Color Exchange Format 3.0

A standard for exchange of color information

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Foreword

This second and third edition cancels and replaces the first edition Color Exchange Format (CxF) 1.xx which has been technically revised and replaced by this document in whole. It was felt that it would be better to redesign the Color Exchange Format into a more robust XML language that is self validating than direct tag compatibility to the earlier edition.

Introduction

Industries and individuals concerned with sharing color information need to be able to accurately, concisely, and reliably specify color data in a repeatable format that can facilitate data transmission and use. In addition, the format should exhibit these features:

Color data must be both human-readable in a standard text editor, and machine-readable.
Automated programs must be able to create valid data files compatible with the format, and to extract necessary information from data files.

End users must be able to extend and customize the format to allow inclusion of specialized information without breaking automated reading of the data files.

The format must allow multiple-language representation of data.
The format should not be proprietary to any one company or consortium of interests, but be freely available for deployment.
Existing applications using CGATS.17 formatted documents in ASCII format should not be rendered obsolete by the new standard.

GretagMacbeth first attempted to introduce a more robust standard in Color Exchange Format (CxF 1.0). This effort ran into difficulties because it relied on proprietary software, and because it provided no convenient way of importing and managing data already captured in another format, such as CGATS.17 ASCII data.

CGATS.17 provides a format that has served the needs of the industry well, although with some limitations. For example, a CGATS file has no convenient and generally-accepted way of managing color-space information or describing and managing custom palettes of colors. Customization of a CGATS.17 file by adding fields can make the file unreadable by any but the original application for which it was intended, limiting the portability of the color data it contains.

It seems clear that the time has come to provide a format that accommodates a wider range of color data in a more efficient way, that fully takes advantage of the strengths and universal acceptance of XML (Extensible Markup Language). Such a standard should use a hierarchical instead of flat approach, be customizable without affecting transportability, and that can accommodate existing data from both CGATS.17 and CxF 1.0 files. This document proposes such a format, **Color Exchange Format CxF**.

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1 Scope

The proposed standard for Color Exchange Format supports existing graphic arts standards that exchange measured, computed, or process control data and the associated metadata necessary for its proper interpretation. Using XML, Color Exchange Format documents also support the exchange of data outside of the Graphic Arts workflow and can support future standards with an extensible architecture, using truly standard XML Names and Metadata tags which can be used with standard XML tools and pass XML validation.

2 Normative references

The following referenced documents are helpful for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Extensible Markup Language (XML) 1.0 (Second Edition), World Wide Web Consortium (W3C), W3C Recommendation 6 October 2000. Available from Internet http://www.w3.org

XSL Transformations (XSLT) Version 1.0, World Wide Web Consortium (W3C), W3C Recommendation 16 November 1999. Available from Internet http://www.w3.org

Committee for Graphic Arts Technologies Standards (CGATS) CGATS.17. Available from Internet http://www.npes.org

Color Exchange Format CxF documents. Available from the Internet at www.colorexchangeformat.com

3 Terms and definitions

3.1 ColorSpecification

Contains information about the ColorValue including its source (measurement specifications), illuminant/observer calculation method (tristimulus specifications), and physical attributes of the objects (size, quantity, finish, etc.). ColorSpecifications are stored in the ColorSpecificationCollection and are shared and referenced by the ColorValues.

3.2 ColorValue

One of a number of defined color space types that can hold values and associated information related to that specific type of device independent color space. An object can have many ColorValues. *Examples are ColorCIELab, ColorCIEXYZ, ColorSRGB, and ReflectanceSpectrum.*

3.3 CustomResources

CustomResources are the “extensible” part of CxF3, additional information not included in the CxF3 Core about color objects and the file itself that is considered application specific in nature and not generally of use to all other applications. CustomResources might contain information for layouts, organizational hierarchies, relationships, and ISO standards required information not included or needed in the general Core Resources. The CustomResources reference the Objects (by Id) that are contained in the CxF3 Core Resources. A CXF file may contain many CustomResources, each CustomResource includes its own namespace, and any application which needs this type of information would need to support that namespace in addition to the CxF3-Core namespace schema.

3.4 DeviceColorValue

One of a number of defined color space types that can hold values and associated information related to that specific type of device dependent color space. A device dependent color space cannot generally be converted to other color space types without the aid of a transform profile between the two devices. *Examples are ColorCMYK, ColorRGB, ColorHTML, and ColorRecipe.*

3.5 Object

The general term used in CXF to identify each specific “Color item” that is being described. The term “object” was chosen over “Color”, “Sample”, or “Measurement” because it more clearly conveys the idea that these items can be either physical or virtual in nature. The items presented may be of physical measurements, or averages of samples, or they may represent a designer’s conceptual idea of a set of “colors” they would like to develop for some program. The exact type of object (ex: “Standard”) can be detailed in the attributes of the object (ObjectType).

3.6 Profile

A set of mathematical values or binary structure that allows transformation to/from one device color space to another. Profiles are stored in the ProfileCollection and are shared and referenced by the ColorValues.

3.7 Resources

All of the information about each color object that is of interest to all readers of the CXF file, including the names, color values, physical attributes, measurement conditions, and profiles are considered CXF3 “resources”. Also referred to as the “CxF3 Core” – it is defined by the CxF3-Core namespace schema. All software which is CXF3 capable should be able to read/write this core information.

3.8 Schema

A schema is an XML document that, conforming to the specifications established by the World Wide Web Consortium, defines the structure of a class of XML documents. The CxF™ 3.0 schema defines the structure, requirements, and enumerations for CxF™ 3.0 documents and defines the namespace (xmlns:cc="http://colorexchangeformat.com/CxF3-core"). With a schema it is possible to determine if a file and its contents are “valid” according to the schema definitions.

4 Requirements

4.1 General description of a Color Exchange Format conforming file

The standard Color Exchange Format as presented in the CxF™ 3.0 captures File Information such as creation and ownership, core color information (the Resources), and any extended information (CustomResources). A CxF3 document will have the extension “.cxf”.

Note: this same extension is also used with CXF1 and CXF2 files – so the application should determine which type of file is being read by examining the root element and namespace.

By using XML, which is a standard for the digital representation of documents, Color Exchange Format also speeds and simplifies the movement and reporting of data from its database collection to a Web-ready representation.

A CxF3 file will be structured as shown in Figure 1.

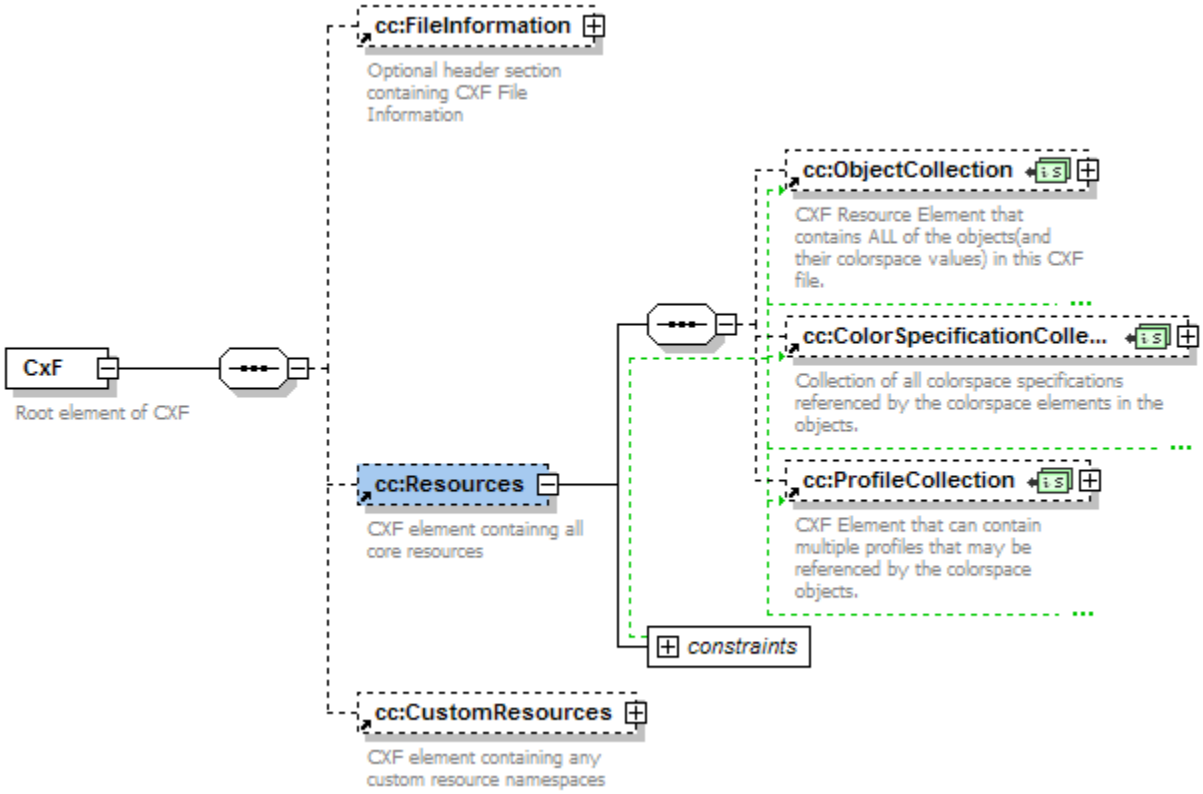


Figure 1

Every valid Color Exchange Format document must contain, at a minimum, the required namespace information in the root CXF element (<CxF xmlns="http://colorexchangeformat.com/CxF3-core">).

In addition, it may include FileInformation ,Resources, and CustomResources.

4.1.1 FileInformation

This optional element contains the header data for a Color Exchange Format container that supports workflow management. Elements include:

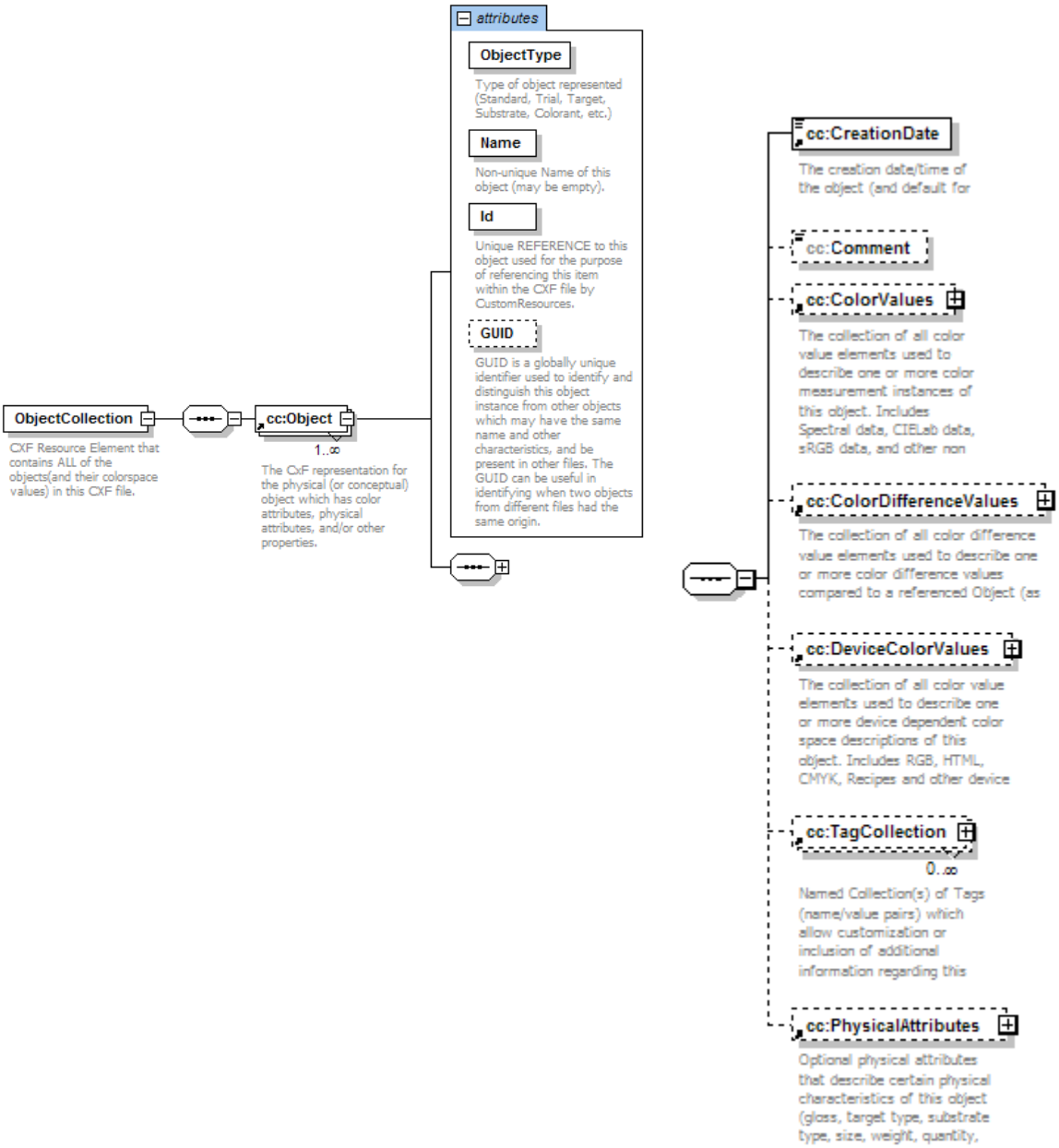
Creator - Name of the data creator. E.x. Program name used to generate file, company name, etc.
CreationDate - Date and time of the creation of this Color Exchange Format file. Date time format is CCYY-MM-DDThh:mm:ss.SSSZ. Optional time zone may be specified either as UTC or UTC offset.
Description of the file, or a data manifest.
Comment – User entered comment for additional information
Tag(s) – Any named tag/value pairs for additional metadata regarding this file.

4.1.2 Resources

A typical file would include information within the appropriate Collections in the Resources:

4.1.2.1 ObjectCollection – stores all of the color objects contained in the file.

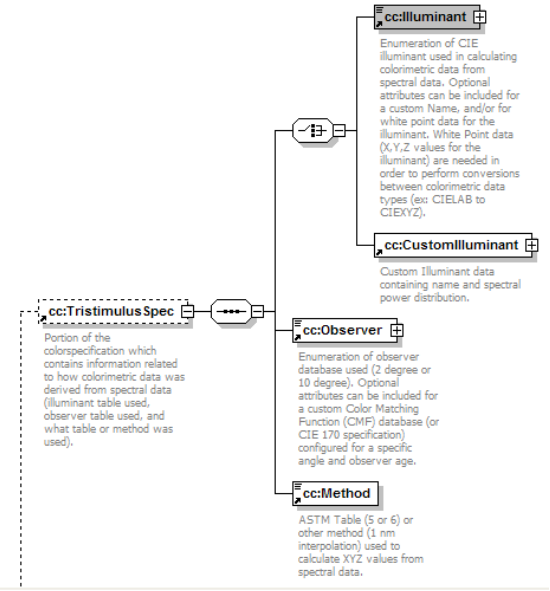
Object elements contain identification attributes and data including ColorValues, DeviceColorValues, ColorDifferenceValues, PhysicalAttributes, and TagCollections.



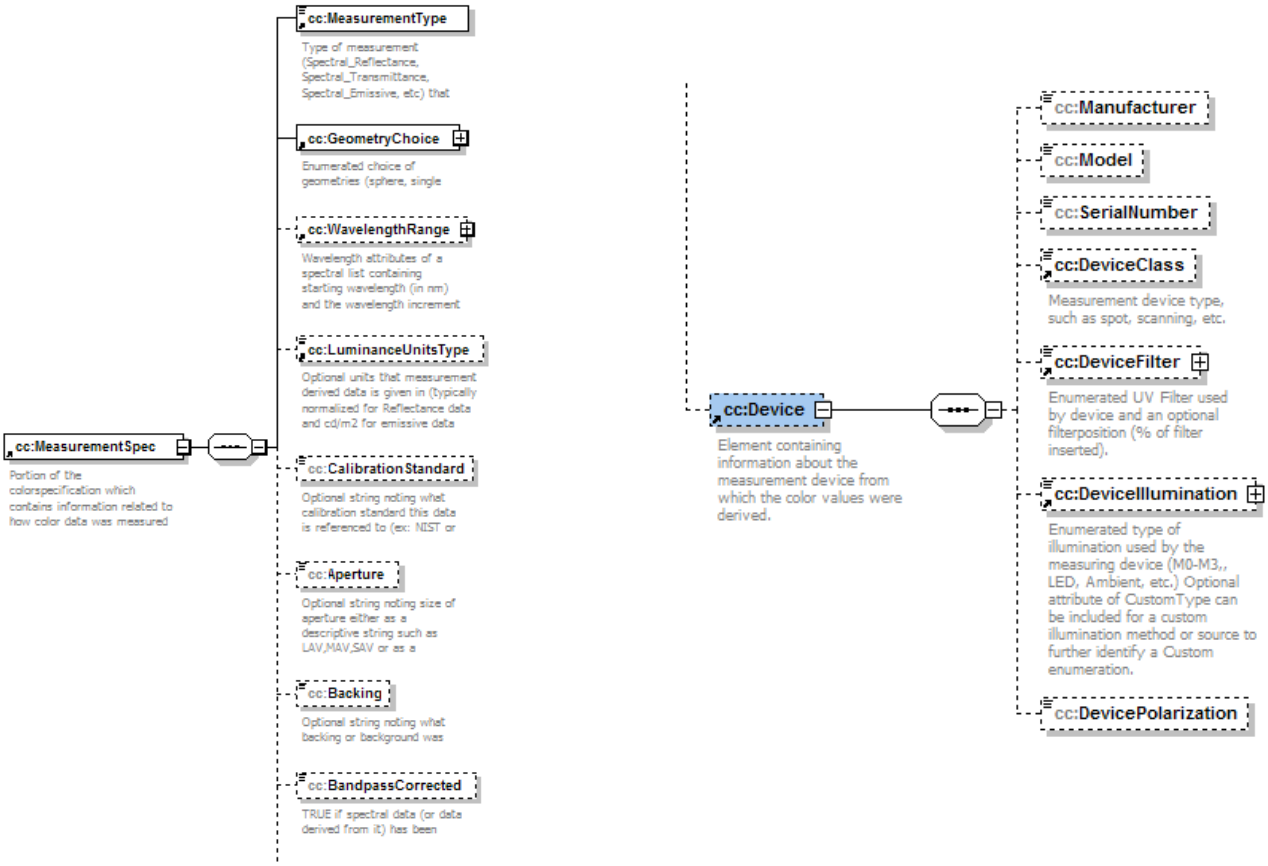
4.1.2.2 ColorSpecificationCollection – stores all of the ColorSpecifications contained in the file.

A ColorSpecification element has an id (used to reference this specification from each Object's ColorValue) and elements including TristimulusSpec, MeasurementSpec, and PhysicalAttributes. **MeasurementSpec (->MeasurementType and ->GeometryChoice) are the only required data**.

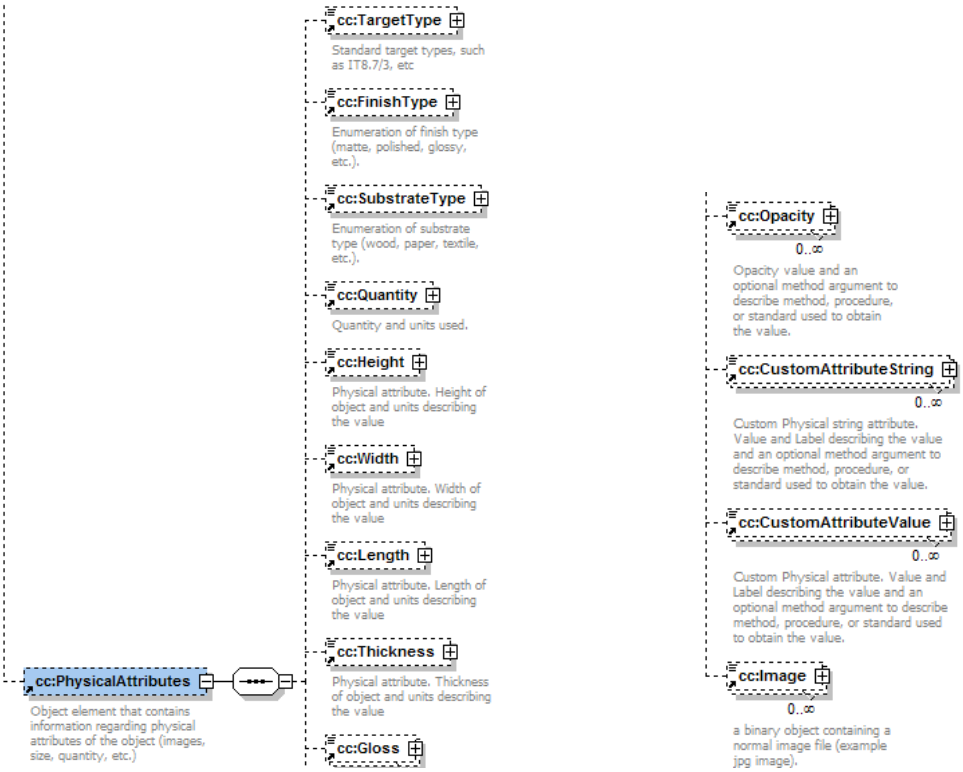
TristimulusSpec (defines colorimetric method and functions used)



MeasurementSpec (defines measurement device and settings)



PhysicalAttributes (defines any common shared physical properties)



4.1.2.3 An example of a CXF3 file (partial - some elements are shown collapsed):

```
<?xml version="1.0" encoding="UTF-8"?>
<CxF xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns="http://colorexchangeformat.com/CxF3-core" xsi:schemaLocation="
http://colorexchangeformat.com/CxF3-core CxF3_Core.xsd">
  <FileInformation>
    <Creator>X-Rite - RFW</Creator>
    <CreationDate>2009-08-18T12:15:33-05:00</CreationDate>
    <Description>Example CXF3 file</Description>
  </FileInformation>
  <Resources>
    <ObjectCollection>
      <Object ObjectType="Standard" Id="R1" Name="dark skin" GUID="30453E30-3068-524A-2E4D-917F2E4D917F">
        <CreationDate>2003-09-28T12:15:33-05:00</CreationDate>
        <ColorValues>
          <ReflectanceSpectrum MeasureDate="2003-09-28T12:15:33-05:00" ColorSpecification="CSD65-2">
        0.0580  0.0594 0.0594 0.0584 0.0581 0.0591 0.0599 0.0601 0.0603 0.0610 0.0634 0.0695 0.0760 0.0786 0.0798 0.0826 0.0897 0.1024
0.1197 0.1350  0.1434 0.1455 0.1499 0.1594 0.1721 0.1842 0.1913 0.1928 0.1878 0.1734 0.1704
          </ReflectanceSpectrum>
          <ColorSRGB ColorSpecification="CSD65-2">
            <MaxRange>254</MaxRange>
            <R>115</R>
            <G>82</G>
            <B>68</B>
          </ColorSRGB>
          <ColorCIELab ColorSpecification="CSD50-2">
        </ColorValues>
        <DeviceColorValues>
        <TagCollection Name="iQC_Tags">
        <PhysicalAttributes>
      </Object>
      <Object ObjectType="Standard" Id="R2" Name="light skin" GUID="30453E30-3068-524A-3E4D-917F2E4D917F">
      <Object ObjectType="Standard" Id="R3" Name="blue sky" GUID="30453E30-3068-524A-4E4D-917F2E4D917F">
      <Object ObjectType="Standard" Id="R4" Name="foliage" GUID="30453E30-3068-524A-5E4D-917F2E4D917F">
      <Object ObjectType="Standard" Id="R5" Name="blue flower" GUID="30453E30-3068-524A-7E4D-917F2E4D917F">
      <Object ObjectType="Standard" Id="R6" Name="bluish green" GUID="30453E30-3068-524A-2E4D-917F2E4D917F">
```

4.1.3 CustomResources

A CxF file might include application specific information within one or more named CustomResources. Each CustomResource will have its own namespace and be validated and defined by its own schema. As a CxF3 element, a CustomResource is available as a string which may be parsed or passed to additional software, libs, or sdk's that are configured to work with that CustomResource type. Examples of CustomResources that are being or have already been developed are:

CxF3-ColorPage	(defines arrangement of objects in page/column/row format)
CxF3-QualityControl	(defines Standard/sample and tolerance relationships)
CxF-Fandeck-1.0	(defines Fandeck arrangement and alternative display names)
SpotInkCharacterisation	(ISO TC130 work in progress)

An example of a CustomResource (ColorPage) in a CxF3 document is shown here:

```
<CustomResources>
  <ColorPage xmlns="http://colorexchangeformat.com/CxF3-colorpage" Name="x-rite Color Checker" NumPages="1" MaxRows="4"
MaxColumns="6">
    <Page Name="ColorChecker" NumRows="4">
      <Row Name="row1" NumColumns="6">
        <Obj Id="R1"/>
        <Obj Id="R2"/>
        <Obj Id="R3"/>
        <Obj Id="R4"/>
        <Obj Id="R5"/>
        <Obj Id="R6"/>
      </Row>
      <Row Name="row2" NumColumns="6">
        <Obj Id="R7"/>
        <Obj Id="R8"/>
        <Obj Id="R9"/>
        <Obj Id="R10"/>
        <Obj Id="R11"/>
        <Obj Id="R12"/>
      </Row>
      <Row Name="row3" NumColumns="6">
      <Row Name="row4" NumColumns="6">
    </Page>
  </ColorPage>
</CustomResources>
</CxF>
```

4.2 Color Exchange Format Document

4.2.1 General

Color Exchange Format supports storing and communicating color data in a structured manor using XML and XSD. This color data may be a single color object or multiple color objects. The CxF3 Core Resources do not impose any sort of relationship or hierarchy on the data included – any such additional relationships or organizational information required should be added with a CustomResource. For instance, a CustomResource of CxF3-QualityControl would contain the information needed to designate the Standard/sample relationships and the tolerances required for each colorspace type. A QC oriented application might want this additional information, but other applications might only be interested in getting/displaying the set of colors without any such relationships.

4.2.2 CxF™ 3.0 Major Schema Elements

A complete layout of the CxF™ 3.0 Schema in PDF form is included as part of this standard as file CxF3.0_Schema_Layout.pdf. The complete and most updated CxF™ 3.0 Schema and documents are available at www.colorexchangeformat.com. Shown below are some of the major elements defined in the schema:

Object:

The following types of elements may be included within an Object:

ObjectType (attribute)	CreationDate	DeviceColorValues
Name (attribute)	Comment	TagCollection
Id (attribute)	ColorValues	PhysicalAttributes
GUID (attribute)	ColorDifferenceValues	

ColorValues:

The following types of elements may be included within ColorValues to hold colorspace information:

ReflectanceSpectrum	EmissiveSpectrum	ColorSRGB
TransmittanceSpectrum	CustomSpectrum	ColorAdobeRGB

ColorCIELab
ColorCIELCH
ColorCIEXYZ
ColorEmissiveCIEXYZ
ColorCIExyY
ColorEmissiveCIExyY
ColorCIELuv
ColorDensity
PrivateSpectrum
PrivateColorValues
CustomColorSpace

DeviceColorValues:

The following types of elements may be included within DeviceColorValues:

ColorHTML
ColorNotation
ColorRGB
ColorHSL
ColorCMYK
ColorCMYKPlusN
ColorCustom
ColorPantoneHexachrome
ColorRecipe
PrivateColorValues

PhysicalAttributes:

The following types of elements may be included within PhysicalAttributes:

TargetType
FinishType
SubstrateType
Quantity
Height
Width
Length
Thickness
Gloss
Opacity
CustomAttributeString
CustomAttributeValue
Image

Annex A - Color Exchange Format compatibility with CGATS 17

ANSI CGATS 17-2005 is the standard text file format for exchanging color measurement data. The standard ASCII text file consists of a Preamble section containing originator information, keyword definitions, etc. and then one or more data sections, each consisting of header and data subsections. The BEGIN_DATA_FORMAT and END_DATA_FORMAT delimiters define the actual data types / units contained in the following tables. The BEGIN_DATA and END_DATA delimiters mark the subsection containing the actual color information in tabular form. CGATS 17 text files can contain device, colorimetric (Lab, XYZ, etc.), densitometric, spectral, naming and other information.

The table below demonstrates that all significant data contained in a CGATS 17 files can be captured and maintained in a CxF™ 3.0 file (without need for a CustomResource in this case, but a CustomResource could be used to make some of the application specific data more structured with defined enumerations and requirements.)

CGATS 17-2005	***CxF 3.0***
Required Fields	
Originator	FileInformation.Creator
File Descriptor	FileInformation.Description
Created	FileInformation.CreationDate
Number of Fields	*Not Required (inherent in XML structure)*
Data Format	*Not Required (inherent in XML structure)*
Number of Sets of Data	*Not Required (inherent in XML structure)*
Data Table	*Not Required (inherent in XML structure)*
Optional Fields	
Comment	FileInformation.Comments
TargetType	FileInformation.Tag (“28178_TargetType”);
Manufacturer	FileInformation.Tag (“Manufacturer”);
Material	FileInformation.Tag (“Material”);
Prod_Date	FileInformation.Tag (“Prod_Date”);
Serial	FileInformation.Tag (“Serial”);
Instrumentation.Manufacturer	MeasurementSpec.Device.Manufacturerer
Instrumentation.Model	MeasurementSpec.Device.Model
Instrumentation.Serial_Number	MeasurementSpec.Device.SerialNumber
Measurement Geometry	MeasurementSpec.GeometryChoice
Measurement Source	MeasurementSpec.Device.DeviceIllumination
Filter	MeasurementSpec.Device.DeviceFilter
Polarization	MeasurementSpec.Device.DevicePolarization
Weighting Function	TristimulusSpec.Observer
Computational Parameter	Tag [name]value
Sample Backing	MeasurementSpec.Backing
Data Table Fields	
Table Descriptor Table Name	*Not Required (inherent in XML structure)*

Data Format Identifiers

Sample_ID	Object.Id
CMYK_C (M,Y,K)	ColorCMYK
D_RED (GREEN,BLUE,VIS)	ColorDensity
RGB_R (G,B)	ColorRGB
SPECTRAL_NM (DEC,PCT)	ReflectanceSpectrum…
XYZ_X (Y,Z)	ColorCIEXYZ
XYY_Y (X,CAPY)	ColorCIExyY
LAB_L (A,B)	ColorCIELab
LAB_L (C,H)	ColorLCH
LAB_DE (DE94,CMC,2000)	ColorDifferenceValues.DeltaCIELab
(ISO_28178 tagcollection)	<cc:TagCollection Name="ISO_28178">
MEAN_DE	Tag (“Mean_DE”)
STDDEV_X (Y,Z)	Tag (“STDDEV_X”)
STDDEV_L (A,B)	Tag (“STDDEV_L”)

Annex B - About XML

Extensible Markup Language (XML) is a universally-accepted file structure that allows for the specification of data without regard to its display (markup) or ultimate use. XML lets you specify data within “elements” of the document, and these elements may have “attributes” that further describe the data. The writer of the XML document follows a “schema”, or DTD (document type definition) that establishes what elements must be present at what position in the document. A software application that is taught the schema relevant to a given document can write data to that document or retrieve data from it in a reliable and secure fashion.

In the case of CxF™ 3.0, if the schema does not anticipate some category of color data that needs to be captured and transmitted, an application development team can extend the CxF™ 3.0 document by creating custom tag collections or completely extend the CXF3 schema by designing and implementing one or more CustomResource schemas to extend the CxF document. If the new document is later used in a system that does not know anything about these custom elements, the system will still be able to access all the color data contained in the specified elements and attributes of the CxF™ 3.0 schema. This robust extensibility is a major reason for the appeal of XML as a vehicle for data capture and transmission.

Almost all modern Internet browsers now include some form of **XSLT**, the formatting and conversion language developed to work with XML. As well, XSLT tools are generally available. An XSLT processor uses a set of transformation rules on a source document (in this case, the CxF™ 3.0 file) to create a new document which may be another XML file or a file in another format (such as HTML). XSLT allows conversion of valid, well-formed XML files for display in browsers and for use in other processes.

XML is a text-based language, and anyone with a simple text-editing program can create or review an XML file.

Annex C - Use Cases

The Color Exchange Format allows for easy encapsulation of data for different purposes. At its lowest level the Color Exchange Format is attempting to achieve 2 things: the concept of “Self Identifying Data”, and a structured methodology for its proper use. The Color Exchange Format attempts to do this while not being self limiting. This concept can be hard to grasp. An additional use of the Color Exchange Format is as a bridge from historical data to be deployed across new technology platforms. The following example use cases for a Color Exchange Format are presented. Electronic CxF™ files that illustrate the workflows below are available in the directory named AnnexC of the accompanying electronic files.

C.1 From Specification to Production

A Creative Director needs to pull together a digital color palette for a fall catalog. Using Design software the designer picks a selection of colors from her Pantone libraries, colors pulled from photographs of the location for the photo shoot and brand colors. She creates a palette called Holidays which contains four color programs:

Classy Red

Winter White

Blue Crystal

Scarlet Ribbon

The resultant CxF™ file is distributed to the Production Design Department, who adds substrate specifications and forwards it to the standards supplier. The standards supplier opens the CxF™ file with their Color control system and verifies that each color can be produced on the requested substrate, or appends similar alternative colors to the CxF™ file that can be matched. Upon receipt of this new file, the Production Design department returns the

CxF™ file with any suggested alternatives to the Creative Director for approval.

The resultant CxF™ file is distributed to the designers working on the Fall catalog. The designers of the catalog use the CxF™ files to create palettes for their applications. Final layouts are sent to the Market manager who can verify that only the correct colors were being used in the final design.

The Creative Director forwards the final CxF™ file to the Production Design Department, who starts the procurement process, adds production specifications to each color object in the CXF file, and forwards the CxF™ file to prospective suppliers. Each supplier opens the CxF™ file in their formulation software and begins formulating the colors within their process. As each supplier makes a match, they return the CxF™ file containing one or more target colors and potential submits for approval to the color approval lab, which opens the CxF™ file with their Color control software and approves or rejects each supplier's submission.

C.2 ASCII Scanner Target Data to CxF™

The electronic data files for section C.2 illustrate the easy updating of legacy IT8 scanner targets (a common use of structured ASCII text files in the Graphic Arts) into the CxF™ 3.0 file format for use in a modern Color Management System.

Annex D - CxF™ Required and Best Practice Guidelines

Schema version 3.0

Below are CxF™ Required and Best Practices guidelines. Best Practices guidelines documents are also available at www.colorexchangeformat.com.

CxF™ documents are validated with an XML schema (XSD) and are only valid if validation succeeds during the read and/or write of the XML document. However XSD validation is not powerful enough to both fully guarantee that CxF™ documents are correct and that users will populate the XML document with data in the correct locations. For these reasons the following rules and guidelines are provided, these will be specified in two sections. The first section will contain required items; these are required to be fulfilled by CxF™ document authors in order for CxF™ documents to be considered valid. The second section will contain best practices; CxF™ authors are strongly encouraged to follow these guidelines even though they may not be required for CxF™ documents to be considered valid.

Required:

-The CxF™ element must be the root XML element and be present in the CxF™ document. (XSD does not have a mechanism to distinguish between root level XSD elements, therefore one can only be specified as the root element by convention.) Note that the X-Rite provided SDK's both require CxF™ to be the root element and generate XML documents using the correct namespace.

-When applications parse/read CxF™ documents they must not reject the entire document if they find color data they do not expect/understand. Rather, they must extract from the CxF™ document aspects of the color they do expect/understand. (Think of CxF™ as a message, a message that describes color. You should listen to the message and use portions of the message that are right for your purposes.)

-To make it possible to share often repeated information (and decrease the file size required) CXF3 maintains two collections. All ColorSpecifications are contained in the ColorSpecificationsCollection and all Profiles are contained in the ProfilesCollection. Every ColorValue type in each Object references the appropriate ColorSpecification (and Profile if needed) by its Id.

-CxF™ documents must be saved using UTF-8 encoding.

Best Practices:

- While FileInformation is an optional element (to allow CXF3 to be used as an internal mechanism for transferring basic color data within a device or software application), when creating CxF3 files for storage or exchange the FileInformation element should be present and include Creator, CreationDate, and

Description elements.

-Support efficiency of the CXF3 format by not including duplicate ColorSpecification or Profile information.

- Define and reference ColorSpecifications for each ColorValue type you include in the CxF3 Object. The ColorSpecification should include the information necessary from another application to determine how it should utilize the colorvalue. At a minimum measurementType and geometry type are required, but colorimetric colorvalues should include illuminant/observer enumerations, and spectral colorvalues should include WavelengthRange and device information.

-Keep tags to a minimum. Use a CustomResource schema to define custom application specific information that no other applications have need for. If tags are added for application specific reasons, use a separate appropriately named TagCollection so those tags can be separated and distinguished from other tags that might be added to the document as it moves through the workflow.

Bibliography

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XSL Transformations (XSLT) Version 1.0, W3C, Recommendation 16 November 1999. Available on the Internet at http://www.w3.org.

CGATS.17 Graphic Technology — Exchange format for color and process control data using XML or ASCII text