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IPC-2547

Sectional Requirements for Shop-Floor Equipment Communication Messages (CAMX) for Printed Circuit Board Test, Inspection and Rework

IPC-2547

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A standard developed by IPC

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IPC-2547

CAMX

– TEST

Sectional Requirements for Shop-Floor Equipment Communication Messages (CAMX) for Printed Circuit Board Test, Inspection and Rework

A standard developed by the Inspection and Test XML Schema Formatting Task Group (2-13c) of the Shop Floor Communications Subcommittee (2-13) of IPC.

The IPC-2547 standard defines an the XML encoding schema, applied for the specific printed board assembly inspection and test equipment including manual visual inspection stations (MVI), automatic optical inspection stations (AOI), automatic laser inspection stations (ALI), manual x-ray (MXI), automatic x-ray inspection stations (AXI), flying-probe in-circuit test stations (FPT), bed-of-nails in-circuit stations (ICT) and functional test stations (FNT).



Users of this standard are encouraged to participate in the development of future revisions.

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Acknowledgment

Any Standard involving a complex technology draws material from a vast number of sources. While the principal members of the Inspection and Test XML Schema Formatting Task Group (2-13c) of the Shop Floor Communications Subcommittee (2-13) are shown below, it is not possible to include all of those who assisted in the evolution of this standard. To each of them, the members of the IPC extend their gratitude.

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Sectional Requirements for Shop-Floor Equipment Communication Messages (CAMX) for Printed Circuit Board Test, Inspection and Rework

Introduction

Factory Information Systems (FIS) form the nervous system of an enterprise, analyzing data and delivering information to the machines and people who need to make information-based decisions. These systems provide a bi-directional flow of information between the factory floor and the rest of the enterprise and beyond.

The CAMX standards (IPC 254X) are designed to foster application integration and shop floor equipment communications based on XML. It assumes that application programs (including equipment interfaces) are distinct entities, and application integration takes place using a loosely coupled, message-passing approach. There is no need for a common object model, programming language, network protocol, persistent storage mechanism or operating system for two applications to exchange XML messages formatted using the CAMX standards. The two applications simply need to be able to format, transmit, receive and consume a standardized XML message.

1 Scope

This document describes event message content and an XML encoding scheme, that enables a detailed definition of messages in the domain of electronics inspection, test and repair/rework (i.e. product and process quality). These messages are to be encoded at a level appropriate to facilitate interoperability in the factory shop floor equipment and information system integration process.

1.1 Interpretation

"**Shall**", the emphatic form of the verb, is used throughout this standard whenever a requirement intended to express a provision that is mandatory. Deviation from a **shall** requirement is not permitted, and compliance with the XML syntax and semantics **shall** be followed without ambiguity, or the insertion of superfluous information.

The words "should" and "may" are used whenever it is necessary to express non-mandatory provisions.

"Will" is used to express a declaration of purpose.

To assist the reader, the word **shall** is presented in bold characters.

2 Applicable documents

The following documents contain provisions that, through reference in this text, constitute provisions of this standard. All documents are subject to revision. Parties who make agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the documents indicated below.

IPC-T-50 Terms and Definitions for Interconnecting and Packaging Electronic Circuits

IPC 2500 Virtual Factory Information Interchange Framework definitions

IPC 2511	Generic Computer Aided Manufacturing (GenCAM) descriptions for Printed Circuit Boards and Printed Board Assembly
IPC 2541	Generic Requirements for Electronics Manufacturing Shop-Floor Equipment Communication Messages (CAMX)
IPC-2546	Sectional Requirements for Shop-Floor Equipment Communication Messages (CAMX) for Printed Circuit Board Assembly
W3C	Date-time format standard

3 General Requirements

The requirements of IPC-2541 are a mandatory part of this standard. That document describes the generic requirements for the CAMX format.

3.1 Terms and Definitions

The definition of all terms used herein **shall** be as specified in IPC-T-50, and the following:

Assembly

An electronic product consisting of a printed circuit board or boards, attached electronic and mechanical components with associated connectors and cabling.

Base-64

A method of encoding binary data into a restricted, printable ASCII characters subset. This method is used by the inspection systems for encoding their binary image format, such as .tif, .jpg, and .bmp.

Board

A single instance of a printed circuit. One circuit image of a fabrication panel. The foundation of an electronic printed circuit assembly.

Component

A single instance of a part package. Identified by an alpha-numeric designator, each of these will have a unique location on a circuit assembly.

Defect

An unacceptable deviation from a norm.

Event

A process action or trigger of significance. Also a term used in this standard as synonymous with message records generated upon the event occurrence.

Fault

The detected manifestation of a defect.

Frame

An instance of a captured optical, x-ray, or infra-red picture, image or other artifact facsimile of a circuit board or assembly. A Frame may be of a relatively small geometry or it may represent an entire assembly.

Image

A single board or assembly circuit instance typically used to identify one member of a homogeneous or heterogeneous panel, but not limited to that.

Item

An identifiable and traceable product or product component instance.

Indictment

A defect condemnation identified during human or automated inspection or test.

Octet

A measured or expected value expressed as an 8-bit byte. Measured and expected values that are not necessarily numeric in nature (e.g. character strings) are expressed and compared as octets.

Panel

An electronic assembly consisting of multiple circuit images. Homogeneous panels are defined as having multiple of the same circuit image revision and assembly (Bill of Materials) revision. Heterogeneous panels are defined as having more than one circuit image and/or more than one assembly revision.

Inspection

A process relating to one or more regions-of-interest of a board or an assembly.

Region Of Interest (ROI)

An area of focus in or on an electronic assembly pertinent to inspection.

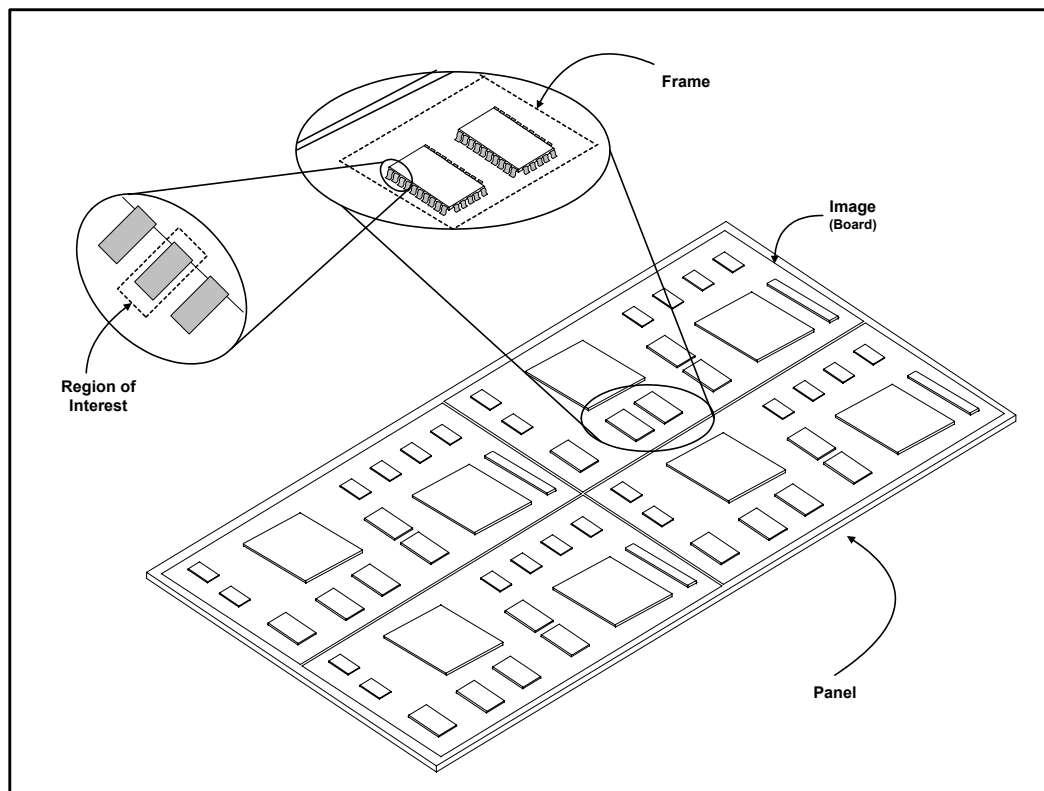


Figure 1 Inspection Frame and Inspection Region of Interest

Signal

An electrically-common logical net or physical conductor or connection.

Station

A uniquely identifiable, task-specific work area of a manufacturing environment.

Stage

A uniquely identifiable task within the sequence of manufacturing steps for electronic assemblies.

Symptom

Description of an element of evidence of a fault or defect.

Termination

A lead, pin, ball, leg or other conductive connection between a component package and the circuit board.

3.2 Date and Time Notation

All 2540 standards **shall** use the World Wide Web consortium (W3C) date time standard. This standard **shall** use the Complete Date plus Hours, Minutes, Seconds, and a decimal fraction of a second and Time Zone Designator. Two decimal places will be used in order to represent time down to a hundredth of a second. For additional information on date and time, see web page:

<http://www.w3.org/TR/1998/NOTE-datetime-19980827>

3.3 CAMX Compliance

The IPC-2501 document defines a message packet structure. The IPC-2541 document defines a set of Equipment, Recipe, Item, and Operator events and related message formats. All test, inspection and repair stations that comply with the IPC-2547 standards **shall** also comply with the event messages contained in the IPC-2541 standard as well as those events that are described in this document. All event messages **shall** be formatted in compliance with the IPC-2501 message packet structure. For consistency in XML style, all CAMX XML Element and attribute names **shall** be in mixed-case with Element names beginning with an upper case letter and attribute names beginning with a lower case letter. XML Elements are order specific and **shall** appear in the order prescribed in the XML schema definitions.

4 Test and Inspection Specific Event Messages

The figure below illustrates the relationships and cardinality of the key event elements.

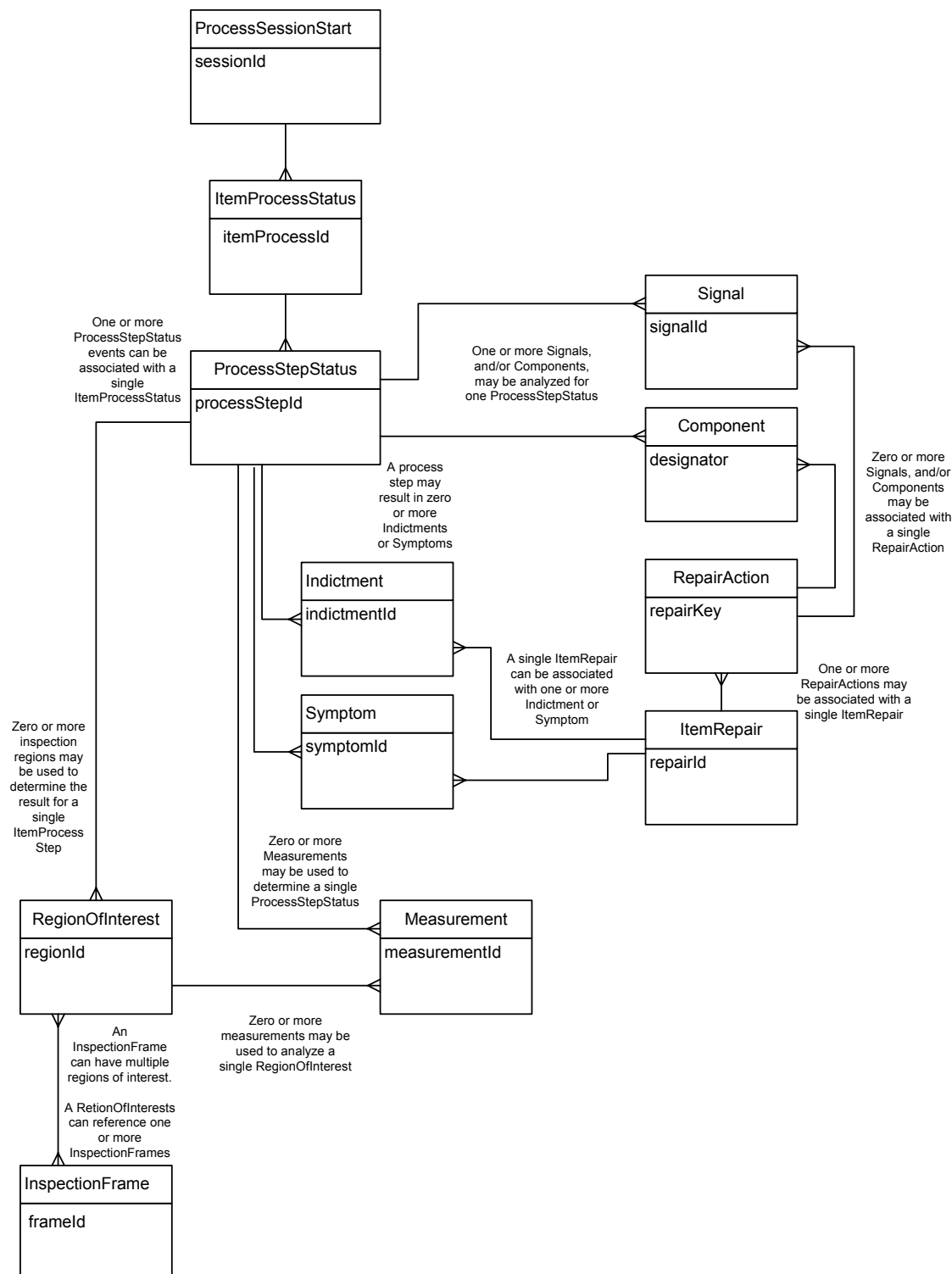


Figure 2 Key Event Object Relationships

Though the events are asynchronous, the relationships are linked using identifiers and identifier references for grouping the event records. Each session has an identifier that shall be unique across at least the reporting domain. The recommendation is to use a date-time in conjunction with a MAC or IP address, *GUID* or Java-style organization package path. For example:

- Network address and date-time ("15.11.9.54-2000-08-05T10:04:31.20+0800")
- Enterprise Id and date-time ("com.ourco.mch2-2000-08-05T10:04:31.20+0800")

This identifier is then referenced in each *ItemProcessStatus*. There is one *ItemProcessStatus* for one execution of the test or inspection program. In turn, each *ItemProcessStatus* has an identifier unique within the reporting domain that is referenced in the *ProcessStepStatus* event for each step of the test or inspection program. Similarly each supporting inspection or test step has an identifier that is unambiguous within the test or inspection program's sequencing. Indictments or symptoms of failing test steps are also unambiguously identified, enabling association with repair events and repair actions.

The tables in this section define the event message attributes that are appropriate for test, inspection, and repair/rework functions. These events are necessary for tracking product and process quality as well as enabling identification and intelligent correlation of fault signatures to effective repair actions. The right-most column (labeled Occ) indicates the expected number of occurrences (cardinality) of each attribute or element. 0-1 indicates an optional field. 1-1 indicates a single mandatory field. 0-n indicates any number, including zero. 1-n indicates at least one.

4.1 Management Event - *ProcessSessionStart*

In recognition that there is a need for information to be shared between factory equipment and processes this event message has been defined to meet this need. There are typically many items processed during one session. Consider this message as an event separator that can be triggered by the equipment itself or by a change in its environment, including a new operator, a shift change, a change in the product or in the program/recipe.

4.1.1 Event: *ProcessSessionStart*

Description: The *ProcessSessionStart* record provides information regarding the product, process, location and environment.

Attribute Name	Attribute Type	Description	Occ
dateTime	dateTime	Date and time of the event	1-1
sessionId	string	Domain unique identifier of this process session	1-1
Product	Element	Identifies the type, lot, batch etc. of the product	1-1
Entity	Element	Identifies the location and enterprise	1-1
shift	string	Identify the work interval.	0-1
Recipe	Element	Identifies the process program, model, best practices or algorithms	0-n
Operator	Element	Equipment operator identifier	0-n
FixtureTooling	Element	Identifies the test fixture(s) if applicable	0-n

4.1.2 Element: Product

Description: The Product element uniquely describes the item and its groupings.

Attribute Name	Attribute Type	Description	Occ
itemType	string	Product type id	1-1
itemClass	string	Identify the product classification such as system, assembly, board,	0-1
boardRevision	string	Identify the board layout revision	0-1
assemblyRevision	string	Identify the assembly version (i.e. bill of materials)	0-1
workOrder	string	Identify the product work order	0-1
batch	string	Identify the product batch	0-1
lot	string	Identify the product lot	0-1
count	positiveInteger	The number of product in the lot or batch	0-1

4.1.3 Element: Operator

Description: The Operator element **shall** contain a unique identifier for the operator such as their employee number or social security number, and may also contain a personal identifier such as the person's name, nickname or logon name.

Attribute Name	Attribute Type	Description	Occ
employeeId	string	Employee number, login name or internal identifier	1-1
givenName	string	Employee's first name	0-1
familyName	string	Employee's last name	0-1

4.1.4 Element: Entity

Description: The Entity element uniquely describes the equipment or process station.

Attribute Name	Attribute Type	Description	Occ
stationId	string	Process station identifier unique to the domain	1-1
stage	string (enumerated)	Process step. One of: MVI ALI AOI MXI AXI MDA FPT ICT FNT INT SYS OLT	1-1
stationRevision	string	Identify the station's hardware revision if applicable	0-1
subStage	string	Additional information regarding the stage, station or processing.	0-1
line	string	Identifier for this manufacturing line or cluster	0-1
building	string	Identify the building	0-1
site	string	Identify the site or location	0-1
enterprise	string	Identify the company	0-1

4.1.5 Element: Recipe

Description: The Recipe element uniquely identifies the recipe, program, algorithms or best practices being executed at the station or specified station zones and/or lanes. The attributes zoneList and laneList are defined using the XML string list syntax specified as a single quoted string containing white-space (e.g. SPACE, TAB) separated, alpha-numeric character groups.

Attribute Name	Attribute Type	Description	Occ
recipeId	string	Identifies the name of the program	1-1
revision	string	Identifies the revision of the program	1-1
zoneList	string (list)	Identifies the zone(s) executing this recipe	0-1
laneList	string (list)	Identifies the lane(s) executing this recipe	0-1
RecipeModule	Element	Identifies the files or individual parts of a multiple part recipe	0-n

4.1.6 Element: RecipeModule

Description: The RecipeModule element uniquely identifies a single component of the recipe, program, algorithms or best practices being executed at the station and identifies its type.

Attribute Name	Attribute Type	Description	Occ
moduleId	string	Identifies the name of the recipe part	1-1
revision	string	Identifies the revision of the recipe part if applicable	0-1
type	string (enumerated)	Identifies the entry type as one of ALGORITHM CONFIGURATION DOCUMENTATION EXECUTIVE FIRMWARE LIMITS SEQUENCE SETUP	0-1

4.1.7 Element: FixtureTooling

Description: The FixtureTooling element uniquely describes the test fixture and can be used to track its actuation count for probing accuracy and maintenance purposes.

Attribute Name	Attribute Type	Description	Occ
fixtureId	string	Identify the test fixture	1-1
revision	string	Identify the revision of the fixture	1-1
serialNumber	string	Identify the particular fixture instance	0-1
type	string	Identify the fixture type or function	0-1

```

<ProcessSessionStart
  dateTime="2000-08-05T10:04:31.20+0800"
  sessionId="NewCo3070-2-2000-08-05T10:04:31.20+0800"
  shift="FIRST">
  <Operator
    employeeId="0024335"
    givenName="Jane"
    familyName="Wilson"/>
  <Entity
    stationId="NewCo3070-2"
    stage="ICT"
    line="3"
    building="B6"
    site="Hillsboro"
    enterprise="CPUCo"/>
  <Recipe
    recipeId="11356-66540"
    revision="3"
    zoneList="3 4 5"
    laneList="1 2"/>
  <FixtureTooling
    fixtureId="11356-66540\2"
    revision="A"/>
  <Product
    itemType="11356-66540"
    boardRevision="B-20000512"
    assemblyRevision="4"
    workOrder="Cpq4592-002"
    batch="12"
    count="144"/>
</ProcessSessionStart>

```

4.2 Event: ProcessSessionEnd

Description: The ProcessSessionEnd record is optional, and can be used as the companion to the ProcessSessionStart record and serve to close the process session.

Attribute Name	Attribute Type	Description	Occ
dateTime	dateTime	Date and time of the event	1-1
sessionId	string	Globally unique identifier of this process session	1-1

```

<ProcessSessionEnd
  dateTime="2000-08-05T10:04:31.20+0800"
  sessionId="NewCo3070-2-2000-08-05T10:04:31.20+0800"
/>

```

4.3 Event: InspectionFrame

Description: An image frame captured for analysis.

The InspectionFrame message describes an inspection frame, uniquely identifying it and providing its size and location in relationship to the board origin. The data payload may include the base-64 encoded image file (e.g., gif, tif, jpg, png) binary. There are typically many InspectionFrame events per item (board, panel or assembly).

Attribute Name	Attribute Type	Description	Occ
dateTime	dateTime	Date and time of the event	1-1
itemInstanceId	string	Item instance identifier	1-1
sessionRef	string	References the session in which this event occurred	1-1
itemProcessRef	string	References the process that captured the frame	1-1
frameId	string	Unique identifier for this frame for later reference	1-1
Region	Region Element	Identify the frame region and orientation with respect to the board origin.	1-1
imageId	string	Identify the board image if panelized or a single item of a multiple item test grouping.	0-1
frameStatus	string (enumerated)	PASSED FAILED Frame either contains zero failing regions-of-interest (PASSED) or contains one or more failing regions (FAILED).	0-1
layer	string	Identify board surface or layer of the frame if applicable. This can be the slice of an x-ray inspection or absent for multiple-frame x-ray image synthesis.	0-1
Base64Encoding	Base64 Element	Encoded frame element	0-1

4.3.1 Element: Region

Description: A rectangular or circular area definition. Point1X and point1Y attributes are always required. If the point2X and point2Y attributes are present then the region is analyzed as rectangular. If point2X and point2Y are not present then the diameter attribute **shall** be present and the region is analyzed as circular.

Attribute Name	Attribute Type	Description	Occ
units	string (enumerated)	Coordinate units (INCH MM PIXEL)	1-1
point1X	double	The region origin X value	1-1
point1Y	double	The region origin Y value	1-1
point2X	double	The opposite corner X value if rectangular	0-1
point2Y	double	The opposite corner Y value if rectangular	0-1
diameter	double	The diameter if a circular region	0-1
decade	double	Unit multiplier in powers of 10 (default is 0).	0-1
Orientation	Element	Rotation of the region vs. the board.	0-1

4.3.2 Element: Orientation

Description: The Orientation element describes the rotation (theta) of an InspectionFrame region with respect to its parent board or the rotation of a RegionOfInterest with respect to its InspectionFrame.

Attribute Name	Attribute Type	Description	Occ
value	double	Rotation value	1-1
units	string (enumerated)	Rotation units (DEGREES RADIANS)	1-1

4.3.3 Element: Base64Encoding

Description: The Base64Encoding element identifies the MIME type of the binary and its encoding. If the binary is decoded at its destination and written to the file system it is given the name and the suffix associated with the type.

Attribute Name	Attribute Type	Description	Occ
name	string	File name	1-1
mimeType	string	Frame MIME type (suffix)	1-1
encoding	string	Base-64 encoded frame	1-1

```
<InspectionFrame
  dateTime="2000-08-05T10:04:31.20+0800"
  itemInstanceId="66540A00343"
  sessionRef=="NewCo3070-2-2000-08-05T10:04:31.20+0800"
```