

**Industrial automation systems and integration —  
Product data representation and exchange —  
Part 238:  
Application protocol: Application interpreted model for  
computerized numerical controllers**

**CHANGES FOR EDITION TWO**

This document describes specific changes for the second edition of ISO 10303-238 based on experience accumulated from deployment of the standard in the period 2007-2016.

***Introduction***

*This Technical Corrigendum corrects ISO 10303-238:2007, Industrial automation systems and integration — Product data representation and exchange — Part 238: Application protocol: Application interpreted model for computerized numerical controllers.*

*The purpose of the modifications to the text of ISO 10303-238:2007 is to allow via point representations for toolpaths to better support high-speed milling operations, permit more detailed representation of tool contact area to better support speed and feed optimization for machining operations, clarify the placement of tool product models for simulation and collision checking, simplify the handling of in-process geometry, correct typographical errors and clarify descriptions in the document, and to replace the object identifier for the document and the applicable schema.*

## ***Modifications to the text of ISO 10303-238:2007***

### ***Page 15, 4.1.5***

*The purpose of this change is to replace In\_process\_geometry application object and separate references on Machining\_workingstep, Turning\_workingstep, and Workplan with references from Executable to as-is, to-be, and removal Workpiece objects. Delete the following line from the list of application objects, and the following list of application objects with additional information requirements on page 17.*

— In\_process\_geometry;

### ***Page 63, 4.2.94***

*The purpose of this change is to extend the definition for Cutter\_contact\_trajectory to permit the orientation of asymmetric tools to be described by augmenting the tool axis curve with a reference direction curve. This is analogous to the way in which ISO 10303 geometry placements are described using an axis direction as well as a reference direction. Replace clause 4.2.94 with the following:*

## **4.2.94 Cutter\_contact\_trajectory**

The Cutter\_contact\_trajectory application object is defined by clause 4.8 of ISO 14649-10:2004. This part of ISO 10303 adds the following information requirements.

The data associated with a Cutter\_contact\_trajectory are the following:

- all of the data defined by ISO 14649-10, as modified below for the its\_toolaxis attributes;
- its\_toolref\_direction;
- path\_maximum\_deviation;
- tool\_axis\_maximum\_deviation.

See 5.2.1.6.1 for additional discussion on the curve parameterization requirements defined by ISO 14649 on the basiccurve, its\_toolaxis, and its\_toolref\_direction data associated with a Cutter\_contact\_trajectory.

**NOTE** The ISO 14649 EXPRESS description for Cutter\_contact\_trajectory, as adapted by this part of ISO 10303, is shown below. Refer to ISO 14649-10 for the original definition and explanation of usage.

```
ENTITY cutter_contact_trajectory
  SUBTYPE OF (trajectory);
  basiccurve:                curve_with_surface_normal;
  its_toolaxis:               OPTIONAL bounded_curve;
  its_toolref_direction:      OPTIONAL bounded_curve;      -- ADDED BY 10303-238
  its_contact_type:           OPTIONAL contact_type;
  path_maximum_deviation:     OPTIONAL length_measure;     -- ADDED BY 10303-238
  tool_axis_maximum_deviation: OPTIONAL plane_angle_measure;-- ADDED BY 10303-238
END_ENTITY;

TYPE curve_with_surface_normal = SELECT (bounded_pcurve, curve_with_normal_vector);
```

```
END_TYPE;

TYPE contact_type = ENUMERATION OF (side, front);
END_TYPE;
```

## Page 65, 4.2.94

*The purpose of this change is to extend the definition for Cutter\_contact\_trajectory to permit the orientation of asymmetric tools to be described by augmenting the tool axis curve with a reference direction curve. Insert the following after clause 4.2.94.1 and renumber the following clauses:*

### 4.2.94.2 its\_toolref\_direction

The its\_toolref\_direction specifies the orientation of an asymmetric tool measured in the plane defined by the its\_toolaxis data. This is specified as a three-dimensional curve specifying IJK direction components at each point along the Cutter\_contact\_trajectory. The curve shall obey the same parameterization constraints as the “its\_toolaxis” data. The its\_toolref\_direction need not be specified for a particular Cutter\_contact\_trajectory.

## Page 65, 4.2.95

*The purpose of this change is to extend the definition for Cutter\_location\_trajectory to permit the orientation of asymmetric tools to be described by augmenting the tool axis curve with a reference direction curve. This is analogous to the way in which ISO 10303 geometry placements are described using an axis direction as well as a reference direction. Replace clause 4.2.94 with the following:*

### 4.2.95 Cutter\_location\_trajectory

The Cutter\_location\_trajectory application object is defined by clause 4.8 of ISO 14649-10:2004. This part of ISO 10303 adds the following information requirements.

The data associated with a Cutter\_location\_trajectory are the following:

- all of the data defined by ISO 14649-10, as modified below for the surface\_normal attribute;
- its\_toolref\_direction;
- path\_maximum\_deviation;
- tool\_axis\_maximum\_deviation.

See 5.2.1.6.1 for additional discussion on the curve parameterization requirements defined by ISO 14649 on the basiccurve, its\_toolaxis, and surface\_normal data associated with a Cutter\_location\_trajectory.

NOTE The ISO 14649 EXPRESS description for Cutter\_location\_trajectory, as adapted by this part of ISO 10303, is shown below. Refer to ISO 14649-10 for the original definition and explanation of usage.

```
ENTITY cutter_location_trajectory
  SUBTYPE OF (trajectory);
```

```

basiccurve:                bounded_curve;
its_toolaxis:              OPTIONAL bounded_curve;
its_toolref_direction:     OPTIONAL bounded_curve;    -- ADDED BY 10303-238
surface_normal:            OPTIONAL bounded_curve;
path_maximum_deviation:    OPTIONAL length_measure;   -- ADDED BY 10303-238
tool_axis_maximum_deviation: OPTIONAL plane_angle_measure;-- ADDED BY 10303-238
END_ENTITY;

```

## Page 66, 4.2.95

*The purpose of this change is to extend the definition for Cutter\_location\_trajectory to permit the orientation of asymmetric tools to be described by augmenting the tool axis curve with a reference direction curve. Insert the following as clause 4.2.94.1 and renumber the following clauses:*

### 4.2.95.1 its\_toolref\_direction

The its\_toolref\_direction specifies the orientation of an asymmetric tool measured in the plane defined by the its\_toolaxis data. This is specified as a three-dimensional curve specifying IJK direction components at each point along the Cutter\_location\_trajectory. The curve shall obey the same parameterization constraints as the “its\_toolaxis” data. The its\_toolref\_direction need not be specified for a particular Cutter\_location\_trajectory.

## Page 67, 4.2.100

*The purpose of this change is to modify the definition for Datum to clarify the relationship between a Datum and the Workpiece on which the Datum appears, in a manner analogous to the its\_workpiece data that relates a Manufacturing\_feature to the Workpiece on which the Manufacturing\_feature appears. Add the following at the end of clause 4.2.100.*

The data associated with a Datum are the following:

— its\_workpiece.

### 4.2.100.1 its\_workpiece

The its\_workpiece specifies the Workpiece on which the Datum is defined.

## Page 70, 4.2.105

*The purpose of this change is to modify the definition for Datum\_target to clarify the relationship between a Datum\_target and the Workpiece on which the Datum\_target appears, in a manner analogous to the its\_workpiece data that relates a Manufacturing\_feature to the Workpiece on which the Manufacturing\_feature appears. Replace the list at the end of clause 4.2.105 with the following:*

The data associated with a Datum\_target are the following:

— identifier;

— its\_workpiece.

**Page 70, 4.2.105**

*The purpose of this change is to modify the definition for Datum\_target to clarify the relationship between a Datum\_target and the Workpiece on which the Datum\_target appears, as described above. Insert the following after clause 4.2.105.1:*

**4.2.105.2 its\_workpiece**

The its\_workpiece specifies the Workpiece on which the Datum\_target is defined.

**Page 76, 4.2.123**

*The purpose of this change is to extend the in-process description of the manufactured product information to any executable, and to extend the description to permit the full range of product properties, such as features and tolerances, to be specified, in addition to the geometry and topology. This replaces the In\_process\_geometry application object and separate references on Machining\_workingstep, Turning\_workingstep, and Workplan. This change also extends the definition of Executable to permit objects to be marked as enabled or disabled. Replace clause 4.2.168 with the following:*

**4.2.123 Executable**

The Executable application object is defined by clause 4.6 of ISO 14649-10:2004. This part of ISO 10303 adds the following information requirements.

NOTE 1 The modifications below extend the ISO 14649 In\_process\_geometry concept to allow the specification of in-process shape, features, and other product properties for any Executable. The shape\_representation is specified using the workpiece.its\_geometry. In particular, the integrated representation allows the use of shapes described by AIC 501 (edge-based wireframe), AIC 502 (shell-based wireframe), AIC 507 (geometrically-bounded surfaces), AIC 508 (non-manifold surfaces), AIC 509 (manifold surfaces), AIC 510 (geometrically-bounded wireframe), and AIC 512 (faceted brep), as well as the AIC 514 (advanced brep) descriptions originally supported by ISO 14649.

The data associated with an Executable are the following:

- all of the data defined by ISO 14649-10;
- as\_is;
- enabled;
- fixture;
- removal;
- to\_be.

NOTE 2 The ISO 14649 EXPRESS description for Executable, as adapted by this part of ISO 10303, is shown below. Refer to ISO 14649-10 for the complete definition and explanation of usage.

```
ENTITY executable
  ABSTRACT SUPERTYPE OF (ONEOF( workingstep, nc_function, program_structure));
  its_id: identifier;
  as_is:   OPTIONAL workpiece;    -- ADDED BY 10303-238
  enabled: OPTIONAL BOOLEAN;      -- ADDED BY 10303-238
  fixture: OPTIONAL workpiece;    -- ADDED BY 10303-238
  removal: OPTIONAL workpiece;    -- ADDED BY 10303-238
  to_be:   OPTIONAL workpiece;    -- ADDED BY 10303-238
END_ENTITY;
```

#### 4.2.123.1 as\_is

The as\_is specifies a Workpiece which describes the shape and other properties of the manufactured product before the Executable is executed. The as\_is need not be specified for a particular Executable. See 4.3.16 for the application assertion.

#### 4.2.123.2 enabled

The enabled specifies whether the Executable is executed or ignored when processing the elements of a machining project. The Executable is executed if enabled is true or not specified, and ignored if enabled is false. The enabled need not be specified for a particular Executable.

#### 4.2.123.3 fixture

The fixture specifies a Workpiece which describes the shape and other properties of the fixture that assists in the holding or positioning of the manufactured product for the Executable. The fixture need not be specified for a particular Executable. See 4.3.17 for the application assertion.

#### 4.2.123.4 removal

The removal specifies a Workpiece which describes the shape and other properties of the material removed from the manufactured product by the Executable. The removal need not be specified for a particular Executable. See 4.3.18 for the application assertion.

#### 4.2.123.5 to\_be

The to\_be specifies a Workpiece which describes the predicted shape and other properties of the manufactured product after the Executable is executed. The to\_be need not be specified for a particular Executable. See 4.3.19 for the application assertion.

### ***Page 93, 4.2.168***

*The purpose of this change is to replace In\_process\_geometry application object and separate references on Machining\_workingstep, Turning\_workingstep, and Workplan with references from Executable to as-is, to-be, and removal Workpiece objects. Delete clause 4.2.168.*

### ***Page 98, 4.2.180.1***

*The purpose of this change is to correct grammar and misspelled words. In both list items, replace “vaue” with “value”. In the last list item, replace “the the” with “the” and replace “;” with “.” at the end of the list item.*

**Page 107, 4.2.194.1**

*The purpose of this change is to correct grammar. In the first sentence of the NOTE, replace “the the” with “the”.*

**Page 108, 4.2.197**

*The purpose of this change is to replace In\_process\_geometry application object and separate references on Machining\_workingstep, Turning\_workingstep, and Workplan with references from Executable to as-is, to-be, and removal Workpiece objects. Replace 4.2.197 with the following. Retain 4.2.197.1 and 4.2.197.2 with no changes.*

**4.2.197 Machining\_workingstep**

The Machining\_workingstep application object is defined by clause 4.6 of ISO 14649-10:2004. This part of ISO 10303 adds the following information requirements.

NOTE 1 The In\_process\_geometry concept referenced by Machining\_workingstep.its\_effect in ISO 14649 is replaced by as-is, to-be, and removal properties associated with the Executable application object.

The data associated with a Machining\_workingstep are the following:

- all of the data defined by ISO 14649-10, except for its\_effect;
- final\_features;
- toolpath\_placement.

NOTE 2 The ISO 14649 EXPRESS description for Machining\_workingstep, as adapted by this part of ISO 10303, is shown below. Refer to ISO 14649-10 for the original definition and explanation of usage.

```
ENTITY machining_workingstep
  SUBTYPE OF (workingstep);
  its_feature:      manufacturing_feature;
  its_operation:    machining_operation;
  -- its_effect:    OPTIONAL in_process_geometry;          -- REPLACED BY 10303-238
  final_features:   OPTIONAL SET [0:?] OF Manufacturing_feature; -- ADDED BY 10303-238
  toolpath_orientation: OPTIONAL axis2_placement_3d;      -- ADDED BY 10303-238
END_ENTITY;
```

**Page 129, 4.2.255.1**

*The purpose of this change is to correct grammar. In the second sentence of the first paragraph, replace “the the” with “the”.*

**Page 143, 4.2.295.1**

*The purpose of this change is to correct grammar. In the second sentence of the first paragraph, replace “the the” with “the”.*

### **Page 169, 4.2.370**

*The purpose of this change is to modify the definition for Tool\_usage to clarify how the tool product model is oriented with respect to toolpaths and machine models for simulation and interference checking. Add the following at the end of clause 4.2.370.*

- gage\_placement;
- tool\_end\_placement.

### **Page 170, 4.2.370**

*The purpose of this change is to modify the definition for Tool\_usage to clarify how the tool product model is oriented with respect to toolpaths and machine models for simulation and interference checking. Add the following after clause 4.2.370.5.*

#### **4.2.370.6 gage\_placement**

The gage\_placement specifies the location on the its\_product tool model where the tool is mounted on a machine. The gage\_placement need not be specified for a particular Tool\_usage. If the gage\_placement is not specified, the location shall be on the tool axis given by the tool\_end\_placement at the distance from the origin given by the overall assembly length of the referencing Machining\_tool.

#### **4.2.370.6 tool\_end\_placement**

The tool\_end\_placement specifies the location on the its\_product tool model of the tool end point. The axis parameter of the tool\_end\_placement indicates the tool axis. The tool\_end\_placement need not be specified for a particular Tool\_usage. If the tool\_end\_placement is not specified, the location shall be the origin of the its\_product tool model.

### **Page 173, 4.2.377**

*The purpose of this change is to modify the definition for touch\_probe so that it becomes a type of machining\_tool, to support a description of the probe usage, associated geometric shape, and other product information available for other types of tool. Replace clause 4.2.377 with the following.*

#### **4.2.377 Touch\_probe**

A Touch\_probe is a type of Machining\_tool (see 4.2.196) which identifies a inspection tool used to measure a workpiece.

NOTE This part of ISO 10303 modifies the definition of Touch\_probe in clause 4.6 of ISO 14649-10 to be a type of Machining\_tool so that Tool\_usage information can be associated with it. The EXPRESS description for Touch\_probe, as adapted by this part of ISO 10303, is shown below.

```
ENTITY touch_probe
  SUBTYPE OF (machining_tool);    -- ADDED BY 10303-238
  -- its_id: identifier;    -- now inherited from machining_tool
END_ENTITY;
```



**Page 173, 4.2.379**

*The purpose of this change is to add cross\_section\_area\_parameters to permit a more detailed representation of tool contact area than the depth and overcut parameters can provide to better support speed and feed optimization for machining operations. Replace clause 4.2.379 with the following. Add Figure 34 to List of figures and renumber subsequent figures.*

**4.2.379 Trajectory**

The Trajectory application object is defined by clause 4.8 of ISO 14649-10:2004. This part of ISO 10303 adds the following information requirements.

The data associated with a Trajectory are the following:

- all of the data defined by ISO 14649-10;
- its\_material\_removal\_depth;
- its\_material\_removal\_overcut;
- its\_material\_removal\_total\_volume;
- cross\_section\_area\_parameters.

NOTE The ISO 14649 EXPRESS description for Trajectory, as adapted by this part of ISO 10303, is shown below. Refer to ISO 14649-10 for the complete definition and explanation of usage.

```

ENTITY trajectory
  ABSTRACT SUPERTYPE OF (ONEOF(cutter_location_trajectory, cutter_contact_trajectory,
    axis_trajectory))
  SUBTYPE OF (toolpath);
  its_direction:          OPTIONAL BOOLEAN;
  its_material_removal_depth:  OPTIONAL material_removal_measure; -- ADDED BY 10303-238
  its_material_removal_overcut: OPTIONAL material_removal_measure; -- ADDED BY 10303-238
  its_material_removal_total_volume: OPTIONAL volume_measure;      -- ADDED BY 10303-238
  cross_section_area_parameters:  OPTIONAL bounded_curve;          -- ADDED BY TC1
END_ENTITY;

TYPE material_removal_curve = bounded_curve; END_TYPE;
TYPE material_removal_measure = SELECT (
  length_measure,
  material_removal_curve
);
END_TYPE;

```

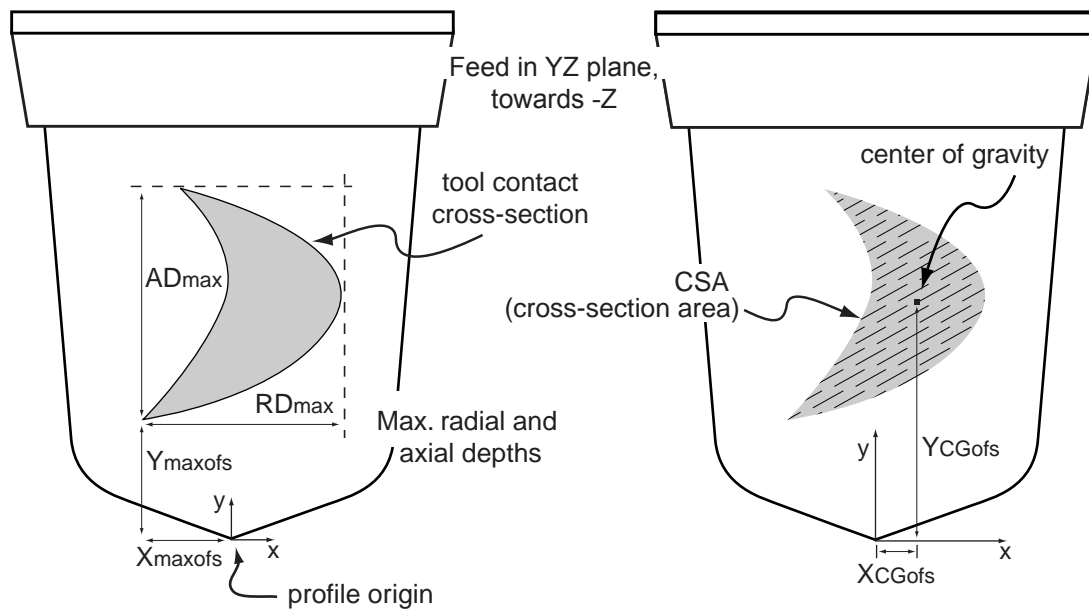
**Page 174, 4.2.379**

*The purpose of this change is to add cross\_section\_area\_parameters to permit a more detailed representation of tool contact area than the depth and overcut parameters can provide to better support speed and feed optimization for machining operations. Insert clause 4.2.379.4 after 4.2.379.3. Add Figure 34 and Figure 35 to List of figures and renumber subsequent figures.*

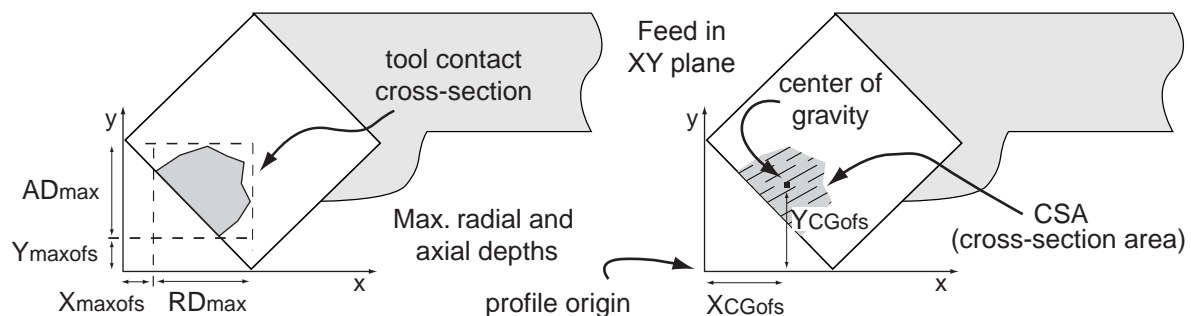
#### 4.2.379.4 cross\_section\_area\_parameters

The `cross_section_area_parameters` specifies the area of material removed at each point of the Trajectory as measured perpendicular to the axis of the cutting tool. This is specified as a seven-dimensional curve specifying the cross section at each point along the toolpath. The curve shall obey the same parameterization constraints as the “`its_speed`” data associated with a Toolpath (See 4.2.371). The `cross_section_area_parameters` need not be specified for a particular Trajectory.

Each point in the seven-dimensional curve shall describe the cross-section area parameters illustrated in Figure 34 and Figure 35. These parameters are as follows:



**Figure 34 - Cross-section parameters for milling**



**Figure 35 - Cross-section parameters for turning**

- dimension 0 shall describe the maximum axial depth of the tool contact cross section, shown by  $AD_{max}$  in Figure 34 and Figure 35. The maximum axial depth for milling shall be measured par-

allel to the tool axis, regardless of whether the direction of feed is perpendicular to the tool axis. The maximum axial depth for turning shall be measured parallel to the spindle axis;

- dimension 1 shall describe the maximum radial depth of the tool contact cross section, shown by RDmax in Figure 34 and Figure 35. The maximum radial depth shall be measured perpendicular to both the tool axis and the feed direction;
- dimension 2 shall describe the location along the X axis where the maximum radial depth measure is located, shown by Xmaxofs in Figure 34 and Figure 35;
- dimension 3 shall describe the location along the Y axis where the maximum axial depth measure is located, shown by Ymaxofs in Figure 34 and Figure 35;
- dimension 4 shall describe the total area of the tool contact cross section in the X-Y plane, shown by CSA in Figure 34 and Figure 35;
- dimension 5 shall describe the location along the X axis of the centre of gravity of the tool contact cross section, shown by XCGofs in Figure 34 and Figure 35;
- dimension 6 shall describe the location along the Y axis of the centre of gravity of the tool contact cross section, shown by YCGofs in Figure 34 and Figure 35.

### **Page 178, 4.2.389**

*The purpose of this change is to replace In\_process\_geometry application object and separate references on Machining\_workingstep, Turning\_workingstep, and Workplan with references from Executable to as-is, to-be, and removal Workpiece objects. Replace 4.2.389 with the following.*

### **4.2.389 Turning\_workingstep**

The Turning\_workingstep application object is defined by clause 4.3 of ISO 14649-12:2005. This part of ISO 10303 adds the following information requirements.

NOTE 1 The In\_process\_geometry concept referenced by Turning\_workingstep.its\_effect in ISO 14649 is replaced by as-is, to-be, and removal properties associated with the Executable application object.

The data associated with a Turning\_workingstep are the following:

- all of the data defined by ISO 14649-12, except for its\_effect;

NOTE 2 The ISO 14649 EXPRESS description for Turning\_workingstep, as adapted by this part of ISO 10303, is shown below. Refer to ISO 14649-12 for the original definition and explanation of usage.

```
ENTITY turning_workingstep
  SUBTYPE OF (workingstep);
  its_features:      LIST [2:?] OF manufacturing_feature;
  its_operation:     turning_machining_operation;
  -- its_effect:     OPTIONAL in_process_geometry;           -- REPLACED BY 10303-238
END_ENTITY;
```

### **Page 182, 4.2.399.5**

*The purpose of this change is to correct grammar. In the first sentence of the NOTE, replace “the the” with “the”.*

### **Page 194, 4.2.417**

*The purpose of this change is to replace In\_process\_geometry application object and separate references on Machining\_workingstep, Turning\_workingstep, and Workplan with references from Executable to as-is, to-be, and removal Workpiece objects. This change also adds the toolpath\_orientation to allow reuse of nested workplans or workingsteps in different locations. Replace 4.2.417 with the following. Retain 4.2.417.1 with no changes.*

## **4.2.417 Workplan**

The Workplan application object is defined by clause 4.6 of ISO 14649-10:2004. This part of ISO 10303 adds the following information requirements.

NOTE 1 The In\_process\_geometry concept referenced by Workplan.its\_effect in ISO 14649 is replaced by as-is, to-be, and removal properties associated with the Executable application object.

The data associated with a Workplan are the following:

- all of the data defined by ISO 14649-10, except for its\_effect;
- its\_minimum\_machine\_params;
- toolpath\_orientation.

NOTE 2 The ISO 14649 EXPRESS description for Workplan, as adapted by this part of ISO 10303, is shown below. Refer to ISO 14649-10 for the original definition and explanation of usage.

```
ENTITY workplan
  SUBTYPE OF (program_structure);
  its_elements:          LIST[0:?] OF executable;
  its_channel:           OPTIONAL channel;
  its_setup:             OPTIONAL setup;
  -- its_effect:         OPTIONAL in_process_geometry;          -- REPLACED BY 10303-238
  its_minimum_machine_params:  OPTIONAL machine_parameters;    -- ADDED BY 10303-238
  toolpath_orientation:  OPTIONAL axis2_placement_3d; -- ADDED BY 10303-238
WHERE
  WR1: SIZEOF(QUERY(it <* its_elements | it = SELF)) = 0;
END_ENTITY;
```

### **Page 194, 4.2.417**

*The purpose of this change is to add the toolpath\_orientation to Workplan allow reuse of nested workplans or workingsteps in different locations. Add the following after 4.2.417.1.*

## **4.2.417.2 toolpath\_orientation**

The toolpath\_orientation specifies the placement of the set of toolpaths associated with the Executables given by the its\_elements parameter. The toolpath\_orientation need not be specified for a particular

Workplan. The placement shall be applied cumulatively in addition to toolpath\_orientations specified by nested Workplan or Machining\_workinstep executables. If the toolpath\_orientation is not specified, the toolpaths shall assume an origin of (0,0,0) and axis directions X=(1,0,0) Y=(0,1,0) and Z=(0,0,1).

### ***Page 196, 4.3***

*The purpose of this change is to add application assertions for the relationship between Datum and Workpiece. Insert the following new subclauses after 4.3.12.*

#### **4.3.13 Datum to Workpiece**

Each Datum references exactly one Workpiece object as its\_workpiece. Each Workpiece acts as its\_workpiece for zero or more Datum objects.

### ***Page 196, 4.3***

*The purpose of this change is to add application assertions for the relationship between Datum\_target and Workpiece, and to add application assertions for the as-is, fixture, removal, and to-be relationships between Executable and Workpiece. Insert the following new subclauses after 4.3.13 (which is renumbered as 4.3.14 by the insertion described above)*

#### **4.3.15 Datum\_target to Workpiece**

Each Datum\_target references exactly one Workpiece object as its\_workpiece. Each Workpiece acts as its\_workpiece for zero or more Datum\_target objects.

#### **4.3.16 Executable to Workpiece (as as\_is)**

Each Executable references at most one Workpiece object as as\_is. Each Workpiece acts as as\_is for zero or more Executable objects.

#### **4.3.17 Executable to Workpiece (as fixture)**

Each Executable references at most one Workpiece object as fixture. Each Workpiece acts as removal for zero or more Executable objects.

#### **4.3.18 Executable to Workpiece (as removal)**

Each Executable references at most one Workpiece object as removal. Each Workpiece acts as removal for zero or more Executable objects.

#### **4.3.19 Executable to Workpiece (as to\_be)**

Each Executable references at most one Workpiece object as to\_be. Each Workpiece acts as to\_be for zero or more Executable objects.

**Page 424, Table 5**

*The purpose of this change is to replace In\_process\_geometry application object with references from Executable to as-is, to-be, fixture, and removal Workpiece objects. Insert the following entry to Table 5 after EXECUTABLE its\_id.*

executable to workpiece (as as_is)	PATH			<pre> machining_process_executable &lt;=   action_method &lt;-     action.chosen_method   { action.name = 'as-is shape' }   action =&gt;     product_definition_process &lt;-     process_product_association.process     process_product_association     process_product_association.defined_product -&gt;     characterized_product_definition     characterized_product_definition = product_definition     product_definition </pre>
<p>enabled</p> <p>#1: if value is true (mapping may also be omitted if value is true)</p> <p>#2: if value is false</p>	descriptive_representation_item	10303-45		<pre> machining_process_executable &lt;=   action_method   characterized_action_definition = action_method   characterized_action_definition &lt;-     action_property.definition   { action_property.name = 'enabled' }   action_property &lt;-     action_property_representation.property     action_property_representation     action_property_representation.representation -&gt;     representation     representation.items[i] -&gt;     representation_item =&gt;     descriptive_representation_item     descriptive_representation_item.description   {#1: (descriptive_representation_item.description = 'enabled' )   #2: (descriptive_representation_item.description = 'disabled')} </pre>
executable to workpiece (as fixture)	PATH			<pre> machining_process_executable &lt;=   action_method &lt;-     action.chosen_method   { action.name = 'fixture shape' }   action =&gt;     product_definition_process &lt;-     process_product_association.process     process_product_association     process_product_association.defined_product -&gt;     characterized_product_definition     characterized_product_definition = product_definition     product_definition </pre>

executable to workpiece (as removal)	PATH			<pre> machining_process_executable &lt;=   action_method &lt;-     action.chosen_method   { action.name = 'removal shape' }   action =&gt;     product_definition_process &lt;-       process_product_association.process     process_product_association     process_product_association.defined_product -&gt;       characterized_product_definition     characterized_product_definition = product_definition       product_definition </pre>
executable to workpiece (as to_be)	PATH			<pre> machining_process_executable &lt;=   action_method &lt;-     action.chosen_method   { action.name = 'to-be shape' }   action =&gt;     product_definition_process &lt;-       process_product_association.process     process_product_association     process_product_association.defined_product -&gt;       characterized_product_definition     characterized_product_definition = product_definition       product_definition </pre>

**Page 427, Table 5**

*The purpose of this change is to replace In\_process\_geometry application object and separate references on Machining\_workingstep, Turning\_workingstep, and Workplan with references from Executable to as-is, to-be, and removal Workpiece objects. Delete the table entry for IN\_PROCESS\_GEOMETRY and subsequent table entries for as\_is, to\_be, and removal.*

**Page 443, Table 5**

*The purpose of this change is to replace In\_process\_geometry application object and separate references on Machining\_workingstep, Turning\_workingstep, and Workplan with references from Executable to as-is, to-be, and removal Workpiece objects. Delete table entry “machining\_workingstep to in\_process\_geometry (as its\_effect)”*

**Page 456, Table 5**

*The purpose of this change is to modify the definition for Tool\_usage to clarify how the tool product model is oriented with respect to toolpaths and machine models for simulation and interference checking. Insert the following after the TOOL\_USAGE its\_product table entry in Table 5.*

gage_placement	axis2 - placement_3d	10303-42		<pre> machining_tool_usage &lt;=   action_method characterized_action_definition = action_method characterized_action_definition &lt;-   action_property.definition { action_property.name = 'gage placement' }   action_property &lt;-     action_property_representation.property     action_property_representation action_property_representation.representation -&gt;   representation   representation.items[i] -&gt;     representation_item =&gt;       geometric_representation_item =&gt;         placement =&gt;           axis2_placement_3d </pre>
tool_end_placement	axis2 - placement_3d	10303-42		<pre> machining_tool_usage &lt;=   action_method characterized_action_definition = action_method characterized_action_definition &lt;-   action_property.definition { action_property.name = 'tool end placement' }   action_property &lt;-     action_property_representation.property     action_property_representation action_property_representation.representation -&gt;   representation   representation.items[i] -&gt;     representation_item =&gt;       geometric_representation_item =&gt;         placement =&gt;           axis2_placement_3d </pre>

**Page 456, Table 5**

*The purpose of this change is to modify the definition for touch\_probe so that it becomes a type of machining\_tool, to support a description of the probe usage, associated geometric shape, and other product information available for other types of tool. Replace the TOUCH\_PROBE and subsequent its\_id table entries in Table 5 with the following.*

TOUCH_PROBE	machining_tool	10303-238		<pre> machining_tool &lt;=   action_resource { action_resource.description = 'touch probe' } </pre>
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**Page 465, Table 5**

*The purpose of this change is to modify the mapping path relating touch\_probe to workpiece complete probing so that is correct with respect to the updated mapping for touch\_probe. Replace the workpiece\_complete\_probing to touch\_probe (as its\_probe) table entry in Table 5 with the following.*

workpiece_- complete_- probing to touch_probe (as its_probe)	PATH			<pre> machining_touch_probing &lt;= [ machining_operation &lt;= ] [ machining_process_executable &lt;= ]   action_method supported_item = action_method supported_item &lt;-   action_resource.usage[i]   action_resource =&gt;     machining_tool </pre>
--	------	--	--	---

**Page 462, Table 5**

*The purpose of this change is to modify the mapping path relating touch\_probe to workpiece probing so that is correct with respect to the updated mapping for touch\_probe. Replace the workpiece\_probing to touch\_probe (as its\_probe) table entry in Table 5 with the following.*

workpiece_- probing to touch_probe (as its_probe)	PATH			<pre> machining_touch_probing &lt;= [ machining_operation &lt;= ] [ machining_process_executable &lt;= ]   action_method supported_item = action_method supported_item &lt;-   action_resource.usage[i]   action_resource =&gt;     machining_tool </pre>
--	------	--	--	---

**Page 471, Table 5**

*The purpose of this change is to replace In\_process\_geometry application object and separate references on Machining\_workingstep, Turning\_workingstep, and Workplan with references from Executable to as-is, to-be, and removal Workpiece objects. Delete table entry “workplan to in\_process\_geometry (as its\_effect)”*

**Page 489, Table 7**

*The purpose of this change is to add the mapping specification for the its\_toolref\_direction data associated with the Cutter\_contact\_trajectory application object. Insert the following entry to Table 7 after CUTTER\_CONTACT\_TRAJECTORY its\_toolaxis.*

its_toolref_ direction	bounded_curve	10303-42		<pre> machining_toolpath &lt;=   action_method characterized_action_definition = action_method characterized_action_definition &lt;-   action_property.definition { action_property.name = 'tool reference direction' }   action_property &lt;-     action_property_representation.property     action_property_representation action_property_representation.representation -&gt;   representation   representation.items[i] -&gt;     representation_item =&gt;       geometric_representation_item =&gt;         curve =&gt;           bounded_curve </pre>
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**Page 492, Table 7**

*The purpose of this change is to add the mapping specification for the its\_toolref\_direction data associated with the Cutter\_location\_trajectory application object. Insert the following entry to Table 7 after CUTTER\_LOCATION\_TRAJECTORY its\_toolaxis.*

its_toolref_ direction	bounded_curve	10303-42		<pre> machining_toolpath &lt;=   action_method characterized_action_definition = action_method characterized_action_definition &lt;-   action_property.definition { action_property.name = 'tool reference direction' }   action_property &lt;-     action_property_representation.property     action_property_representation action_property_representation.representation -&gt;   representation   representation.items[i] -&gt;     representation_item =&gt;       geometric_representation_item =&gt;         curve =&gt;           bounded_curve </pre>
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**Page 502, Table 7**

The purpose of this change is to add the mapping specification for the `cross_section_area_parameters` data associated with the `Trajectory` application object. Insert the following entry to Table 7 after `TRAJECTORY` `its_material_removal_total_volume`.

cross_section_area_parameters	bounded_curve	10303-42		<pre> machining_toolpath &lt;=   action_method characterized_action_definition = action_method characterized_action_definition &lt;-   action_property.definition { action_property.name = 'cross section area parameters' }   action_property &lt;-     action_property_representation.property     action_property_representation action_property_representation.representation -&gt;   representation   representation.items[i] -&gt;     representation_item =&gt;       geometric_representation_item =&gt;         curve =&gt;           bounded_curve </pre>
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**Page 684, Table 11**

The purpose of this change is to replace `In_process_geometry` application object and separate references on `Machining_workingstep`, `Turning_workingstep`, and `Workplan` with references from `Executable` to `as-is`, `to-be`, and `removal Workpiece` objects. Delete table entry “`turning_workingstep` to `in_process_geometry` (as `its_effect`)”

**Page 721, Table 13**

The purpose of this change is to add the mapping specification for the `its_workpiece` data associated with the `Datum` application object. Insert the following entry to Table 13 after `DATUM`.

datum to workpiece (as its_workpiece)	PATH			<pre> datum =&gt;   shape_aspect shape_aspect.of_shape -&gt;   product_definition_shape &lt;=     property_definition     property_definition.definition -&gt;       characterized_definition characterized_definition = characterized_product_definition characterized_product_definition characterized_product_definition = product_definition product_definition </pre>
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**Page 723, Table 13**

*The purpose of this change is to add the mapping specification for the its\_workpiece data associated with the Datum\_target application object. Insert the following to Table 13 after DATUM\_TARGET id.*

datum_target to workpiece (as its_workpiece)	PATH			<pre> datum_target =&gt;   shape_aspect   shape_aspect.of_shape -&gt;     product_definition_shape &lt;=       property_definition       property_definition.definition -&gt;         characterized_definition characterized_definition = characterized_product_definition characterized_product_definition characterized_product_definition = product_definition product_definition </pre>
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**Page 764, 5.1**

*The purpose of this change is to correct grammar. In the last sentence of note 6, replace “the the” with “the”.*

**Page 778, 5.2.1.2.2**

*The purpose of this change is to correct a grammar error. In the second sentence of the second paragraph, insert “to” before “support” in the phrase “has been added to Manufacturing\_feature (See 4.2.198) support”.*

**Page 782, 5.2.1.3.1**

*The purpose of this change is to simplify awkward text. In the second sentence of the second paragraph, replace “that the profile is swept sweeps” with “that the swept profile sweeps”.*

**Page 782, 5.2.1.3.2**

*The purpose of this change is to correct a grammar error. In the second sentence of the fifth paragraph, replace “For a placement is at the top” with “For a placement at the top”. In the third sentence, replace “For a placement is at the bottom” with “For a placement at the bottom”.*

**Page 782, 5.2.1.3.2**

*The purpose of this change is to correct the description of the placement. In the second sentence of the fifth paragraph, replace the phrase “Z => Y and Y => -Z” with “Z => -Z and Y => -Y”.*

**Page 784, 5.2.1.3.3**

*The purpose of this change is to correct a grammar error. In the second sentence of the fifth paragraph, replace “For a placement is at the top” with “For a placement at the top”. In the third sentence, replace “For a placement is at the bottom” with “For a placement at the bottom”.*

**Page 784, 5.2.1.3.3**

*The purpose of this change is to correct the description of the placement. In the second sentence of the fifth paragraph, replace the phrase “Z => Y and Y => -Z” with “Z => -Z and Y => -Y”.*

**Page 786, 5.2.1.3.4**

*The purpose of this change is to correct a grammar error. In the second sentence of the seventh paragraph, replace “For a placement is at the top” with “For a placement at the top”. In the third sentence, replace “For a placement is at the bottom” with “For a placement at the bottom”.*

**Page 786, 5.2.1.3.4**

*The purpose of this change is to correct the description of the placement. In the second sentence of the fifth paragraph, replace the phrase “ $Z \Rightarrow Y$  and  $Y \Rightarrow -Z$ ” with “ $Z \Rightarrow -Z$  and  $Y \Rightarrow -Y$ ”.*

**Page 789, 5.2.1.4.1**

*The purpose of this change is to correct the references to exchange structure elements in the second example. In the text of EXAMPLE 2, replace “#10” with “#40” and replace “#20” with “#50”.*

**Page 791, 5.2.1.4.2**

*The purpose of this change is to correct a grammar error. In the second sentence of NOTE, replace “is appears” with “appears”.*

**Page 792, 5.2.1.4.5**

*The purpose of this change is to correct a grammar error. In the first sentence of NOTE, replace “the use of these are deprecated” with “the use of these is deprecated”.*

**Page 793, 5.2.1.4.6**

*The purpose of this change is to clarify the example. Replace the first paragraph of the example with the following.*

EXAMPLE In the exchange file fragment below, #10 describes a count of 5 encoded as a measure\_with\_unit. The count unit is encoded by #20. Example 1 in 5.2.1.4.1 describes a count measurement encoded using measure\_representation\_item.

**Page 793, 5.2.1.4.8**

*The purpose of this change is to correct the exchange file fragment in the example. Replace the usage of TIME\_MEASURE with LENGTH\_MEASURE in the first exchange file fragment. The fourth line of the first exchange file fragment should be as follows.*

```
MEASURE_WITH_UNIT(LENGTH_MEASURE(12.),#30)
```

**Page 794, 5.2.1.4.9**

*The purpose of this change is to correct the exchange file fragment in the example. Replace the usage of PLANE\_ANGLE\_MEASURE with MASS\_MEASURE in the exchange file fragment. The fourth line of the exchange file fragment should be as follows.*

```
MEASURE_WITH_UNIT(MASS_MEASURE(2.),#20)
```

**Page 799, 5.2.1.4.18**

*The purpose of this change is to correct a grammar error. In the first sentence of NOTE, replace “the use of these are deprecated” with “the use of these is deprecated”. In the second sentence of NOTE, replace “an volume measure” with “a volume measure”.*

**Page 800, 5.2.1.4.19**

*The purpose of this change is to correct a grammar error. In the first sentence of the last paragraph, replace “These representation subtypes identifies” with “These representation subtypes identify”.*

**Page 804, 5.2.1.5.2**

*The purpose of this change is to correct awkward text. In the first sentence of the second paragraph, replace “engineering discipline’s” with “the engineering discipline from whose”. In the first sentence of the third paragraph, replace “the the” with “the”. Replace the entire second sentence of the EXAMPLE, with the following.*

The product\_context (#40) identifies a design discipline, the product\_definition\_context (#70) identifies a life cycle stage, and instances #50 and #60 identifies this part of ISO 10303.

**Page 806, 5.2.1.6.3**

*The purpose of this change is to correct reversed X and Y coordinates in the NOTE. In the first sentence of the second paragraph, replace the parenthetical expression with “(from +X,0 to 0,+Y to -X,0 to 0,-Y)”.*

**Page 806, 5.2.1.6.3**

*The purpose of this change is to permit a more concise representation of arc toolpaths to better support high-speed milling operations. Insert the following paragraph at the end of 5.2.1.6.3.*

A toolpath containing a circular arc may also be described using a polyline with an instance of the via\_arc\_point subtype of cartesian\_point (See 5.2.3.1.94).

**Page 806, 5.2.1.6.4**

*The purpose of this change is to permit a more concise representation of arc toolpaths to better support high-speed milling operations. Insert the following paragraph at the end of 5.2.1.6.4.*

A toolpath containing a complete circle may also be described using a polyline with two instances of the via\_arc\_point subtype of cartesian\_point (See 5.2.3.1.94).

**Page 810, 5.2.2.1.10**

*The purpose of this change is to add assembly\_component\_usage to the AIM security\_classification\_item definition to better support workpiece product models brought in from AP203 data. Insert “assembly\_component\_usage,” before “machining\_operation” in both the first sentence and in the EXPRESS specification.*

**Page 861, 5.2.3.1.58**

*The purpose of this change is to add EXPRESS constraints to the AIM machining\_process\_executable definition for the as\_is, enabled, fixture, removal, and to\_be data. Insert the following text for WR9 at the end of the EXPRESS definition for machining\_process\_executable.*

```
WR9: (verify_optional_action_property      (SELF, 'enabled')) AND
      (verify_enumeration_action_property (SELF, 'enabled',
      ['enabled', 'disabled'])) AND
```

```

(1 >= SIZEOF (QUERY (act < *
  USEDIN (SELF, 'INTEGRATED_CNC_SCHEMA.ACTION.CHOSEN_METHOD') |
  (act.name = 'as-is shape')))) AND
(0 = SIZEOF (QUERY (act < *
  USEDIN (SELF, 'INTEGRATED_CNC_SCHEMA.ACTION.CHOSEN_METHOD') |
  (act.name = 'as-is shape') AND NOT
  ('INTEGRATED_CNC_SCHEMA.PRODUCT_DEFINITION_PROCESS'
    IN TYPEOF (act))))) AND

(1 >= SIZEOF (QUERY (act < *
  USEDIN (SELF, 'INTEGRATED_CNC_SCHEMA.ACTION.CHOSEN_METHOD') |
  (act.name = 'fixture shape')))) AND
(0 = SIZEOF (QUERY (act < *
  USEDIN (SELF, 'INTEGRATED_CNC_SCHEMA.ACTION.CHOSEN_METHOD') |
  (act.name = 'fixture shape') AND NOT
  ('INTEGRATED_CNC_SCHEMA.PRODUCT_DEFINITION_PROCESS'
    IN TYPEOF (act))))) AND

(1 >= SIZEOF (QUERY (act < *
  USEDIN (SELF, 'INTEGRATED_CNC_SCHEMA.ACTION.CHOSEN_METHOD') |
  (act.name = 'removal shape')))) AND
(0 = SIZEOF (QUERY (act < *
  USEDIN (SELF, 'INTEGRATED_CNC_SCHEMA.ACTION.CHOSEN_METHOD') |
  (act.name = 'removal shape') AND NOT
  ('INTEGRATED_CNC_SCHEMA.PRODUCT_DEFINITION_PROCESS'
    IN TYPEOF (act))))) AND

(1 >= SIZEOF (QUERY (act < *
  USEDIN (SELF, 'INTEGRATED_CNC_SCHEMA.ACTION.CHOSEN_METHOD') |
  (act.name = 'to-be shape')))) AND
(0 = SIZEOF (QUERY (act < *
  USEDIN (SELF, 'INTEGRATED_CNC_SCHEMA.ACTION.CHOSEN_METHOD') |
  (act.name = 'to-be shape') AND NOT
  ('INTEGRATED_CNC_SCHEMA.PRODUCT_DEFINITION_PROCESS'
    IN TYPEOF (act))))) ;

```

### Page 862, 5.2.3.1.58

*The purpose of this change is to describe EXPRESS constraints to the AIM machining\_process\_executable definition for the as\_is, enabled, fixture, removal, and to\_be data. Insert the following text as the last item in the list describing formal propositions.*

**WR9:** The **machining\_process\_executable** shall satisfy the following conditions:

- the **machining\_process\_executable** shall be the **definition** of at most one **action\_property** with a **name** of 'enabled', and the **representation** used to describe the **action\_property** shall contain a **representation\_item** of type **descriptive\_representation\_item** with a **description** of 'enabled' or 'disabled';
- the **machining\_process\_executable** shall be the **chosen\_method** of at most one **product\_definition\_process** with a **name** of 'as-is shape';

- the **machining\_process\_executable** shall be the **chosen\_method** of at most one **product\_definition\_process** with a **name** of 'fixture shape';
- the **machining\_process\_executable** shall be the **chosen\_method** of at most one **product\_definition\_process** with a **name** of 'removal shape';
- the **machining\_process\_executable** shall be the **chosen\_method** of at most one **product\_definition\_process** with a **name** of 'to-be shape'.

### **Page 889, 5.2.3.1.75**

*The purpose of this change is to add EXPRESS constraints to the AIM machining\_tool\_usage definition for the Tool\_usage gage\_placement and tool\_end\_placement application object data. Insert the following text for WR4 and WR5 at the end of the EXPRESS definition for machining\_tool\_usage.*

```
WR4: ((verify_optional_action_property (SELF, 'gage placement')) AND
      (verify_rep_item_for_action_property (SELF, 'gage placement',
      [ 'INTEGRATED_CNC_SCHEMA.AXIS2_PLACEMENT_3D' ]))) ;

WR5: ((verify_optional_action_property (SELF, 'tool end placement')) AND
      (verify_rep_item_for_action_property (SELF, 'tool end placement',
      [ 'INTEGRATED_CNC_SCHEMA.AXIS2_PLACEMENT_3D' ]))) ;
```

### **Page 890, 5.2.3.1.75**

*The purpose of this change is to add EXPRESS constraints to the AIM machining\_tool\_usage definition for the Tool\_usage gage\_placement and tool\_end\_placement application object data. Insert the following text at the end of the list of formal propositions.*

**WR4:** The **machining\_tool\_usage** shall be the **definition** of at most one **action\_property** with a **name** of 'gage placement', and the **representation** used to describe the **action\_property** shall contain a **representation\_item** of type **axis2\_placement\_3d**.

**WR5:** The **machining\_tool\_usage** shall be the **definition** of at most one **action\_property** with a **name** of 'tool end placement', and the **representation** used to describe the **action\_property** shall contain a **representation\_item** of type **axis2\_placement\_3d**.

### **Page 892, 5.2.3.1.76**

*The purpose of this change is to add EXPRESS constraints to the AIM machining\_toolpath definition for the its\_toolref\_direction data associated with the Cutter\_location\_trajectory and Cutter\_contact\_trajectory application objects. Replace WR14 and WR15 in the EXPRESS definition for machining\_toolpath with the following text.*

```
WR14: NOT (SELF.description = 'cutter location trajectory') OR
      ((verify_required_action_property (SELF, 'basic curve')) AND
      (verify_rep_item_for_action_property (SELF, 'basic curve',
      [ 'INTEGRATED_CNC_SCHEMA.BOUNDED_CURVE' ]))) AND

      (verify_optional_action_property (SELF, 'surface normal')) AND
      (verify_rep_item_for_action_property (SELF, 'surface normal',
      [ 'INTEGRATED_CNC_SCHEMA.BOUNDED_CURVE' ]))) AND
```



```

(verify_optional_action_property      (SELF, 'tool axis')) AND
(verify_rep_item_for_action_property (SELF, 'tool axis',
  ['INTEGRATED_CNC_SCHEMA.BOUNDED_CURVE'])) AND

(verify_optional_action_property
  (SELF, 'tool reference direction')) AND
(verify_rep_item_for_action_property
  (SELF, 'tool reference direction',
  ['INTEGRATED_CNC_SCHEMA.BOUNDED_CURVE'])) AND

(verify_optional_action_property
  (SELF, 'path maximum deviation')) AND
(verify_length_measure_action_property
  (SELF, 'path maximum deviation')) AND

(verify_optional_action_property
  (SELF, 'tool axis maximum deviation')) AND
(verify_angle_measure_action_property
  (SELF, 'tool axis maximum deviation'))
);

WR15: NOT (SELF.description = 'cutter contact trajectory') OR
((((verify_required_action_property      (SELF, 'basic curve')) AND
  (verify_rep_item_for_action_property (SELF, 'basic curve',
    ['INTEGRATED_CNC_SCHEMA.BOUNDED_PCURVE'])) )

OR

((verify_required_action_property      (SELF, 'basic curve')) AND
  (verify_rep_item_for_action_property (SELF, 'basic curve',
    ['INTEGRATED_CNC_SCHEMA.BOUNDED_CURVE'])) AND

  (verify_required_action_property      (SELF, 'surface normal')) AND
  (verify_rep_item_for_action_property (SELF, 'surface normal',
    ['INTEGRATED_CNC_SCHEMA.BOUNDED_CURVE'])) )
) AND

(verify_optional_action_property      (SELF, 'tool axis')) AND
(verify_rep_item_for_action_property (SELF, 'tool axis',
  ['INTEGRATED_CNC_SCHEMA.BOUNDED_CURVE'])) AND

(verify_optional_action_property
  (SELF, 'tool reference direction')) AND
(verify_rep_item_for_action_property
  (SELF, 'tool reference direction',
  ['INTEGRATED_CNC_SCHEMA.BOUNDED_CURVE'])) AND

(verify_optional_action_property      (SELF, 'contact type')) AND
(verify_enumeration_action_property (SELF, 'contact type',
  ['side', 'front'])) AND

(verify_optional_action_property
  (SELF, 'path maximum deviation')) AND
(verify_length_measure_action_property

```

```
(SELF, 'path maximum deviation')) AND

(verify_optional_action_property
  (SELF, 'tool axis maximum deviation')) AND
(verify_angle_measure_action_property
  (SELF, 'tool axis maximum deviation'))
);
```

### **Page 893, 5.2.3.1.76**

*The purpose of this change is to add EXPRESS constraints to the AIM machining\_toolpath definition for the cross\_section\_area\_parameters data associated with the Trajectory application object. Replace WR16 in the EXPRESS definition for machining\_toolpath with the following text.*

```
WR16: NOT (SELF.description IN ['axis trajectory',
  'cutter location trajectory',
  'cutter contact trajectory']) OR
((verify_optional_action_property
  (SELF, 'material removal depth')) AND
((verify_length_measure_action_property
  (SELF, 'material removal depth')) OR
(verify_rep_item_for_action_property
  (SELF, 'material removal depth',
  ['INTEGRATED_CNC_SCHEMA.BOUNDED_CURVE'])))) AND

(verify_optional_action_property
  (SELF, 'material removal overcut')) AND
((verify_length_measure_action_property
  (SELF, 'material removal overcut')) OR
(verify_rep_item_for_action_property
  (SELF, 'material removal overcut',
  ['INTEGRATED_CNC_SCHEMA.BOUNDED_CURVE'])))) AND

(verify_optional_action_property
  (SELF, 'material removal total volume')) AND
(verify_rep_item_for_action_property
  (SELF, 'material removal total volume',
  ['INTEGRATED_CNC_SCHEMA.MEASURE_REPRESENTATION_ITEM'])) AND

(verify_optional_action_property
  (SELF, 'cross section area parameters')) AND
(verify_rep_item_for_action_property
  (SELF, 'cross section area parameters',
  ['INTEGRATED_CNC_SCHEMA.BOUNDED_CURVE']))
);
```

### **Page 895, 5.2.3.1.76**

*The purpose of this change is to describe EXPRESS constraints added to the AIM machining\_toolpath definition for the its\_toolref\_direction data associated with the Cutter\_location\_trajectory application object. Insert the following text as the third item in the list describing formal propositions for WR14.*

- the **machining\_toolpath** shall be the **definition** of at most one **action\_property** with a **name** of 'tool reference direction', and the **representation** used to describe the **action\_property** shall contain a **representation\_item** of type **bounded\_curve**;

### **Page 896, 5.2.3.1.76**

*The purpose of this change is to describe EXPRESS constraints added to the AIM machining\_toolpath definition for the its\_toolref\_direction data associated with the Cutter\_contact\_trajectory application object. Insert the following text as the third item in the list describing formal propositions for WR15.*

- the **machining\_toolpath** shall be the **definition** of at most one **action\_property** with a **name** of 'tool reference direction', and the **representation** used to describe the **action\_property** shall contain a **representation\_item** of type **bounded\_curve**;

### **Page 897, 5.2.3.1.76**

*The purpose of this change is to describe EXPRESS constraints added to the AIM machining\_toolpath definition for the cross\_section\_area\_parameters data associated with the Trajectory application object. Insert the following text at the end of the list describing formal propositions for WR16.*

- the **machining\_toolpath** shall be the **definition** of at most one **action\_property** with a **name** of 'cross section area parameters', and the **representation** used to describe the **action\_property** shall contain a **representation\_item** of type **bounded\_curve**.

### **Page 898, 5.2.3.1.79**

*The purpose of this change is to update the EXPRESS constraints on the AIM machining\_touch\_probing definition so that they are correct with the updated mappings related to the Touch\_probe application object. In WR4 of the EXPRESS definition for machining\_touch\_probing, replace the line:*

```
(verify_required_action_property      (SELF, 'probe'))
```

*with the following text:*

```
(1 = SIZEOF (QUERY (mt <*  
  USEDIN (SELF, 'INTEGRATED_CNC_SCHEMA.ACTION_RESOURCE.USAGE') |  
  ('INTEGRATED_CNC_SCHEMA.MACHINING_TOOL' in TYPEOF(mt))))
```

### **Page 899, 5.2.3.1.79**

*The purpose of this change is to update the EXPRESS constraints on the AIM machining\_touch\_probing definition so that they are correct with the updated mappings related to the Touch\_probe application object. In WR5 of the EXPRESS definition for machining\_touch\_probing, replace the line:*

```
(verify_required_action_property      (SELF, 'probe')) AND
```

*with the following text:*

```
(1 = SIZEOF (QUERY (mt <*  
  USEDIN (SELF, 'INTEGRATED_CNC_SCHEMA.ACTION_RESOURCE.USAGE') |  
  ('INTEGRATED_CNC_SCHEMA.MACHINING_TOOL' in TYPEOF(mt)))) AND
```

### **Page 900, 5.2.3.1.79**

*The purpose of this change is to update the EXPRESS constraints on the AIM machining\_touch\_-probing definition so that they are correct with the updated mappings related to the Touch\_probe application object. Replace the last item in the list describing formal propositions for WR4 with the following:*

— the **machining\_touch\_probing** shall appear in the **usage** set of exactly one **machining\_tool**.

### **Page 900, 5.2.3.1.79**

*The purpose of this change is to update the EXPRESS constraints on the AIM machining\_touch\_probe definition so that they are correct with the updated mappings related to the Touch\_probe application object. Replace the third item in the list describing formal propositions for WR5 with the following:*

— the **machining\_touch\_probing** shall appear in the **usage** set of exactly one **machining\_tool**.

### **Page 902, 5.2.3.1.80**

*The purpose of this change is to update the EXPRESS constraints on the AIM machining\_workingstep definition so that they are correct with the removal of references to the In\_process\_geometry application object from Machining\_workingstep, Turning\_workingstep, and Workplan. Delete WR4 from the EXPRESS specification and renumber WR5 to WR4. Delete the description of WR4 from the Formal propositions and renumber the description of WR5 to WR4.*

### **Page 903, 5.2.3.1.81**

*The purpose of this change is to update the EXPRESS constraints on the AIM machining\_workplan definition to remove references to the In\_process\_geometry application object and add a constraint for the Workplan toolpath\_orientation. Replace WR4 in the EXPRESS definition with the following:*

```
WR4: ((verify_optional_action_property (SELF, 'toolpath orientation')) AND
      (verify_rep_item_for_action_property (SELF, 'toolpath orientation',
      [ 'INTEGRATED_CNC_SCHEMA.AXIS2_PLACEMENT_3D' ]))) ;
```

### **Page 904, 5.2.3.1.81**

*The purpose of this change is to update the EXPRESS constraints on the AIM machining\_workplan definition to remove references to the In\_process\_geometry application object and add a constraint for the Workplan toolpath\_orientation. Replace WR4 in the Formal propositions with the following:*

**WR4:** The **machining\_workplan** shall be the **definition** of at most one **action\_property** with a **name** of 'toolpath orientation', and the **representation** used to describe the **action\_property** shall contain a **representation\_item** of type **axis2\_placement\_3d**.

### **Page 924, 5.2.3.1**

*The purpose of this change is to permit a more concise representation of arc and helix toolpaths to better support high-speed milling operations. Insert the following new subclauses after 5.2.3.1.93. Add via\_arc\_point and via\_helix\_point to Index. Add Figure 53 to List of figures.*

### 5.2.3.1.94 via\_arc\_point

A **via\_arc\_point** is a **cartesian\_point**. When appearing in the **points** list of a **polyline**, the **via\_arc\_point** defines an arc starting at the previous point in the **polyline**, passing through the **via\_arc\_point**, and ending at the next point in the **polyline**. The arc defined by the **via\_arc\_point** shall be less than  $2\pi$ .

If two via points are considered coincident if any two consecutive points in the via re considered coincident, they shall be considered to decline a straight line segment rather than an arc. context of enclosing representation. Extra via points between two non via points must define arcs of the same radius.

NOTE 1 Since the arc defined by a via is less than  $2\pi$ , a full circle is described using more than one via point. The use of a via point to describe an arc is also found in the **circular\_path** entity in ISO 10303-105[3].

If a via point and the preceeding or following point in a polyline are considered coincident, the via point shall be considered to define straight line segments rather than an arc.

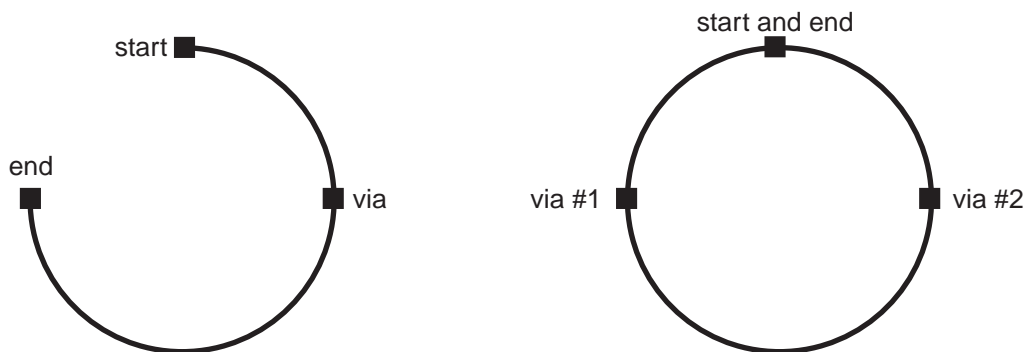
NOTE 2 Two points are considered coincident if they lie within the uncertainty distance given by the **global\_uncertainty\_assigned\_context** of the enclosing representation.

EXAMPLE In the exchange file fragment below, #10 describes a 270 degree arc on the XY plane, starting at point #20, passing through point #30 and ending at point #40. Instance #50 describes a complete circle on the XY plane, starting and ending at point #60, passing through point #70 and point #80.

```
/* 270 degree arc, centered at (0,0,0) */
#10=POLYLINE('',(#20,#30,#40));
#20=CARTESIAN_POINT('start',(0,1.,0));
#30=VIA_ARC_POINT('via',(1.,0,0));
#40=CARTESIAN_POINT('end',(-1.,0,0));

/* complete circle, centered at (0,0,0) */
#50=POLYLINE('',(#60,#30,#40,#60));
#60=CARTESIAN_POINT('start and end',(0,1.,0));
#40=VIA_ARC_POINT('via #1',(-1.,0,0));
#30=VIA_ARC_POINT('via #2',(1.,0,0));
```

Figure 53 illustrates the arc and a complete circle described by the exchange file fragment.



**Figure 53 - Arcs with via points**

EXPRESS specification:

```

*)
ENTITY via_arc_point
  SUBTYPE OF (cartesian_point);
  WHERE
    WR1: SIZEOF(USEDIN(SELF, 'INTEGRATED_CNC_SCHEMA.POLYLINE.POINTS')) > 0;
    WR2: (0 = SIZEOF (QUERY (pl <*
      USEDIN(SELF, 'INTEGRATED_CNC_SCHEMA.POLYLINE.POINTS') |
      ((pl.points[1] = SELF) OR (pl.points[HiIndex(pl.points)] = SELF))
    )));
END_ENTITY;
( *

```

Formal propositions:

**WR1:** The **via\_arc\_point** shall appear in the **points** list of at least one **polyline**.

**WR2:** The **via\_arc\_point** shall not appear as either the first or last element in the **points** list of any **polyline**.

### 5.2.3.1.95 via\_helix\_point

A **via\_helix\_point** is a **cartesian\_point**. When appearing in the **points** list of a **polyline**, the **via\_helix\_point** defines an helix starting at the previous point in the **polyline**, passing through the **via\_helix\_point**, and ending at the next point in the **polyline**. As with **via\_arc\_point**, when projected to the plane, the arc defined by the **via\_helix\_point** shall be less than  $2\pi$ .

If a via point and the preceeding or following point in a polyline are considered coincident, the via point shall be considered to define straight line segments rather than a helix.

NOTE Two points are considered coincident if they lie within the uncertainty distance given by the **global\_uncertainty\_assigned\_context** of the enclosing representation.

EXPRESS specification:

```

*)
ENTITY via_helix_point
  SUBTYPE OF (cartesian_point);
  WHERE
    WR1: SIZEOF(USEDIN(SELF, 'INTEGRATED_CNC_SCHEMA.POLYLINE.POINTS')) > 0;
    WR2: (0 = SIZEOF (QUERY (pl <*
      USEDIN(SELF, 'INTEGRATED_CNC_SCHEMA.POLYLINE.POINTS') |
      ((pl.points[1] = SELF) OR (pl.points[HiIndex(pl.points)] = SELF))
    )));
END_ENTITY;
( *

```

Formal propositions:

**WR1:** The **via\_helix\_point** shall appear in the **points** list of at least one **polyline**.

**WR2:** The **via\_helix\_point** shall not appear as either the first or last element in the **points** list of any **polyline**.

**Page 956, 5.2.5.28**

*The purpose of this change is to eliminate the AIM verify\_optional\_in\_process\_geometry function which is no longer used with the removal of references to the In\_process\_geometry application object from Machining\_workingstep, Turning\_workingstep, and Workplan. Delete 5.3.5.28 and renumber the remaining clauses.*

**Page 976, 6.1**

*The purpose of this change is to replace In\_process\_geometry application object and separate references on Machining\_workingstep, Turning\_workingstep, and Workplan with references from Executable to as-is, to-be, and removal Workpiece objects. Replace the last list item in 6.1 with the following.*

- no geometric shape information shall be specified for Manufacturing\_feature explicit-representation, Workpiece its\_geometry or its\_bounding\_geometry, or Workpiece\_setup its\_restricted\_area.

**Page 977, 6.2**

*The purpose of this change is to replace In\_process\_geometry application object and separate references on Machining\_workingstep, Turning\_workingstep, and Workplan with references from Executable to as-is, to-be, and removal Workpiece objects. Replace the last list item in 6.2 with the following.*

- geometric shape information may be specified for Workpiece its\_geometry or its\_bounding\_geometry, or Workpiece\_setup its\_restricted\_area.

**Page 1003, Annex A**

*The purpose of this change is to add assembly\_component\_usage to the AIM security\_classification\_item definition to better support workpiece product models brought in from AP203 data. Insert “assembly\_component\_usage,” before “machining\_operation” in the EXPRESS SELECT type list for security\_classification\_item.*

**Page 1103, Annex A**

*The purpose of this change is to correct the expanded EXPRESS listing for machining\_tool\_usage to match the EXPRESS in 5.2.3.1.75. Replace the EXPRESS definition for machining\_tool\_usage with the following text.*

```
ENTITY machining_tool_usage
  SUBTYPE OF (action_method);
  WHERE
  WR1: ((verify_optional_action_property (SELF, 'tool position')) AND
        (verify_descriptive_action_property (SELF, 'tool position')));

  WR2: ((verify_optional_action_property (SELF, 'tool carousel')) AND
```

```

        (verify_descriptive_action_property (SELF, 'tool carousel')));

WR3:  (1 >= SIZEOF (QUERY (act <*
        USEDIN (SELF, 'INTEGRATED_CNC_SCHEMA.ACTION.CHOSEN_METHOD') |
        (act.name = 'tool usage')))) AND
(0 = SIZEOF (QUERY (act <*
        USEDIN (SELF, 'INTEGRATED_CNC_SCHEMA.ACTION.CHOSEN_METHOD') |
        (act.name = 'tool usage') AND NOT
        ('INTEGRATED_CNC_SCHEMA.PRODUCT_DEFINITION_PROCESS' IN TYPEOF (act))
        )));

WR4:  ((verify_optional_action_property (SELF, 'gage placement')) AND
        (verify_rep_item_for_action_property (SELF, 'gage placement',
        ['INTEGRATED_CNC_SCHEMA.AXIS2_PLACEMENT_3D'])));

WR5:  ((verify_optional_action_property (SELF, 'tool end placement')) AND
        (verify_rep_item_for_action_property (SELF, 'tool end placement',
        ['INTEGRATED_CNC_SCHEMA.AXIS2_PLACEMENT_3D'])));
END_ENTITY;

```

## Page 1105, Annex A

*The purpose of this change is to add EXPRESS constraints to the expanded EXPRESS listing for machining\_toolpath definition to match the EXPRESS in 5.2.3.1.76. Replace WR14, WR15, and WR16 in the EXPRESS definition for machining\_toolpath with the following text.*

```

WR14: NOT (SELF.description = 'cutter location trajectory') OR
        ((verify_required_action_property      (SELF, 'basic curve')) AND
        (verify_rep_item_for_action_property (SELF, 'basic curve',
        ['INTEGRATED_CNC_SCHEMA.BOUNDED_CURVE'])) AND

        (verify_optional_action_property      (SELF, 'surface normal')) AND
        (verify_rep_item_for_action_property (SELF, 'surface normal',
        ['INTEGRATED_CNC_SCHEMA.BOUNDED_CURVE'])) AND

        (verify_optional_action_property      (SELF, 'tool axis')) AND
        (verify_rep_item_for_action_property (SELF, 'tool axis',
        ['INTEGRATED_CNC_SCHEMA.BOUNDED_CURVE'])) AND

        (verify_optional_action_property
        (SELF, 'tool reference direction')) AND
        (verify_rep_item_for_action_property
        (SELF, 'tool reference direction',
        ['INTEGRATED_CNC_SCHEMA.BOUNDED_CURVE'])) AND

        (verify_optional_action_property
        (SELF, 'path maximum deviation')) AND
        (verify_length_measure_action_property
        (SELF, 'path maximum deviation')) AND

        (verify_optional_action_property
        (SELF, 'tool axis maximum deviation')) AND
        (verify_angle_measure_action_property
        (SELF, 'tool axis maximum deviation'))

```



```

);

WR15: NOT (SELF.description = 'cutter contact trajectory') OR
(((verify_required_action_property (SELF, 'basic curve')) AND
 (verify_rep_item_for_action_property (SELF, 'basic curve',
   ['INTEGRATED_CNC_SCHEMA.BOUNDED_PCURVE']))) )

OR

((verify_required_action_property (SELF, 'basic curve')) AND
 (verify_rep_item_for_action_property (SELF, 'basic curve',
   ['INTEGRATED_CNC_SCHEMA.BOUNDED_CURVE']))) AND

(verify_required_action_property (SELF, 'surface normal')) AND
(verify_rep_item_for_action_property (SELF, 'surface normal',
   ['INTEGRATED_CNC_SCHEMA.BOUNDED_CURVE']))) )
) AND

(verify_optional_action_property (SELF, 'tool axis')) AND
(verify_rep_item_for_action_property (SELF, 'tool axis',
   ['INTEGRATED_CNC_SCHEMA.BOUNDED_CURVE']))) AND

(verify_optional_action_property
 (SELF, 'tool reference direction')) AND
(verify_rep_item_for_action_property
 (SELF, 'tool reference direction',
   ['INTEGRATED_CNC_SCHEMA.BOUNDED_CURVE']))) AND

(verify_optional_action_property (SELF, 'contact type')) AND
(verify_enumeration_action_property (SELF, 'contact type',
   ['side', 'front']))) AND

(verify_optional_action_property
 (SELF, 'path maximum deviation')) AND
(verify_length_measure_action_property
 (SELF, 'path maximum deviation')) AND

(verify_optional_action_property
 (SELF, 'tool axis maximum deviation')) AND
(verify_angle_measure_action_property
 (SELF, 'tool axis maximum deviation'))
);

WR16: NOT (SELF.description IN ['axis trajectory',
   'cutter location trajectory',
   'cutter contact trajectory']) OR
(((verify_optional_action_property
 (SELF, 'material removal depth')) AND
 ((verify_length_measure_action_property
 (SELF, 'material removal depth')) OR
 (verify_rep_item_for_action_property
 (SELF, 'material removal depth',
   ['INTEGRATED_CNC_SCHEMA.BOUNDED_CURVE'])))) AND

```

```

    (verify_optional_action_property
      (SELF, 'material removal overcut')) AND
    ((verify_length_measure_action_property
      (SELF, 'material removal overcut')) OR
    (verify_rep_item_for_action_property
      (SELF, 'material removal overcut',
        [ 'INTEGRATED_CNC_SCHEMA.BOUNDED_CURVE' ]))) AND

    (verify_optional_action_property
      (SELF, 'material removal total volume')) AND
    (verify_rep_item_for_action_property
      (SELF, 'material removal total volume',
        [ 'INTEGRATED_CNC_SCHEMA.MEASURE_REPRESENTATION_ITEM' ])) AND

    (verify_optional_action_property
      (SELF, 'cross section area parameters')) AND
    (verify_rep_item_for_action_property
      (SELF, 'cross section area parameters',
        [ 'INTEGRATED_CNC_SCHEMA.BOUNDED_CURVE' ]))
  );

```

### **Page 1109, Annex A**

*The purpose of this change is to update the EXPRESS constraints on the AIM machining\_workingstep definition so that they are correct with the removal of references to the In\_process\_geometry application object from Machining\_workingstep, Turning\_workingstep, and Workplan. Delete WR4 and renumber WR5 to WR4 in the EXPRESS definition for machining\_workingstep.*

### **Page 1110, Annex A**

*The purpose of this change is to update the EXPRESS constraints on the AIM machining\_workplan definition to remove references to the In\_process\_geometry application object and add a constraint for the Workplan toolpath\_orientation. Replace WR4 in the EXPRESS definition for machining\_workplan with the following:*

```

WR4: ((verify_optional_action_property (SELF, 'toolpath orientation')) AND
      (verify_rep_item_for_action_property (SELF, 'toolpath orientation',
        [ 'INTEGRATED_CNC_SCHEMA.AXIS2_PLACEMENT_3D' ]))) ;

```

### **Page 1213, Annex A**

*The purpose of this change is add the EXPRESS definitions for via\_arc\_point and via\_helix\_point to the expanded EXPRESS listing to match the EXPRESS in 5.2.3.1.94 and 5.2.3.1.95. Insert the following text after the EXPRESS definition for vertex\_shell. Add via\_arc\_point and via\_helix\_point to Index.*

```

ENTITY via_arc_point
  SUBTYPE OF (cartesian_point);
  WHERE
    WR1: SIZEOF(USEDIN(SELF, 'INTEGRATED_CNC_SCHEMA.POLYLINE.POINTS')) > 0;
    WR2: (0 = SIZEOF (QUERY (pl < *
      USEDIN(SELF, 'INTEGRATED_CNC_SCHEMA.POLYLINE.POINTS') |
      ((pl.points[1] = SELF) OR (pl.points[HiIndex(pl.points)] = SELF))
    )));
END_ENTITY; -- 10303-238: integrated_cnc_schema

```

```

ENTITY via_helix_point
  SUBTYPE OF (cartesian_point);
  WHERE
    WR1: SIZEOF(USEDIN(SELF, 'INTEGRATED_CNC_SCHEMA.POLYLINE.POINTS')) > 0;
    WR2: (0 = SIZEOF (QUERY (pl < *
      USEDIN(SELF, 'INTEGRATED_CNC_SCHEMA.POLYLINE.POINTS') |
      ((pl.points[1] = SELF) OR (pl.points[HiIndex(pl.points)] = SELF))
    )));
END_ENTITY; -- 10303-238: integrated_cnc_schema

```

### Page 1262, Annex A

*The purpose of this change is to eliminate the AIM `verify_optional_in_process_geometry` function which is no longer used with the removal of references to the `In_process_geometry` application object from `Machining_workingstep`, `Turning_workingstep`, and `Workplan`. Delete the EXPRESS definition for `verify_optional_in_process_geometry`.*

### Page 1287, Table B.1

*The purpose of this change is add the short names for `via_arc_point` and `via_helix_point` to match the EXPRESS in 5.2.3.1.94 and 5.2.3.1.95. Insert the following into Table B.1 after `vertex_shell`.*

VIA_ARC_POINT	VARPN
VIA_HELIX_POINT	VHLPN

### Page 1289, C.2

*The purpose of this change is to update the object identifier used by ISO 10303-28 implementations to identify the namespace for the EXPRESS schema. Replace subclause C.2 with the following text.*

## C.2 Requirements specific to ISO 10303-28

If the implementation method is ISO 10303-28, the file format shall be encoded according to the syntax and EXPRESS language mapping defined in ISO 10303-28 and in the AIM defined in Annex A of this part of ISO 10303. The ISO 10303-28 configuration shown below shall be used.

```

<?xml version="1.0"?>
<configuration
  xmlns="urn:oid:1.0.10303.28.2.1.2"
  xmlns:xs="http://www.w3.org/2001/XMLSchema">

  <schema targetNamespace="urn:oid:1.0.10303.238.2.0.1" />
  <option exp-attribute="attribute-content" tagless="true" />
  <uosElement name="iso_10303_28_terse" >
    <add_attribute name="schema" type="xs:NMTOKEN" usage="required" />
  </uosElement>
</configuration>

```

## ISO 10303-238 - Changes for Edition Two

The `iso_10303_28_terse` element shall identify the use of this part of ISO 10303 by the namespace ‘urn:oid:1.0.10303.238.2.0.1’ and the ‘schema’ attribute value of ‘integrated\_cnc\_schema’.

**EXAMPLE** The ISO 10303-28 configuration results in instance data written using the “attribute-content” encoding enclosed in the `iso_10303_28_terse` UOS element, as shown in the fragment below.

```
<?xml version="1.0"?>
<iso_10303_28_terse
  xmlns="urn:oid:1.0.10303.238.2.0.1"
  xmlns:exp="urn:oid:1.0.10303.28.2.1.1"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  schema="integrated_cnc_schema">

  <exp:header>
    <exp:name>dataset</exp:name>
    <exp:preprocessor_version>stepnc writer</exp:preprocessor_version>
  </exp:header>

  <!-- instance data -->
  <Axis2_placement_3d id="id1" Name="" Location="id2" Axis="id3" Ref_direction="id4"/>
  <Cartesian_point id="id2" Name="loc" Coordinates="3.5 -3.5 -4.16875"/>
  <Direction id="id3" Name="Z direction" Direction_ratios="0 0 1"/>
  <Direction id="id4" Name="X direction" Direction_ratios="1 0 0"/>
</iso_10303_28_terse>
```

### ***Page 1294, E.1***

*The purpose of this change is to update the object identifier for the document. Replace the object identifier with the following text.*

{ iso standard 10303 part(238) version(2) }

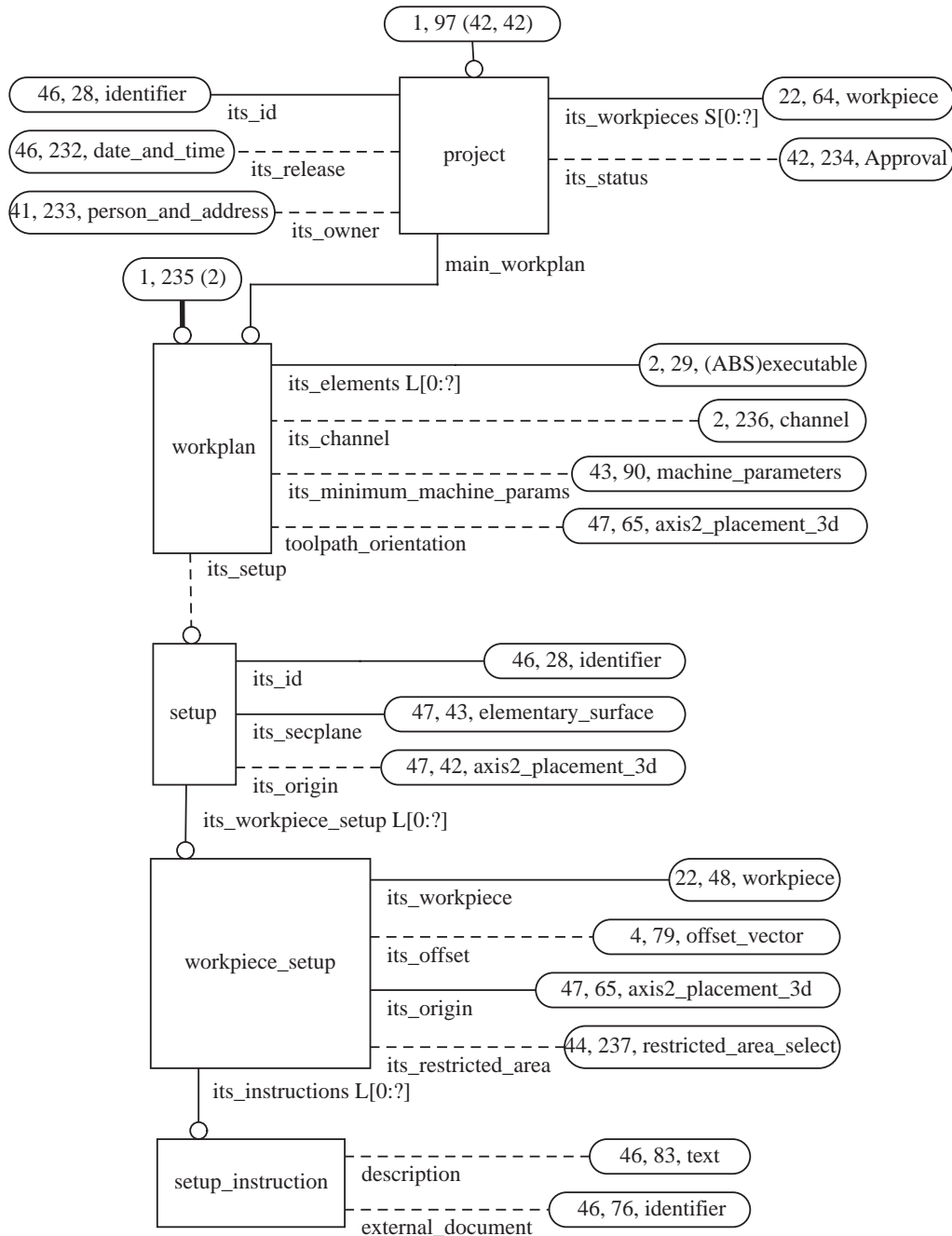
### ***Page 1294, E.2***

*The purpose of this change is to update the object identifier for the schema. Replace the object identifier with the following text.*

{ iso standard 10303 part(238) version(2) schema(1) integrated-cnc-schema(1) }

**Page 1297, Figure G.1**

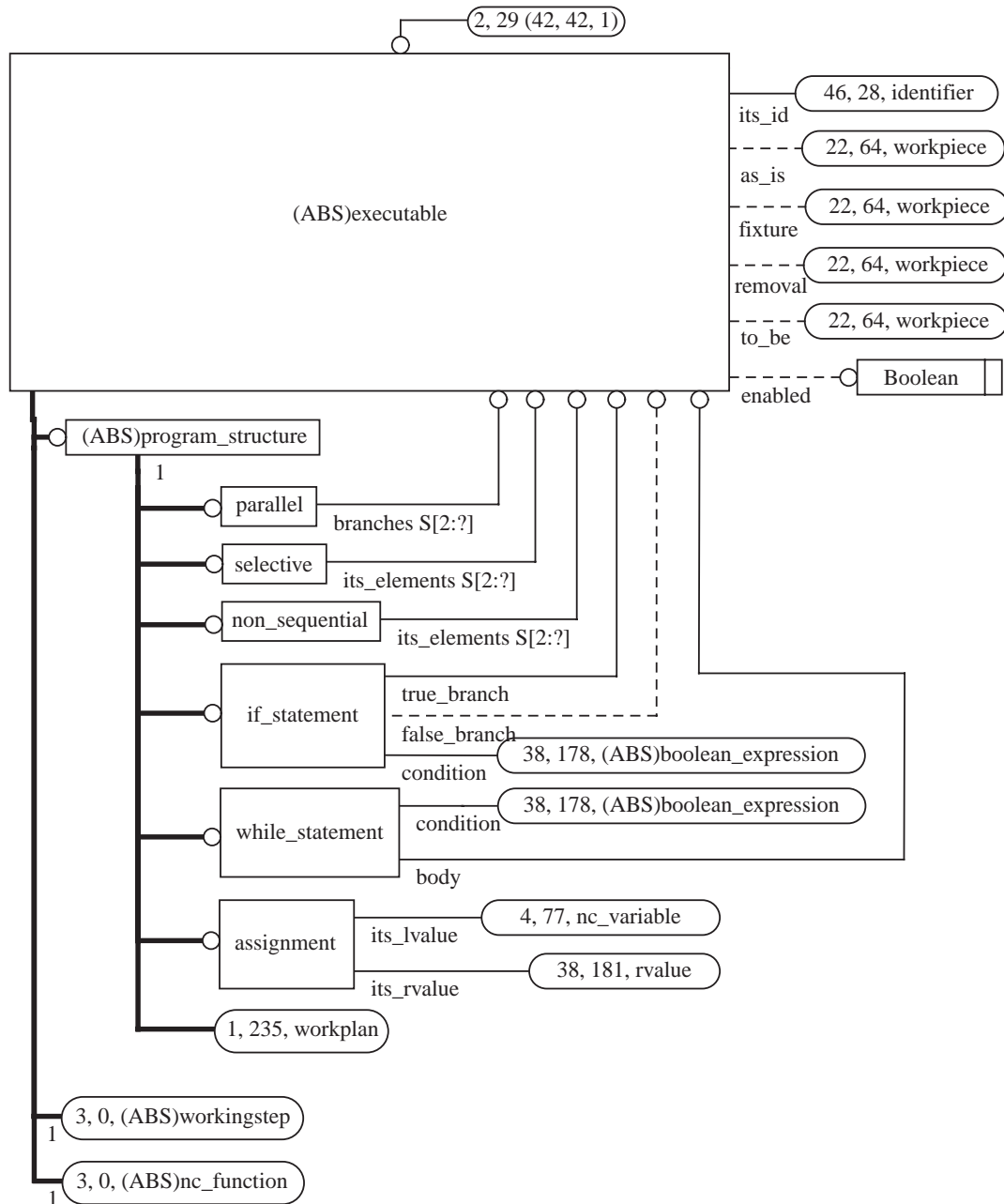
The purpose of this change is to update the ARM EXPRESS-G with the modifications to the Workplan application object. Replace Figure G.1 with the following.



**Figure G.1 - ARM diagram (1 of 48)**

**Page 1298, Figure G2**

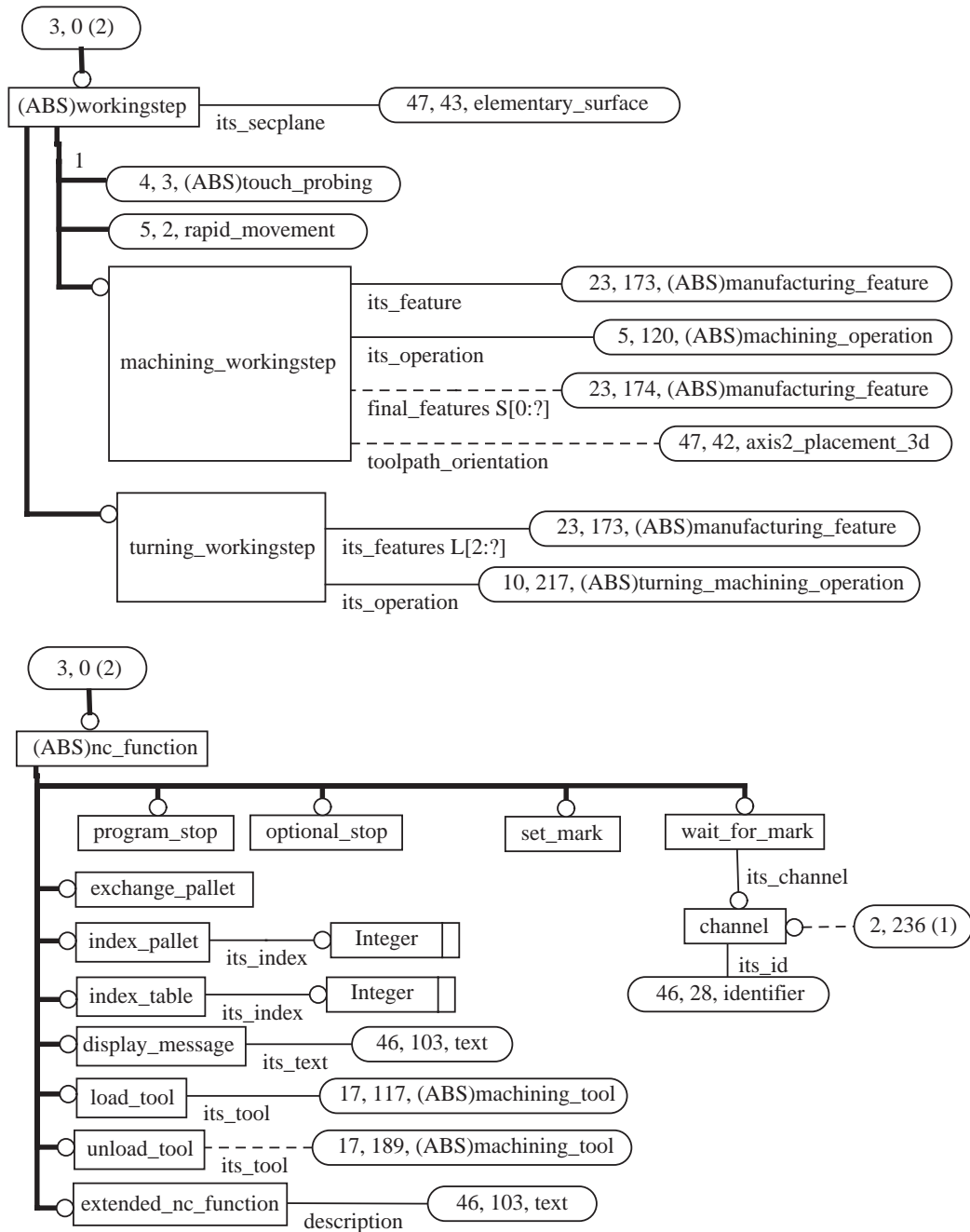
The purpose of this change is to update the ARM EXPRESS-G with the modifications to the Executable application object. Replace Figure G.2 with the following.



**Figure G.2 - ARM diagram (2 of 48)**

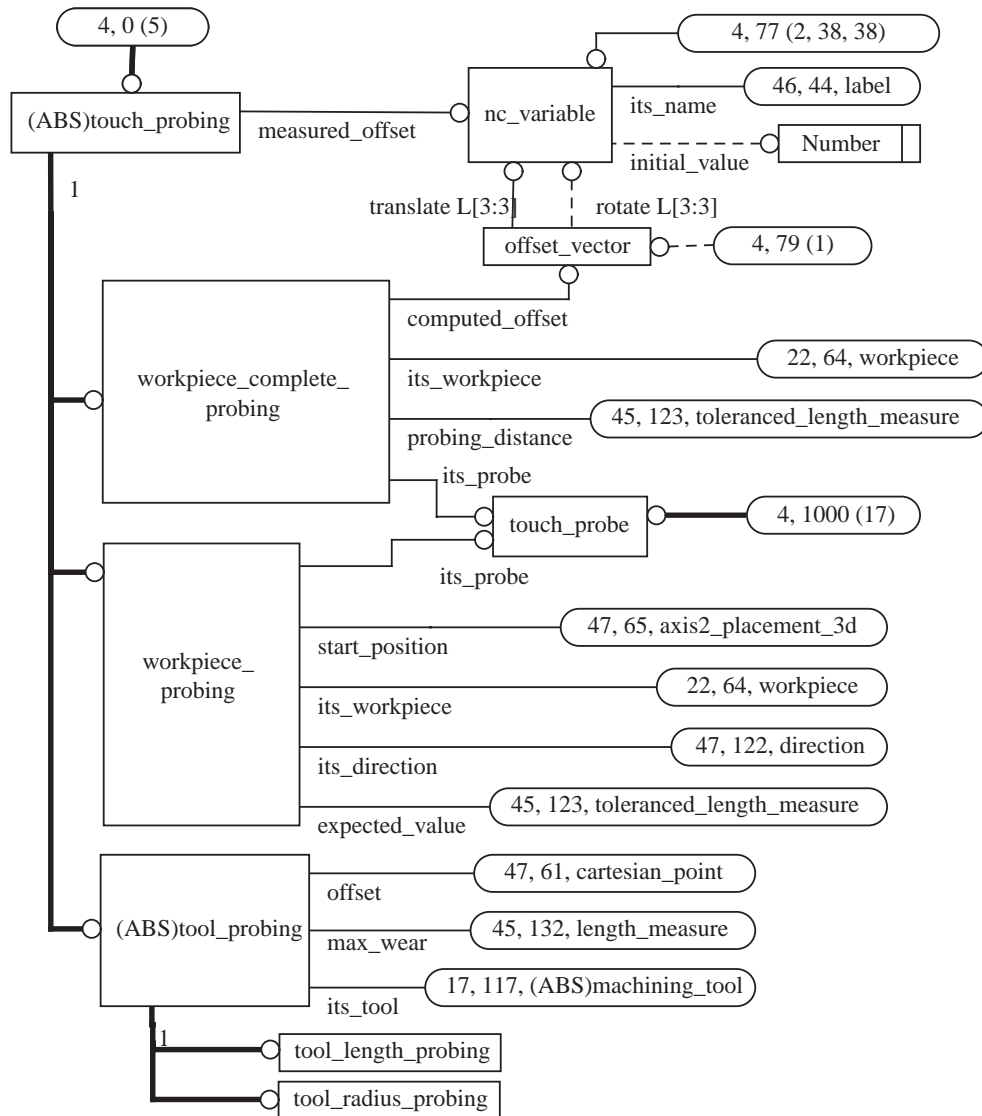
**Page 1299, Figure G.3**

The purpose of this change is to update the ARM EXPRESS-G with the modifications to the Machining and Turning\_workingstep application objects. Replace Figure G.3 with the following.

**Figure G.3 - ARM diagram (3 of 48)**

**Page 1300, Figure G.4**

The purpose of this change is to update the ARM EXPRESS-G with the modifications to the Touch\_probe application object. Replace Figure G.4 with the following.

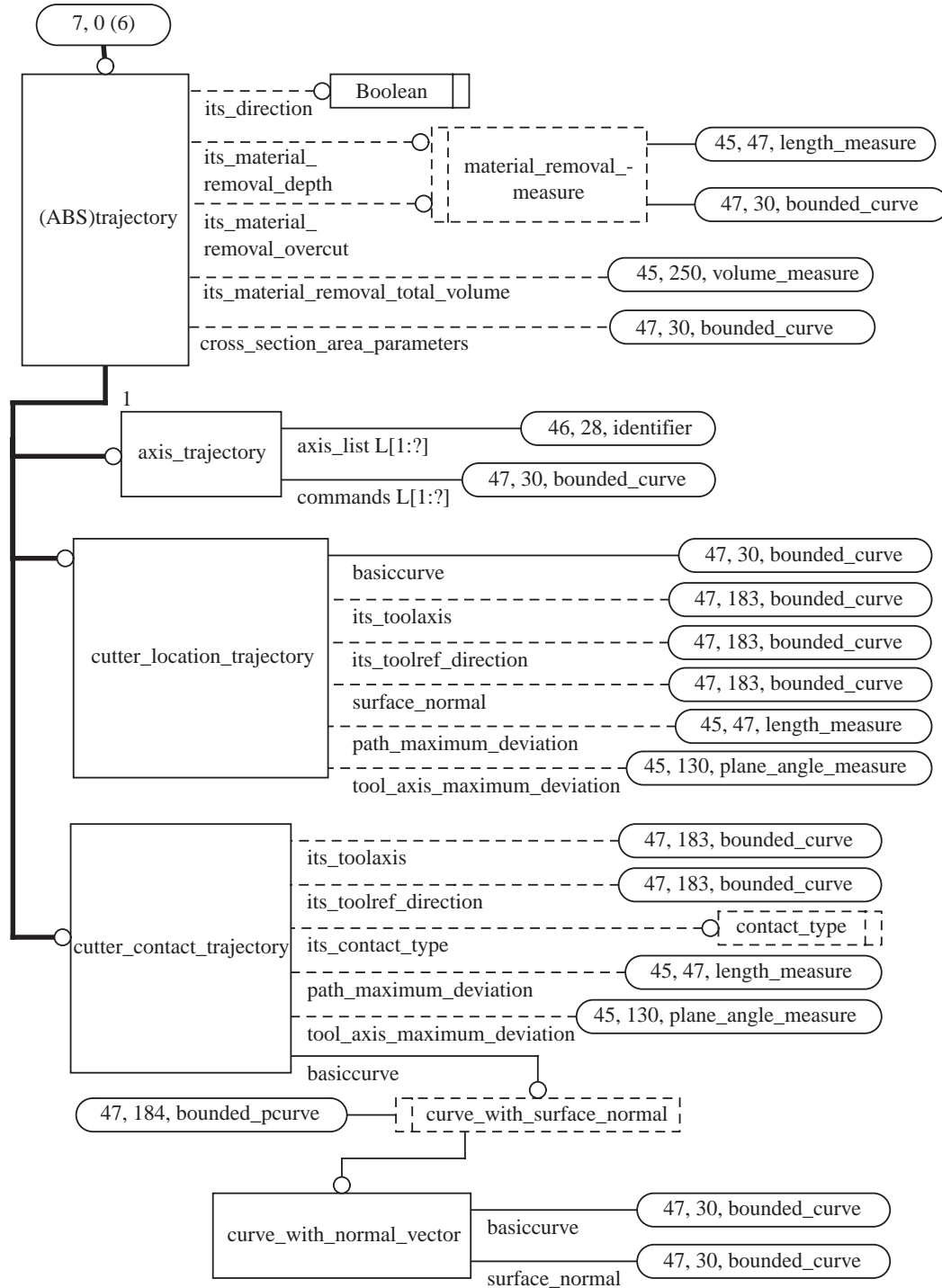


**Figure G.4 - ARM diagram (4 of 48)**



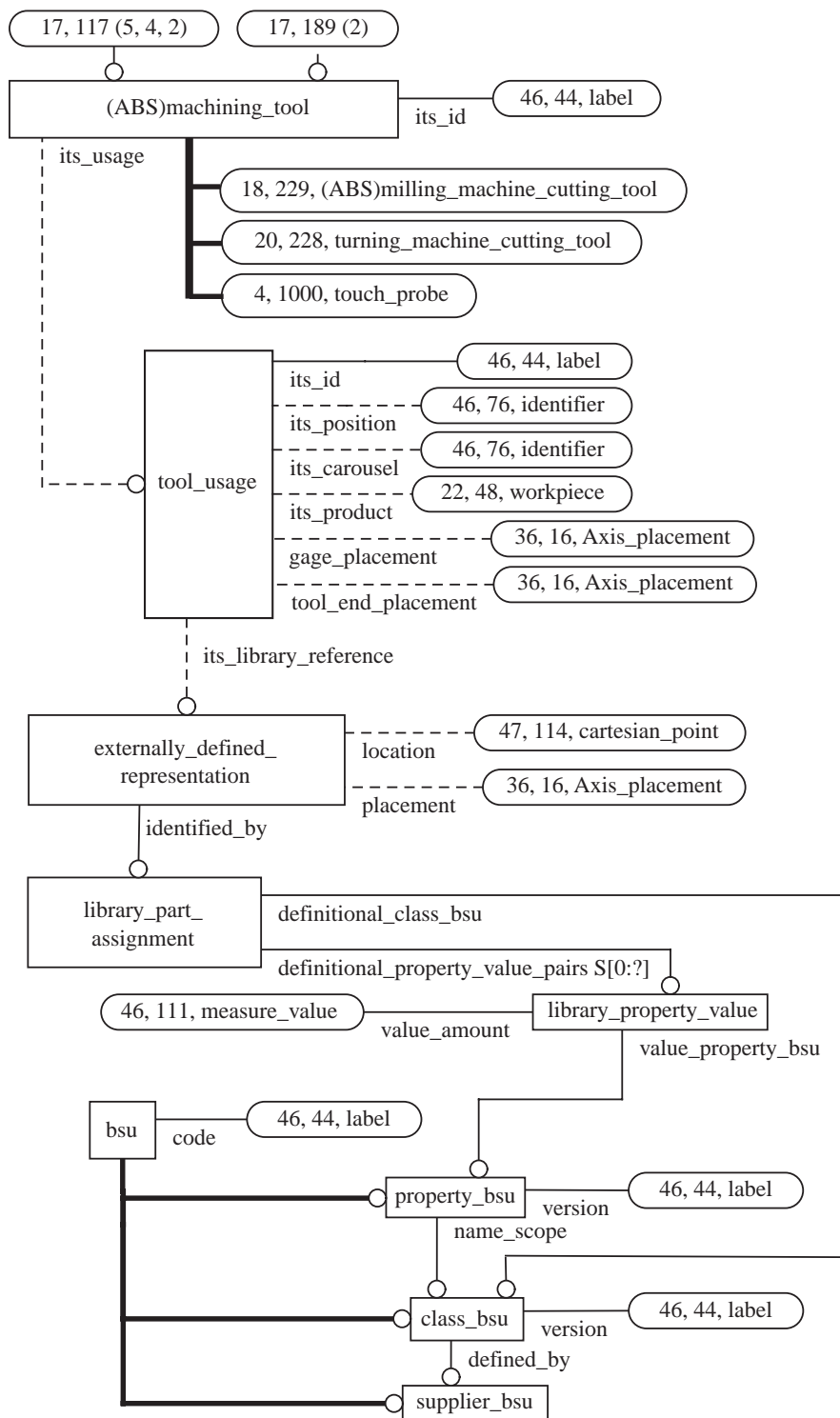
**Page 1303, Figure G.7**

The purpose of this change is to extend the ARM EXPRESS-G with the *cross\_section\_area\_parameters* data associated with the *Trajectory* application object. Replace Figure G.7 with the following.

**Figure G.7 - ARM diagram (7 of 48)**

**Page 1313, Figure G.17**

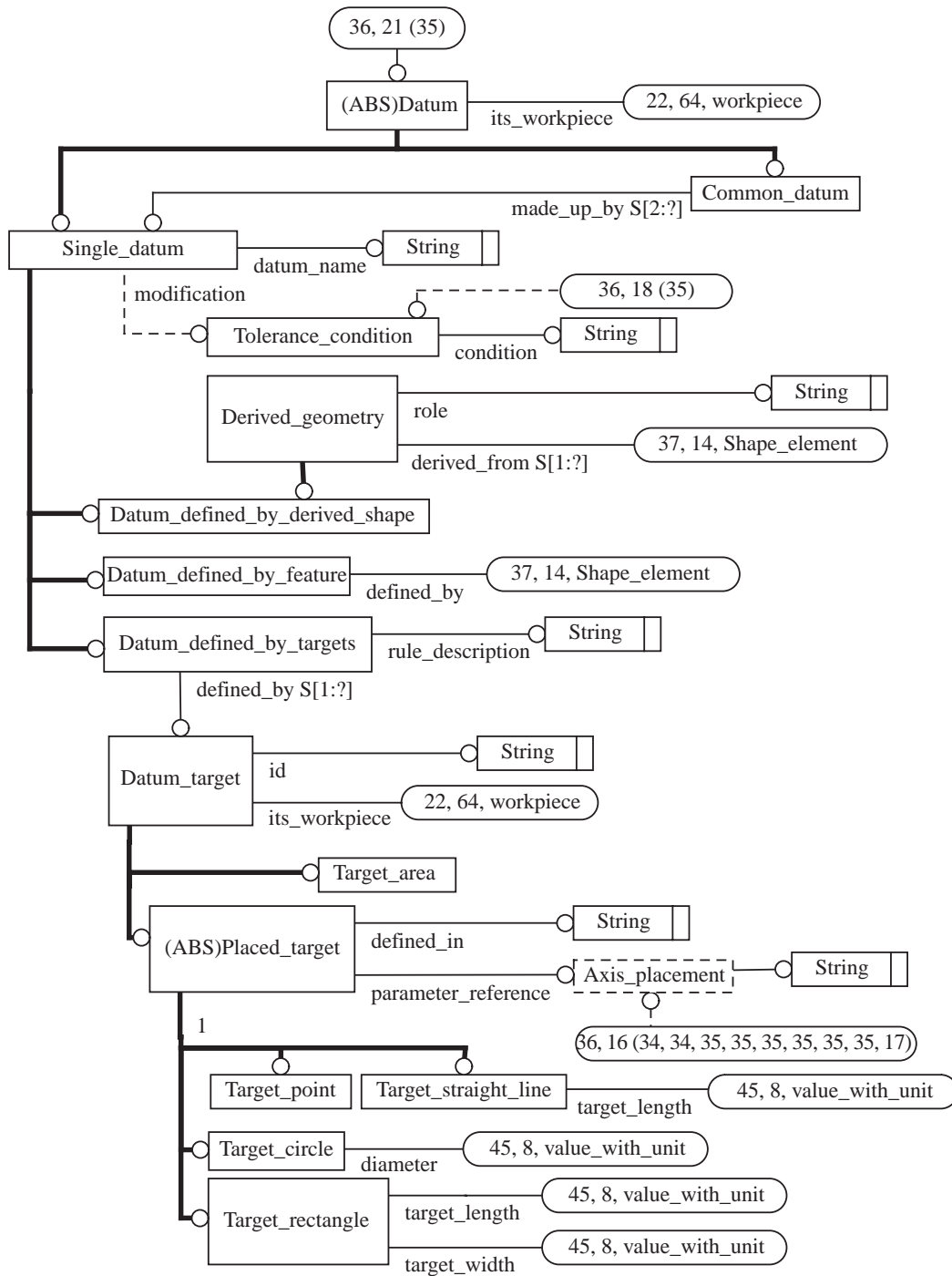
The purpose of this change is to update the ARM EXPRESS-G with the modifications to the Touch\_probe application object. Replace Figure G.17 with the following.



**Figure G.17 - ARM diagram (17 of 48)**

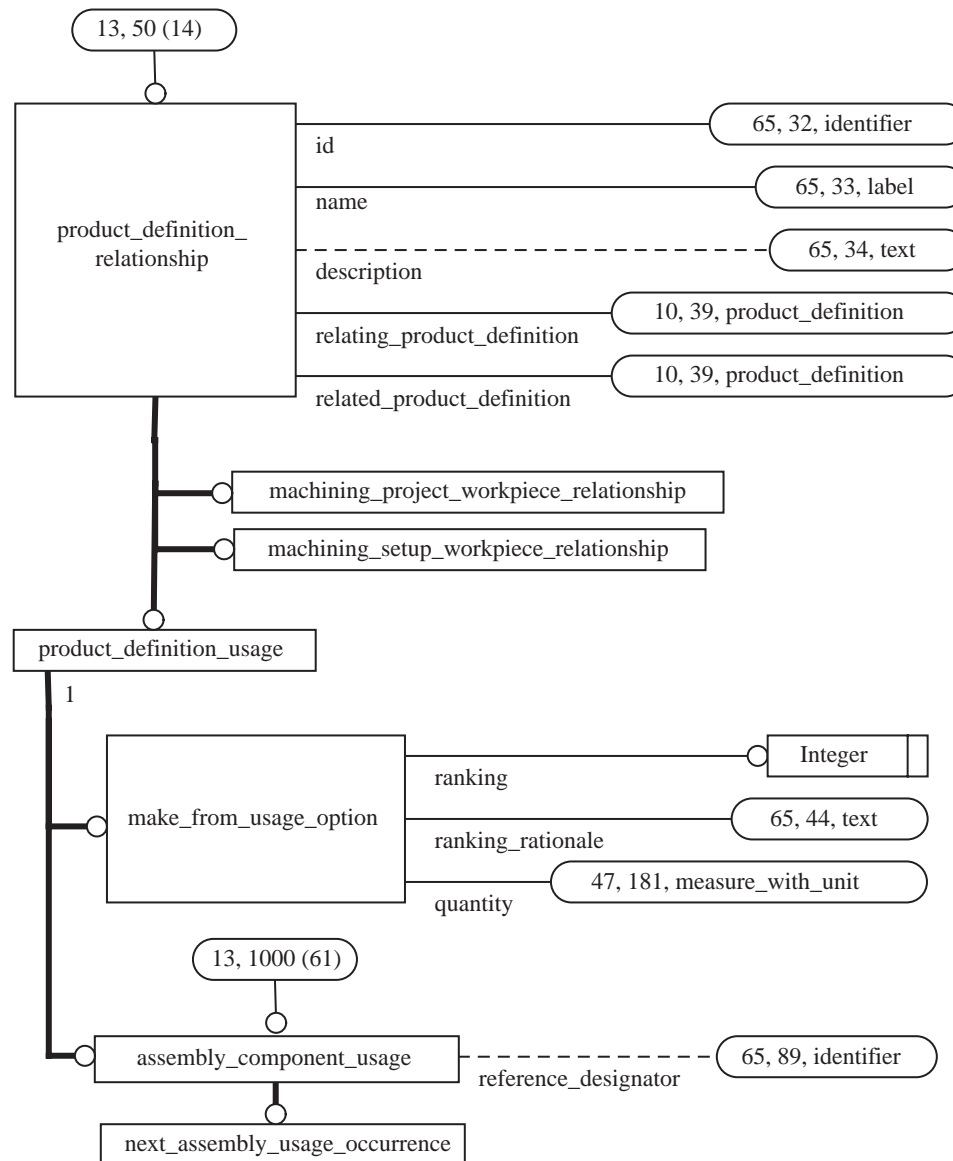
**Page 1332, Figure G.36**

The purpose of this change is to update the ARM EXPRESS-G with the modifications to the Datum and Datum\_target application objects. Replace Figure G.36 with the following.

**Figure G.36 - ARM diagram (36 of 48)**

**Page 1359, Figure H.13**

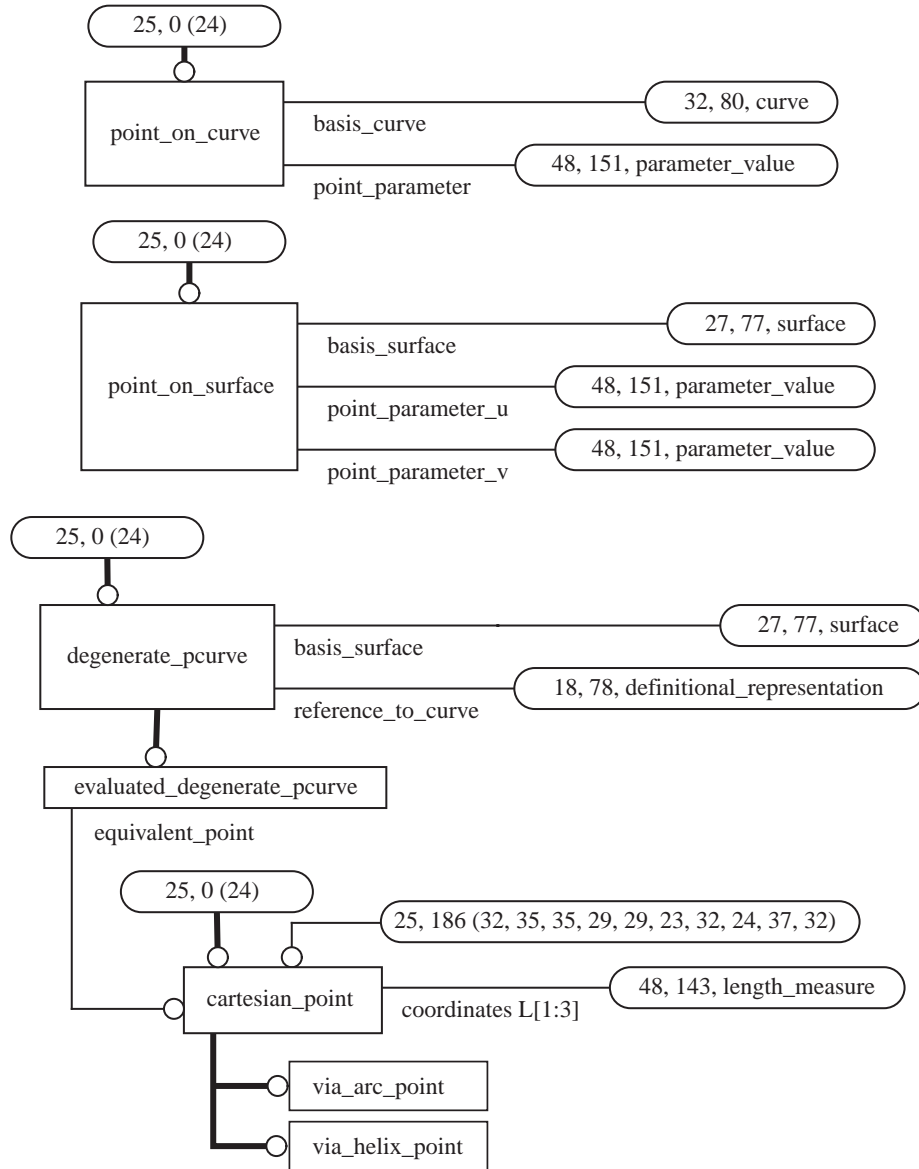
The purpose of this change is to add *assembly\_component\_usage* to the *AIM security\_classification\_item* definition to better support workpiece product models brought in from AP203 data. Replace Figure H.13 with the following.



**Figure H.13 - AIM EXPRESS-G diagram product definition relationship**

**Page 1371, Figure H.25**

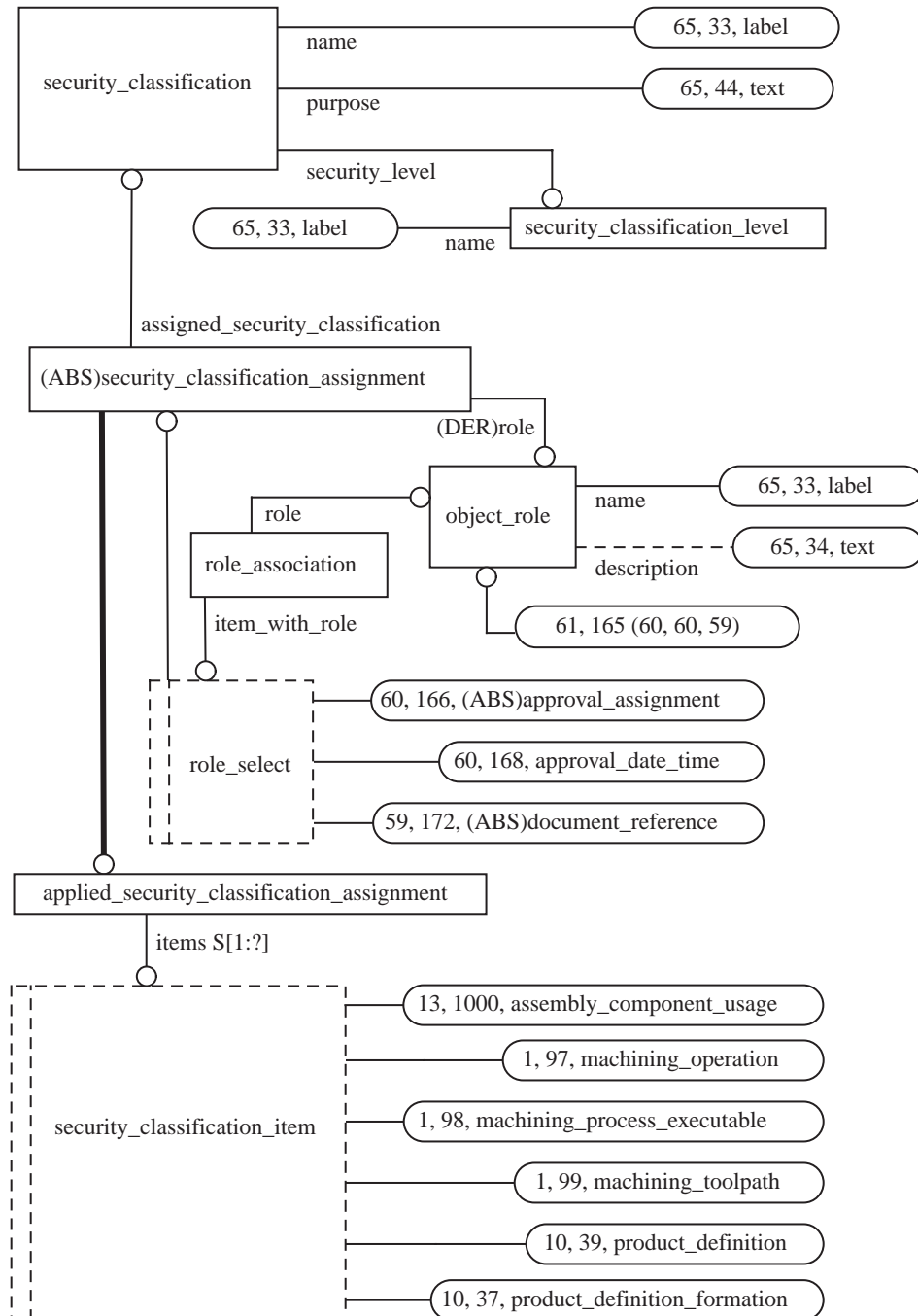
The purpose of this change is to add *via\_arc\_point* and *via\_helix\_point* to the AIM EXPRESS-G diagrams. Replace Figure H.25 with the following. Add *via\_arc\_point* and *via\_helix\_point* to Index.



**Figure H.25 - AIM EXPRESS-G diagram points**

**Page 1407, Figure H.61**

The purpose of this change is to add *assembly\_component\_usage* to the AIM *security\_classification\_item* definition to better support workpiece product models brought in from AP203 data. Replace Figure H.61 with the following.



**Figure H.61 - AIM EXPRESS-G diagram security classification**

***Page 1518, Bibliography***

*Insert the reference below and renumber all following references.*

- [3] ISO 10303-105, *Industrial automation systems and integration -- Product data representation and exchange -- Part 105: Integrated application resource: Kinematics*

## ***Change History (delete before publication)***

### **Version 1.8 (in progress)**

Clarified how the geometric accuracy impacts a via arc so that if a via point is within the geometric uncertainty of another point, then the arc degenerates to a line between them. Added assembly\_component\_usage to the security classification item select type to better support workpieces brought in from AP203 data.

Fine-tuned the mappings for touch probe to workpiece probing.

### **Version 1.7 (2009-02-27)**

Fixed the wording of some of the “Purpose of” statements. Added mapping for fixture to the mappings for as-is, to-be, and removal workpieces on executable and updated all EXPRESS-G diagrams. Added enabled parameter to Executable. Fixed the EXPRESS definition in Annex A for machining\_tool\_usage so that it matches Clause 5. Added its\_toolref\_direction to both Cutter\_contact\_trajectory and Cutter\_location\_trajectory. Added gage\_placement and tool\_end\_placement to Tool\_usage to clarify how the tool product model is oriented with respect to toolpaths and machine models. Added toolpath\_orientation to Workplan.

### **Version 1.6 (2008-08-26)**

Added its\_workpiece links to both Datum and Datum\_target to clarify usage of shape\_aspect of\_shape in the AIM. The definition and mapping are the same as the Manufacturing\_feature its\_workpiece.

Replaced In\_process\_geometry application object and separate references on Machining\_workingstep, Turning\_workingstep, and Workplan with references from Executable to as-is, to-be, and removal Workpiece objects. This extends the in-process description of the manufactured product information to any executable, and extends the description to permit the full range of product properties, such as features and tolerances, to be specified, in addition to the geometry and topology.

### **Version 1.5 (2008-06-02)**

Clarified description and diagram for cross-section parameters.

### **Version 1.4 (2008-05-30)**

Replaced the RDavg and XRDavg parameters with cross-section area and XY offset of the center of gravity. Updated description and figures.

### **Version 1.3 (2008-05-16)**

Enhanced descriptions of the RDavg and XRDavg parameters. Modified the definition and all associated mappings and EXPRESS-G diagrams for the Touch\_probe application object so that it is now a type of Machining\_tool. This lets us associate product, geometric shape and other tool usage information with probes, which was previously not possible because they were a unique concept, not related to any other tools. Reordered a few changes so that everything is now listed in page order.



**Version 1.2 (2008-05-14)**

Added note on feed direction to turning cross-section diagram. Enhanced description of maximum axial depth parameter.

**Version 1.1 (2008-05-12)**

Updated the via\_arc\_point example to use 3D points rather than 2D. Updated the cross section parameter diagram to have the origin at the center and to use the APT general tool profile. Also added text in the definition of ADmax to say that it is always measured perpendicular to the tool axis, regardless of the feed direction.

**Version 1.0 (2008-04-22)**

Initial version circulated to STEP Manufacturing for discussion.