appropriate element of an AP usage guide.

**-L** Technical discussions (optional and informative)

This annex, if provided, contains a summary of relevant technical discussions and the resolution of issues raised during the development of the AP. This annex provides background information for potential users of the AP and for developers of similar or related APs. The material given should not cast doubt or self justify. Only material which supports the normative text shall be given.

**JM** Bibliography (informative)

This annex lists all informative references relevant to the AP. At a minimum, it shall contain references to the IDEF0 activity modelling format, to the Supplementary directives [9] and to the format used for annex **FG** if EXPRESS-G has not been used.

## 4 Development and qualification of a STEP application protocol

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This clause specifies the requirements and process for developing and qualifying an AP. Figure 4-1 illustrates the overall STEP development process and shows "Plan & Execute STEP AP Projects" as activity A4. Figure 4-2 decomposes A4 into three activities: "Plan & Develop Application Protocol" as activity A41, "Develop Abstract Test Suite" as activity A42, and "Develop Prototype AP Implementation" as activity A43. Figure 4-3 decomposes A41 to the next level of detail. The tasks and objectives included in activity A41 are described in this clause.

The ISO/IEC Directives define seven stages in the development life cycle of an international standard:

Preliminary Stage	Collaborative planning on technical subjects for possible standardization projects, e.g., within an SC4 AP planning project
Proposal Stage	SC4 P-members ballot starting a new project, e.g., an SC4 AP project
Preparatory Stage	Project develops a Working Draft
Committee Stage	Consensus is achieved on a Committee Draft (CD)
Enquiry Stage	National Bodies vote on a Draft International Standard (DIS)
Approval Stage	National Bodies vote on a Final Draft International Standard (FDIS)
Publication Stage	ISO publishes the International Standard

The Preliminary Stage is used by SC4 to convene a group of experts in an application protocol planning project to investigate the need for APs within a specified domain. The use of the Preliminary Stage is optional. To start an AP planning project, an AP planning project proposal (see clause A.1) is submitted to the SC4 Secretariat. The Preliminary Stage is begun when a simple majority of the P-members vote to approve the AP planning project. The AP planning project focuses on documenting requirements for APs in the specified domain and can prepare one or many AP New Work Item Proposal(s). AP planning projects work with industry to define and coordinate AP projects

An AP planning project provides an international forum for defining the scopes and requirements of specific AP projects. The AP planning project provides oversight and coordination for AP projects within its application domain and ensures effective harmonization with other, relevant AP projects. AP planning projects shall conduct broad outreach activities to identify and contact organizations and experts that can contribute to defining the scope and requirements of needed APs. Industry organizations and programs should collaborate in AP planning projects to define a common, industry-wide AAM, information exchange requirements, priorities for developing APs, industry AP roadmaps, and AP New Work Item Proposals (NP). The definition of high-value, product data exchange scenarios in conjunction with the

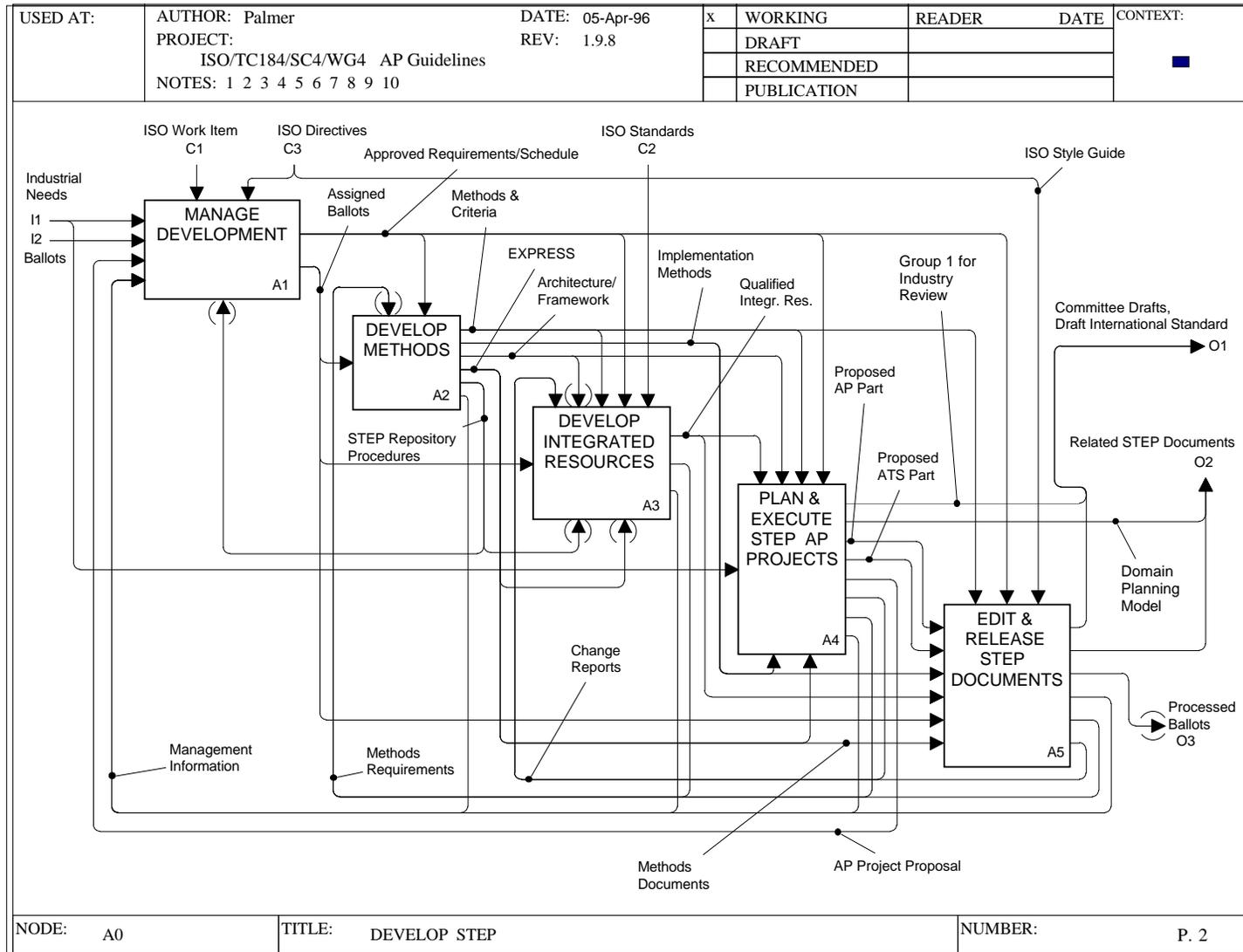


Figure 4-1: Activity A0, Develop STEP

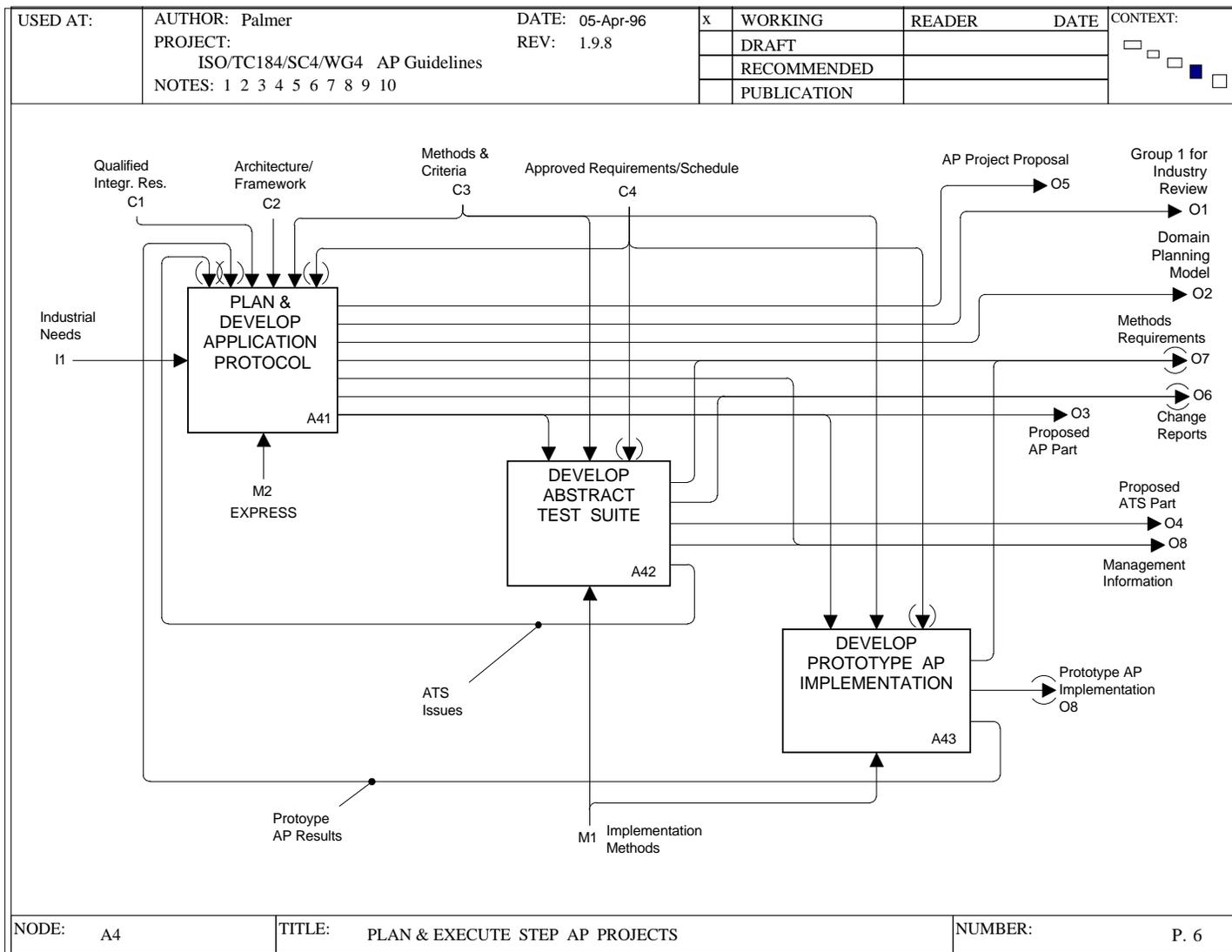


Figure 4-2: Activity A4, Plan & Execute STEP AP Projects

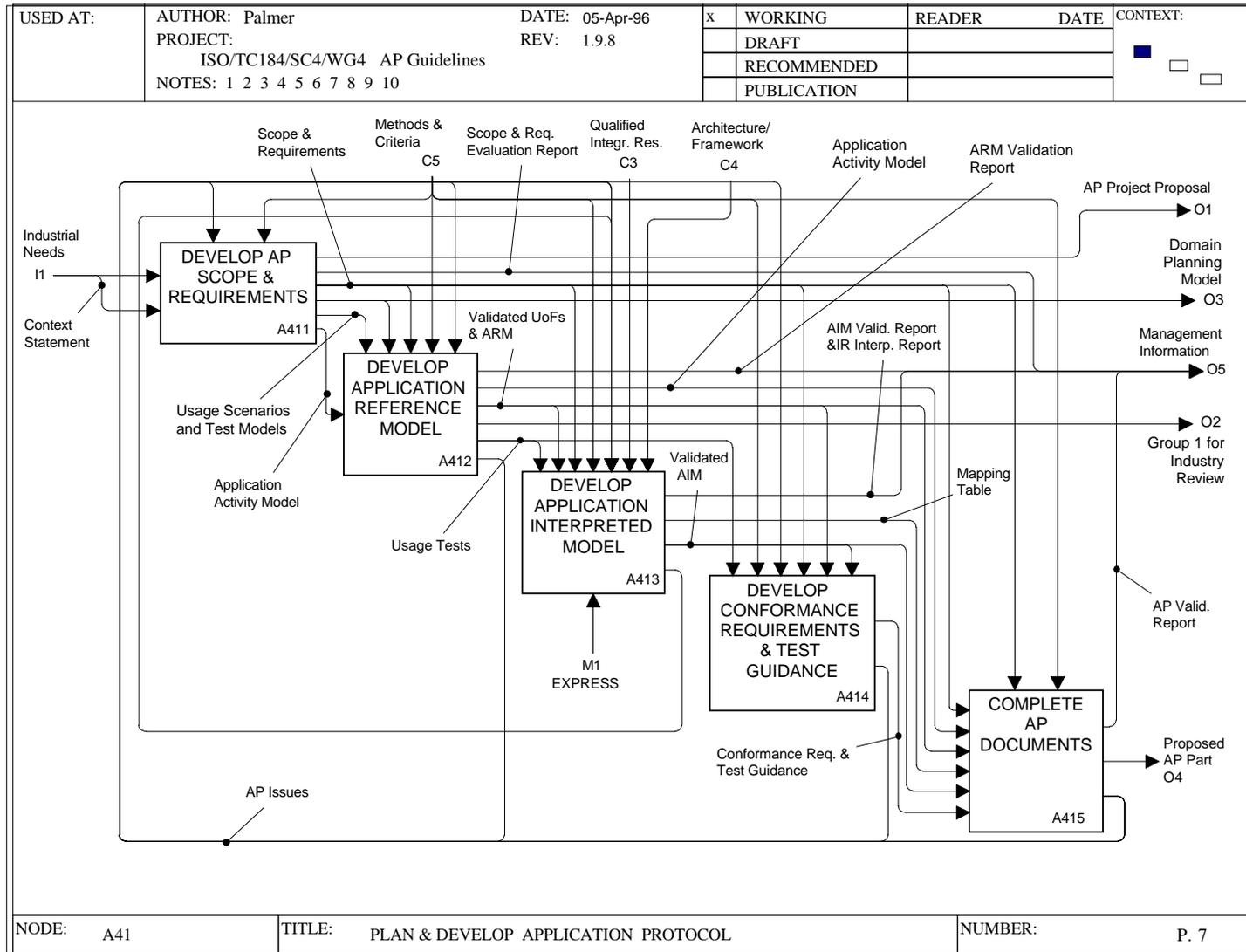


Figure 4-3: Activity A41, Plan & Develop Application Protocol

common AAM provides a useful baseline for defining the industry priorities for the delivery of APs.

The ISO/IEC Directives specify dates after the approval of a New Work Item for when a project must advance to the next stage:

- Working Draft within six months, or
- Committee Draft within two years, or
- Final Draft International Standard within three years.

The ISO Technical Management Board will review any AP project which has not attained the required progress and may decide to cancel the project. This decision will be based on information provided by the SC4 Secretariat.

An AP shall be developed and reviewed incrementally as components of the AP documentation are completed. The objectives of the incremental development and review process are twofold. First, the review of an AP's scope and information requirements, prior to developing the AIM, provides the opportunity to establish international consensus on the detailed requirements and to identify requirements common with other applications for the purpose of AP integration planning. Second, a comprehensive review at each stage improves the quality of the AP and provides to the STEP project useful feedback on the AP development, review, and qualification process [8] [9] [10] [11]. APs shall be documented in accordance with the *Supplementary directives for the drafting and presentation of ISO 10303* [9].

At the beginning of each AP project, the AP project team shall meet with representatives of both the WG4 STEP Part Qualification and Validation Project (QVP) and the SC4 Editing the Quality Committee. The objectives of these meetings are to instruct the AP project team on how to efficiently and correctly develop and document APs and to ensure that the teams have all necessary supporting documents. AP project leaders should ensure all team members are provided sufficient training to understand and contribute to the AP development process. Without this training, AP teams often make mistakes that must be corrected, and this re-work delays the completion of the AP project. The QVP and the Editing Quality Committee will answer questions on documenting an AP and will provide informal reviews of components of an AP document at any point in the development process. The AP project leader is responsible for delivering to the SC4 Secretariat updates to the AP project schedule whenever there are significant changes. The maintenance of accurate schedules for all projects is essential to manage effectively the resources and work of SC4.

Each component of an AP proceeds through three basic steps: 1) define the requirements and evaluation criteria for the component, 2) develop the component, and 3) exercise the criteria to evaluate the component. Each stage in the development process builds upon the precision and documentation of the previous step.

The process for developing an AP is described below (see Annex B for an AP development schedule template). The AP review and qualification process is summarized in 4.8. The formal qualification of

an AP by the ~~Part Qualification and Validation Project~~ **Quality Committee and by industry** is divided into two stages. The first formal qualification reviews the ~~Group 1 components~~ **document** of the AP. Group 1 of the AP includes the scope, definitions, information requirements, application activity model, **usage scenarios**, application reference model, **conformance requirements and conformance classes (if applicable)**, the corresponding **initial** issues log, **and the initial AP validation report with the scope and requirements evaluation clause and the ARM validation clause completed**. The Quality Committee reviews the ~~Group 1~~ **document to ensure that the document is sufficiently complete and understandable to warrant review by all sectors of the industries which may use the AP.**

**After successful completion of the Group 1 review by the Quality Committee, the AP project distributes the Group 1 document, with supporting information on STEP and the review process, for review by industry and relevant organizations.** This review ensures that the initial components are correct, complete, and stable prior to investing resources in the development of the subsequent components of the AP which are based upon Group 1. Group 2 includes all other components of the AP, i.e., the application interpreted model, the AIM annexes, conformance requirements, the issues log, the completed AP validation report, and all remaining annexes of the AP.

#### Summary of the AP development process

1. Industry representatives document requirements for APs and develop a proposal for a STEP AP planning project (see clause A.1). The proposal shall be submitted ~~by a SC4 member country~~ to the SC4 secretariat. The AP planning project proposal describes the scope of the project, i.e., type(s) of product, application tasks, discipline views, types of product data, and stages of the product life cycle to be included, evidence of international industry need for APs in this area, committed human resources to the project, overlaps and relationships to other APs, and the schedule for delivering AP project proposals.
2. ~~The AP Coordinator~~ **SC4 Secretariat** reviews the proposal to ensure that the proposal is complete and distributes each complete proposal to ~~the PMAG~~ **SC4 members** for review and approval. If the proposal is incomplete or ambiguous, ~~the AP Coordinator~~ **SC4 Secretariat** returns the proposal to the submitter with recommendations for improvement.
3. ~~The PMAG~~ **SC4** reviews the proposal to ensure that the proposed AP planning project: 1) is compatible with existing AP planning projects and AP projects, 2) will address industry requirements shared by many organizations and countries, and 3) has sufficient human resources to complete the planned work. Based on the results of this analysis and the recommendations of **industry and the WG conveners**, ~~the PMAG decides~~ **SC4 votes** whether to approve the proposed AP planning project.
4. Industry representatives, application experts, and vendors of computer-aided tools ~~analyze and document~~ **an industry consensus AAM, usage scenarios, example product representations, data exchange** requirements, and priorities for APs within a specific application domain. With the assistance of STEP experts, application experts assess the correspondence of the application requirements to: 1) existing AP planning projects and AP projects, and 2) the scope and

architecture of STEP. These analyses provides the basis for an initial definition of the scope of an AP or suite of APs, a **planning model for the application domain**, and a development plan.

5. The AP project team meets with the ~~Part Qualification and Validation Project and the Editing Quality Committee~~ for instruction on how to efficiently and correctly develop and document APs. **The AP project team meets with WG6 for instructions on how to efficiently and correctly develop the conformance classes and abstract test suite for the AP.**
6. Industry representatives and application experts document an AAM (**which decomposes relevant activities of the common AAM defined for the industry**), a representative set of usage scenarios and product representations, a data planning model, UoFs, information requirements, and an initial definition of conformance classes and produce the initial Working Draft of the AP. The initial Working Draft may include a complete application reference model. The initial Working Draft and an AP New Work Item Proposal ~~project proposal (see clause A.3)~~ are submitted to the SC4 Secretariat for a vote for approval by SC4. The AP ~~project proposal~~ describes the scope of the project, evidence of international industry need for the AP, committed human resources to the project, overlaps and relationships to other APs, and the schedule for completing the AP. It is recommended that AP project proposals be defined as part of an AP planning project. ~~A member body of SC4 shall submit the proposal to the AP Coordinator.~~
7. ~~The AP Coordinator~~ **SC4 Secretariat** reviews the proposal to ensure that the proposal is complete and distributes each complete proposal to ~~the PMAG~~ **SC4** for review and approval. **The SC4 Secretariat summarizes the results of this review and sends the summary to the nominator for the proposal.** If the proposal is incomplete or ambiguous, ~~the AP Coordinator~~ **SC4 Secretariat** returns the proposal to the submitter with a summary of components requiring further development and recommendations for improvement.
8. ~~The PMAG~~ **SC4** reviews the proposal to ensure that the proposed AP project: 1) is compatible with existing AP projects, 2) will address industry requirements shared by many organizations and countries, and 3) has sufficient human resources to complete the planned work. **The SC4 Secretariat summarizes the results of this review and sends the summary to the nominator for the proposal.** ~~The PMAG uses this analysis and the recommendations of the WG conveners and the PMAG members to determine whether to approve the proposal as an SC4 AP project. After the PMAG approves the AP project,~~ **Using the results of this analysis, SC4 votes whether to approve the project. After SC4 approves an AP New Work Item Proposal, the SC4 Secretariat assigns Part numbers for the AP and the corresponding abstract test suite (ATS) and the project leaders for the AP and the ATS.**
9. The AP project team uses the AAM, scope, **usage scenarios, validation testing and requirements, and input from industry to refine** ~~as the basis for defining the application reference model (ARM, UoFs, and conformance classes and refining to refine the units of functionality (UoFs).~~
10. The AP project team conducts industry reviews and evaluations of the AAM, scope, **usage scenarios, and requirements, ARM and initial conformance classes.** **As part of these reviews, the**

AP project teams maintains a list of industry reviewers and companies that are interested in the development, utility and future use of the AP. The results of these reviews and the basis for industry acceptance of these elements of the AP are documented in a scope and requirements evaluation report. This report is included as a clause of the AP validation report. Issues defined during these reviews shall be documented in the AP issues log.

11. The AP project team ~~submits~~ conducts an overview of the information requirements, ARM, and UoFs for review and comments by with the WG4 AIM Development Project (ADP) and the WG4 AP Integration Project (APIP). The ~~APD~~ADP will assist the AP project in the development of the AIM and determines whether additions to the existing integrated resources are required to meet the information requirements. If additions to the integrated resources are required, the ~~APD~~ADP and the AP project team defines a plan for developing these additions.

The APIP is responsible for the identification of AICs and management of the AIC library. The AP project teams receive guidance on the use and documentation of AICs from APIP.

12. The AP project team validates the ARM and UoFs and produces the ARM validation report. This report is included as a clause of the AP validation report. The AP project team ~~produces~~ defines ARM test purposes and usage tests as part of validating the ARM. The ARM test purposes are an important starting point for the development of the AP's abstract test suite.
13. The AP project team submits Group 1 of the AP to the ~~Qualification and Validation Project Quality Committee~~ for initial qualification review and to the ~~Editing Committee~~ for initial editorial review.
14. The AP project team documents the plan for resolving comments and issues raised in the ~~WG4 Quality Committee~~ reviews and ~~submits the completed~~ the Group 1 of the AP. to the SC4 chair for distribution to the SC4 members as a Committee Draft for Comment (CDC).<sup>8)</sup>
15. The AP project is responsible for establishing effective mechanisms for validating the contents of the Group 1 document and for ensuring industry review and consensus on the contents of the Group 1 document. As a minimum, the AP project distributes the Group 1 document to all industry representatives who have submitted comments or input to the AP project. A simple explanation of STEP APs and instructions on how to effectively review and comment on the AP shall be included with the Group 1 document. The AP project produces a short summary of the Group 1 document, the role of the AP in any defined suite of APs, and instructions for obtaining copies of the document. If extensions to the scope or additional information requirements are planned for the AP, this shall also be explained to the industry reviewers.

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<sup>8)</sup> At their June 1992 meeting, the PMAG strongly recommended that all AP projects circulate for review and comment by SC4 member bodies and liaisons the Group 1 documentation. This review provides a mechanism to ensure international consensus on the scope and requirements before resources are expended in developing the AIM and other related documentation. At their October 1993 meeting, the PMAG began discussions on revising this recommendation.

The AP project notifies relevant industry organizations, the convener of the parent WG, the SC4 AP Coordinator and relevant standards development organizations that the Group 1 document is complete and available for review and comment. The AP project shall provide to the SC4 Secretariat paper and digital copies of the Group 1 document, and the list of industry reviewers to whom the Group 1 document was distributed. The SC4 Secretariat shall distribute the summary of the Group 1 document and the list of industry reviewers to the P and O members of SC4 and the A and B liaisons of SC4. The AP project is responsible for distributing the Group 1 review packet to industry.

To ensure maximum feedback from this industry review, AP projects should send follow-up inquiries to the reviewers prior to the closing of the review period to encourage the submission of comments.

16. The AP project team reviews the comments from ~~the SC4 CDC~~ industry reviews of the Group 1 document and ~~develops a plan for resolving~~ determines how to resolve the issues ~~raised~~.
17. The ADP, working with the AP project team, selects and interprets resource constructs for the AIM. ~~With the assistance of ADP, the AP project team documents the rationale for the selection and specialization of Integrated Resource constructs to support the AP information requirements. This information and summaries of concepts and issues which required extensive discussion or analysis shall be included in the Integrated resources interpretation clause of the AP validation report.~~

The AP project team, with ADP assistance, produces the mapping table, the AIM (EXPRESS and EXPRESS-G), and updates Integrated resources interpretation ~~report~~. ~~The interpretation report is included as a clause of the AP validation report.~~
18. AP project team compiles and validates the AIM and produces the AIM validation ~~report~~. ~~This report is included as a clause of the AP validation report.~~ The AIM compilation shall consist of the use of at least two software tools that accept the AIM EXPRESS short listing as input and produce the AIM EXPRESS expanded listing to be included in Annex A of the AP document. The AIM listings shall be checked for errors with at least two software tools. The results of these tests and the name and version of the tools employed shall be included in the AIM validation clause of the AP validation report.
19. The AP project team ~~defines~~ updates the conformance requirements and ~~conformance classes and documents~~ implementation method specific requirements.<sup>9)</sup>

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<sup>9)</sup> ~~AP projects shall produce an abstract test suite (ATS) for the AP. The ATS is required to go through the SC4 STEP Part approval process [11].~~

20. The AP project team completes the AP document and submits the document, ~~i.e., both Group 1 and Group 2,~~ to the ADP for approval and to the ~~QVP~~ **Quality Committee** for final qualification approval.
21. The AP project team resolves all qualification issues, approves the AP to Project Draft status, and submits the AP to the convener of the parent WG ~~and to the WG4 Convener~~ for approval **for distribution as a Committee Draft for ballot**. The AP issues log and the AP validation report ~~are~~ shall be circulated with the AP for these reviews.
- ~~22. The AP project team submits the AP to the Editing Committee for review and approval.~~
232. The AP project team submits to the ~~PMAG~~ **SC4 Secretariat paper and electronic copies** of the AP for review and ~~approval~~ **Committee Draft ballot by SC4**.

The AP projects should, where possible, utilize the work of existing AP projects in the development of new APs. This requires that AP developers understand the scope and status of other AP projects and the integrated resources and coordinate their work with the necessary WGs and STEP projects. ~~A useful document for understanding other AP projects is the *STEP Parts Status and Summary Report* [15].~~

AP developers shall maintain a comprehensive issues log and shall forward to each WG and AP project issues relevant to their charter. AP projects shall maintain accurate schedules and shall submit revisions to schedules to the ~~AP Coordinator and to the editor of~~ **SC4 secretariat for updates to the *STEP Parts Status and Summary Report*** SC4 project management records.

#### **4.1 Development and review of the scope and information requirements**

The first phase of developing an AP is the definition of its scope and information requirements. Definition of the scope and information requirements begins with the formulation of a statement of the application context and functional requirements for the AP. This statement shall define the type(s) of product, the stages in the life cycle of the product(s), the product data application(s), and the use of the product data within the application(s) targeted for the AP. The detailed scoping and information requirements definition shall proceed from this statement.

Scope definition shall be refined via the development of an application activity model (AAM). The AAM describes the input and output information requirements of the processes within the application context. The AAM shall be documented with the process modelling technique IDEF0 [4]. The AAM shall include a glossary that defines all activities and elements in the model. **The AAM for an AP project should be developed in conjunction with the common, industry wide AAM which covers the complete life cycle for the industry's product(s). The development of these AAMs will be an iterative process. The detailed analysis of the AAM for an AP project will often provide insights and refinements for the common, industry wide AAM.**

The identification of product data usage scenarios pertinent to the application and example parts or products that will be represented with the AP shall be used as aids to defining detailed ~~data~~ **information requirements. The AP project shall define usage scenarios that illustrate high value information exchanges**

relevant to a majority of the industries which could use the AP. Usage scenarios should illustrate major information exchange problems for the target industries and the business value of developing and using the AP. Usage scenarios may describe new ways to use product data exchange to improve work processes.

As the AAM and information requirements become more detailed, the scoping statement prepared at the beginning of the scoping phase shall be updated to correspond.

The AP's scope, AAM, and information requirements shall be carefully defined and documented. This documentation, in addition to the example products and product data usage scenarios, provides the foundation for developing the AP. The usage scenarios are extremely valuable in the subsequent validation of the ARM and the AIM.

At each level of decomposition of the AAM, the activities, inputs, controls, outputs, and mechanisms should be examined, and a determination made as to whether they are in scope for the AP. The inclusion of mechanisms, e.g., resources and tools, in an AAM should be carefully analyzed. Often, mechanisms are organization or enterprise dependent, and those dependencies shall not be included in the AAM. Only those mechanisms that are organization and enterprise independent shall be included. The AP development process is designed to develop organization and enterprise independent models.

An AAM for the existing "as is" processes should be developed before defining an AAM for future "to be" processes. The decision to scope an AP based on future processes rather than existing processes requires careful analysis of the industry need(s), objectives sought by the proposed improved process, the time required to deliver the AP to industry, and the relative costs and benefits.

The AP scope statement shall include a summary of the type(s) of product, the application processes, the types of product data, and the discipline views of the product that are within the scope. For clarification, the scope statement may also identify the type(s) of product, the application processes, the types of product data, and the discipline views of the product that are outside of the scope.

As the scope, requirements, and AAM are further defined, the AP project should develop an initial planning model which identifies the primary concepts and relationships to be supported by the AP. The planning model will evolve as the details of the AP are developed. The AP team should conduct fitness testing and evaluations of these AP components by experts in the application. The majority of these expert reviewers should not have participated in the AP development. Representatives from all relevant industries and from a broad spectrum of user organizations should be included to the maximum extent possible.

The objectives of this review are to ensure that: 1) the scope and requirements are accurate, viable, and meet a significant industrial need; 2) the AAM accurately represents all areas which are described by the scope statement, and 3) the documentation is sufficient, unambiguous, and conveys the correct meanings.

All issues raised during the review(s) and the resolutions of these issues shall be documented in the AP's Scope and Requirements Evaluation Report clause of the AP Validation Report. This report shall include the list of workshops, surveys, and reviews used in the assessment, the identification of the organizations

participating in the reviews, the list of the expert reviewers, with their qualifications, summaries of the review(s) and the evaluations, and an issues log with the issues resolved. The report shall be included in the AP validation report.

#### **4.2 Development and review of an application protocol project proposal**

Each new AP project must be approved by the voting members of SC4. A proposal for a new AP may originate from a national body member of SC4, the SC4 Secretariat, another ISO TC or SC, an organization in liaison, the ISO Technical Management Board or the ISO Chief Executive Officer. The ISO New Work Item Proposal (NP) form (available from the SC4 Secretariat) shall be used for proposing an AP project. An AP NP should be submitted to SC4 when industry sponsorship, commitment of necessary expertise and funding, and international consensus on the scope and requirements for the AP project have been established.

An AP New Work Item Proposal shall include:

- title of project;
- scope;
- purpose and justification;
- target date for publication as an International Standard;
- relevant documents to be considered;
- relationships to activities of other international bodies;
- overlaps with other APs and AP projects;
- STEP resource schemas targeted for use by the AP;
- sponsoring organizations, participants, project plan, and schedule;
- summary of industry reviews of the scope and requirements;
- a partial draft of the proposed document.

The partial draft shall include an outline of the proposed document, a complete statement of scope, and sufficient technical content so that its requirements and position in the SC4 architecture can be understood. The draft document shall comply with the format and table of contents for an AP [9] and shall include:

- scope;
- normative references;

- essential definitions;
- application activity model;
- planning model;
- assumptions about the application context;
- units of functionality (UoFs);
- information requirements;
- initial definition of conformance classes.

The document may include the initial application reference model. This document constitutes the initial Working Draft of the proposed AP.

~~Once the scope, requirements, and AAM are complete and an international need for the AP has been documented, the AP team shall complete an application protocol project proposal (see clause A.3) and submit the proposal to the PMAG AP Coordinator for review and approval by the PMAG and SC4. The AP Coordinator will notify the proposal advocate of any missing information. The proposal will not be reviewed by the PMAG until necessary information has been provided.~~

~~The PMAG shall review the AP project proposal to ensure that: 1) there is significant, international industrial need for the proposed AP; 2) the proposed AP is consistent with the integration architecture, existing projects, and the scope of STEP; 3) multiple SC4 Member Bodies have committed sufficient human resources to complete the work, 4) the proposal is complete and understandable, and 5) the project is viable and likely to succeed. PMAG solicits review and comments from the relevant projects within SC4. The PMAG ensures that the project proposal is distributed to all appropriate parties.~~

~~During this review, particular attention shall be assigned to identify commonality with other AP projects. Common information requirements and overlaps between APs are often identified by examining the scope statements, AAMs, and the structure and definition of proposed UoFs. After the relationships and overlaps with other APs have been resolved and documented, the PMAG shall consider approving the proposed AP as a new AP project. If the PMAG determines that the AP should not be initiated as an SC4 project, the rationale for this decision shall be delivered to the AP nominator. The PMAG shall recommend a project leader for each AP project and shall submit these recommendations for approval by SC4.~~

~~An AP project proposal shall consist of the following information:~~

- ~~1. AP title;~~
- ~~2. Date of submission to the PMAG;~~
- ~~3. Nominator: (ISO TC184/SC4 member body or liaison)~~
- ~~4. Proposal advocate;~~

- ~~5. Scope and functional requirements:~~
- ~~6. Application activity model:~~
- ~~7. Evidence of international industrial need:~~
- ~~8. Summary of industry review:~~
- ~~9. Overlap with other APs:~~
- ~~10. ISO 10303 resource schemas(s) required:~~
- ~~11. Participants and hours assigned to the project:~~
- ~~12. Schedule for the project:~~

### 4.3 Development and review of the application reference model

When the detailed scope ~~and~~, functional requirements **and planning model** have been defined, the information domain of the AP shall be defined by the use of the application reference model (ARM). The ARM shall be developed using a formal data description language, i.e., EXPRESS, IDEF1X, or NIAM. ARMs specified using EXPRESS shall include an EXPRESS-G presentation. Each application information requirement that is within scope in the AAM shall be expressed in the ARM. Conversely, each element of the ARM shall satisfy a documented information need of the application. The ARM shall describe fully the data needs of the application, using the terminology of the application.

An ARM shall be sufficiently detailed so that the selection and interpretation of the integrated resources (see 4.4) can be done accurately. The ARM documents the required data and relationships. The graphical presentation of the ARM, i.e., EXPRESS-G, IDEF1X, or NIAM, aids the understanding and review of the information requirements and definitions. The ARM diagrams shall be at a detail level sufficient to present the requirements in a manner that it is understandable to an application domain expert. The information requirements shall be modelled only to the level necessary to convey the information that is important from the application experts' point of view.

A mechanism for modularizing the scope of an AP into manageable constructs is to define units of functionality. A UoF is a collection of application objects and assertions that conveys one or more well-defined concepts within the context of an ARM. A UoF usually supports an application function or process. UoFs are used to organize and summarize the functionality of the ARM. For example, if a geometric modelling application has a requirement for wireframe geometry, then a UoF may be defined which provides a grouping of those application objects in the ARM which are intended to support geometric modelling using wireframe geometry. ~~UoFs are models of aggregates of data which are important to the application domain experts.~~

As the ARM is developed, the constructs which correspond to each UoF shall be grouped together so that they are readily identifiable. A list of the UoFs with definitions shall be maintained. This list shall include the application processes of the AAM that require each UoF. **This correspondence shall be documented in the ARM validation report.** Documenting UoFs facilitates the integration of APs at the ARM level.

As the ARM is refined, traceability and consistency shall be maintained between the scope, functional requirements, AAM, and ARM. The AP development team shall ensure that each requirement identified in the AAM is expressed in the ARM.

AP projects shall maintain knowledge of the domain and status of other AP projects [15] and shall investigate possible overlaps with other APs and AP projects. This shall include the analysis for common information requirements, similar units of functionality, and correspondence between ARMs. The WG4 AIM Development Project and AP Integration Project also conduct such analyses to identify overlaps among APs. Overlaps are evaluated for AP integration requirements.

APs with similar UoFs or information requirements shall be compared semantically by the WG4 AP Integration Project to determine functional equivalence. When two or more APs have equivalent UoFs or common information requirements, the same interpretation of the integrated resources shall be used in the APs' AIMS. This interpretation shall be accomplished by the inclusion of a common module in each of the APs. This common module is called an application interpreted construct (AIC) [1614]. AICs and a list of the AIMS that use each AIC shall be included in the AIC Library. The AIC Library is maintained by the WG4 AP Integration Project. This method will provide for consistency of STEP data representation among APs.

After the ARM is developed it shall undergo validation to ensure that it fulfills the functional requirements, is self-consistent, and covers the scope of the application completely. This validation should be done by both expert modellers for integrity testing and application experts for fitness testing. The functionality documented in the ARM shall meet the requirements expressed in the scope. Additionally, the functionality documented in the ARM shall not exceed the boundaries defined in the scope and the requirements.

The example parts and the input and output data requirements **test models and usage scenarios** used in the initial scope and requirements definition should be used for building the usage tests for validating the ARM. Usage tests document typical operations for creating or accessing product data. The set of ARM usage tests should be carefully defined to ensure coverage of the application context and functional requirements, the information defined in the ARM, and possible combinations of product representations. Difficulty in defining a meaningful usage test which exercises an application object may indicate that the application object is not needed. **To ensure sufficient coverage for validating the ARM, the usage tests should use at least seventy percent of the application objects, attributes, and assertions.**

~~Once the ARM is complete and has been validated with the usage tests, the AP team shall submit the ARM and the ARM validation report to WG4 for qualification. WG4 shall assign personnel to work with the AP project to ensure that the model(s) is correct and complete [10]. Upon completion of the WG4 review, the AP project team shall determine how to resolve the WG4 comments and the schedule for distributing the Group 1 of the AP for review and comment by SC4. The WG4 comments, the AP project's plan for resolving all issues, and the completed clauses of the AP validation report shall be included with the Group 1 distribution. The SC4 review of the Group 1 Committee Draft for Comment (CDC) provides a mechanism to ensure international consensus on the scope and requirements before resources are expended in developing the AIM and other related documentation.~~

#### **4.3.1 ARM and information requirements documentation**

Clause 4 of the AP shall include a high level description of the information requirements, a summary of the structure used to partition the information requirements, and subclauses for specifying UoFs, application objects, and application assertions. The description of the information requirements shall be sufficient to prepare the reader for the material in the three subclauses.

The grouping of UoF's into logical sets that aid in the understanding of the information domain is recommended. The logic of these groups of UoFs shall be included in 4.1. The definition of UoFs and groups of UoFs shall be done in conjunction with the definition of conformance classes for the AP. UoFs are used as modules for defining conformance classes. A diagram or table which illustrates the mapping of UoFs to conformance classes shall be included in 4.1.

Nested or hierarchical structures of UoFs are not recommended. This type of structuring can obscure the semantics of the individual UoFs. Additionally, overlap of UoFs should be minimized. If one or more application objects participate in more than one UoFs, the scope and constituents, i.e., application objects and assertions, of the overlapping UoFs shall be carefully analyzed for logical restructuring which removes the overlap. If an application object does not participate in any UoF, the UoFs and application objects should be re-examined for logical structure and completeness of the UoFs.

The information requirements, application objects, and application assertions shall be defined in prose. ~~The elements listed within these subclauses shall be organized by UoFs, or to match the structure of the ARM, or alphabetically.~~ UoFs, application objects and application assertions shall have unique names, i.e., no application elements shall share the same name.

The documentation for an AP's ARM and information requirements includes five components.

1. ARM

The ARM shall be included in annex EG of the AP. The ARM uses the terminology of the application and shall be documented with IDEF1X, NIAM, or EXPRESS.

2. units of functionality

Units of functionality shall be defined in 4.1 of the AP. This subclause provides a list of the UoFs defined for the AP, a description of the functions that each UoF supports, and the list of application objects included in the UoF.

3. application objects

The application objects shall be defined in 4.2 of the AP and are derived from the ARM. Each object which exists in the ARM shall be defined.

4. application assertions

The application assertions shall be defined in 4.3 of the AP and are derived from the ARM. These assertions define relationships among application objects, the cardinality of the relationships, and the rules required for the integrity and validity of the application objects and UoFs.

#### 5. ARM validation-report clause

An ARM validation-report clause is part of the AP validation report and describes the methods, tests, and verdict criteria which were used to validate the ARM.

#### 4.3.1.1 EXPRESS ARMs

If the ARM has been modelled using EXPRESS, then the application object definitions and application assertions shall be specified as follows:

- Each entity shall be stated in the application object definitions.
- Each attribute whose data type is either a base data type or a defined data type which is not a SELECT data type with a select list that contains entity types or other select types with select lists that contain entity types shall be stated as an-ATTRIBUTE attribute of that entity in the application object definition.
- Each attribute whose data type is an aggregate of either a base type or a defined type which is not a SELECT data type with a select list that contains entity types or other select types with select lists that contain entity types shall be defined as an-ATTRIBUTE attribute in the application object definition, with the cardinality defined in the definition.
- Each attribute whose data type is an aggregate of either an entity type or a SELECT type with a select list that contains either entity types or other select types with select lists that contain entity types shall be stated in the application assertions with the cardinality defined by the aggregate bounds.
- Each attribute whose data type is an entity type shall be stated as a-RELATIONSHIP relationship between the two entities in the application assertions.
- Each attribute whose data type is a SELECT data type with a select list that contains entity types or other select types with select lists that contain entity types shall be stated as a-RELATIONSHIP relationship between the entity containing the attribute and each of the options in the SELECT list in the application assertions.
- The INVERSE statements of referenced entities shall be examined in order to specify the cardinality constraints in the application assertions.

#### 4.3.1.2 IDEF1X ARMs

If the ARM has been modelled in IDEF1X, then the application object definitions and application assertions shall be specified as follows:

- Each entity shall be stated in the application object definitions.
- Each attribute shall be stated as an ~~ATTRIBUTE~~ **attribute** in the application object definitions.
- The business rule defining each relationship shall be stated in the application assertions.
- The notes which document any additional constraints shall be stated in the application assertions.

#### 4.3.1.3 NIAM ARMs

If the ARM has been modelled in NIAM, then the application object definitions and application assertions shall be specified as follows:

- Each NOLOT shall be stated in the application object definitions.
- For each NOLOT, each LOT connected directly by a bridge (FACT TYPE between NOLOT and LOT) shall be stated as an ~~ATTRIBUTE~~ **attribute** of the entity which was stated for that NOLOT in the application object definitions.
- If the role adjacent to the LOT has no ALWAYS or MANDATORY constraint, then the LOT or ~~ATTRIBUTE~~ **attribute** is OPTIONAL and shall be stated as such in the attribute definition.
- If the role adjacent to the LOT has a SIMPLE UNIQUE constraint, then the LOT or ~~ATTRIBUTE~~ **attribute** is UNIQUE and shall be stated as such in the attribute definition.
- If two or more LOTs share a JOINT UNIQUE constraint, then the LOTs or ~~ATTRIBUTES~~ **attributes** are jointly UNIQUE and shall be stated as such in the definitions for each attribute.
- Each IDEA shall be stated as a ~~RELATIONSHIP~~ **relationship** between the NOLOT corresponding objects in the application assertions.

#### 4.3.2 ARM validation

The AP team shall summarize its plan for ARM validation and the validation results in an ARM validation ~~report~~ **clause of the AP validation report**. This ~~report~~ **clause** shall include the rationale for the selection of representative test ~~parts and~~ **models, usage scenarios, and** usage tests and the analysis of the degree of coverage provided by the validation testing. This ~~report~~ **clause** shall summarize the impact that these results had on the ARM and the final scope of the AP. This ~~report~~ **clause** may include ~~an issues log~~ **a summary of ARM validation issues and how these were resolved**. ~~This report shall be included in the AP validation report.~~ **The usage tests shall be included in the AP validation report.**

The validation of the ARM is a critical and resource intensive activity. Complete model validation of a complex ARM is impractical. It is usually evident from the development of the AAM that recurring demands for the same information exist. These facts can be used to prioritize the parts of the ARM to be validated. The objective of the ARM validation testing is to provide a significant level of confidence in the correctness and robustness of the model. The AP team shall document the required level of confidence and the steps that were completed to reach that level.

One method for validating an ARM is to build a prototype database which closely matches, if not replicates, the constructs of the ARM. This prototype database is then tested for its ability to accommodate representative ~~test~~ **example** parts or products from the application context. Representative usage tests in the form of queries are posed upon these populations of the database to evaluate whether the "simulated ARM" is sufficient to support the in-scope processes defined in the AAM.

ARM validation shall, at a minimum, include paper populations of the data structure and reference path analyses to check whether the ARM can support the representative ~~test parts~~ **example product representations** and can support the representative usage tests. Both of these methods will benefit from the use of software tools to control and aid in the development and testing of complex ARMs.

Detailed validation testing of the ARM provides feedback on the structure and requirements defined in the model. There will be iterations between the population and reference path analysis of the ARM and its development. Each iteration shall be documented in the ARM validation report along with a summary of the test coverage, data, and path analyses which were used in the validation, and a summary of the impact of the test results on the model.

#### **4.4 Development and review of the application interpreted model**

The application interpreted model (AIM) is an EXPRESS schema which specifies the interpretation of the integrated resources to satisfy the information requirements of the AP. The AIM specifies the implementable constructs of the AP. The WG4 AIM Development Project, with the assistance of the AP team, shall produce the AIM. The documentation for an AIM includes six components.

1. Mapping table
2. AIM EXPRESS short listing
3. AIM EXPRESS ~~annotated~~ **expanded** listing
4. AIM EXPRESS-G
5. Integrated resources interpretation ~~report~~ **clause**
6. AIM validation ~~report~~ **clause**

#### 4.4.1 Integrated resources interpretation<sup>10)</sup>

The AIM is developed by interpreting the integrated resource constructs based on the information requirements. The AIM may **specify subtypes of entities imported from the integrated resources** or **add global rules to integrated resource constructs** in order to satisfy those application specific requirements which are specified in the ARM.<sup>11)</sup> Since the integrated resources are generic in nature, AIMs will take a more specific view of these entities. To restrict the population of particular attributes of an entity, a global rule shall be specified. This rule shall contain constraints on the particular entity or group of related entities.

Subtyping of an integrated resource construct is necessary when an ARM concept is only partially supported by that construct. In this case, a subtype of that integrated resource construct shall be created and those attributes and rules necessary to complete the concept attached to that subtype. Only DERIVED attributes may be specified in the AIM except for the purpose of completion and assignment of **product data management resources**. **When the practice of subtyping is used for the completion and assignment of product data management resources, it specifies** ~~Subtyping in the AIM is also used to specify the constructs in the AIM to which those~~ product data management resources (such as date\_time, person\_organization, approval, etc.) ~~shall be~~ **applied**. In this case, a SELECT type ~~shall be~~ **is** created in the AIM which specifies the entities which are required to have product data management resources applied to them. A subtype of the entity in the ~~specific~~ product data management schema shall be created and an attribute placed in that entity whose type is a SET [1:?] of the newly created SELECT.

The AP team shall document the rationale for each subtype and rule added in the AIM in an integrated resources interpretation report. This report shall be included in the AP validation report. The WG4 AIM Development Project shall manage the development of proposed subtypes.

As the number of APs grows over time, there will inevitably be some overlap in scope between different APs. These areas of overlap may be indicated by commonality in the scope statements or the use of the similar UoFs in their ARMs. These areas may also be indicated by the common use of resource constructs within APs. When two APs contain equivalent information requirements, these APs shall use the same interpretation of the integrated resource constructs. Figure 4-4 depicts this aspect of the AIM development and integration process.

When interpreting the integrated resources to ~~match~~ **satisfy** the information requirements, the following steps shall be taken [3] [13]:

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<sup>10)</sup> STEP interpretation methods are still being documented jointly by the WG4 AIM Development Project and the WG5 Methods Project.

<sup>11)</sup> ~~Refer to Issue #2.~~

A. Identify integrated resource constructs corresponding to application objects.

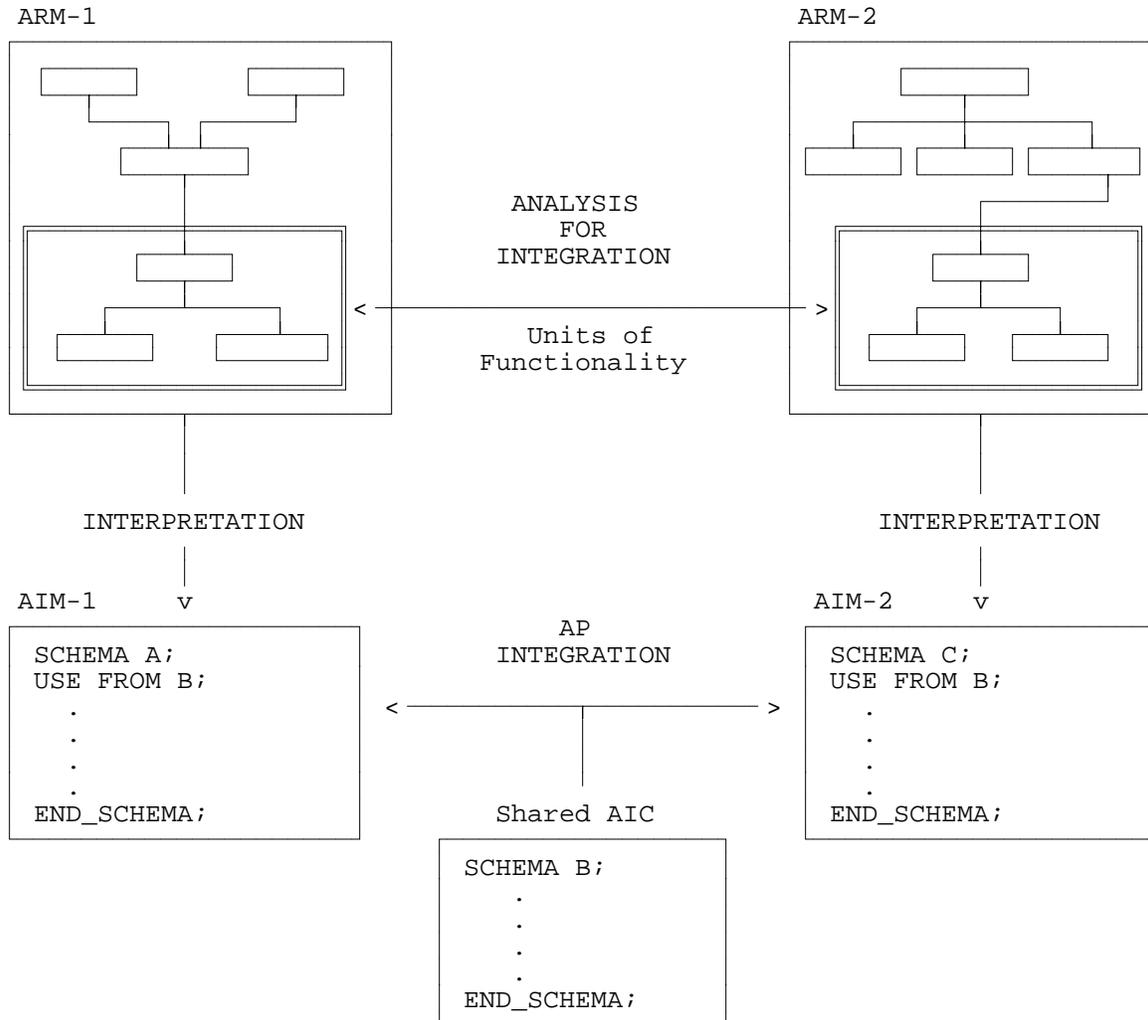
To represent the required functionality using integrated resource constructs, each of the application objects must be examined to find a corresponding construct or group of constructs in the integrated resources. At this point of interpretation, only those constructs which satisfy an information requirement directly shall be identified. The method by which the integrated resources are interpreted directly by the AIM is described in 4.4.4, AIM EXPRESS documentation.

B. Identify requirements for specializing integrated resource constructs.

In addition to those constructs in the ARM which have a direct correspondence to constructs in the integrated resources, there may be some constructs which have a partial correspondence. Some constructs in an ARM may correspond to the general semantic intent of an integrated resource construct, yet require the extension or constraint refinement of that construct to attain complete semantic correspondence. The completion refining of these concepts is called specialization. At this point in the AIM development process, those constructs requiring specialization in the AIM are identified.

C. Specialize constructs with partial correspondence.

For those integrated resources entities for which a specialization requirement has been identified in order to completely satisfy information requirements, subtypes or global rules with attributes, rules, and constraints are added defined in the AIM. The refinement of an entity may be accomplished through the specification of constraints or definition of derived attributes. There are two types of ways in which specialization which may be done accomplished in an AIM. The first way to achieve type of specialization is by defining a new subtype of the integrated resource entity whose semantics are being refined to match satisfy the a particular requirements of the application context. This is accomplished by defining a subtype of the integrated resource entity whose semantics are being refined. The subtype entity may contain DERIVED attributes with attribute names that are specialized to be consistent with the semantics of the information requirements or local rules that constrain the use of the specialized entity to be consistent with the information requirements. The second way in which type of specialization may be accomplished is by the additional constraining of an entity that is imported from the integrated resources. This second method is typically used to restrict attribute value population or cardinalities among entities that have relationships to each other. When a new one these types of constraint needs to be added to the integrated resource in order to satisfy the information requirements, either a local or a global rule shall be added to the AIM depending on the use of the construct. See [13] for the specific rules on developing the application interpreted model.



**Figure 4-4: Analysis for AP integration**

D. Develop mapping table (see 4.4.2).

While the AIM is developed, the AP team shall record in a table in clause 5.1 of the AP document the selections and specializations made from the integrated resources to establish correspondence to each information requirement. This mapping will list each information requirement and its corresponding AIM construct(s). If a path of entity references in the AIM must be followed to completely satisfy a particular requirement as it is given in the ARM, the mapping table shall indicate the complete reference path which needs to be given to represent the required information in the AIM.

E. Develop integrated resource interpretation ~~report~~ **clause**.

The AP team shall produce an integrated resource interpretation ~~report~~ **clause** to summarize the rationale with which the AIM was derived and all specializations of integrated resource constructs. In developing the constraints on entities, a number of constraints may be required to constrain different entities for the same purpose. These constraints shall be grouped together in the integrated resource interpretation report with a description of their purpose in the AIM. **The integrated resource interpretation clause is included in the AP validation report.**

#### 4.4.2 Mapping table

During the interpretation of the integrated resources, the mapping of the correspondence between the application objects and the constructs of the AIM shall be documented and maintained. The resultant mapping table shows the AIM construct(s) required for each application object [12] [9].

In EXPRESS, a single attribute or entity may not be enough to establish a full understanding of a concept. Although a single attribute or entity may be the AIM construct to which an ARM construct maps, that attribute or entity will not provide all of the information necessary to completely understand the semantic. The specification of a reference path in the mapping table occurs when an attribute in the ARM and the entity to which it belongs do not correspond to the same entity in the AIM. Often an attribute in the ARM is developed at a higher level of detail than the integrated resources. In this case, the reference path is provided so that the complete semantic (including the relationship of the attribute to the entity in the ARM) is represented in the mapping table. Additionally relationships in the ARM will always have reference paths to show the complete set of entity instances required in the AIM to satisfy the relationship, subtypes created in the AIM will show the supertype from the integrated resources in the reference path and any mapping rules or choices will be specified in the reference path.

The example table below (see Figures 4-5 and 4-6) illustrates a number of types of mappings that will be found in the mapping table of an application protocol. Two units of functionality are given, Advanced\_b\_rep and Authorization. The mappings of two application elements, ADVANCED\_B\_REP and APPROVAL, are provided. The mappings are described as follows:

Application element	AIM element	Source	Rules	Reference path
ADVANCED_B_REP	advanced_brep_representation	203		shape_representation=> advanced_brep_representation

Figure 4-5: Example 1 of a mapping table

Application element	AIM element	Source	Rules	Reference path
APPROVAL	cc_design_approval	203	1, 2	approval_assignment => cc_design_approval
date	date	41		cc_design_approval<= approval_assignment approval_assignment.assigned_approval-> approval<- approval_date_time.dated_approval approval_date_time.date_time-> date_time_select=date_and_time date_and_time.date_offset-> date
purpose	approval.purpose	41		cc_design_approval<= approval_assignment approval_assignment.assigned_approval-> approval approval.purpose

- 1) approval\_requires\_approval\_date\_time
- 2) approval\_requires\_approval\_person\_organization

Figure 4-6: Example 2 of a mapping table

- The application element `ADVANCED_B_REP` maps to the AIM entity `advanced_brep_representation`. The source column value denotes that the AIM entity `advanced_brep_representation` is an AP specialization, originating in AP 203. This specialization requires a reference path from the integrated resource entity from which it is specialized. The reference path denotes that the AIM entity `advanced_brep_representation` is a subtype of the integrated resource entity `shape_representation`.
- The application element `APPROVAL` maps to the AIM entity `cc_design_approval`. The source column denotes that the AIM entity `cc_design_approval` originates in AP 203. This specialization requires a reference path from the integrated resource entity to the specialized subtype. Rules 1 and 2 which are found at the end of the table constrain the use of the approval structure.
- The application element `APPROVAL` has an attribute `date` which maps to the date entity in the AIM. The date entity originates in Part 41 as indicated in the source column. Since the attribute maps to an entity in the AIM, a reference path is given from the entity `cc_design_approval` (this is the entity to which the application element `APPROVAL` was mapped) to the date entity (this is the entity to which the ARM attribute `date` is mapped). The reference path is to be read as follows:
  - `cc_design_approval` is a subtype of approval assignment,
  - approval assignment has an attribute named `assigned_approval` that references the entity approval,
  - approval is referenced by the attribute `dated_approval` in the entity `approval_date_time`,
  - `approval_date_time` has an attribute named `date_time` which references a select type called `date_time_select`,
  - in this case, the `date_time_select`, references the `date_and_time` entity,
  - the `date_and_time` entity has an attribute named `date_offset`,
  - the attribute `date_offset` references the entity `date`.
- The application element `APPROVAL` has an attribute `purpose` which maps to the purpose attribute of the approval entity in the AIM. The source of the attribute `purpose` in the entity approval is Part 41.

STEP experts and application experts shall review the mapping table by to ensure that they are complete and correct. The mapping is complete when each ARM construct has an equivalent construct(s) in the AIM.

### 4.4.3 Application interpreted constructs

During the interpretation process, one or more groups of constructs may be identified for which the information requirements are equivalent to another ISO 10303 application protocol. In this case, common interpretations are used and schemas to satisfy the common information requirements are developed for inclusion in the application interpreted models. These schemas are referred to as application interpreted constructs. All application protocols which have been identified as sharing a common information requirement shall use the appropriate application interpreted construct schema in its entirety. The AP Integration Project of WG4 will keep a library of all application interpreted constructs and a list of all application interpreted models of ISO 10303 application protocols which use them.

### 4.4.4 AIM EXPRESS documentation<sup>12)</sup>

The AIM shall be documented in three formats:

1. AIM EXPRESS-G;
2. AIM EXPRESS short listing;
3. AIM EXPRESS ~~annotated~~ **expanded** listing.

#### 4.4.4.1 AIM EXPRESS-G

Once an initial correspondence between application elements and the Integrated resources constructs has been established, an EXPRESS-G representation of the AIM should be produced. The EXPRESS-G diagrams are useful in developing the AIM EXPRESS listings, both the short listing and the annotated listing. The AIM EXPRESS-G diagrams shall include all ENTITYs, ~~and~~ ENUMERATION and SELECT types. **Each ENTITY drawn in the EXPRESS-G diagram shall include its attributes and their names, but not references to base types or defined types other than ENTITY, ENUMERATION or SELECT types.** An EXPRESS-G model for all entities in the AIM shall be provided as annex **GH**.

#### 4.4.4.2 AIM EXPRESS short listing

The AIM EXPRESS short listing provides the interface specification between AIM schema and the resources it uses, i.e., integrated resources and AICs. There is a single EXPRESS schema for each AIM. This EXPRESS schema specifies the elements from the integrated resources and the AICs that are used in the AP and contains the types, entity specializations, rules, and functions that are specific to the AP. ~~All entities from the integrated resources, including those which are to be specialized, shall be specified in the AIM EXPRESS short listing using the USE FROM construct.~~

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<sup>12)</sup> Detailed requirements for documenting AP Parts of ISO 10303, including any required text, are provided in the *Supplementary directives for the drafting and presentation of ISO 10303* [9].

Any entity which is declared in the AIM EXPRESS short listing shall be a subtype of an entity that is brought into the scope of the schema from using the USE FROM statement. These are the integrated resources entities which need to be specialized in the AIM. Data types shall be specified in the short listing to specialize the used integrated resources. Rules and functions which are needed to further constrain an entity or relationship shall be included in the short listing.

The AICs shall be incorporated into the AIM schema by the use of the USE FROM <AIC schema> statement. ~~Each AIC's USE FROM statement shall be followed by a tail comment which references the subclause of annex A in which the AIC EXPRESS schema is specified.~~ An AIC ~~only~~ shall be used in an AIM **only** in its entirety.

In addition to EXPRESS declarations, documentation modifications may be necessary to the understanding of the interpretation of constructs that are imported into the AIM from the integrated resources. Certain documentary functions are required in order to achieve a complete interpretation and certain functions are desirable for clarification of the generic resource constructs in a specific application context. Functions which have been identified for the modification of imported constructs are:

- addition of application specific examples;
- clarification of the interpretation of the meaning of an entity within the context of the application protocol;
- clarification of the interpretation one or more attributes of an imported entity;
- specification of AP specific informal propositions for an entity;
- documentation of associated global rules that are associated with each imported entity for which there is a global rule defined in the AIM.

Each of these functions will be documented in a subclause of clause 5.2 of the AP document. Every textual modification for each imported construct will be documented in a separate subclause specifically dedicated to the documentation of textual modifications for that construct.

#### 4.4.4.3 AIM EXPRESS ~~annotated~~**expanded** listing

The AIM EXPRESS ~~annotated~~**expanded** listing consists of the ~~complete documentation~~**EXPRESS specification containing the result** of the expanded USE FROM statements and the AP unique EXPRESS declarations. ~~The annotated listing shall contain definitions of each type, entity, attribute, rule, and function in the AIM schema. For each type, entity subtype, rule, and function that is defined in the AIM EXPRESS short listing, the description in the AIM EXPRESS annotated listing shall reference the specification in the corresponding subclause of the AIM EXPRESS short listing and not repeat the definition.~~ Discrepancy between the short listing and the ~~annotated~~**expanded** listing shall not occur **shall** be avoided in all cases. If there is a discrepancy between the short listing and the expanded listing, a statement that the expanded listing shall take precedence will be made in annex D of the AP.

~~The AIM EXPRESS annotated listing shall contain a schema which defines the AIM, along with the AIC schemas which are incorporated into the AIM. The fundamental concepts, scope, and assumptions for each AIC shall be documented with the AIC schema.~~

#### **4.4.5 AIM validation**

Comprehensive validation testing of a complex AIM is resource intensive. The objective of AIM validation testing is to provide a significant level of confidence in the correctness and robustness of the model. The AP team shall document the required level of confidence and the steps that were completed to reach that state. **The AP team shall document the usage scenarios, test models, AIM test purposes, and verdict criteria used to validate the AIM.**

~~The AP team shall summarize the AIM validation test plan and test results in the AIM validation report clause of the AP validation report. This report clause shall include the rationale for the selection of test models, test purposes, test pieces and usage scenarios. A selection of the ARM validation tests shall be included in the AIM tests. An analysis of the degree of coverage provided by the validation testing shall be included. This report may include an issues log a summary of AIM validation issues and how these were resolved. This report shall be included in the AP validation report. . This report shall be included in the AP validation report.~~

#### **4.4.6 AP usage guide**

During the development and validation of the AP, descriptions of the way in which the AP is to be used and illustrative business cases shall be developed. This information shall be continually refined with the objective of eventually producing an AP usage guide **which facilitates the implementation and use of the AP by industry.** The AP usage guide is an optional and informative annex of the AP.

A subclause in the usage guide may be reserved for each applicable implementation method. Examples of the use of the AP within each implementation method applicable may be explained in these subclauses. For a file exchange implementation, an example exchange file may be included. The inclusion of an exchange structure with values which are representative of those for which the AP was specified is an appropriate element of an AP usage guide.

### **4.5 Development and review of conformance requirements**

Conformance testing is the evaluation of an implementation for all required characteristics, i.e., to determine whether an implementation conforms to the standard. For an AP, this includes the information requirements, the AIM (entities, types, attributes, functions, procedures, rules, and the full range of values), and any implementation **method** specific requirements defined in annex C of the AP.

With the assistance of WG6, the AP team shall define the conformance requirements and any conformance classes<sup>13)</sup> for the AP after careful analysis of the requirements of industry, the objectives of conformance testing, and the consequences of enforcing or not enforcing completeness. If conformance classes are used, the conformance requirements for the individual classes shall be explicitly listed in clause 6. **The definition of each conformance class shall specify which data flows from the AAM are supported.**

If completeness is enforced, each implementation must be able to process the full range of values for every attribute of every entity identified in a particular conformance class. For example, if widgets have a color attribute which is an enumeration of red, blue, and green, then all conforming processors must be able to produce (preprocessor) or interpret (postprocessor) all three colors of widgets. This does not imply that all three colors of widgets must appear in each exchange, merely that a system can distinguish widgets of the different colors, if desired.

Using the above example, if completeness of color attributes is not enforced, a "conforming" implementation may be at liberty to lose all the color information or to change blue and green widgets into red ones. From the perspective of the industrial need to maintain the color information, this condition is unacceptable. AP developers are advised to require completeness of implementation of all AP required characteristics. A clear statement of the required completeness shall be included in clause 6 of the AP.

A list of high level conformance requirements for an AP implementation is provided below. The AP developers shall consult WG6 on proposed modifications and additions to these conformance requirements.

1. The information requirements of the AP shall be preserved in the implementation. This includes support for valid combinations of entities and their attributes. Consequently, all application objects and assertions from clause 4 shall be maintained.
2. All entities, types, and their associated constraints identified in a particular conformance class shall be supported. Treatment of options and default values shall conform to the AIM.
3. Only those constructs specified in the AIM shall be produced or accepted by an implementation.
4. An implementation of ISO 10303 combines an application protocol with an implementation form. Such an implementation shall satisfy all general requirements applicable to the implementation form (given in the appropriate part of the 20-series class) and any AP-specific options given in annex C of the AP.

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<sup>13)</sup> The definition of a conformance class shall include a table indicating which constructs from the AIM shall appear in each conformance class.

Clause 6 of an AP shall reference the implementation specific requirements specified in annex D of that AP. This reference includes the correct use of the AIM mapped by the implementation form and conformance to the implementation form.

The conformance requirements shall be reviewed and evaluated by experts (application experts, implementation experts, and AP methods experts) who did not participate in the original development. These experts and WG6 shall assess the utility, practicality, understandability, and coverage provided by this clause of the AP. The results of this review shall be included in the **conformance requirements evaluation clause of the AP validation report**.

#### **4.6 Summary of application protocol validation**

The basic concept of AP validation is to ensure that the scope and information requirements are completely and unambiguously delivered in the AP. This requires that the scope, requirements, ARM, AIM, and conformance requirements are complete and consistent. The components of the AP shall be evaluated for their soundness and for their internal consistency. Each AP project shall develop and ensure the execution of an AP validation plan. The AP validation plan shall be reviewed with the **WG4 AP Guidelines and Framework Project and WG6 describe the usage scenarios, usage tests, target coverage of the ARM, AIM, and instantiation of the AIM for the validation, and the roles and responsibilities of each member of the AP team during the validation process**.

The AP validation plan and the resulting AP validation report shall be maintained by the AP project as a supporting document during the development of the AP. A well documented AP validation report is a useful reference for the AP project and reviewers of the AP while the AP is being developed. The completed AP validation report shall be submitted with the completed Draft AP for review and acceptance by the **WG4 Qualification Project Quality Committee**.

As part of the validation process it is essential to include the viewpoints of many individuals from the different disciplines that may use the AP. Suggested reviewers of the AP include:

- application experts to determine whether the AP comprehensively and unambiguously describes the application domain;
- experts in the modeling methodology used for the ARM to determine that the ARM is correctly specified;
- STEP experts to determine that the AP correctly uses the STEP specification;
- implementation experts to determine the utility and implementability of the AIM and any specified conformance classes.

A summary of the AP validation process for proposed APs is given below, followed by a more detailed description of the complete methodology:

1. Scope and requirements evaluation analyzes the completeness and correctness of the scope, requirements, and AAM.

2. ARM validation evaluates the completeness and correctness of the ARM's representation of the information requirements for the application area and correspondence to the scope and AAM.
3. AIM validation evaluates the completeness and correctness of the AIM's representation of the AP information requirements as specified by the ARM.
4. Conformance requirements evaluation analyzes the completeness of coverage, correctness, and self-consistency of these requirements with the ARM, AIM, and implementation requirements.
5. AP validation through simulated implementations via prototypes uses test implementations of the AP to evaluate the utility, correctness, and completeness of the AP.

Activity 1, scope and requirements evaluation, requires a team of experts from the subject application area to provide peer reviews of the scope, requirements, and AAM. The AP team shall conduct a walk-through and evaluation of these items by these experts. The majority of these expert reviewers should not have participated in the AP modelling effort. The objectives of this review are to ensure that: 1) the scope and requirements are accurate, viable, and complete to meet an important industrial need; 2) the AAM accurately represents all areas which are described by the refined scope statement, and 3) the documentation is sufficient, unambiguous, and conveys the correct meanings. Sample instances of **product models** and the concepts that the AP is intended to support are also used to verify the scope and requirements statement.

Activity 2, ARM validation, ensures that the ARM satisfies the stated scope and requirements of the AP, is consistent with the AAM, and is syntactically and semantically complete and correct. This activity uses experts from the subject application area to provide peer reviews of the ARM. The sample **product models, i.e., test models**, and the usage scenarios which were used to define the scope should be used to validate the ARM.

For an optimum model validation of the ARM, the reviewers should not be the same experts that participated in the development of the ARM. This portion of the process is manpower intensive. In the future it may be possible to use software tools to evaluate the ARM for completeness or correctness.

The ARM shall be reviewed manually to establish the validity of the semantics of the ARM. The ARM shall be reviewed to verify that the relationships between application objects are understandable and correct and that all required objects appear in the ARM. In addition, the ARM should be loaded into a software tool(s) to check consistency of the ARM and the completeness of the representation.

The definitions of all application objects and relationships shall be checked for completeness and understandability. The definitions shall be understandable to the prospective users of the AP. The users of the AP will include developers of STEP implementations and application experts. There shall be a definition for every element in the ARM. Some AP developers have been tempted to omit definitions of certain elements on the grounds that they are "self evident" or "standard terms". The problem with this approach is that what is self evident to one individual is not self evident to another. When this model validation is successfully completed, the AP team shall produce a summary report on the ARM validation.

Activity 3, AIM validation, involves the evaluation of the AIM and the specified implementation form(s) for the ability to carry all of the information requirements specified in the AP. This model validation shall check that all items of information defined in the ARM can be carried in the AP format as specified by the AIM and any implementation specific requirements. The objective is to ensure semantic correspondence between the ARM and the AIM. The ARM and the AIM shall be checked to verify that they truly correspond to each other. They shall be checked two ways:

- all ARM constructs map completely to one or many AIM constructs, and
- all AIM constructs map completely to one or many ARM construct.

An important aspect to check is that all the constraints modelled in the ARM are represented in the AIM. The AIM shall be successfully compiled on the EXPRESS compiler(s) designated by the ~~Qualification and Validation Project~~ **Quality Committee**. The results of the compilation(s) of the AIM shall be included in the AIM validation report. AIM validation shall require both application area experts and experts in the capabilities and use of STEP to generate populated test pieces and path traversals.

Activity 4, conformance requirements evaluation, analyzes the completeness of coverage, correctness, and consistency of these requirements with the ARM, AIM, and implementation requirements. The conformance requirements shall be checked to ensure that they meet industry needs and are useful, testable, and stated clearly. If conformance classes are also specified for the AP, the conformance classes are evaluated against these same criteria.

Activity 5, AP validation by developing and testing AP prototypes, is a recommended additional step for providing a higher level of confidence in the implementability and utility of the AP. The creation of a prototype requires AP developers to analyze the AP in ways that probably would not be considered in reviews of the AP. If a prototype is not developed it is essential that the AP validation efforts include the development of detailed usage scenarios and test cases to simulate validation checks that a prototype software development effort would produce.

The development and validation of a STEP AP is an iterative process of progressive detailing and refinement. Each step in this process provides critical feedback for the next version of the draft AP. While the AP validation effort is underway, new versions of the AP may be released during the review process. It is important to ensure that comments generated on previous versions of an AP are addressed by the new version of the AP.

#### **4.6.1 AP validation report**

The AP validation report documents: the AP validation process, the results of each validation activity, how these results were evaluated, and how all validation problems and errors were resolved. The AP validation report shall be developed in parallel with the development of the AP. The report shall include the following clauses:

- 1 Introduction;

- 2 AP validation plan;
- 3 Usage scenarios and usage tests;
- 34 Scope and requirements evaluation-report;
- 45 ARM validation-report;
- 56 Integrated resources interpretation-report;
- 67 AIM validation-report;
- 78 Conformance requirements evaluation-report

The AP validation report may include an additional clause on AP validation with prototype implementations and an annex describing sample test parts, usage scenarios, and success criteria used during the AP validation activities.

Clause 1 provides an overview of the validation process, problems identified and procedures used to resolve problems, issues, and errors. The Introduction shall also describe market assessments of industry needs for the AP and any metrics used to assess industry and application experts confidence in the results of the validation activities.

Clause 2 describes the AP validation plan and the resources and experts used to complete the validation. This clause may also document the relationships between each validation activity and how traceability between activities and results was maintained. Collaboration on validation activities with other STEP projects shall be documented in this clause.

Clause 3 describes the usage scenarios and usage tests. Each usage scenario shall describe a sequence of industry events which use some portion of the product data considered for inclusion in the scope of an application protocol. An IDEF0 representation for each usage scenario shall be included. This IDEF0 representation shall be a decomposition of the AAM for the AP. Each usage test shall specify a usage scenario, test model, test queries and verdict criteria for assessing an information model or an implementation of an AP.

Clause 34 describes the analysis performed to determine the accuracy and completeness of the AP's scope, functional requirements, and AAM. This analysis is based on the requirements from industry and the evaluations by industry and application experts.

Clause 45 describes the validation testing of the ARM. These tests verify the completeness and correctness of the information requirements modelled in the ARM and the ARM's correspondence to the scope and AAM. This clause shall document that each "in scope" information stream of the AAM is supported by the ARM. This clause shall describe the usage scenarios, example product representations, ARM test purposes, and verdict criteria used to validate the ARM.

Clause 56 records the interpretation of the integrated resources to meet the information requirements of the AP and the resolutions to problems identified during the interpretation process. This clause shall include sections of the AP's mapping tables and explanations necessary to clarify the rationale for selections from the integrated resources and modifications to the integrated resources.

Clause 67 describes the validation testing of the AIM. This validation ensures the correlation of the information requirements in the ARM to the constructs defined in the AIM and verifies that the AIM is complete and self-consistent. ~~This clause shall describe the usage scenarios, example product representations, AIM test purposes, and verdict criteria used to validate the AIM.~~ The results of the compilations of the AIM ~~and the identification of the software tools used~~ shall be included in this clause.

Clause 78 describes the assessment of the completeness of coverage, correctness, and self-consistency of the conformance requirements and any specified conformance classes with the information requirements, AIM, and implementation requirements.

During the development of the AP, the AP project may choose to distribute a subset of these clauses to selected reviewers. The AP validation report, with all relevant clauses completed, shall be submitted with the AP as part of each review by the ~~WG4 STEP Part Qualification and Validation Project~~ **Quality Committee**.

#### **4.7 Development of the abstract test suite**

A standardized abstract test suite (ATS) for each AP shall be developed by the AP developers and approved by SC4 as a separate ~~1200~~ **300** series Part of ISO 10303. The ATS is the complete set of abstract test cases embodying all ~~application element, i.e., application object and application assertion, test purposes, AIM test purposes and verdict criteria~~ necessary to perform conformance testing of AP implementations. ~~The development of the abstract test suite provides valuable feedback on the correctness, completeness and potential ambiguity of the AP. For this reason, AP projects should start the development of the abstract test suite in parallel with the validation of the AP.~~

Abstract test cases are independent of implementations and are used to produce comparable results from the conformance testing of different implementations. An executable test case is derived from an abstract test case in a form which allows it to be run on the implementation under test. Requirements on the structure and content of the ATS are provided in ISO 10303-33. *Guidelines for the development of STEP Abstract Test Suites* [1715] provides further information to enable the consistent development of the ~~1200~~ **300** series Parts of ISO 10303.

#### **4.8 Summary of the AP review and qualification process**

To produce quality application protocols requires cooperation by many organizations external to SC4 and close coordination among the SC4/WGs projects. The SC4-PMAG **Secretariat** monitors the progress of AP projects ~~and provides oversight coordination and resource allocation.~~ During the development of an AP, the ~~WG4 AIM Development Project and the WG4 STEP Part Qualification and Validation Project~~ **Quality Committee** shall provide technical advice and reviews for AP projects. The AP project shall

ensure timely meetings and reviews by these projects as the AP is developed. These should include discussions on requirements definition, modelling methods, and AP evaluation criteria.

The AP review and qualification process within SC4 is summarized below. Reviews by experts external to SC4, e.g., industry organizations and application experts, should be organized by the AP project at sufficient intervals to ensure that the AP meets the needs of international industries. Complete documentation of the AP qualification criteria is provided in the *STEP application protocol qualification manual* [11]. Complete documentation of the STEP Part qualification process and procedures is provided in the *STEP Part qualification procedures* [10].

1. AP qualification planning meeting of the ~~WG4 STEP Part Qualification and Validation Project (QVP)~~ **Quality Committee (QC)** and the AP project team to introduce the AP qualification process and to distribute relevant documents
2. **QVPQC** reviews and ~~approves~~ **comments on** the AAM, scope, ARM, UoFs, and information requirements documentation
3. WG4 AP Integration Project (APIP) reviews and evaluates ARM, UoFs, and information requirements
4. AIM Development Project (ADP) team ~~approves~~ **reviews and comments on the** ARM ~~and~~, UoFs **and information requirements**
5. ADP team reviews and accepts ARM to AIM mapping, integrated resources interpretation report, and AIM
6. **QVPQC** reviews and approves ARM to AIM mapping and AIM documentation
7. WG6 reviews and ~~approves~~ **comments on** conformance requirements and any conformance classes
8. AP team reviews and approves AP to Project Draft status. ~~The AP is approved by the convener of the parent WG to Release status and is then submitted~~ **and submits the AP for review and approval by QVPQC**
9. **QVPQC** leader conducts AP Qualification preview, i.e., assesses AP for gross errors
10. AP team resolves problems identified in 9 and distributes the updated AP to ~~QVPQC~~
11. **QVPQC** leader prepares for AP Qualification Workshops:
  1. Develop workshop plan and schedule
  2. Ensure AP conformance to ISO 10303 documentation requirements
  3. Review the AP issues log, AP validation report, and any technical discussions
12. Preliminary Qualification Workshop, conduct breadth and selected depth evaluations

13. ~~QVP~~QC leader prepares preliminary qualification report and assigns off-site qualification tasks
14. ~~QVP~~QC members conduct off-site qualification tasks
15. Final Qualification Workshop, discuss results of qualification tasks and additional work needed to successfully complete AP qualification
16. ~~QVP~~QC leader reviews the revised AP and after all outstanding ~~QVP~~ QC issues have been resolved, signs off on the AP as ready for review and approval by the appropriate WG conveners and the Editing Committee for distribution for committee draft ballot
17. ~~The WG4 Convener, the convener of the parent WG of the AP project, and the Editing Committee Chairman~~ conducts a final reviews of the AP and approve the AP for distribution for committee draft ballot

## 5 Process for approving a STEP application protocol

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After an AP is complete and has been approved by the WGs and the Editing Committee, the AP is submitted to the ~~PMAG~~ **SC4 Secretariat** for review and approval ~~as an ISO for distribution for committee draft (CD) ballot.~~ **The SC4 Secretariat will ensure that evidence of broad industry review and validation of the AP is provided with the submission of the AP and will perform quality checks on the components of the AP, as defined in the ISO directives and SC4 resolutions. If sufficient evidence of review and validation is not provided or if quality problems in the AP are identified, the SC4 Secretariat will require the problems to be resolved by the AP project before approving the document for distribution. Once the PMAG has approved the CD **After approving the document for distribution, the SC4 Secretariat distributes forwards the CD to the office of the ISO Chief Executive Officer for registration as a CD, and the SC4 Secretariat begins the ballot process for formal balloting.** The ballot is sent to all participating (P-member) and observing (O-member) SC4 member countries and also to Class A Liaison organizations. All recipients are asked for comments on the CD. Voting members of SC4 are asked to vote on the acceptance of the CD as a draft International Standard (DIS). ~~All voting P-members of SC4 have an obligation to reply. A minimum voting period of three~~ **four** months is prescribed ~~by ISO~~ **by SC4 resolutions on first CDs.** ~~In most cases, SC4 extends this voting period to four months.~~ Ballot comments are collected and summarized by the SC4 Secretariat.**

~~A team consisting of the SC4 Chairman, the PMAG Chairman, the Editing Committee Chairman, representatives of the responsible WGs, and the AP project leader review the ballot comments to determine the degree of consensus obtained and how to resolve the ballot comments. Based on this evaluation, a decision is made whether to:~~

- ~~a) discuss the CD and comments at the next SC4 meeting;~~
- ~~b) register the CD as a DIS, or~~
- ~~c) ask that a revised CD be prepared for circulation.~~

~~Within four weeks after the closing date for submission of replies, the SC4 Secretariat prepares the compilation of comments and arranges for the circulation to all P-members and O-members of SC4. When preparing this compilation, the SC4 Secretariat indicates its proposal, made in consultation with the SC4 chairman and, if necessary, the project leader, for proceeding with the project, either~~

- ~~a) to discuss the committee draft and comments at the next meeting, or~~
- ~~b) to circulate a revised committee draft for consideration, or~~
- ~~c) to register the committee draft for the enquiry stage~~

If, within two months from the date of dispatch, two or more P-members disagree with proposal b) or c) of the secretariat, the committee draft shall be discussed at an SC4 meeting.<sup>14)</sup>

Once the CD is approved by SC4 ballot and all ballot comments are resolved, the SC4 Secretariat submits the AP to ISO for formal registration as an enquiry draft, i.e., DIS. The ISO Central Secretariat distributes circulates the AP to all national bodies of ISO with a formal ballot on the approval of the DIS as an Final Draft International Standard. All national bodies have an obligation to reply. A six five month voting period is prescribed. Ballot comments are returned to SC4 the ISO Central Secretariat. The Central Secretariat sends the comments to the SC4 Secretariat.

On receipt of the results of the voting and any comments, the SC4 chairman, in cooperation with the SC4 Secretariat and, if necessary, the project leader, and in consultation with the ISO Chief Executive Officer, decides on one of the following courses of action:

- a) when a two-thirds majority of the votes cast by P-members of SC4 are in favor, not more than one-quarter of the total votes cast are negative and consensus is reached, to register the enquiry draft as a Final Draft International Standard, or
- b) when the above approval criteria are not met:
  - 1) to circulate a revised enquiry draft, i.e., a second DIS, for voting, or
  - 2) to circulate a revised committee draft for comments, or
  - 3) to discuss the enquiry draft at the next meeting.<sup>15)</sup>

The DIS is approved as International Standard if a two-thirds majority of the votes are positive, and if not more than one quarter of the total number of votes are negative. The last ballot is a two month ballot on the Final Draft International Standard (FDIS) for final proof review. Any technical comments received from the FDIS ballot are for information only. Additional details on this process are provided in the ISO TC184/SC4 Reference Manual [14] clause 2 of the ISO/IEC Directives Part 1: Procedures for the technical work.

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<sup>14)</sup> ISO/IEC Directives Part 1, 2.5.3

<sup>15)</sup> ISO/IEC Directives Part 1, 2.6.4

## **Annex A**

### **Application protocol planning project proposals**

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#### **A.1 AP planning project proposal**

An application protocol planning project proposal shall be submitted to the ~~PMAG AP Coordinator~~ **SC4 Secretariat** for review and approval by ~~the PMAG~~ **SC4**. An AP planning project provides an international forum for defining the scopes and requirements of specific AP projects. The AP planning project provides oversight and coordination for AP projects within its application domain. The AP planning project proposal shall include:

1. Application protocol planning project title:
2. Date of submitting the proposal to ~~the SC4 PMAG~~:
3. Nominator (ISO TC184/SC4 member body or liaison):
4. Proposal advocate:
  - Organization:
  - Mail address:
  - Telephone:
  - Facsimile:
  - Electronic mail:
5. Scope of the AP planning project:
6. Application activity model:
7. Evidence of industry need for APs in this domain:
8. Overlap and relationships to other APs or AP planning projects:
9. Required resource schemas:
10. Current participants and committed human resources for the AP planning project:
11. Schedule for delivery of AP project proposals with existing resources:

## A.2 Explanations of AP planning project proposal questions

1. AP planning project title: Provide the title for the application protocol (AP) planning project. The title shall clearly and succinctly state the domain.
2. Date of submission: Provide the date of submission of the proposal to the AP Coordinator of the SC4 ~~Project Management Advisory Group (PMAG)~~ Secretariat.
3. Nominator: Provide the name of the ISO TC184/SC4 member body or liaison who is sponsoring this AP Planning Project within ISO. Include the names of the supporting National Standardization Bodies.
4. Proposal advocate: Provide the name and location of the proposal proponent and positions (if any) in ISO committees. Furnish organization name to division level, postal address, telephone number, facsimile number, and electronic mail address.
5. Scope: State the domain of discourse of the AP planning project, i.e., type(s) of product, application tasks, discipline views, types of product data, and stages of the product life cycle included. Indicate whether considered within the scope of approved SC4 work items. If not in the scope of approved SC4 work items, list P-member countries that are committed to participating in the project.
6. AAM: Provide the application activity model (AAM) which defines the application context, information flows, and processes of the industry applications that will be investigated by the project. "In scope" and "out of scope" information flows shall be identified. Definitions of all objects on the AAM shall be provided.
7. Industry need: Furnish evidence of international industrial need or potential for APs in this domain. This may include conclusive international trade assessments, e.g., international auto industry; large national government program requirements, e.g., CALS; international program requirements, e.g., EC M-IT-04; breadth of industry participation in the planning project; and funding allocated to support this project.
8. Overlap with other APs or AP planning projects: Define the overlaps and relationships between this AP planning project's scope and requirements and those of other APs or AP planning projects.
9. Resource schemas: List which integrated resource schemas are targeted to support APs in this application domain?

10. Participants and plan: State the level of effort currently devoted to this AP planning project and the breadth of international expertise assigned to this project. List the individuals and the companies that will work on this AP. How many manhours per year are assigned to working on the project outside of ISO committee meetings?
- List the vendors of computer-aided tools and information systems that will participate in defining the APs and in reviewing the output of this project. List the industry associations and other groups of application experts that will participate in defining the APs and in reviewing the output of this project.
- Provide a summary of the plan for identifying the customers of the potential APs, assessing the market demand for these APs, completing an AP planning model, defining the potential APs' scope boundaries, and establishing broader industrial participation and consensus on these results.
11. Schedule: State the schedule for delivery of AP project proposals to ~~the PMAG SC4~~ with the current level of committed resources. AP planning projects shall provide a status report to ~~PMAG SC4~~ within 6 months. At least one AP project proposal shall be submitted within one year from approval of the planning project. If no proposal is submitted within one year, ~~the PMAG SC4~~ shall review the viability of the planning project and consider canceling the planning project.

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**~~A.3 AP project proposal~~**

**~~A.4 Explanations of AP project proposal questions~~**

## **Annex B**

### **Application protocol development schedule**

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As an aid to planning the schedule and human resource requirements for developing a STEP application protocol, this annex provides a template schedule with estimated resource requirements. Any estimation of the time and human resources required for developing a specific AP is dependent upon numerous variables, some of which are: the maturity, stability, and scope of the application; the skills and abilities to work as a team of AP development project members; the availability and participation of application domain experts; the completeness and stability of the required Integrated Resources; and the availability of reliable tools for developing, validating, and documenting the AP.

The included AP development schedule presumes:

- 1) the application domain is well understood, with common product data and task descriptions used internationally;
- 2) the scope of the AP matches the boundaries of commonly used CAx applications;
- 3) stable standards are available for the definition of the application elements and the development of the ARM;
- 4) a sufficient mix of application domain experts, e.g., technical experts from the relevant industries, participate in defining and reviewing components of the AP;
- 5) the AP development project members understand the STEP architecture, the STEP methods, e.g., EXPRESS, and the AP development process;
- 6) a lack of integrated tools for developing and documenting the AP; and
- 7) the AP will not require new schemas to be added to the Integrated Resources.

This schedule does not include resources for developing prototypes of the AP, and it does not include the time and resources required for developing the AP's abstract test suite (ATS). Each AP project shall produce an ATS. The AP development schedule should only be used as a starting point for defining the schedule and human resource requirements for a specific AP development project.

+ = Requires Industry Participation

**Figure B-1: AP Schedule Template, Part 1 of 2**

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**Figure B-1: AP Schedule Template, Part 2 of 2**

+ = Requires Industry Participation

## Annex C

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